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Report on Data Review of Energy Behavioural Data D3.3

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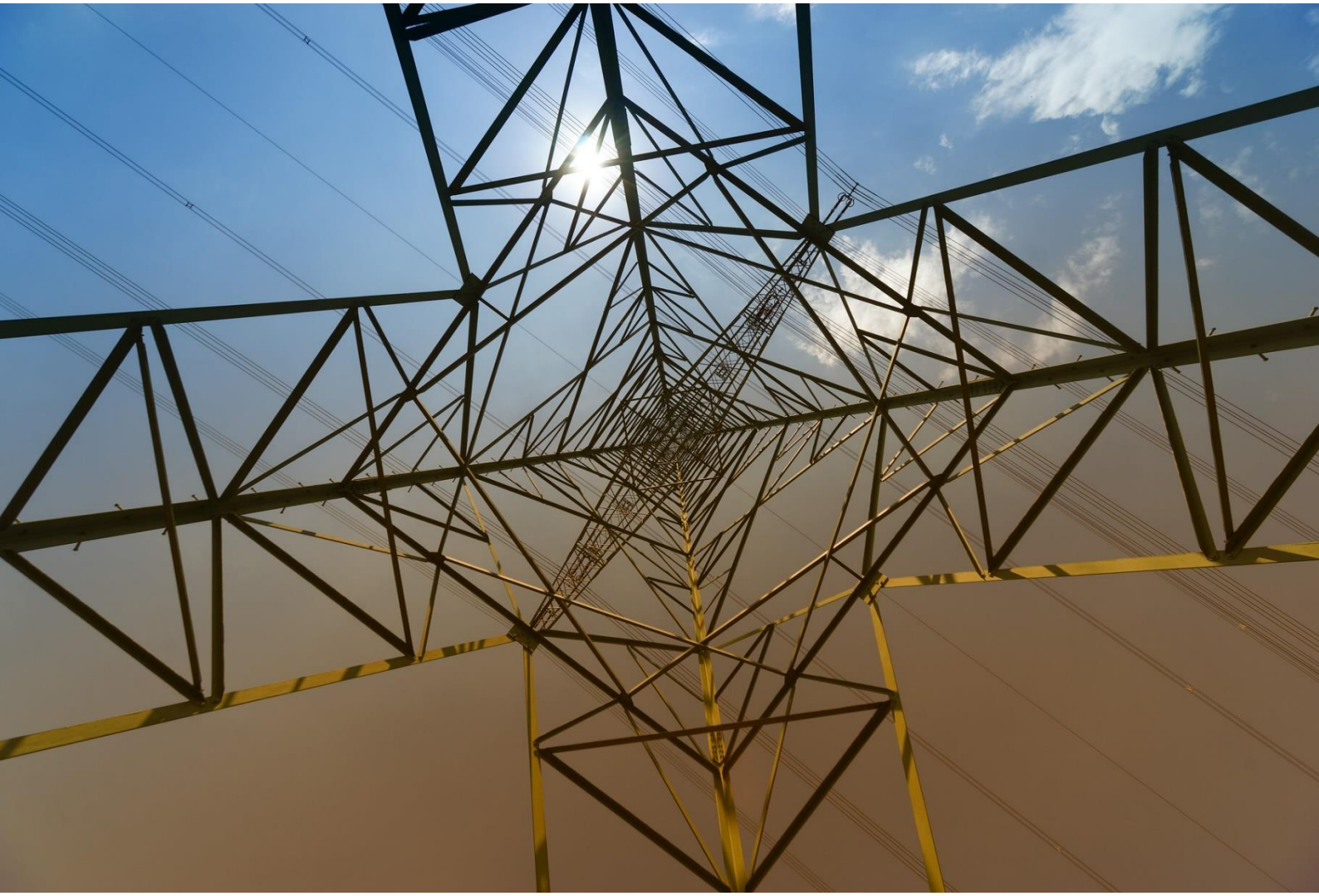

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ENCHANT Report

Report on Data Review of Energy Behavioural Data D3.3
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ABSTRACT

This report is a deliverable for the ENCHANT EU H2020 Project, which outlines research based evidence from various previous projects: It summarizes the types of interventions applied on a wide variety of energy-related choices, mainly involving households, sample characteristics, pilot locations, contextual moderators, intervention means, effects and conclusions, while also pointing at raw data, where available, in order to inform the realization of ENCHANT pilots (invested in WP4) and of a complex policy-making engine with real life evidence (invested in WP6). While pointing out the diversity of approaches, the current report also attempts to draw links between research procedures employed and the conclusions reached in various projects and to draw a number of inferences. It also hints at the main deficiencies and gaps of previous research.

The current report reviews a large body of academic literature building on the previously issued Data Collection Strategy Plan D2.1 under Work Package 2. It is closely related to a similar meta-analysis (Deliverable D3.1) that was performed by Work Package 3 at an earlier stage with regards to projects implemented under the framework of H2020 projects. These two reports joined together are aimed at accomplishing the objective assumed under ENCHANT to build on a relevant body of knowledge accumulated in dispersed attempts to understand the most effective behavioural instruments to improve energy consumption in households.

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1. Introduction

This report has been issued under the work of Work Package 3, which delivers supportive tasks for the work of other Work Packages. More precisely, this output feeds into the design of ENCHANT pilots, but also into the work of WP6. By providing details on types of interventions applied in the past on a wide variety of energy-related choices, sample characteristics, pilot locations, contextual moderators, intervention means, effects and overall conclusions, the current deliverable contributes with a large body of validated knowledge to the design of the ENCHANT pilots, which aim at implementing these conclusions at a scale unprecedented by research precedent. Furthermore, this report feeds into the activity of WP6 the main goal of which is to deliver a policy-recommendation engine that takes into account the features and conclusions of all relevant research, including ENCHANT pilots, in order to be able to produce highly informed policy solutions.

The evidence supply task of WP3 is split into two main steps. The first step was secured in a previous deliverable D3.1. issued by WP3, and which referred mainly to the investigation of previous H2020 projects implemented after 2018, which coincides with the development of a consistent set of energy efficiency norms in the EU. The second step is performed through the current deliverable, which assesses academic publications resulting from the most relevant field research performed to understand how behavioural interventions may be employed to influence the adoption of more efficient and sustainable energy consumption in households. The scope of this report is to enlarge the existing project-based repository with evidence coming from research initiatives coming from beyond the sphere of H2020 grants.

From a methodological point of view, the current report builds upon the work performed by WP2 and published in deliverable D2.1. which had selected publications resulting from behavioural interventions, through a highly complex search method. WP3 made important use of this database to perform its work. WP3 performed a systematic analysis of these articles based on the methodology developed in D3.1. Without going into the details of this methodology, which was described thoroughly in our first report (D3.1), it is suffice to say that it is ties between ENCHANT objectives as described in the grant proposal, the conclusions of the WP2 literature review and a very detailed a description of data needs delivered by WP6. Based on the assessment, only the most relevant academic articles have been kept for a more detailed review. This procedure not only ensured consistency with previous project outputs, but also it made sure that conclusions and results are relevant for the work of ENCHANT.

The current report summarizes the types of interventions applied in the projects on a wide variety of energy-related choices, sample characteristics, pilot locations, contextual

moderators, intervention means, effects and conclusions, while also pointing at raw data sets or summaries, depending on their availability. The report focuses mainly, but not exclusively, on the seven intervention typologies that have been identified as relevant for the ENCHANT project, namely: feedback on consumer's own consumption, social norms, information including simplification, monetary incentives, commitment, competition, collective versus individual framing, and on the following behaviours: investment, maintenance, and behavioural adjustment. Due to the fact that intervention studies rarely make use of just one intervention type in order to enable a clear-cut distribution into categories, the research team has structured its selection by the most important intervention reported in the papers, either in terms of effect size or project effort (where hypotheses have been contradicted by research results).

The report structure is straight-forward: We propose five blocks of pilots, three are based on the type of the dominant intervention employed: (1) Changing consumption behaviour through social norms; (2) Changing consumption behaviour through commitment strategies; (3) Changing consumption behaviour through monetary incentives. (4) Changing consumption behaviour through information. A fifth set incorporates meta-analyses, which are more general in character than the rest of the studies reviewed. There are other three interventions, which are targeted in ENCHANT, namely competition, framing and feedback, which will be presented under these three categories. While presenting each of the selected projects in a more or less inverted chronological order we try to present the general logic of each project in order to make better sense of their more targeted features - aspects that are meaningful for ENCHANT purposes and should be taken into consideration while designing the ENCHANT pilots and the decision-making tool. More specifically, each paper is accompanied by the presentation of its general aim, the methodological design and the research results. At the end of each project presentation, we have displayed the relevant information in a synthetic box and the availability and form of the relevant data. An integrated analytical table is presented in the appendix. General conclusions will be formulated at the end.

2. Relevant Findings in Existent Publications

2.1. Changing consumption behaviour through social norms interventions

Social norms and energy conservation beyond the US

(Andor, Gerster, Peters, & Schmidt, 2017)

In this article, Andor et al (2017) apply a methodological framework employed in previous studies performed in the US in the German context in order to test the effect of social norms and feedback instruments on energy consumption in households.

Methodology: Through a large-scale RCT, they test the assumption based on previous findings that social comparison-based home energy reports (HER) have a larger effect on energy consumption than other types of consumption feedback (i.e., 1.5% decrease in energy consumption in the US (Allcott H. , 2011)). In cooperation with the German company Grunspar, which is a medium-sized energy service provider, four social comparison quarterly reports for the test group (with no additional communication for the control group) have been disseminated to a random sample of 11,630 households in Kassel, Germany, between November 2014 and April 2015. These social comparison-based quarterly reports compare the average annual consumption of the beneficiaries to that of their neighbours in general, and to a 20% segment of most efficient neighbours and scores the performance of the recipient in comparison to these two groups. The overall performance of the recipient is evaluated on a three-level evaluation scale. The instrument is illustrated below:

Findings: The authors find that the effect sizes of HER on energy consumption are much lower in Germany than in the US, pointing out the context-dependence of such social norms interventions (Andor, Gerster, Peters, & Schmidt, 2017).

Key elements: Social norm/Feedback RCT intervention through home energy reports (HER) with an average effect of 0.7% reduction in energy consumption, deployed on a sample of 11,630 residential electricity consumers.

The online appendix is available at: https://www.rwi-essen.de/media/content/pages/publikationen/ruhr-economic-papers/rep_714_online_appendix.pdf

Buying an electric car: A rational choice or a norm-directed behavior?

(Bobeth & Kastner, 2020)

The article discusses determinants of electric car acquisition based on the technology adoption model.

Methodology: Bobeth and Kastner (2020) use a technology adoption model (TAM) to test the drivers of the intention to buy an electric vehicle. Within the study TAM is adapted in such a way as to allow for comparison and contrast with norm activation model (NAM), in which social and personal norms play a key role.

Findings: Electric car adoption was affected by rational and norm-directed motives. Results indicated the general suitability of both a rationality-oriented and a norm-oriented approach. In the integrative model, both a TAM construct (perceived usefulness) and NAM constructs (personal norms and social norms) appeared to be significant predictors of intention. From both sets of drivers personal norms and social norms explained the highest share of variance.

Key element: It was concluded that the norm activation model based on social and personal norms was most efficient in predicting adoption intention.

Data is available at:
https://www.sciencedirect.com/science/article/abs/pii/S1369847820304460

When it is not about the money: Social comparison and energy conservation among residents who do not pay for electricity

(Bator, 2019)

The article displays two interlinked studies in which the authors applied a complex set of interventions consisting of information, feedback on own consumption, commitment, social norms, and a variant of monetary incentives through the distribution of low-cost energy (as opposed to free energy) or monitoring equipment. The experiments had two main objectives: to encourage a more efficient and aware use of energy in general and of air-conditioning specifically in low to moderate-income families and to establish the impact variation between in-person and impersonal interventions.

Methodology: The studies were performed on total of 2,000 low to moderate-income multifamily apartment buildings in downstate New York, where approximately 5,000 residents do not pay for energy. A total of 900 households were randomly selected for interventions, but due to a lower-than expected door response, the two subsequent interventions/studies were applied only to a total of 794 randomized apartments, out of which 242 were in the control condition. Of the remaining 552 apartments in the normative feedback condition, 208 were contacted, received the treatment, and signed a commitment form. The analyses compared these 208 social normative feedback apartments to the 242 control apartments.

Interventions were deployed across two interlinked studies with separate intervention groups. Both experiments were conducted during summer months, which were associated with higher electricity consumption due to the use of air-conditioning. Both studies focused on reducing the use of cooling technology, one through an in-person intervention and the second through impersonal interventions (see below).

Study 1 consisted of face-to-face communications that provided a social norm feedback (essentially, comparison to neighbours' energy use); the installation of a room

thermometer for self-evaluation of indoor temperature, and of free compact fluorescent lamps (CFLs); the communication of energy saving tips in order to encourage a reduced use of air-conditioning; a written commitment to more efficient energy consumption inside the home in the form of signed certificates. The information material was conveyed to residents at the moment of the social-norm-based feedback intervention, and it comprised best practices to reduce air-conditioning use, and, more generally, for energy efficiency. Moreover, with the fluorescent bulbs (CFLs) beneficiaries were also provided with CFL fact sheets and information. The in-person visits were performed by AmeriCorps members (Bator, 2019).

The second study eliminated face-to-face contact and provided instead materials under residents' doors.

Findings:

The results showed that there was a significant omnibus change over time ($F(4.55, 2041.60)=8.88$, $p < .001$, Greenhouse-Geisser epsilon correction), but, neither the treatment ($F(1,449)=.01$, $p=.94$) nor the time x treatment interaction ($F(4.55, 2041.60)=.92$, $p=.46$) were statistically significant.

Key elements: Information, Feedback, Commitment, Monetary and Social Norm with 5.8% short term and 5.3% long term effect in energy consumption reduction.

No replication data available

A meta-analysis of field-experiments using social norms to promote pro-environmental behaviors. Global Environmental Change

(Bergquist, Nilsson, & Schultz, 2019)

This article is a meta-analysis recording 91 field experiments using social norms, performed between 1978 and 2019.

