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DISCUSSION PAPER

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Do Energy-Saving Nudges Deliver During High-Price Periods? Field Experimental Evidence From the European Energy Crisis

Do energy-saving nudges deliver during high-price periods? Field experimental evidence from the European Energy Crisis

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Abstract

Urged by the European Energy Crisis and the threatening consequences of severe natural gas shortages, energy providers launched gas-saving initiatives incorporating financial incentives to reduce residential natural gas consumption. In collaboration with one of Germany's largest energy providers, we conducted a natural field experiment (N = 2,598) to evaluate the effectiveness of a behaviorally-guided co-design of such a gas-saving initiative by implementing two established behavioral instruments – reminders of gas saving intentions and descriptive norm feedback. Our findings show limited effectiveness of the behavioral instruments during the high-price period. The feedback risks a "boomerang effect" among households with above-average initial savings, who reduce their conservation efforts in response. The reminder does not significantly enhance savings in our main specifications, yet, realizes 1 percentage point savings in alternate models refining for outliers. Potential mechanisms include a significant intention-action gap and misperceived effectiveness of energy-saving actions, which are not alleviated by the reminder.

Keywords: Residential energy savings, energy crisis, behavioral interventions, survey data, field experiment

JEL Classification: C93; D04; D91; Q41

1 Introduction

The European Energy Crisis of 2022/2023, triggered by Russia's war against Ukraine, required massive reductions in natural gas consumption. In Germany, where this study was implemented, the government introduced an "Emergency Plan Gas," which set thresholds at which the natural gas consumption of German industry would have been capped in the event of shortages [1]. However, energy-intensive industries had only limited capacities to substitute gas such that the enforcement of the "Emergency Plan Gas" would have implied substantial societal costs, including production and employment losses.

For these reasons, promoting rapid residential energy savings became of utmost importance. Yet, due to fixed contracts, energy suppliers could not fully pass-through rising wholesale market prices to their customers.[1] In addition, research on the impact of price incentives on residential gas savings shows mixed results [3–7]. Particularly, studies suggest that programs offering bonus payments for savings attract only a small fraction of (self-motivated) customers [8, 9].

We study whether behavioral instruments ("nudges") can motivate residential customers to deliver the much-needed natural gas savings. Specifically, we investigate whether a behaviorally-informed program design can serve as a complement to price signals during a "high salience – high stake" event such as the Energy Crisis. On the one hand, a recent meta-analysis reports price and behavioral incentives to serve as complements [10]. On the other hand, an increasing evidence base suggests that not well targeted behavioral instruments also pose a risk of backfiring [11, 12].

We use field-experimental interventions and survey evidence to study the impact of different behavioral instruments within a residential gas saving program that was introduced by one of Germany's largest energy providers in winter 2022/2023. We concentrate on two different well-established low-cost nudges: a social norm comparison feedback [13–15] that each participant received half way through the program and a reminder of savings plans that was randomly distributed among half of the participants [16–18].

We report three main results. First, in line with [13] we find a clear threat of a boomerang effect resulting from the social comparison feedback on gas savings. Participants who realized that their interim savings were greater than those of the average program participant reduced their savings efforts in the second phase of the program. Second, we find a reminder effect that is small in magnitude (around 1 percentage point) but might still turn out to be cost-effective in a high-price, high-stakes environment. The effect does not statistically significantly differ from zero in our main specifications but it does when refining the analysis for potential outliers. Third, accompanying surveys provide evidence of an intention-action gap, of a misperceived effectiveness of energy saving actions, and of the reminder treatment addressing neither of them. Thus, our study reveals only a limited effectiveness of the studied behavioral instruments during high-price periods.

[1] In Germany, the shortage in natural gas supply caused wholesale gas prices to increase by up to 560 % compared to pre-war levels in 2020[2].

2 Study set-up: the Gas Bonus Program

Our data stems from a field experiment and surveys implemented in collaboration with one of Germany's largest energy providers (annual sales:>7.5 billion Euros in 2023), operating in a German city with more than 300,000 inhabitants. In summer 2022, the energy provider set up the gas bonus program (GBP) to encourage savings in residential natural gas consumption. Program participants received financial incentives for reducing their weather-adjusted gas consumption compared to the levels in the two preceding billing periods. The financial incentives targeted both individual-level savings (0.05 Euros per kWh gas saved, up to 125 Euros) and collective ("community") savings (additional 20(40) Euros if average participant savings reached 10(15) %).