Methodology: Bergquist et al conducted this study, which aggregated the impact of these interventions, in order to encourage pro-environmental behaviours.

Findings: The meta-analysis showed that the results of 91 field-experiments revealed a positive main effect of social norms on pro-environmental behaviours compared to no-treatment control conditions. Moderation analysis found that social norms induced implicitly were more influential than social norms induced explicitly and that social norms tended to be more influential in individualistic countries than in collectivistic ones.

Key elements: social norms have a positive impact on pro-environmental behaviours, ranging between 0.276 and 0.368 and tend to be more influential in individualistic countries than collectivistic ones.

Do the effects of social nudges persist? Theory and evidence from 38 natural field experiments
(Brandon, et al., 2017)

Brandon et al (2017) investigated the extent to which the effects in behavioural changes can be maintained in the long run. As such, their study applied information and social norm interventions in 38 intervention waves over a 6-year period in randomly selected households across 21 utilities in an American context. Scientists compared treatment and control homes after intervention in order to establish persistence of effects.

Methodology: Brandon et al 2017 utilized empirically tested strategies from previous studies to design each of the 38 waves of interventions as a separate experiment. The field experiments were implemented in partnership with a utility provider, Opower, across 21 utilities between 2008 and 2014. An RCT method was employed to devise the intervention/control groups. Households in the control group were left untouched, while those assigned to the treatment group received a periodic mailer from Opower, called the Home Energy Report or HER (see Figure below). HER combine various treatment instruments such as: comparison with other households in the neighbourhood with respect to energy usage, energy conservation tips, and information on energy efficient technologies to motivate energy conservation. Treatment households received home energy HER monthly, bi-monthly, or quarterly before move-out.

Findings: HER reduced energy consumption in treatment groups and nearly half of the reduction caused by the HER persisted after the treatment.

Key elements: effect persistence over time is linked to investment in energy efficient technology and not (only) to habit formation
Appendix data available at:
https://www.nber.org/system/files/working_papers/w23277/w23277.pdf

Testing for crowd out in social nudges: Evidence from a natural field experiment in the market for electricity

(Brandon, List, Metcalfe, Price, & Rundhammer, 2019)

The study tested the crowding out effect in social nudges during peak load events in interventions in electricity consumption applied to 42.100 American households. Two social nudges were applied: one targets energy conservation during peak load events, whereas the other promotes aggregate conservation.

Methodology: The RCT natural field experiment involved essentially four intervention groups, which received either (1) no communication, (2) home energy reports (HER), (3) peak energy reports (PER), or (4) both HER and PER. Brandon et al related the effect of receiving both social nudges during peak load events to the sum of the conservation effects caused by the HER and PER treatments in isolation.

Findings: Receipt of the PER resulted in a 3.8% reduction in electricity consumption during a peak load event, whereas the receipt of the HER resulted in a 2.1% reduction under the same conditions. When received in combination, the two social nudges caused

households to reduce their electricity consumption by more than the sum of their independent effects: 6.8%.

Key elements: social nudges reduce peak load electricity consumption by 2 to 4% when implemented in isolation, and by nearly 7% when implemented combined.

This article contains supporting information online at www.pnas.org/lookup/suppl/doi:10.1073/pnas.1802874115/-/DCSupplemental

Tackling energy poverty through behavioral change: A pilot study on social comparison interventions in social housing districts.

(Caballero & Della Valle, 2020)

Caballero and Della Valle (2020) report on a pilot conducted in Bolzano (Italy) aimed at assessing the effectiveness of social norms (via comparison interventions) in households affected by energy poverty.

Methodology: Research appeals to injunctive and descriptive norms embedded within In-Home Devices (IHD) in recently retrofitted homes.

Key elements: There is a larger electricity consumption reduction in the control group than the test group, suggesting that social comparison interventions might backfire in a context of elderly population and energy poverty.

No replication data available.

The behavioural effect of electronic home energy reports: Evidence from a randomised field trial in the United States

(Henry, Ferraro, & Kontoleon, 2019)

The article describes the application of information and social norm interventions at the level of households by means of monthly HERs for a period of a year (2015) and measures the impact on energy consumption. The intervention informs households about their own consumption and that of average and efficient households. Additionally, it offers recipients information about the energy efficiency of the home and ways to improve consumption through behavioural change.

Methodology: The interventions were implemented on 9,383 households by a home sensing company through an utility provider by applying a RCT research design. Electronic and bill-based information were sent to two distinct intervention groups containing, essentially, the same type of information.

Findings: The programme reduced household electricity consumption by 2.9%, 95% CI [-5.0%, −0.76%].

Key elements: With a 2.8% average reduction in electricity consumption based on monthly HERs, Henry et al 2019 claim that electronic HERs are at least as effective as reports delivered by post in reducing electricity consumption, while they are administered at a lower cost.

Data available at:
https://www.sciencedirect.com/science/article/abs/pii/S0301421519304094#ec-research-data

The critical role of second-order normative beliefs in predicting energy conservation

(Jachimowicz, Hauser, O'Brian, Sherman, & Galinsky, 2018)

Jachimowicz et al (2018) look at second-order normative beliefs, or beliefs about other people's beliefs that saving energy helps the environment and their impact on consumption.

Methodology: The study is essentially a meta-analysis of 211 existing RCT HER studies implemented by the utility provider Opower across various US states. Results were triangulated with a survey to test the relevance of first-order personal beliefs over second-order normative beliefs, and an experimental survey targeting the effect of manipulated second-order beliefs. The first was addressed to over 2,000 individuals, whereas the second targeted 561 pre-registered participants from Amazon Mechanical Turk (AMT) and showed that the manipulation of second-order beliefs was successful in informing respondents' energy consumption intentions. This effect was traced back to the fact that participants in the *high second-order beliefs* condition had significantly higher levels of second-order beliefs (M=5.28, SD = 1.49) than participants in the *low second-order beliefs* condition (M=4.10, SD=1.55; t(559)=9.21, p<.001).

Findings: Opower RCTs recorded energy savings between 0.81% and 2.55% across several US states. The survey found that second-order normative beliefs predicted energy savings rates (coeff=0.755, SE=0.323, p=0.030), whereas first-order personal beliefs did not (coeff=0.209, SE=0.324, p=0.527).

Key elements: Second-order normative beliefs can predict energy savings, but first-order personal beliefs cannot.

The survey response data collected on AMT is available on the Open Science Framework:
https://osf.io/jaz4w

Social Learning and Solar Photovoltaic Adoption

(Gillingham & Bollinger, 2020)

The paper examined the adoption of solar photovoltaic systems through the lens of incentives based on social learning and peer interaction.

Methodology: The study was based on the umbrella program Solarize, deploying community-level information campaigns in the state of Connecticut for the adoption of residential solar systems. Interventions were applied at the municipality-level, in 53 municipalities. The interventions were applied between 2012 to 2015. Fundamental to this design was the selection of volunteer ambassadors from the local communities entrusted with performing the primary outreach in their communities. A survey was applied on solar panel adopters after the Solarize campaigns.

Findings: On average, treatments were found to lead to an average of 37 additional installations over the course of a campaign within the treated municipalities, which was established to be a 1,000% increase above control.

From the findings of the post-intervention survey, it became clear that the top five sources of information which were either extremely or very important in relation to behavioural change involve social learning processes: town events, recommendations from friends, neighbours or the townsperson and talking to a solar ambassador.

It should, however, be noted, that the systems installed in Connecticut were also eligible for state rebates, federal tax credits, and net metering incentives. Therefore, the importance of financial interventions in causing these effects is not excluded. Nonetheless, they do not constitute a priority for the study.

Key elements: The study deployed solar power-related information campaigns in municipalities of the state of Connecticut, USA, from 2012 to 2015 and obtained a spectacular rate of adoption of 1000% of photovoltaic installations compared to control. Results were associated with important information channels that incorporated a high degree of social learning.

Additional information is available at:
https://pubsonline.informs.org/doi/abs/10.1287/mnsc.2020.3840

The interaction of descriptive and injunctive social norms in promoting energy conservation
(Bonan, Cattaneo, d'Adda, & Tavoni, 2020)

Bonan et al (2020) investigate the impact of different components of home energy reports (HERs) on household consumption in the Italian context: (1) information on others' behaviour (descriptive feedback) and (2) approval for norm compliant behaviour (injunctive feedback).

Methodology: The project applied an RCT strategy implemented with an Italian utility provider in 2016 across 464,523 customers (n = 418,178 treatment, n = 46,345 control). The treatment group received social norms and information-based interventions related to their own electricity use, compared to that of other more efficient or similar neighbouring households. Additionally, beneficiaries had access to an analysis of their own consumption and tips on improvement. Interventions were performed online via email (eHERs).

Findings: The study concluded that the average savings acquired, i.e. -0.353%, were much smaller than those of previous studies performed in the US. When descriptive and injunctive feedback were in conflict, conservation behaviour became a function of the relative strength of the two types of feedback. Additional social-norm feedback produced smaller gains when it reinforced existing and similar information. For high users, normative and injunctive feedbacks pulled behaviour in the same direction. This resulted in a reduced electricity consumption almost twice the level of the average treatment effect. For low electricity users, conforming to the reference groups' behaviour motivated a consumption increase (a 'boomerang' effect), but the injunctive feedback included in the eHER succeeded to counterbalance the negative effect of the descriptive feedback. The injunctive feedback, therefore, induced stronger behavioural reactions among high electricity users also exposed to the supporting descriptive feedback, than among low electricity users, for whom the two types of feedback were at odds.

Key element: There are complementarities between different types of normative messages rather than superiority of any one kind of feedback.

Motivating non-ratepaying households with feedback and social nudges: A cautionary tale
(Crago, Spraggon, & Hunter, 2020)

The study examined the effect of feedback and a social norm nudges in the form of own consumption information, including monetization, and peer comparison (to average and efficient neighbours) on non-rate paying households.

Methodology: The experiment was based on RCT design-based hourly observations of 62 households over thirteen weeks. The measurements were performed after the distribution of HERs to a treatment group as opposed to a control group. Evaluations were performed in comparison.

Findings: Results suggested that neither feedback nor peer comparison were effective instruments to reduce the energy use of non-rate paying households, which may have increased their consumption in some contexts. For high users HER feedback even generated an increase of energy consumption of 14.2%. Authors' explanations pointed at the reinforcement effect of the benefits of free electricity by way of interventions.

Key element: Feedback and social norms might not be effective behavioural interventions in a context in which financial incentives to reinforce intended effects are absent.

Tell me something I don't already know: Informedness and the impact of information programs
(Byrne, La Nauze, & Martin, 2018)

Byrne et al. (2018) investigated the impact of information interventions on households with various income backgrounds in the Australian context.

Methodology: Prior to treatment, Byrne et al. ran a baseline survey via email and a linked website to collect data on home characteristics, such as the number of rooms and residents, gas appliances, and air-conditioning. Additionally, the study innovatively elicited households' perception about their relative energy use with the following question: "Compared to energy use in Melbourne homes as large as yours, what statement best describes your household's monthly energy use? a. High (top 20%) b. Above average (top 40%) c. Average d. Below average (bottom 40%) e. Low (bottom 20%)".

Findings: Byrne et al 2018 found no evidence that households systematically underestimated relative energy use. Low-energy users were no more informed about their relative use than high users. The interpretation provided in the paper was that most households think that they are "average" users. Moreover, high- and low-energy users symmetrically underestimate and overestimate their positions in the energy use distribution. Byrne et al 2018 also found a „boomerang" effect, as households that had overestimated their energy consumption, increased, after the information treatment, their consumption by 6.3%. Regardless of beliefs, households in the lowest quintile of the baseline energy use increased their energy use by 11.7% in response to the information treatment, while households in the highest quintile decreased their use by 11.0%, showing that both low- and high-energy users exhibit a reversion toward the mean as a result of treatment.

Key element: Highest energy consumption households had the largest decrease in consumption, with 11.7% following information treatment. Interventions may also have „boomerang effects" as those underestimating their energy consumption or those placed in the lower quintile of energy consumption before the experiment, subsequently increased their consumption by 6.3% and 11% respectively.

Encouraging energy conservation at work: A field study testing social norm feedback and awareness of monitoring

(Wong-Parodi, Krishnamurti, Gluck, & Agarwal, 2019)

The study performed by Wong-Parody at al. tests the impact of social norm, feedback and monetary incentives treatments on a sample 46 pre-recruited university administrative staff.

Methodology: Recruitment emails were sent to staff previous to interventions asking them to participate in a research study monitoring network connectivity and power quality, explained as both the quality Wi-Fi and the rate of power spikes and failures in their office. This was essentially a deception strategy used for two reasons: (1) to ensure that participants were unaware that their energy use was being monitored during the baseline phase of the study, so it could be employed as a state of control for the monitoring condition; (2) to prevent the sample from being biased towards those who would naturally participate in a study related to energy conservation. They were also instructed that the study would involve plugging a small energy meter the size of a phone

adapter inline with office computers. As an incentive to partake, participants entered a lottery to win one of two $200 Amazon gift cards. The intervention was described as a sequence of events: Whereas during the first 4 weeks no intervention was applied except for energy consumption monitoring, over the following month beneficiaries received weekly messages containing information on their own energy consumption. This was followed by another four weeks of non-intervention and monitoring, whereas at the end of the period (week 12) participants were applied a questionnaire to account for perceptions on their behavioural change.

Key element: Social norms and feedback treatments led to a 10% decrease in energy consumption during intervention and 11% decrease in follow-up monitoring.

Information provision and energy consumption: Evidence from a field experiment
(Aydin, Brounen, & Kok, 2018)

The study consisted of a field experiment performed on the island of Texel (Netherlands) by the local utility provider Liandel, using in-home displays (IHD), smart meters and price incentives, on 300 pre-registered consumers, from January to August 2014. The study applied a complex set of interventions: Participants received weekly information regarding the best way to use their IHD, as well as high frequency feedback on their energy consumption. Moreover, participants were urged to commit to a certain consumption level during their treatment period and received occasional tips on how to improve energy consumption.

Methodology: The experiment was conducted in two phases. At first, households (March, 2014) in the treatment sample were supplied with IHD and received information about their energy use levels and expenses. Participants were also supplied with smart energy plugs that helped detect the energy-intensive appliances within their home. In addition to the high-frequency feedback (which was available every 15 min), participants were asked to set goals for their energy consumption. Using the IHD, household beneficiaries were enabled to monitor their real consumption and compare it to goals. In the second phase of the experiment (May, 2014) participants received weekly messages regarding the best way to use their IHD, as well as high frequency feedback on their energy consumption. Personal advice for saving energy was provided three times a week. During this period, households also received information regarding their consumption levels relative to other households. All communication about consumption, energy saving advice and relative comparisons were provided through the IHD. The control group was represented by a randomly selected sample of 54 households whose energy consumption levels was monitored by Liandel throughout the entire treatment period.

Findings: Aydin et al 2018 found that information treatment reduced electricity consumption by around 20% on average in the treatment group, but that most of the feedback effect occurred during off-peak hours, and in clusters of households that were older and more focused on energy conservation. Treatment caused a steady decrease of

consumption during the project, with a slight upward change during its last part in both treatment and control group. This change coincided with the beginning of the summer months.

Key element: High frequency-personalised information (i.e., 3 times a week) over the course of several months, coupled with commitment and social norms interventions caused an effect of up to 20% reduction in energy consumption.

Explaining interest in adopting residential solar photovoltaic systems in the United States: Toward an integration of behavioural theories
(Wolske, Stern, & Dietz, 2017)

This study aimed to investigate the psychological and social determinants of consumer interest in photovoltaic panels. The design of the study drew on theoretical developments from the diffusion of innovations theory, theory of planned behaviour, and value-belief-norm theory.

Methodology: The study was based on an online survey of 904 homeowners from Arizona, California, New Jersey and New York, who had not yet adopted solar panels at the moment of the study. The survey was fielded through a paid panel. The choice of states was motivated by the fact that they had the largest residential photovoltaic market at the time of the study. The sample had a balanced number of respondents from each state.

Findings: Consumer characteristics with the largest influence on interest in pursuing the installation of residential solar panels were: those who believed solar panels would personally benefit them, those who trusted installers, and those with a higher baseline interest in new technologies. Moreover, pro-environmental personal norms were found to increase only indirectly the interest in photovoltaics through perceived personal benefits.

Key element: Belief in future personal benefit, trust in installers and higher interest in new technologies were found to be individual-level characteristics which predict interest in photovoltaic panels.

The study displays limited details on the methods employed. Some additional information can be found at:
https://www.sciencedirect.com/science/article/abs/pii/S2214629616303279

Social comparison and energy conservation in a collective action context: A field experiment
(Kandul, Ghislaine, & Lanz, 2020)

Kandul et al. proposes a research in which he studies in comparison the effectiveness of various types of social norm interventions applied in a collective action context in order to cause an energy conservation behaviour.

Methodology: The RCT study developed by Kandul et al. implemented interventions based on information, feedback on the relative average indoor temperature levels and social norms (i.e. social comparisons, environmental values, propensity to cooperate for financial gain/corporate responsibility). The sample included 821 household apartments split into control and various treatment groups as displayed below. Interventions were delivered through letters. A differentiated comparison was applied on both different interventions and amongst different groups (i.e. control and test, below-average pre-treatment temperatures and above-average pre-treatment temperatures).

Findings: Treatment effect estimates vary between −0.25 and −0.31Degrees Celsius (−1.1% and −1.3% respectively) variation in indoor temperature. There is no documented „boomerang effect" observed by Kandul et al in relation to some consumer groups, such as low energy consumers as identified in other similar studies. Treatment effects are heterogenous across interventions and pre-treatment energy consumption patterns (i.e., high temperature, low temperature).

Key element: A homogenous 1.3% effect decrease in indoor temperature levels was observed even in the absence of monetary incentives to encourage energy conservation.

No replication data, but supplementary material available at: https://ars.els-cdn.com/content/image/1-s2.0-S0165176520300045-mmc1.pdf

Based on the results obtained in studies applying a leading social norm intervention a number of intermediary conclusions can be formulated. Social norm interventions have been found to vary across context and socio-economic strata. They tend to be more influential in individualistic rather than collectivistic environments and have a backfire effect in energy poor, financially poor or elderly households. Social norms were also found to be more effective with high consumers than other types of households and to cause a boomerang effect with households that had a general tendency to underestimate their consumption. It was also found that trust in various agents may play an important role in technology adoption, such as was the case of PV which were associated with higher trust in installers and the future benefits of the technology presented.

Complementarities have been identified among various types of normative interventions in various instances, even in the case of social nudges. Moreover, these combined normative nudges tend to be particularly effective in peak load events. It was also found that nudges used with a higher frequency, for a longer period of time and which have a higher degree of personalization tend to be more impactful. Also implicit normative interventions are more effective than explicit ones, while second order normative beliefs can be stronger than first order ones. In contrast, complementarities have been identified to be absent when normative interventions are combined with other types of

interventions (such as feedback). In such combo interventions, the use of financial incentives have been found to have a corrective/reinforcing effect.

In terms of cost-effectiveness, one study pointed out that online HERs may be just as effective as offline ones, however, at a lower expense.

With regard to the sustainability of effects over time, some studies pointed out an overall decreasing tendency of normative interventions, whereas one study cautioned that persistence over time could be strongly linked to investment rather than habit formation.

2.2. Changing consumption behaviour through commitment strategies

Pull the plug: How private commitment strategies can strengthen personal norms and promote energy-saving in the Netherlands
(van der Werff, Taufik, & Venhoeven, 2019)

Methodology: The study tested the effect of interventions based on a private commitment strategy, in which people pledged to change their behaviour in order to lower household energy consumption. Participants were recruited in the educational centre of the zoo 'Ouwehands Dierenpark' in the Netherlands. Volunteers and the three authors of this paper asked visitors whether they were willing to participate in a university study. Recruitment was performed Wednesdays, Saturdays, Sundays and during every day of the week during school holidays over a period of 5 months. Visitors who agreed to participate were asked to read a project poster providing information about the energy use of household appliances and the relationship between energy use and climate change. In addition, one third of participants were presented with a poster showing factual information on the consequences of climate change, and one third of were presented with a poster showing a polar bear on ice stating: 'Help save me, pull the plug'.

Findings: The study found that private commitment only influenced energy saving behaviour when the behaviour was perceived to be relatively effortful. When people found it easy to engage in the behaviour, the private commitment did not promote energy saving behaviour. Stronger personal norms were positively related to energy saving behaviour, but people's injunctive norms and environmental self-identity did not explain why making a private commitment changed energy saving behaviour when this behaviour was perceived to be relatively effortful. Van der Weff et al 2019 found no effects of the polar bear poster on switching off appliances or any of the other variables.

Key element: When people find the energy saving behaviour somewhat demanding, private commitments may increase their personal norm to engage in it.

No replication data available

When nudges fail to scale: Field experimental evidence from goal setting on mobile phones
(Löschel, Rodemeier, & Werthschulte, 2020)

The study proposed by Löschel et al. (2020) took a novel approach to the evaluation of policy interventions of everyday energy consumption at the level of residential customers. It deployed a large-scale nudge intervention in realistic conditions, mimicking what a scaled-up intervention of this kind would look like. Authors advertised a mobile application tracking energy consumption to a large public in the municipality of Münster, Germany, a city with over 310,000 inhabitants, and measured both the interest for the

product, as well as the effects of its use on energy consumption. The intervention employed essentially a commitment strategy to cause behavioural change, but also monetary incentive, self-reporting, information and feedback on consumption.

Methodology: The authors deployed a mobile application in Germany, in partnership with a large public utility company. The application was designed to help energy consumers set consumption goals for themselves. The randomized treatment consisted in receiving a nudge prompting users to set themselves a goal. The sign-up to the app was based on self-selection from the public reached by a mass marketing campaign advertising the app.

The interventions applied through the app were: a) self-reporting, b) information, c) commitment, d) and e) feedback on consumption.

The experiment ran for seven months in 2018. Every user who downloaded the app was offered a financial incentive of EUR45 for completing five meter readings, 30 days apart. The amount of energy consumed every month was calculated in between these meter scans. After a scan, participants in the treatment group were prompted to set a consumption goal for the next month and were given feedback on meeting their consumption target at the end of the month.

Findings: Demand for the app was low despite conducting a large and intensive marketing campaign through flyers distributed through the energy bill, and despite the sign-up financial incentive put in place. The effect of the nudges on electricity consumption among app users was estimated at a null value. Moreover, receiving the nudge decreased the likelihood of using the app over time. The authors confirmed through a post-experiment survey that the null effect might be explained by the self-selection to app usage: users with already low baseline consumption and high levels of energy-related knowledge were the ones attracted to download and use the app. Effects did not significantly improve baselines.

Key elements: The study demonstrated that an entirely voluntary treatment sign-up scheme to a goal setting/nudge facility would be the equivalent of preaching to the choir. Self-selection was strong despite the financial incentive. Moreover, the effect of receiving nudges to meet a self-selected consumption goal had a zero-effect on energy consumption.

Additional information on the materials of the experiment can be found in the paper's annexes at: https://www.econstor.eu/handle/10419/223352

How to promote conservation behaviours: the combined role of environmental education and commitment

(Barata, Castro, & Martins-Loução, 2017)

The study involved interventions based on information and commitment, among teenagers with the aim of promoting energy and water conservation at home.

Interventions were essentially applied during an energy efficiency project, implemented in the Botanical Garden of The Lisbon University, entitled 'SoS Climate Change and Biodiversity' with the aim to raise awareness about the need for sustainable behaviour in energy and water consumption, in order to contribute to mitigating climate change and the loss of biodiversity. The event took place in 2008 and was repeated in 2010. Results are based on data collected across both instances.

Methodology: 418 students (214 male and 204 female) aged between 11 and 15 years (6th–9th grade of the Portuguese school system), from 21 classes in four different schools in Lisbon, were invited to participate in both occasions. An RCT design was applied in every pilot. Students were divided in two groups: an intervention group comprised of twelve classes (248 students), and control group, which included nine classes (170 students). To test the influence of commitment on behaviour, 136 students from seven classes, 80 from group 1 and 56 from group 2, signed a public/collective commitment to make an effort to save energy and water at home for one month. The other 135 students signed a similar private commitment (80 from group 1 and 55 from group 2).147 students (88 from group 1 and 59 from group 2) did not sign any commitment being part of the control group. Conservation behaviours were measured in two ways – directly through the collection of consumption data and through a pre- and post-survey.

Findings: Results indicated that (1) participants may have saved more energy than non-participants and (2) those signing a public commitment saved more energy and water than those who signed private or no commitment at all.

Key element: Public commitments had the strongest effect from all interventions applied, bearing a 7% effect size.

Survey questionnaire available at:
https://www.sciencedirect.com/science/article/pii/S0301421519305798

One for all? The impact of different types of energy feedback and goal setting on individuals' motivation to conserve electricity
(Brandsma & Blasch, 2019)

Brandsma and Blasch (2019) investigated in their study how different types of energy feedback, combined with goal setting, impact consumers' motivation to save electricity in the Netherlands.

Methodology: Authors implemented a survey among customers of the Dutch green energy provider Qurrent. Participants were randomly assigned to different goal setting conditions and were required to indicate their willingness to conserve energy considering different types of energy feedback. Participants were advised to set themselves either a high, low or no energy conservation goal. The survey also covered participants' value orientations and various demographic and behavioural characteristics. Respondents' value types – hedonic, egoistic, altruistic and biospheric – were used to test predictions

derived from goal framing theory. Before large-scale application, the survey was pre-tested on a small, convenience sample. After that the survey was upscaled and an invitation to the survey was sent by email to 10.000 customers (in May, 2017). After three weeks, 835 customers responded, which corresponds to a response rate of 8.35%. The total sample size was 651 consumers.

Findings: It was concluded that individuals scoring high on biospheric values were more likely to save electricity. However, their motivation did not increase in response to setting an energy conservation goal. Individuals with egoistic values seemed less willing to reduce their electricity consumption. A high conservation goal was only found to be effective in combination with a monetary feedback: it increased the motivation to save electricity by 6.7% in comparison to the low goal condition and 6.6 percentage points in comparison to the control condition.

Key element: Certain social values were found to be strong predictors of energy saving behaviour (i.e. biospheric values), whereas goal setting interventions were found to be more effective in generating motivations to save when coupled with monetary incentives.

Based on the findings of studies applying a dominant commitment intervention, a number of conclusions can be drawn: Public commitments tend to be more effective than individual ones, however individual commitments were found to be important when associated with a consumption behaviour that was perceived as somewhat demanding. Voluntary participation in commitment pilots lead to null effects. As in the case of normative interventions, positive effects of monetary incentives were found also in complementarity with commitment.

2.3. Changing consumption behaviour through monetary incentives

Harnessing policy complementarities to conserve energy: Evidence from a natural field experiment
(List, Metcalfe, Price, & Rundhammer, 2017)

The study explores the effects of the interaction between interventions based on social norms and monetary interventions on residential energy consumption. Results demonstrate an important complementarity between the two types of interventions.

Methodology: The study was based on a field experiment conducted in two waves from March 2013 to April 2015 in the Northeast of the US with the collaboration of Opower, a company providing software services to utility consumers, and the provider of Home Energy Reports (HERs). HERs containing information about monthly consumption alongside a social comparison chart and recommendations of behaviors to reduce consumption were sent as letters via traditional mail and email. The monetary intervention consisted of financial rewards in the form of rebates per kWh if consumption dropped below a baseline.

The sample was composed of 195,826 households, randomly assigned to three groups: a control group receiving no treatment, a HER only group (receiving only the information but not the monetary incentives) and a rewards group, which before receiving HERs had been monetarily incentivized.

Findings: List et al 2017 found that the receipt of HERs decreased daily usage by about 0.32 kWh, on average (or 9.75 kWh/month at 30.5 days), which implies a decrease in energy demand of about 1.3% compared to average control usage in the treatment

period. But reductions in average daily use for households that were offered the opportunity to enrol in the rewards program were approximately 0.10 kWh (40 percent) higher than those observed amongst counterparts that only received the monthly HERs. They observe strong impacts of the program (i.e., interventions in combinations), particularly amongst low-usage and low- variance households, customers who typically are less responsive to normative messaging.

Key element: The study provided indications about potential targeting strategies based on baseline consumption of electricity. Results indicated that households with lower baseline consumption were more responsive to the combined information, social norms and monetary incentive treatment, whereas higher baseline consumers were more responsive to the information and social comparison treatment. Overall, coupling social norms and monetary incentives showed high complementarity, the financial adding an increase by 40% to the effects of social norms.

An online appendix is available at http://www.nber.org/data-appendix/w23355

Experimental evidence on the effect of information and pricing on residential electricity consumption
(Burkhardt, Gillingham, & Kopalle, 2019)

Motivated by the appeal of information-based interventions to encourage energy consumers to reduce peak-hour consumption, as cost-effective policy-solutions to grid overload, this study examined the behavioural response of households in Austin, Texas to information provision and monetary incentives.

Methodology: The field experiment (conducted in 2013 and 2014) was designed to test responses to increasing electricity prices in peak hours during the summer and to decreasing electricity prices at night during an off-season period. A peculiarity of this study design was that it desegregated energy consumption by appliances.

The sample was located in the Mueller neighbourhood of Austin, Texas, an area with higher-than-average incomes, higher environmental consciousness and higher adoption of electrical vehicles. All participants were awarded a $200 sign-up incentive. Only households with both circuit meters and meters on the major appliances were accepted.

Interventions applied to separate groups involved passive information provision (access to an online portal tracking appliance-level consumption), active information provision (participants were sent a reminder via text message 24h before a peak consumption window), active information with recommendations (the text message was accompanied by one of the following three recommendations - "Pre-cool your home," "Reduce your air conditioning usage," or "Do not use your clothes dryer"), pricing (the text message was accompanied by information about the price variation applied to this group) and a control group.

Findings: Only the pricing group changed their consumption behaviour significantly during the peak periods, with a 14% reduction per hour. For this group, an additional spill-over reduction in the period immediately following the treatment window (7.7.% decrease in the 30 minutes after) was identified. Based on disaggregated consumption it was concluded that the largest part of reduction was based on air conditioning (74% of reduction). Similarly, offering pricing incentives (lower energy prices) for charging electric cars at night resulted in a significant load-shift to night-time. Access to a portal tracking household's consumption, notifications about peak consumption hours and recommendations on reducing consumption did not result in significant behavioural effects.

Key element: Monetary incentives were more effective in causing consumer behaviour even for households which are, generally, more conscientious about energy efficiency than the average. Air conditioning constituted the most important source of energy savings during peak consumption time-windows in a hot climate. In populations with a high adoption of electric vehicles there was a non-trivial opportunity to shift

consumption from daytime to night-time hours by incentivizing charging electric cars at night.

This working paper does not disclose data, but it provides extensive additional statistics and information on the experiment design in the paper appendices at: https://www.nber.org/papers/w25576

Reducing household electricity consumption during evening peak demand times: Evidence from a field experiment

(Azarova, Cohen, Kollmann, & Reichl, 2020)

The study created a body of evidence for the behavioural effects of using smart meters and pointed out supply side solutions to problems created by peak electricity consumption. Authors concluded that the most likely way of reducing peak consumption is through home appliances with a low time dependency. Behavioural change with respect to the time of their usage would have less efficacy but would be more cost effective and scalable than automating consumption time.

Methodology: The study was based on a field experiment implemented in Upper Austria on a sample of 1,257 households reflective of the population in the region. Three types of interventions were implemented and conclusions pertained to the comparison between their individual effects: high monetary incentives, altruistic incentive and collective framing. The final objective was to detect the upper bound of the behavioural change achievable through monetary incentives. The sample was randomly split into four groups: Monetary incentive group (involved the award of 7 days of free electricity), Altruistic group (involved the donation of 7 days of free electricity to a local orphanage), Collective group (involved the donation of 7 days of free electricity to a local orphanage and an additional collective action framing, informing recipients about the total number of free electricity days that could be achieved if each user took part in the experiment), Control group. In order to benefit from an incentive, a required reduction threshold was set at 50% of the household's average consumption during a specific time window. This window was a 15-minute interval, beginning at 18:00, on Tuesday, September 25th 2018.

The data was sourced from the PEAKapp project, which aimed at promoting energy efficiency and shifting energy consumption towards renewables. The project included an app where consumers could access statistics about their energy use. The basic feature of this app was sending out push-up notifications to participants' mobile phones. Due to the experiment's reliance on PEAKapp, participants were recruited from among a population which was already enrolled in an energy project, having installed consumption meters and access to the PEAKapp application providing direct and independent information about the household's consumption. This information provision was not leveraged in the study design with the exception of one push phone notification, sent 30 minutes before the experiment.

Findings: The outcomes were weak in the non-monetary conditions (a decrease of 0.005 kWh in the control and collective frame groups and an increase of 0.004 kWh in the altruistic incentive group), and comparatively stronger in the monetary incentive group (a 0.013 kWh reduction). Overall, this constituted a 16% reduction from the typical consumption of the households during the targeted time window. However, the monetary group showed an important rebound effect after the 15-minute time window was over, of around 7%-8% increase in relation to their previous mean consumption during the same period of time.

As an explanation for these achievements, participants reported 30% postponed dishwasher, washing machine or dryer usage, 27% postponed cooking, 60% turned off the circuit breaker. Conclusions supported the idea that households are willing to sacrifice some of their comfort during short periods of peak consumption provided a monetary incentive. However, the high monetary incentives may have triggered behaviours (flipping the circuit breaker) which would likely be unsustainable over a long period of time.

Key element: Monetary incentive was more efficient than other interventions in achieving upper bound of behavioural change (16% reduction in consumption compared to the households' typical previous consumption during the same time window) but involved a large rebound effect afterwards. Altruistic incentives did not engender a statistically significant change in consumption behaviour.

Supplementary material with details about the study design can be found in the article's appendix (https://doi.org/10.1016/j.enpol.2020.111657). No replication data is provided.

Heterogeneous Treatment Effects of Nudge and Rebate: Causal Machine Learning in a Field Experiment on Electricity Conservation

(Murakami, Shimada, Ushifusa, & Ida, 2020)

The study performed in a Japanese context brought evidence regarding the effects of monetary, feedback, and social comparison interventions on energy saving behaviour. The authors looked beyond average treatment effects into heterogenous responses based on a series of sample characteristics, using a machine learning algorithm.

Methodology: Murakami et al (2020) implemented an RCT research project on 954 households with smart meters, customers of Chubu Electric Power Co., the second largest electricity provider in Japan. Beyond the control group, two intervention groups for separate treatments were formed: (1) rebate or monetary incentive, and (2) nudge or non-monetary incentive. Using high- frequency data (at 30-minute intervals) of household electricity usage and observable household characteristics, authors estimated the average, heterogeneous treatment effects at the household level and the determinants of such heterogeneities. All three groups (i.e., rebate, nudge, and control) received information feedback about daily electricity use (kWh) and peak-time electricity use (kWh) together with a participation reward. The rebate group composed of 313 households also

received monetary incentives for energy conservation (100 yen per 1 kWh saved in peak-demand hours, compared to the usage in the same window in the previous week). The nudge group of 314 households received a social comparison nudges for energy conservation (a bar chart showing how the household's energy use compares to similar households during peak-demand hours, along with an injunctive norm – "Good!" - in the case in which the household's consumption was lower – see figure below).

Findings: Based on the average treatment effects analysis, it was established that the rebate group registered a significant reduction in consumption during peak hours (-4.3.%). In the social comparison group reduction was comparatively lower (- 0.7%). Additionally, the authors observed that outcomes in the nudge group were highly heterogeneous, which was linked to the difference in households' baseline consumption. The outcomes in the rebate group also displayed heterogeneity based on baseline peak-hour consumption. Specifically, in both groups, households with a lower-than-average baseline consumption, register the highest average treatment effects, that is -5.6% in the rebate group and -3.8% in the nudge group. Meanwhile, houses with higher-than-average baseline consumption achieved insignificant effects.

It was concluded that baseline consumption before a policy intervention is a necessary targeting tool for policymakers. Baseline may also include building age, size, household size, household structure, which are important effect factors in all treatment groups. However, authors recommended caution with overly complex targeting strategies which may result in high data management costs. Instead, one important predictor with a large effect, may be a preferable alternative.

Key element: Results display a higher effect size of monetary interventions (4%) as compared to social norm in a context of a high heterogeneity of treatment effects coming down to baseline consumption and experiment timing. Households with a lower-than-average baseline consumption generated the highest reduction in both groups, while households with higher-than-average baseline consumption displayed no conservation effects in neither of the groups. The boomerang effect was important (37%).

Additional information can be found in the paper's appendices: http://www.econ.kyoto-u.ac.jp/dp/papers/e-20-003.pdf

Do Extrinsic Incentives Undermine Social Norms? Evidence from a Field Experiment in Energy Conservation

(Pellerano, Price, Puller, & Sánchez, 2017)

The study presented by Pellerano et al. (2017) investigated the complementarity of non-monetary and monetary incentives to reduce monthly electricity consumption in the residential sector.

Methodology: The study was designed as an RCT field research comprising 27,634 households in Quito, Ecuador and was implemented by the local utility company Quito Electric between March and June 2014. A special characteristic of the sample was an average baseline consumption lower than most samples studied in similar experiments in North America or Europe. Participants were randomly split into three intervention groups. One group received a social comparison treatment. The second received a social comparison treatment combined with a financial incentive, which involved the information that a lower than 110kWh consumption would result in large monthly savings. These savings are due to the local pricing scheme which significantly increased the cost of energy per mWh after meeting the 110kWh threshold. Treatments were distributed via a flyer sent by regular mail in the bill. The last group served as a control group and, thus, was not applied any treatment. Crucially, all households were subject to the same tariff, including those in the control group. However, the energy provider did not inform consumers about this pricing scheme, so the assumption of authors was that consumers were not aware of the 110kWh threshold before the experiment.

The dependent variable, average monthly electricity consumption, was operationalized from the three months following the receipt of the interventions. Data on the consumption and number of days between meter reads was used. This allowed researchers to interpret their estimations as the effect on a month of consumption.

Findings: Pellerano et al 2017 confirmed the hypothesis according to which there is a tension between extrinsic financial incentives and intrinsic ones (moral, social, environmental). Results displayed that adding economic incentives to social norm messages not only does not strengthen the effect of the latter but may even reduce it. The social comparison treatment alone decreased monthly consumption by 1.36 kWh compared to the control group, which translated into an average treatment effect of 1%. The combined social comparison and financial incentive treatment resulted in an outcome of - 0.7% compared to the control group. Additionally, heterogeneous effects emerged when adding monetary incentives over the social comparison intervention. Authors concluded that social comparison interventions could both lead to increases in consumption (i.e,. boomerang effects) or further decreases in consumption.

Key element: Results indicated a small effect of a social comparison intervention on reducing monthly residential energy consumption. Findings indicated that when a social comparison intervention is combined with a financial one, the monetary considerations may annul the effects of the former. However, the study was conducted on a sample with a low baseline average monthly consumption, interventions were delivered only once by mail, whereas the data for analysis was collected from a period of three months after the intervention.

Peaking Interest: How Awareness Drives the Effectiveness of Time-of-Use Electricity Pricing
(Prest, 2019)

Prest focused in his study on explaining heterogeneity in residential electricity consumption responses to monetary interventions aimed at reducing peak consumption. Interventions were expressed through dynamic pricing.

Methodology: The study draws on data from a pricing experiment in Ireland and relies upon an existent machine learning algorithm to estimate heterogeneity in treatment effects. The study design distributed treatments across 16 different intervention groups and one control group and tested outcomes against 150 household characteristics in 3.006 households. The a priori assumption was that these characteristics would be important sources of heterogeneity. Households received the monetary incentive of pricing and an additional feedback intervention. The experiment ran from January to December 2010

Findings: The most important source of heterogeneity was considered to be consumer awareness, followed by information provision and baseline consumption. While consumers responded to the existence of a price change it became clear that the effect size consumption was not proportional to the magnitude of the price change. Price salience/awareness of the existence of a dynamic price scheme appeared to be much more important in reducing energy consumption than the concept of applying the right price. No other variables from the rich list of 150 characteristics were detected as a source of heterogeneity.

Results indicated that the most important driver was consumer awareness, as households who reported that they had been aware of their time-varying pricing reduced their peak consumption 4.5 times more than those who were unaware (–10% versus –2.3%). Frequency of the information interventions mattered as well, as in-home electricity displays delivered an average treatment effect that was nearly twice as large (–15%) as that of simple bimonthly energy usage statements (–8%). Information amplified household responses even among those who reported being aware of their pricing mechanism, meaning that this information effect did not reflect improved awareness.

Key element: The most important sources of heterogeneity in consumer responses to dynamic electricity pricing are: the salience of the pricing scheme, home monitors with a display and baseline electricity consumption. While awareness about the dynamic pricing scheme mattered the most, the magnitude of the price did not.

Replication data is available at: https://doi.org/10.7910/DVN/CNQUN3

Do small pecuniary incentives motivate residential peak energy reductions? Experimental evidence
(Royal & Rustamov, 2018)

Royal and Rustamov (2018) evaluated the efficacy of mobile text-based interventions in conjunction with monetary incentives in reducing peak energy consumption. The study brought evidence towards the hypothesis that dynamic pricing as monetary incentives were superior to non-monetary incentives when applied in policy interventions with the aim of reducing peak residential energy consumption in households.

Methodology: The authors built upon a body of literature supporting dynamic electricity pricing based on demand in order to fix the inefficiencies arising from the asymmetry of fixed consumer energy prices and varying supply costs.

Data was accessed in the larger framework of a field experiment conducted five years prior to the current analysis (2013) during the summer months, under the coordination of Pecan Street Inc., a research institute associated with the University of Texas at Austin. The current study used a convenience sample of 250 high-income pre-registered households from the Mueller neighbourhood in Austin, Texas. Data resulted from hourly electricity meter readings and notifications on increased peak costs on extreme heat events previously forecasted.

Treatments were delivered to four intervention groups balanced on the number of electric car ownership: A Price group, a Portal group, a Text group, and an Action group. A balanced control group was set up as well. The Price group was charged during peak hours with a 1000% increase in the price/kWh and offered a 20% discount from the baseline rate during non-peak hours of event days. A 200$ online credit account was assigned, and beneficiaries could either discharge their credit as premiums or received the discounts during peak hours. The account was accessible to them on a current basis. Those treated with Price also received SMS notifications and an email about rate changes during peak hours before each event day. The Portal group only had access to the same portal showing a hypothetical credit balance, without receiving any financial incentive. They also received email notifications only. The Text and Action groups received SMS and email notifications without any price incentive or access to the credit portal. The Text treatment received simple reminders to reduce consumption, while the Action group received detailed instructions on how to reduce consumption.

Findings: The outcomes from the financial incentive outweighed those in the non-pecuniary groups. The Price treatment resulted in statistically significant reductions of 0.4kWh during peak hours, associated with an increase of 0.20 kWh in the three hours prior to the peak. This was explained through the efforts to pre-cool homes and an additional spill-over effect of 0.23 kWh reduction in the first hour after the peak period. By contrast, the non-pecuniary groups registered nonsignificant effect sizes associated with increases in consumption in the hours preceding peak time. Furthermore, those who received SMS texts in the nonpecuniary groups reduced consumption by 5% on average, when compared to the control group. The detailed action messages and the online portal by themselves did not have notable effects.

Checking for heterogeneous effects, the authors concluded that households with lower baseline consumption over the five months prior to the experiment achieved larger reductions after pricing incentives (43.5% savings), while those with larger than median baseline consumption achieved smaller savings (15%).

Based on these results it was established that pricing incentives were able to influence energy consumption even in the case of affluent households and while using small discounts and premiums. Information interventions alone seemed to be insufficient and

may have resulted in unwanted effects, such as increases in cooling homes pre-peak periods without a matching offset during peak-periods. It was recommended for policymakers and companies to include baseline consumption data when applying pricing incentives.

Key element: It was established that monetary incentives produce larger effects in peak-hour consumption. Furthermore, it was concluded that SMS notifications had an effect on consumption when compared to the control condition.

Increasing the energy cognizance of electricity consumers in Mexico: Results from a field experiment
(Stojanovski, Leslie, Wolak, Wong, & Thurber, 2020)

This study deploys a field experiment in Puebla, Mexico, to study the effects of information about a dynamic pricing scheme on residential energy consumption.

The field experiment took place in July 2015. A door-to-door campaign provided a 20-minute workshop to randomly selected households from affluent neighbourhoods of Puebla. The workshop covered information on a new dynamic scheme of pricing electricity recently introduced in Puebla and ways to reduce consumption. In total, 472 of households received the information intervention and an additional untreated 32,228 were assigned to the control group.

Methodology: Stojanovski et al 2020 applied an RCT experiment, with information-based interventions to 265 households facing nonlinear price schedules. Information regarding different electricity-consuming actions that could be undertaken to change electricity costs was also delivered. Interventions were implemented in the form of in-person 20-minute information sessions. Information was conveyed in an engaging and straightforward format that would persuade electricity users to make self-interested decisions to change their electricity consumption.

Findings: Those who received the information treatment reduced their consumption by 2.7%. as opposed to the average effect of -1.2% in the entire treatment group. The sample that received in-person educational workshops displayed a larger effect size, with an average of 6.2% reduction in consumption. The estimated impacts were durable with no observed rebound for at least a year. One source of heterogeneity of the information treatment was attained education. Households with less educational attainment displayed the highest consumption reduction, which is consistent with the assumption that an intervention which imparts new knowledge to consumers may lead to significant behavioural change.

Key element: In-person information-based interventions can achieve lasting decreases in energy consumption and larger effects are encountered in the heavy consumer category.

Additional information is available in the paper annexes at:
10.1016/j.jeem.2020.102323

Still underdetected – Social norms and collective efficacy predict the acceptance of electric vehicles in Germany

(Barth, Jugert, & Fritsche, 2016)

The study performed by Barth et al. aimed at establishing the capacity of under-detected social norms and collective efficacy to predict the acceptance of new technology such as electric vehicles (EV) in the German context. Research was conducted exclusively through surveys.

Methodology: Through preliminary interviews, Barth et al (2016) explored the beliefs of electric vehicle experts and non-experts. They then deployed a survey on 601 participants, in which it was tested whether cost-related advantages and disadvantages were predictive of EV acceptance and whether norms and collective efficacy had independent effects even when controlling for cost-related factors and demographic variables.

Findings: The hierarchical regression analyses of survey data showed that social norms and collective efficacy have equal or even stronger effects on acceptance than cost-related factors.

Key element: when controlled for cost-related factors it was found that social norms and collective efficacy interventions have equal or at least just as strong effects as cost-related factors.

Measuring the Welfare Effects of Residential Energy Efficiency Programs

(Allcott & Greenstone, 2017)

The study conducted by Allcott and Greenstone sets out to evaluate the welfare impacts of residential energy efficiency programs when they are impacted by imperfect information (for example, situations where consumers have no information or incomplete information, or asymmetrical information compared to that detained by the supply side), behavioural biases and externalities. Their welfare analysis falls outside of the scope of the current review. The study was however included because it contains a large-scale natural experiment testing the influence of monetary, informational and priming incentives upon consumer enrollment in home energy efficiency audits.

Methodology: The study evaluated data from energy efficiency programs included in the Better Buildings Neighbourhood Program implemented in Wisconsin, USA. The field experiment was deployed on a sample of 100,000 households recruited from two large energy efficiency programs in Wisconsin.

The Better Buildings Neighbourhood Program involved two steps which had to be undertaken by homeowners in order to benefit from support for optimizing their home with energy efficiency renovation measures:

- The first step required homeowners to accept a home energy audit following which they would receive consumption-related recommendations.
- The second step involved a decision on the type and extent of subsidized measures and renovations preferred to undertake.

The authors believed that imperfect information and behavioural barriers could prevent homeowners to take these two steps. As a consequence, they designed the study experiment to provide additional information, financial incentives and behavioral primes and check whether any of these interventions would increase enrollment in home energy audits.

Interventions were applied through letters sent to participants by regular mail between June 2012 and February 2013. The following options were communicated: subsidies for home audits (discounted by $25 or $100), six non price conditions, of which three were informational (private and social benefits; low interest financing options; comparison with smaller ways of reducing energy consumption, like turning off the lights) and three were behavioural (graphical primes for saving money, local and global environmental protection and a more comfortable home; saving time frames of an either one year or seven years time frame.

Findings: Financial incentives increased take-up of home energy audits by 32% compared to the control group. Auditing offers without monetary incentives increased the probability of auditing by 13% compared to the control group. The $100 audit rebate increased take-up by the largest amount, 32%.

Key element: Financial incentives resulted in a 32% increase in take-up of home audits as compared to the control group. Non-financial incentives increased audit acceptance by a modest 13% compared to the control group. Results suggest that:

- Financial incentives have a larger effect on take-up of energy efficiency programs than information provision and behavioural nudges;
- Consumers are unlikely to be affected by imperfect information[1] and behavioural failures, since the corrections received from the informational and behavioural treatments did not have a large impact on energy audit take-up;
- The lack of awareness about the programs did not constitute a major barrier to program enrolment.

A large amount of additional information is provided in the paper appendices; however, the study data was not made available (https://www.nber.org/papers/w23386).

The Role of Sales Agents in Information Disclosure: Evidence from a Field Experiment
(Allcott & Sweeney, 2016)

Alcott and Sweeney (2016) designed a field experiment to investigate the demand for energy efficient durable appliances, such as water heaters, in the United States. A series of treatments were applied through telephonic sales: information provision, customer rebates, and additional monetary incentives for sales agents. Retailers were awarded an

[1] The basic assumption was that imperfect information about energy efficiency programmes prevents homeowners from engaging with the program. Because the financial incentive had a larger effect than providing additional information, the results did not support the theory.

important role in the decision-making process of consumers buying water heaters. Therefore, the project also designed interventions on retailers to push energy efficient durable goods labelled under Energy Star, an American efficiency program.

Methodology: The authors carried out a field experiment with the participation of a large retailer. At the time of the experiment, only 3% of the retailer's sales went towards efficiency labelled goods. Sales agents at the retailer's call centre contacted 20,000 customers which were included in the study and delivered treatments (information and customer rebates) to the treatment groups. Sales agents (N=77, at two call centres) were also split into groups, which received or did not receive monetary incentives for selling efficiency labelled water heaters. Groups were randomized through the retailer's internal software which was used to indicate to sellers which kind of treatment scrips should be delivered to each calling customer. The experiment had 4 phases with different matrices of combinations of interventions between: rebates, which varied between $0, $25 and $100, sales incentives ("spiffs"), of either $0, $25 and $100, information provision on the efficiency label and control.

Findings: Two sets of results are relevant: The first one concerns the behaviour of the sales representatives and the second set regards the behaviour of the customers. Sales representatives over-reported compliance with experimental instructions. In actuality, sales agents tend to only provide information on the Energy Star label to customers who were already interested in energy efficiency (agents in the information only condition were only 10% more likely to mention Energy Star compared to the control group, those in the rebates only group were 14% more likely to do so). However, spill-over effects of discussing labels in the spiff and control groups were identified. The implication of this is that there are high costs to discussing energy efficiency which motivate sales agents to approach the topic only with customers who are likely to care about it (costs related to the length of the call and increased likelihood of customers postponing to make a purchase decision once more information is provided).

The results on the customer choice outcome indicate that none of the treatments applied to customers had an effect on the overall sales of Energy Star labelled water heaters. While the influence of these treatments turned out to be economically insignificant in the overall pattern of sales of the retailer of energy-consuming durable goods, they were, nevertheless, large when compared to the small share of energy efficient sales obtained in the control group. Increases in sales varied between 0.006% probability for a $100 rebate on energy efficient water heaters to 22% when the $100 rebate was combined with a monetary incentive (spiff) for the sales agent. The information provision treatment alone increased sales by a probability of 1.5%. The small customer rebate of $25 led to a statistically insignificant decrease in energy efficient products sold.

A post-intervention survey revealed that despite an important effort invested in conveying information on energy efficiency, customer participants were still confused about energy efficient water heaters and conveyed misleading responses over whether they purchased or not such equipment after the experiment, suggesting that the information provided by sales agents under the time pressure of a call centre was inadequate.

Key element: The market share of Energy Star labelled durable appliances was already small for the retailer who partnered with the authors of this field experiment. This small share was not significantly increased following the informational and monetary treatments applied. However, the treatments did increase purchases of energy efficient appliances when compared to a control group.

Data and supplemental material are available at:
http://dx .doi.org/10.1287/mnsc.2015.2327.

The role of demand-side incentives and charging infrastructure on plug-in electric vehicle adoption: analysis of US States
(Narassimhan & Johnson, 2018)

From 2008 to 2018, over 400 policy incentives have been issued in the United States with the purpose of encouraging the adoption of electric cars. This article leveraged nationwide data related to vehicle purchase from 2008 to 2016 to quantify the influence of these policies on the investment behaviour of Americans and assessed the effectiveness of interventions.

Methodology: This is an observational study based on a proxy instrument to measure electric vehicle purchase, namely data retrieved from IHS Automotive vehicle registration, which covered new vehicle registrations of 39 vehicle models from 2008–2016. The dependent variable, purchases of electric vehicles, was differentiated by the type of vehicle: plug-in electric vehicles (PEV), plug-in hybrid electric vehicles (PHEV) and battery electric vehicles (BEV). Purchases were expressed as purchases per capita at state level. The types of incentives used in different states of the United States were included in the empirical models as independent variables along with PEV charging infrastructure and were operationalized as the number of public charging stations per capita drivers in each state per quarter.

Findings: The main outcome was that rebates were found to influence PEV adoption more than tax credits or sales tax waivers, such that a 1% increase relative to the vehicle's purchase price was associated with a 1.8% increase in BEV purchases with a tax-credit and 2.16% with a rebate. A 1% increase in tax incentives relative to a vehicle's manufacturer's suggested retail price (MSRP) was associated with a 1.15% increase in purchases.

In line results from previous studies, the analysis found that states with reserved lane access incentives for PEVs registered higher purchases when compared to states without the incentive.

Gasoline price levels in a state were strongly correlated with the purchases of the Prius plug-in when compared to other top selling PHEV and BEVs.

Environmental awareness, which was proxied in the study by the League of Conservation Voters[2] (LCV) score of house representatives from different states, was found to be significantly correlated with the purchases of PHEV vehicles.

Finally, BEV purchases were found to be more correlated to median household incomes when compared to PHEVs.

Key elements: Monetary incentives were found to be the most effective policy intervention influencing the adoption of electric cars by Americans between 2008 and 2016. Rebates on the upfront price of the vehicles were found to be more effective than tax credits. An even stronger effect was determined by improving the infrastructure accommodating electric vehicles, including adding more public charging stations per capita and introducing reserved lane access. Environmental awareness was identified to be another strong predictor of electric vehicle adoption that could be successfully used as a targeting strategy for other policy incentives.

Additional data can be found at: http://stacks.iop.org/ERL/13/074032/mmedia

Framing electricity plan choices to enhance green energy usage: A choice experiment with panel data from Germany
(Neumann & Mehlkop, 2020)

Neuman and Mehlkop were puzzled over why consumers were not signing up to green electricity plans to a larger degree in the context of rising environmental public opinion concerns and a highly deregulated energy market with a variety of green options. In their study they drew upon the theories of constraints to rational choice to demonstrate that consumers' energy investments reflected biases rather than true preferences. The study credited framing effects with both inhibition and encouragement to switch to green electricity plans.

Methodology: In performing this study, researchers worked with a panel survey experiment deployed in two waves on a sample of 3320 respondents from Germany. Respondents were presented with vignettes presenting a scenario in which they would have to choose a new electricity plan for their home. Each vignette presented two choices between a renewable energy plan and a grey plan of a mix of 25% renewable and 75% non-renewable energy sources. There were three conditions of yearly price differences between the two: 0 EUR, 250 EUR, 500 EUR. The first wave employed a savings-from-the-previous-energy-plan frame and the second wave employed a costs-increase-from-the-previous-plan frame. A participant who was assigned in wave 1 to the 250 EUR price difference, remained on the same price difference in wave two, but this time, instead of the savings frame they were presented with a cost frame. The figure below illustrates the experimental design.

[2] The League of Conservation Voters is an American environmental advocacy group which produces this score of how much state representatives vote for environmental bills: https://scorecard.lcv.org

Findings: Based on a descriptive statistical analysis it was concluded that, in the case of no cost difference between green and non-renewable electricity plans, respondents overwhelmingly (over 80%) chose the green plan. However, when a price difference between the two became salient, that is, when the green plan was more expensive than the non-renewable plan by either 250 or 500 EUR per year, the choice for the green plan decreased overall, yet it decreased more dramatically when the price difference was framed as a supplementary cost relative to the previous plan. Results were confirmed by a multivariate logistic regression model.

It was also concluded that normative expectations from family and friends and environmental attitudes had a small effect on the choice of green option when there was a cost difference between the two plans. This effect was found to be slightly larger in the savings frame.

Key elements: Given a choice between a renewable and a non-renewable energy plan of the same yearly cost, German respondents from a representative sample overwhelmingly choose to sign up for a green plan. Preferences about renewables did not explain why renewable electricity had a small share of the German energy market. Cognitive biases proved to have a better explanation power as demonstrated by the framing experiment. The framing of the price of renewable energy plans in the context of savings instead of additional costs had an important effect in determining consumers to actively choose the renewable plan over the non-renewable alternative. The intervention was deemed to be better suited in contexts in which the price differences between renewable and non-renewable plans are not very large.

Limited additional statistical information can be found in the article appendices: https://doi.org/10.1016/j.erss.2020.101741

The Welfare Effects of Persuasion and Taxation: Theory and Evidence from the Field
(Rodemeier & Löschel, 2020)

The authors were interested in the welfare effects of information and taxation policies meant to encourage investment in energy efficient goods. In order to obtain a comprehensive model of quantifying welfare effects for any policy intervention of this type, authors set up a field experiment with relevant outcomes in term of investment behaviour response.

Methodology: The study was based on an online field experiment performed on the website of a large European retailer of household lighting. The sample was composed of visitors to the German version of the online store interested in purchasing light bulbs and included 640,000 consumers. The trial randomized information incentives (full or partial information about the monetary savings resulting from the use of energy efficient light

bulbs) and pricing incentives (different rebates). The information treatments were delivered through banners on the website.

Findings: full information on the energy costs associated with energy efficient technologies reduced demand for LED bulbs by 13.3% from baseline demand. By contrast, price discounts had a large positive effect of 20% on demand for LED-based bulbs. The outcomes obtained as a result of the less informative banner conditions were not statistically or economically significant.

The negative effects of information disclosure were blamed on underlying beliefs which highly overestimated the amount of savings awarded by energy efficient lighting technologies. Post experiment survey respondents in the uninformed control group believe that using a LED light bulb would save them EUR 52.7 per year in energy costs. For those exposed to the less informative banner this figure grew, on average, by EUR 9.2 while for those exposed to the full information banner, this belief decreased by a proportionate amount (EUR 9.53).

Key element: The effects of information provision regarding energy efficient goods depends on underlying consumer beliefs. Contrary to intuition, providing full information about the amount of yearly savings decreased demand for energy efficient lighting technologies by 13%.

Full details about the study design can be found at:
https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3587339

Can we hope for a collective shift in electric vehicle adoption? Testing salience and norm-based interventions in South Tyrol, Italy
(DellaValle & Zubaryeva, 2019)

The authors asked why electric vehicle adoption was not prevalent in areas where upfront prices did not seem to be a barrier to adoption. In order to identify what could nudge residents into replacing their fossil fuel-based cars with electric ones the study was deployed in affluent locations in Italy with high shares of electricity produced regionally from renewable sources and incentivized electric vehicle prices and applied two interventions: a norm-based and a future monetary benefit salience intervention.

Methodology: The study was based on an online survey experiment on a convenience sample of 591 respondents from South Tyrol, Italy. Respondents were randomized in three groups: future benefit salience, social norm and control. Treatments were delivered through survey vignettes.

Findings: It was found that making future monetary benefits salient would significantly increase the likelihood of acquiring an electric vehicle. The effect was, however, heterogenous based on the personal preference for big vehicles, future benefits, and

strong pro-environmental attitudes. Additionally, the norm-based intervention did not result in significant outcomes.

Key elements: Only the intervention regarding information about future monetary benefits succeeded to increase preferences for electric vehicles. The social comparison intervention had no effect on participants' adoption attitudes.

More information about the design of the online experiment can be found at: https://www.sciencedirect.com/science/article/pii/S2214629618312003

Prices versus nudges: What matters for search versus purchase of energy investments?
(Holladay, LaRiviere, Novgorodsky, & Price, 2019)

Authors were interested in exploring the importance of social comparison nudges compared to monetary incentives for consumers' decision to conduct a home energy efficiency audit and perform subsequent energy efficiency investments.

Methodology: The study was based on a field experiment conducted in partnership with an electricity provider, applied in a medium-sized metropolitan area in the Southeast of the United States. Interventions were applied via letters sent b y mail from December 2012 through August 2012. The complete sample contained 100,548 homeowners.

All letters stated that any durable good purchase that satisfied a broad range of criteria would be eligible for a rebate of a maximum of $500. Households also received a letter containing their monthly electricity usage for a year. The experiment was a three-by-four design with three subsidy levels crossed with four information treatments in addition to a control group. Three of the information treatments were paired with a social comparison nudge. These varied in the type of measurement of monthly electricity use: monthly kWhs consumed, monthly expenditures in dollars, or pounds of CO_2 attributable to their monthly electricity consumption. These four information treatments were crossed with monetary incentives for the energy audit alone ($0, $20, $50).

Findings: Both types of interventions increased consumer decisions to have an energy home audit. However, neither was relevant for follow up investment decisions.

Key elements: Effect size in percentage points from baseline or control are not calculated.

More information can be found in the paper annexes:
https://doi.org/10.1016/j.jpubeco.2018.12.004

Nudges in the marketplace: The response of household electricity consumption to information and monetary incentives
(Sudarshan, 2017)

Sudarshan (2017) investigated the interaction between monetary and information-based interventions in curbing residential electricity usage.

Methodology: The study consisted of an experiment conducted in India between May and August 2012, deploying an information treatment and a monetary incentive combined with information. Additionally, a control group was set up. All participants were subject to a dynamic pricing scheme. In total, 534 households from an urban area in India participated in the randomized field experiment.

Findings: The information treatment alone reduced consumption by 7% and made households more responsive to the dynamic pricing scheme. However, when information was combined with monetary incentives, there was no significant effect on electricity consumption.

Key elements: The informational nudge had an important effect of reducing electricity consumption by 7%, yet, when combined with monetary incentives, effects were annulled.

A supplementary appendix is available at:
https://www.sciencedirect.com/science/article/abs/pii/S0167268116302979

Latent demand for zero-emissions vehicles in Canada (Part 2): Insights from a stated choice experiment
(Kormos, Axsen, Long, & Goldberg, 2019)

The study explored latent demand for zero-emissions vehicles (ZEVs), namely plug-in hybrid electric vehicles (PHEVs), battery electric vehicles (BEVs), and hydrogen fuel cell vehicles (HFCVs) in Canada.

Methodology: The study deployed a survey on a representative sample of 2123 new vehicle-buying households. The survey was applied in 2017 and it followed the Reflexive Participant approach, which assumes that consumers construct their interests and preferences as they learn about ZEVs. This meant that the survey delivered information about ZEV technologies before delivering questions about consumer preferences and a choice experiment.

Findings: Three categories of households displayed the highest level of interest in ZEVs: electric-vehicle-enthusiast (representing 13% of the sample), PHEV-oriented (22%), and ZEV-neutral (21%). These categories were also associated with higher pro-environmental attitudes. Moreover, across all survey respondents, preferences tilted towards valuing lower purchase prices and higher levels of ZEV purchase subsidies. Interestingly, there were no discernible patterns in preferences about the valuation of range and charging and refuelling access.

Estimated latent ZEV demand was equivalent to 29% of new market share under conditions with no ZEV incentives, little or no-home charging access, and little hydrogen fuelling. Simulated latent demand increased to 44% with a CAD $7500 ZEV purchase incentive, and further increased to 48% with greater access to PEV charging infrastructure.

Key elements: The study demonstrated that there was considerable opportunity to increase consumer investment behaviour in zero-emissions vehicles in Canada by introducing two important policy measures: subsidies on the upfront price of vehicles and improvement of public charging infrastructure.

The paper is not accompanied by replication data or supplementary material.

Effectiveness of electric vehicle incentives in the United States
(Jenn, Springel, & Gopal, 2018)

The study examined data from a vehicle registration dataset covering registrations in the United States in order to establish the success of state-level programs meant to incentivize consumer demand for electric vehicles.

Methodology: Data was leveraged from datasets belonging to R.L. Polk/IHS Automotive and the National Renewable Energy Laboratory. The final dataset contained all new vehicle registrations in the US from January 2010 through November of 2015. The study integrated an estimation of consumer awareness proxied from a comprehensive set of newspaper articles retrieved from Lexis-Nexis related to electric vehicles. Also, the study used a database consisting of classifiers trained in using the Stanford Natural Language Processing Group.

Findings: After data analysis, it was found that for every $1000 offered under the form of rebates or tax incentives, there was an equivalent 2.6% increase in average sales of electric vehicles. Another important determinant was found to be access to a high-occupancy vehicle (HOV) lane, which increased demand by 4.7%. Moreover, rising consumer awareness was identified as essential for successful electric vehicle incentivizing programs.

Key elements: In the US market, the two most important incentives for consumer demand of electric vehicles were found to be monetary incentives in the form of price rebates and tax credits and access to HOV lanes.

The paper does for disclose replication data or additional material.

Moral Suasion and Economic Incentives: Field Experimental Evidence from Energy Demand
(Ito, Ida, & Tanaka, 2018)

This study focuses on the persistence over time of energy conservation behaviours during peak demand hours when responding to intrinsic (moral suasion) or extrinsic incentives

(dynamic pricing). This study is among the first to comparatively measure habituation and dishabituation effects of monetary and non-monetary energy conservation treatments.

Methodology: The authors designed a field experiment applied on 691 households from the Keihanna area of Kyoto, Japan, during the summer of 2012 and the winter of 2013. Partners in the project were the Japanese Ministry of economy, a power company, and Mitsubishi Heavy Industries. Households received a participation incentive of $240 and free installation of smart energy meters with in-home displays. The sample was randomly split in three groups: moral suasion (they received a text notification urging them to reduce consumption during peak periods), monetary incentive (they experienced dynamic pricing and received text messages about the cost/kWh), and control (did not receive any treatment, but were still given electricity meters and in-home displays). Data on electricity consumption were collected every 30 minutes. Surveys were applied prior and after the treatment. Treatments, through text messages, were applied in several cycles during two waves for the purpose of testing habituation and dishabituation effects.

Findings: Both interventions displayed variation in response behaviours over time. The intrinsic motivation incited strong habituation over time if repeated interventions were applied, and dishabituation if the treatment was stopped for a longer period. Upon re-application, subjects responded again with reducing their energy consumption. Initially, the request group reduced their peak hour consumption by 8% compared to the control group, but by the end of the intervention period, their reductions became smaller and consumption comparable to that of the control group. The financial incentive registered a larger consumption reduction behavioural response, significant habit formation over time and little habituation. The reductions observed in the price increase group were between 14% in the lowest price increase time windows and 17% in the hours with the highest peak price increase. During the three months break between treatment waves, the monetary incentive group showed significant habit formation. This could be explained by the investments made in energy efficient appliances in response to the financial treatment applied or by new utilization habits for daily energy consumption.

Key elements: The study treats the issue of monetary and non-monetary incentives to reduce residential energy consumption during peak hours in a novel way, by estimating not only treatment effects, but also, habituation effects over time. The study found that a monetary treatment was more effective at incentivizing energy conservation behaviours and more importantly, that it produced no habituation effects. Moreover, when dynamic pricing was applied over a longer period of time, households displayed habit formation. One explanation ventured was that dynamic pricing may incentivize residents to invest in energy efficient appliances. The hypothesis, however, was not tested in the experiment. By contrast, the non-monetary incentive obtained a smaller energy reduction effect, which disappeared over time, demonstrating the emergence of strong habituation.

The data set and an additional appendix can be found at:
https://www.aeaweb.org/articles?id=10.1257/pol.20160093

Providing the Spark: Impact of Financial Incentives on Battery Electric Vehicle Adoption
(Clinton & Steinberg, 2019)

The study investigated investment behaviour in battery electric vehicles (BEVs) in response to the financial incentives offered by US states since 2011.

Methodology: The analysis was based on historical data on national vehicle registration between 2011 and 2015, as well as data about state-level policies meant to incentivize BEV adoption. The design included controls for the effect of expanding electric vehicle charging infrastructure, alongside gasoline and electricity prices, demographic state-level attributes and state-level environmental attitudes.

Findings: The main findings of the study were that rebates offered on the upfront price of BEV were effective, having increased BEV registrations in the period 2011-2015 by a rate of 8% per $1000 of incentive offered. By contrast, tax credits were ineffective. Compared to a counterfactual scenario (i.e., estimated number of BEV registrations in the absence of rebates), for the total amount of rebates offered in this period, BEV registrations increased by 11%.

Key elements: Using a model capable of estimating the counterfactual investment trend estimated in the absence of any policy incentives, the study indicated that the total amount of rebates offered in the US during the period 2011-2015 were responsible for a 11% increase in electric vehicle registrations.

Details about this study can be found in the study appendix at:
https://doi.org/10.1016/j.jeem.2019.102255
Replication data are not provided.

Assessing the effectiveness of city-level electric vehicle policies in China
(Qiu, Zhou, & Sun, 2019)

In their article the authors brought evidence from China about the effectiveness of various policies designed to incentivize the take-up of electric vehicles. The study included both demand and supply side incentives.

Methodology: The study employed data containing electric vehicle purchases in 88 Chinese cities, which implemented pilot policy programs to incentivize electric vehicle adoption. Data included runs from January 2014 to August 2015 and was collected from various national and local administrative bodies. Electric car adoption was proxied with the number of car registrations in each of the 88 cities. Controls used were the price of gasoline, population density and per capita disposable income. The authors employed two panel data models, one static and one dynamic, both obtaining consistent results.

Findings: Out of the four demand-side policies examined, only two, charging discount and infrastructure construction subsidy, showed notable positive results in terms of electric vehicle purchases. The two supply-side policies were found to have a non-significant impact on electric vehicle adoption. The models also lead to the conclusion that there was a dynamic lag effect of the volume of sales of electric vehicles, meaning that sales in a given period had been affected by the volume of sales in the previous period which might be interpreted as an influence of social norms.

Key elements: In an effort to encourage electric vehicle adoption, the Chinese government implemented a series of pilot policy incentives for electric car adoption at the level of multiple cities. These measures included both supply and demand side incentives. The study looked at the effectiveness of 6 of these policies in 88 Chinese cities between January 2014 and August 2015. It found that only charging discounts and infrastructure construction subsidies could prove to be effective at increasing the registrations of electric vehicles in the studied cities.

Do electric vehicle incentives matter? Evidence from the 50 U.S. states
(Wee, Coffman, & Sumner, 2018)

Wee et al. estimated the effectiveness of policies incentivizing electric vehicle adoption in the US from 2010 until 2015.

Methodology: The study compiled a dataset of policies practiced in the US during the study period and used these as independent variables exercising effects of the number of registrations of electric vehicles at the state level. The particularity of the study consisted in that incentives were aggregated under two categories: incentives that could be quantified in dollars and which were indexed into subsidies, and those that could not be indexed into an index variable. The models included demographic and economic controls along with the number of charging stations available.

The authors identified four main types of demand side policies impacting purchases of electric vehicles in the US, as explained below:

- Capital Financial Incentives, involving:
    - vehicle purchase incentives: those directly related to the purchase of EVs, such as rebates, excise tax credits, income tax credits and sales tax exemptions;
    - home charger incentives: subsidies for the purchase and installation of home charging systems;
- Operating Financial Incentives such as reduced vehicle license tax (VLT) or registration fees, time-of-use (TOU) electricity rates specifically for EV charging, and an exemption from emissions inspection for EVs;
- Preferred Access Incentives: such as the use of HOV lanes without occupancy restrictions, and parking privileges such as designated or free parking;
- Disincentives: an annual EV fee intended to make up for lost gasoline tax revenues.

Findings: The estimated models found that each $1000 in subsidies for the price of a specific model of electric vehicle increased registrations for that model by 5% to 11%. At an average value of subsidy of $2305, an 17.3% increase in U.S. EV registrations was reached. Only the indicator for subsidies displayed significant positive results, while non-monetary incentives did not result in significant effects.

Remarkably, regression estimates explained about 90% of the variation in electric vehicle registration between US states. The authors also noted cases of states which terminated vehicle purchase subsidies during the study period.

Key elements: An important takeaway from the study is that electric vehicle subsidies may lead to additional registrations. Conclusions were that a $1000 increase in the value of subsidies for a specific model in a specific state leads to an additional 5–11% increase in the number of registrations of that model in that state.

This paper does not provide replication data.

The impact of car specifications, prices and incentives for battery electric vehicles in Norway: Choices of heterogeneous consumers
(Zhang, Qian, Sprei, & Li, 2016)

This study examines the choices of heterogeneous personal consumers and business buyers with regards to electric vehicles in Norway from 2011 to 2013. In Norway, electric vehicles enjoyed superior market penetration compared to other countries. In the first quarter of 2014, the authors noted that 14.5% of new vehicles sold in Norway were battery electric vehicles (BEVs).

Methodology: The authors assumed that consumer choices regarding BEVs depended on their municipal market, so they measured policy incentives for electric vehicles at the level of municipalities. The dependent variable was made up of sales of electric vehicles in Norway from 2011 to 2013, aggregated at the municipal level and split into personal and commercial consumers.

The technical characteristics of electric vehicles counted among the independent variables assessed were: brand, price, range, battery, number of seats, top speed and market share.

Likewise, the policy incentives considered as independent variables were: free public parking, exemption from registration tax, toll exemptions, value added tax exemption, bus lane access, reduced ferry rates and public charging station construction.

Findings: The technological improvement of battery electric vehicles and the incentives applied generated a significant impact on the choice of investment in such vehicles. Car specifications, prices and incentives were found to have equally strong impacts on

electric vehicle sales for both individual and commercial customers, yet the effects of these variables on business buyers were less pronounced.

Contrary to the results obtained in other studies looking at HOV (high occupancy vehicles) access lanes, this study found that bus lane access had a negative impact on the choices of personal consumers.

Key elements: Results demonstrated that even in Norway, a country with a significant market share of electric cars compared to most other countries, monetary incentives were still an effective policy for encouraging electric car adoption. Moreover, the study showed that technological development could increase electric car sales as it served to alleviate range anxiety. Personal buyers were more responsive to these incentives than commercial buyers.

This paper does not provide additional data.

Analysing the Impact of ENERGY STAR Rebate Policies in the US
(Datta & Filippini, 2016)

The study evaluated the effectiveness of the Energy Star program and its impact in terms of promoting investments in energy efficient appliances when combined with price rebates. Energy Star was introduced in 1992 in the United States as a voluntary energy efficiency labelling program.

Methodology: The sales of durable energy-consuming appliances selected to be evaluated in the study were laundry washers, dishwashers, refrigerators, and air conditioning units. The duration of the evaluation period was six years, from 2001 until 2006. The study leveraged existent variation between American states and over time in the coverage of rebates associated with Energy Star labelled appliances. 47 US states were included in the dataset. Controls included were: the price of residential electricity, per capita income, the effect of education, environmental consciousness, and climate.

Findings: According to the results, whenever the Energy Star label was associated with price rebates, it increased sales by between 9% and 18% compared to the mean sales of Energy Star appliances not accompanied by any price rebates.

Key elements: Using a 6-year panel dataset on the effectiveness of the Energy Star labelling program in the US in combination with price rebates, the study found that rebates increased purchases of energy efficient appliances by 6% to 18% compared to the mean level of sales of under an undiscounted efficiency programme.

The paper does not provide replication data.

Electric vehicle incentive policies in Canadian provinces
(Azarafshar & Vermeulen, 2020)

The effects of price rebates on the purchase of electric vehicles in Canada constituted the main interest of this paper.

Methodology: The authors accessed regional level data on electric vehicle sales from September 2012 to December 2016. The regions included were Ontario, Quebec, and British Columbia. The study included a number of control variables, such as income, unemployment rate, education, median age as well as gasoline and electricity prices.

Findings: Results indicated that price incentives were responsible for an increase in electric vehicle sales by 5% to 8%. Price incentives were responsible for 35% of electric vehicle sales in the three Canadian provinces.

Key elements: Price incentives are important instruments to increase the adoption of electric vehicles in the Canadian context.

The study offers some additional data on the estimated models in the appendices at: https://doi.org/10.1016/j.eneco.2020.104902

Renewable generation across Italian regions: Spillover effects and effectiveness of European Regional Fund
(Carfora, Romano, Ronghi, & Scandurra, 2017)

The study performed by Carfora et al. evaluated the effectiveness of European Regional Development incentives in promoting investments in renewable energy sources (RES) in Italy.

Methodology: The dataset included developments in 19 Italian regions from 2007 to 2013. Analysis was based on the assumption that there may be spill-over effects between similar regions. The level of similarity was analysed based on the following list of quantifiable region-level characteristics: quotas of value added tax from agricultural, industrial and services sectors, ratio of middle and large companies relative to population size, education, cultural, research and health expenditures, mortality rate, employment and poverty rates, per capita electricity consumption and number of residence permits.

The dependent variable, investment in non-hydro RES generation, was proxied through a ratio between the electricity generated by renewable sources (not from hydro-sources) and the total electricity generation per region.

Findings: Results indicated the possible absence of a relation between the level of incentives and the share of renewable energy production in Italian regions. The authors pointed out that the regions that displayed a higher share of RES on average (such as Tuscany and Basilicata) were also those with lower levels of per capita public incentives. The possible explanation offered was that the absorption of European funds may depend

to a high extent on regional bureaucracy and institutional capacity as well as on local politics which may result in the misuse of European funds and instruments aimed at incentivizing investments in renewable energy production.

Key elements: Results show no relation between available European Regional Development incentives and investments in renewable energy production in Italy and point at a possible important bias related to the capacity and efficiency of the agency involved in implementing these incentives.

Additional or replication data is not provided.

Household dynamics of technology adoption: A spatial econometric analysis of residential solar photovoltaic (PV) systems in Germany
(Dharshing, 2016)

The article proposed by Dharshing in 2016 adds up to the studies discussing the boundaries of popular adoption of green technologies. More specifically, it looks at the spatial patterns which may explain household adoption of photovoltaic panels such as the spatial distribution of economic factors, socio-demographic and attitudinal adopter characteristics. The country under scrutiny in this paper is Germany.

In Germany, the growth rate of the capacity of installed photovoltaic systems reached a peak in 2012 and started dropping in the subsequent years. The regional density of photovoltaic systems installed between 2000 and 2013 was larger in the South-East regions of Germany.

Methodology: The analysis was based on longitudinal data retrieved from 807,969 residential photovoltaic systems across 402 German counties for the time-period 2000–2013.

Findings: The results indicated that the return on investment of PV systems, policy incentives, local irradiation, income, education, and environmental attitude had a significant positive impact on regional PV take-up, while unemployment and the construction of new buildings were negatively correlated with residential PV installation rates. A possible explanation ventured by Dharshing for why the newer building stock has less PV systems, was that installation of PV systems may be driven by building renovation programs.

Key elements: It was found that there was a significant relation between socioeconomic status and regional PV adoption rates as well as between economic benefits derived from return on investment, policy incentives and local solar irradiation. Construction dynamic of new buildings and unemployment were negatively correlated to PV adoption.

Additional or replication data are not provided for this paper.

Pro-environmental incentives and loss aversion: A field experiment on electricity saving behavior
(Ghesla, Grieder, Schmitz, & Stadelmann, 2020)

The study performed by Ghesla et al. applied an innovative non-monetary intervention based on pro-environmental incentives, targeting everyday consumption of electricity. The pilot deployed self-reporting, commitment, and social norm-related interventions.

Methodology: The study was based on a field experiment applied in Germany in collaboration with a German utility. Participants were explicitly told that their consumption behaviour during the experiment would not result in any monetary benefits or additional costs. They were asked to submit their monthly consumption manually, since most households in Germany did not use smart metering. The sample (1636 households) was randomly distributed over four groups, one control and three experimental as follows: the first group received a goal of saving 5% compared to their baseline consumption; the second and third group received environmental incentives framed either as a gain (a tree would be planted in recognition of their reaching a 5% reduction compared to their baseline consumption) or loss (the tree would not be planted if they failed to reach the 5% saving goal).

In addition, all groups, including control, received information on energy consumption reduction.

The experiment ran for four months from October 2016 to January 2017. Information was sent to participants via email.

Findings: The effects of the pro-environmental incentives framed as potential loss led to a reduction of 5% in energy consumption compared to control. The environmental incentive delivered in a gain frame generated a 2% reduction effect on consumption.

Key elements: The study demonstrated that non-monetary incentives based on environmental framing have a high potential to reduce daily energy consumption, and that subtle framing differences regarding environmental costs and losses may maximize conservation responses.

Authors also noted that policy makers are cautious about using loss-framed incentives due to fears that people might avoid interventions. No significant attrition was noted in the environmental loss experimental group, indicating that such fears may be unfounded.

Supplementary material related to this article can be found online at: https://doi.org/10.1016/j.enpol.2019.111131

Nudging People to Save Energy in Smart Homes with Social Norms and Self Commitment
(Kroll, Paukstadt, Kreidermann, & Mirbabaie, 2019)

This conference proceedings paper reports results from a pre-study investigating how digital nudges in a smart home app could be used to influence energy-saving behaviours in household consumers.

Methodology: The authors selected 5 types of smart home appliances: heating, lights, air conditioning (A/C), washing machines and dishwashers and determined 5 types of energy saving behaviours measured on a 1-5 scale for each of them.

Participants allocated to a self-commitment nudging group, were presented the 5 energy efficiency options for each device, and asked to choose a goal for each appliance.

Participants in the social comparison nudge group received snippets of information about the usage habits of similar households instead of self-commitment.

The social comparison and self-commitment nudges were combined to be implemented in a third experimental group. A control was added to the three experimental groups as well.

These treatments would be delivered through an application in a final study. For the pre-study purposes, a mock-up application was presented to a student and university colleague sample of 113 participants.

Findings: One important disclaimer of this research is that it was a pre-study conducted to validate the design of a much larger experimental pilot and that it did not address the size of the effects on energy saving behaviour. The pre-study analysis showed possible evidence of a significant statistical difference in energy-saving behaviour in the individual nudge conditions.

Key elements: Pre-study aiming at validating an experimental research design with no effect size measurements involved.

How large is the effect of financial incentives on electric vehicle sales? – A global review and European analysis
(Münzel, Plötz, Sprei, & Gnann, 2019)

The authors performed a review of studies dealing with the effects of policy incentives on the adoption of electric vehicles on the European market. To this end they used data coming from 32 European countries in a time frame of 8 years (2010 - 2017) to estimate factors which may impact electric vehicle adoption.

Methodology: The dependent variable, electric vehicle sales shares, was constructed from the registration figures of new vehicles collected from the European Alternative Fuel Observatory (EAFO) website.

The independent variables involve policy incentives grouped by the following European regions: Eastern, Northers, Western, Southern.

Findings: Results indicated that energy prices and financial incentives had a positive effect with respect to electric vehicle adoption across European countries with an average increase of 5%-7% in electric vehicle sales attributable to policy incentives.

To strengthen conclusions, the study also offers an overview of econometric studies dealing with the same topic but focusing primarily on their methods and designs.

Key elements: Leveraging data from 32 European countries from 2010 to 2017, the study demonstrated that investment behaviour with respect to electric vehicle was highly impacted by financial incentives implemented through public policies.

Supplementary data and the source code used can be found online at: https://doi.org/10.1016/j.eneco.2019.104493

Based on the findings of the assessed studies employing monetary interventions, a number of conclusions can be drawn. As noticed previously, monetary incentives have been found across studies to have the potential to boost the results of combined interventions. However, it has also transpired that the capacity of monetary incentives to produce habituation effects may be limited, or that they may even result in rebound effects, unless applied for a longer period of time. Moreover, if social norms tended to be effective in households with a high baseline consumption, the same treatments only became effective in households with a low baseline when combined with financial schemes. Still, one study pointed out that social norms effects may be even annulled by monetary incentives.

Monetary incentives tend to be even more effective with more conscientious consumers. This has transpired across a number of studies analysing the uptake of renewable technology, such as PVs, electric cars, but even in the purchase of energy efficient appliances. These studies were also related to findings that the capacity and effectiveness of the implementing agentry could play an important role in successfully achieving results. So did the framing of prices, with saving-centered framings being found to be more effective than cost-related ones. One study pointed out that framings can be even more successful than social comparison in the uptake of renewables. But despite the importance of underlying beliefs and knowledge with regard to energy efficient technologies, a few studies have pointed out that an unduly display of lifetime costs of products may discourage consumers from buying energy efficient appliances and encourage the acquisition of less efficient alternatives. This may be explained by the generally low ability of consumers to perform cognitive reflection. Linked to this

conclusion, some studies found that the awareness of pricing schemes and dynamics was more effective than the knowledge of their magnitude in guiding efficient consumption behaviour. Information nudges based on this assumption proved to be especially effective during peak consumption events. Another study pointed out that the shorter the nudging exercise and the more frequent, the higher their benefits. Longer nudging interventions were found to result in progressively decreasing effects.

2.4. Changing consumption behaviour through information

Making Energy Costs Salient Can Lead to Low-efficiency Purchases
(d'Adda, Gao, & Tavoni, 2020)

D'Adda et al. presented an online field experiment assessing the impact of energy efficiency information on consumer decisions about purchasing refrigerators. The field experiment was applied in Italy with the collaboration of a large online retailer of appliances.

Methodology: The study varied the salience of monetary savings on energy consumption from energy efficient refrigerators to visitors of the retailer's website between the 1st and the 16th of October 2018. The sample of website visitors were tracked through browser cookies and account registration. Overall, 120,779 customers were exposed to study conditions. They were automatically and randomly exposed to one of the following situations: the yearly energy costs of refrigerators, the lifetime (15 years) cost of refrigerators, a control condition with no information on energy costs.

Findings: Results indicated that making energy savings from energy efficient durable appliances salient over all may decrease the purchase of energy efficient appliances and increase both purchases of and attention time awarded to less efficient alternatives. Increasing the time frame over which the energy cost estimation was provided (yearly versus lifetime) resulted in an increased purchase of less energy efficient products even more. Specifically, participants treated with the one-year cost information were 1.7% less likely to buy an A+++ refrigerator, 0.8 % less likely to buy an A++ refrigerator, and 2.5% more likely to buy an A+ refrigerator. The 15-year cost treatment increased the share of least efficient refrigerators by 9.1%. Moreover, treated customers viewed 2.2 more pages with refrigerators and spend 188 more seconds searching.

Results were interpreted as an overestimation of the savings awarded from the use of energy efficient products. Once this misconception was corrected, the higher upfront price of energy efficient large appliances did not seem justified in the context of the overall cost of the appliance (upfront cost, plus energy usage cost). It was concluded that the effect of salient and correct information depended to a very large extent on consumers' pre-existing beliefs. Based on these conclusions, authors recommended that prioritizing the information as an encouragement for customers to make more energy efficient choices may not work by itself and requires careful consideration. Making energy more expensive or energy efficient appliances more attractive could be better alternatives.

Key elements: The provision of yearly or lifetime costs of energy efficient refrigerators decreased their purchase and increased instead the purchase of less efficient alternatives. The longer cost projection was responsible for the largest part of the effects. Outcomes may be explained by the underlying and pre-existing customer tendency to overestimate the savings afforded by energy efficient appliances.

Details about the design of the experiment and the technological implementation can be found in the study appendices:
http://e2e.haas.berkeley.edu/pdf/workingpapers/WP045.pdf

Cognitive reflection and the valuation of energy efficiency

(Andor, Frondel, Gerster, & Sommer, 2019)

The article investigated the role of cognitive reflection on the purchase of energy efficient electricity-consuming durables.

Methodology: The study employed a combination between stated-choice experiments on the purchase of refrigerators and randomized information treatments on a sample of 3,600 German households' heads. Stated-choice experiments asked participants to choose among a set of alternatives that differed in at least one attribute, allowing for the inference of energy efficiency parameters and willingness-to-pay of the individual. Information treatments involved the conveyance of a diverse set of information, such as varying energy efficiency classes, or annual electricity consumption rates of refrigerators. Participants were randomly assigned into two groups: The treatment group, received information in the form of EU energy labels. Based on this, they were enabled to make three binary choices among two refrigerators with varying energy efficiencies. By contrast, for participants in the control group efficiency classes were omitted. All choice sets included a benchmark refrigerator, which allowed the authors to trace out the demand curve over the range of energy uses, relative to the benchmark appliance.

Findings: Andor et al (2019) found that consumers with low cognitive reflection (i.e., with a low ability to resist an intuitive response based on second thoughts about its correctness) valued energy efficiency less. They also found that participants choosing the more energy-efficient refrigerator differed across experimental groups.

Key element: The display of energy efficiency classes comes at a cost: consumers with a low level of cognitive reflection paid less attention to the more detailed information regarding the annual energy consumptions of appliances.

Supplementary data can be found online at:
https://doi.org/10.1016/j.eneco.2019.104527

In conclusion, as pointed out before, limited consumer cognitive reflection may recommend the display of less detailed information with regard to the lifetime consumption of appliances in order to secure for an increased uptake of more efficient technologies and decreasing purchase of lesser efficient alternatives.

2.5. Meta-analyses on the impact of behavioural interventions on energy consumption

The impact of information-based interventions on conservation behavior: A meta-analysis
(Nemati & Penn, 2020)

Nemati and Penn (2020) conducted a meta-analysis of 116 studies from 1975 to 2017 dealing with information-based interventions on conservation behaviour (of electricity, gas and water). From the total sample, 95 articles deal with conservation of electricity usage.

Methodology: The dependent variable is the effect size reported in percentage change in consumption of resource from baseline consumption. Analysis is performed after controlling for publication bias.

Findings: Nemati and Penn find that the average effect of information-based treatments is a reduction in consumption by 6.24%. The median effect size for studies dealing with electricity use is a 3.53% reduction in consumption.

Key element: On average information-based interventions reduce consumption by 6.24% and interventions with a shorter duration or with more frequent reporting show larger estimated effect sizes.

Full details of the meta-analysis can be found at:
https://www.sciencedirect.com/science/article/pii/S0928765518303828

The impacts of energy efficiency policies: Meta-analysis

(Labandeira, Labeaga, Linares, & Lopez-Otero, 2020)

In the indicated study, Labandeira et al. performed a meta-regression analysis of the effects of energy efficiency policies in existing literature.

Methodology: Authors specifically account for the occurrence of rebound effects, using the following definition: „ a phenomenon that occurs when an improvement in energy efficiency does not result in a proportional reduction of energy demand, or it even causes an increase in energy demand" (Labandeira et al 2020: 10).

Findings: Labandeira et al concluded that the impacts on energy demand stretched between -75.9% and +40%, with an average effect size of -9.7% and a median of 6%.

Key element: Authors pointed out the high variation in the recorded impact of energy efficiency policies in existent studies, with some studies highlighting large rebound or boomerang effects and others none.

Meta-analysis of randomised controlled trials testing behavioural interventions to promote household action on climate change

(Nisa, Bélanger, Schumpe, & Faller, 2019)

The study presented by Nisa et al. is a meta-analysis of randomised controlled trials comprising 3,092,678 observations, based on which the authors tried to assess the effects of behavioural interventions on climate change. Authors concluded that these promoted climate change mitigation to a small degree and had little traction as they could not be sustained post-intervention.

Methodology: The evaluation was performed on a sample of 83 studies. 40% of the papers targeted families, comprising a total of 724,792 households. The remaining interventions targeted discrete participants, adding to a total of 2,367,886 individuals. Sample sizes were generally small (under 100 per experiment) in more than half the papers. Only about 13% of the papers reported a large, robust number of observations (i.e. over 500 per experiment) but this small group of papers corresponds to over 90% of the total number of available observations. Around 60% of the papers were based on studies in which participants opted-in or explicitly consented to participate. Most interventions were short-lived, with a mean duration 64 days (SD = 140 days) and median 7 days. Half of the interventions lasted up to 1 week, two-thirds lasted up to a month (67.4%) and 83.4% up to 3 months.

Findings: Based on the meta-analysis it was concluded that behavioural interventions promote climate change mitigation to a very small degree and while the intervention lasts (d = −0.093 95% CI −0.160, −0.055), with no evidence of sustained positive effects once the intervention had ended. With the exception of recycling, most household mitigation behaviours displayed low behavioural plasticity. The intervention with the highest average effect size, i.e., nudges, was tested in a limited number of behaviours.

Key element: The highest average effect size was recorded in nudging interventions, especially in commitment.

As a concluding remark to this section, the high impact heterogeneity of behavioural interventions may suggest the fact that an increased importance should be allocated to a diversity of variables. However, as it has been pointed out on various occasions, the list of variables to be considered should be reasonable in length and not impede the realization of research.

3. Conclusions

The present report is a synthetic description of a large body of knowledge resulting from a high number of field studies. The main objective of this review was to aggregate insights into a diversity of instances pertaining to energy efficient behaviour. Focus has been on the types of interventions applied, the behavioural changes achieved and the nature of circumstances that have increased or diminished impact.

While the reviewed articles present a variety of situations, there are at least two ways of grouping them together: either by the type of the most important interventions employed (social norms, commitment strategies, information and monetary incentives) or by the types of consumption instances, as most of the case studies presented relate either to in-house consumption and the adoption of more efficient appliances or usages; investment in sustainable resources (PVs or other renewable energy sources); or to the adoption of electric vehicles. The report is structured according to the first option given the relevance of assessing how one dominant type of interventions may lead to different outcomes in interaction with other interventions. An alternative sectorial approach can also have important benefits, which can be particularly useful for policy purposes as it might result in a clear list of positive effects and biases to be taken into account when targeting specific types of energy behaviours. For the purpose of designing the ENCHANT interventions and the decision-making algorithm, understanding the interaction of various interventions was primordial. It is, furthermore, important to state that none of the pilots presented one singular type of interventions and that interventions have been implemented in combination. This has brought a considerable degree of complexion to our analysis leading us to understand the potential of one dominant type of intervention to lead to different outcomes in a different blend of interventions. Moreover, the approach allowed us to intercept an additional set of factors, which may be used in a more advanced analysis that would enquire into the potential of the methodological specificities of each project (sample size, location, socio-economic characteristics, etc.). to create a meaningful layer of the biases to influence result.

As indicated also by the structure of this report we can easily conclude that the majority of interventions applied were identified in the area of monetary incentives, either through the distribution of direct payments to participants, for instance in order to discount for various energy efficient consumption behaviour; or as indirect benefits suggested by the project scripts – essentially, future benefits resulting from present decisions to consume efficiently. Monetary incentives have, in general, been identified as highly effective in relation to sustainable mobility adoption (as opposed to social comparison), or in peak-hour consumption. Also, as it will be detailed below, but for some exceptions, they have been generally identified to be maximizing effect factors in a number of social norm and

commitment interventions, when applied in conjunction. Other examples, lesser in frequency, have displayed an overwhelming effect of monetary incentives in combination with informational nudges for instance, as the latter, even if important in size, have been annulled when combined with pecuniary schemes. Effects of monetary incentives have been found to be highly positive in households that are more conscientious with their own consumption. In multiple studies it has occurred a higher effect of monetary incentives on lower-baseline-consumption households than otherwise. However, irrespective of baseline or socio-economic belonging, households tended to react highly positively to financial incentives when being offered a home audit. An important feature to monetary incentives (including price variation) was the awareness of their occurrence (through visualisation or nudges), which have proved to be more impactful than the knowledge of their size. Quite the opposite, too much information about a financial incentive might discourage consumers to adopt sustainable solutions as that requires important cognitive reflection. More so, the appropriate framing of financial incentives might make a difference (presenting benefits in terms of earnings rather than costs). Underlying consumer beliefs might play a role in decisions under any circumstance.

Social-norm interventions are, in contrast to monetary incentives, the type of treatment that has proved to be highly context-dependent. That is, what might work in a certain cultural context might be ineffective in another. Also, it is highly probable that they may backfire at the level of certain social groups, such as the elderly and energy poor, which have reacted to such treatments contrary to the rest of the population. In contradiction, they have proved to be highly efficient on individuals with highly pro-environmental behaviour. Nevertheless, different types of normative messages may be complementary and add up to minimize the negative effects. When information-based social norms are administered face-to-face rather than through impersonal communication, results have been found to be more important across population groups, even though their long-term sustainability may be called into question. Investment or financial incentives associated with social norms have, in turn, been found to maximize long-term effects. In various instances, social norm effects have also been maximized through the use of long-term high-frequency personalized information and commitment, without applying any monetary incentives at all. Moreover, interventions implemented for a shorter period of time and involving more frequent reporting have increased the effects of social norms in several instances.

Commitment interventions, just like social norms, were also found to be more effective when strengthened through monetary incentives. However, when commitment was public instead of personal it proved to increase in effectiveness even on its own.

Despite the different foci, contexts and specificities of the pilots described in this report, the large volume of research on the topic stands as proof for the over-all interest in energy consumption reduction across fields. Most of these projects have developed in isolation determined by the same sense of purpose. However, after this attempt to bring their results together and in dialogue, at least two conclusions can be made: (1) Even in isolation, research enterprises generally mutually confirm their findings, without annulling the importance of nuances; (2) There is a great deal of coherence and complementarity in the findings. Both are important outcomes given the centrality of the topic at the same time in public agendas and at the level of households, especially now at a point where evolutions on the energy market come with high costs on individual or national budgets, and a modification of consumption habits and technologies proves inevitable.

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