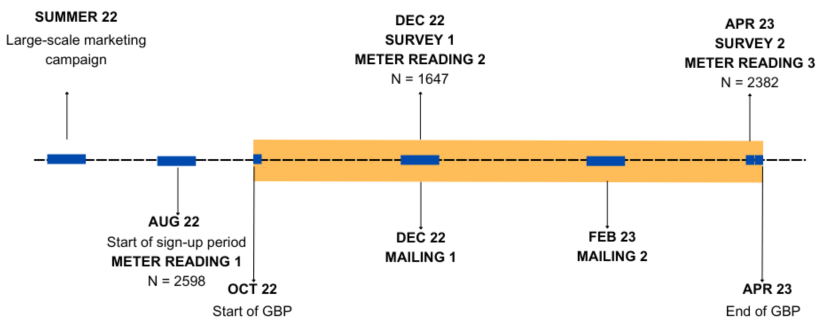


Fig. 1: Program and study timeline

Figure 1 illustrates the program and study timeline. During the summer of 2022, the energy provider launched an extensive marketing campaign to recruit participants (see Methods). Based on this, a total of 2,598 participants voluntarily signed up. The program phase started on 1 Oct 2022 and spanned a total of six months until 31 Mar 2023. Each participant received two newsletter mailings that included the co-designed behavioral instruments. Mailing 1 was sent in Dec 2022 and Mailing 2 in Feb 2023. In addition, we conducted two surveys with program participants; Survey 1 was conducted in Dec 2022 (N=450), before Mailing 1, and Survey 2 in Apr 2023 (N=383). Participants submitted meter readings during sign-up (Meter reading 1, N=2,598), in

December (Meter reading 2, N=1,647) and at the end of the program (Meter reading 3, N=2,382). Meter reading 1 and 3 were mandated to calculate the gas consumption savings (see Methods).

Table 1: Savings and sample characteristics

	Mean	Median	Std. Dev.	N
Savings (%)	0.32	0.31	0.17	2,338
Ind. payment (Euros)	107.26	125.00	34.71	2,338
Family house (yes=1)	0.62	1.00	0.49	2,338
Owner (yes=1)	0.77	1.00	0.42	410
Persons in hh (count)	2.30	2.00	0.93	412
Children in hh (count)	0.28	0.00	0.68	412
Education				
Low education	0.07	0.00	0.26	370
Medium education	0.45	0.00	0.50	370
High Education	0.48	0.00	0.50	370
Employment				
Employed	0.49	0.00	0.50	408
Unemployed	0.01	0.00	0.11	408
Retired	0.44	0.00	0.50	408
No information	0.05	0.00	0.22	408
Monthly net household income				
Low (<2000 Euros)	0.08	0.00	0.27	406
Lower-middle (2000-4000 Euros)	0.33	0.00	0.47	406
Upper-middle (4001-6000 Euros)	0.18	0.00	0.39	406
High (>6000 Euros)	0.09	0.00	0.29	406
No information	0.31	0.00	0.46	406

Note: 'Savings (%)' gives the difference between a reference kWh consumption and the kWh consumption of the GBP period. The reference is the consumption of the past two billing periods, normalized by their respective heating degree days and multiplied by the heating degree days of the GBP period. 'Ind. Payment (Euro)' gives the individual payment that participants received. The amount could range from 0 to 125 Euros. The data set is truncated at the lower and upper first percentile of the savings distribution (final N=2,338; raw N= 2,382).

Table 1 displays the summary statistics of our final sample of 2,338 participants.[2] On average, GBP participants saved 32 % of gas in the program period in comparison to a weather-adjusted reference level based on own gas consumption in the two prior billing periods. Consequently, each participant received the "community bonus" of 40 Euros. The average individual-level payment was 107.26 Euros, while the median participant reached the maximum individual payment of 125 Euros. Looking at the sample demographics, it is striking that comparatively older households that own a family house have enrolled in the program: 62 % of the study sample lives in a family house. 77 % of our sample own their dwelling, implying 23 % of tenants. The median participant lives in a 2-person household without children. Participants tend to be rather highly educated with 48 % of the sample having a university degree.

[2] Due to outlier values in gas savings, we truncate the raw data by removing respondents with savings at the lower and upper first percentile of the savings distribution (see Methods).

Notably, our sample splits into 49 % being employed and 44 % being retired. This large fraction of retired participants may also explain the income distribution in our sample. Despite the relatively high educational degree, the largest fraction of 33 % reports a lower-middle net household income of 2000–4000 Euros per month.[3]

3 Design of behavioral instruments to encourage gas savings

Figure 2 gives an overview of the behavioral instruments and analyses of this study. Central are the two newsletter mailings (see Figure A2 and Figure A3) that we use to implement the behavioral instruments tested: 1) the feedback nudge (non-randomized) and 2) the reminder nudge (randomized).

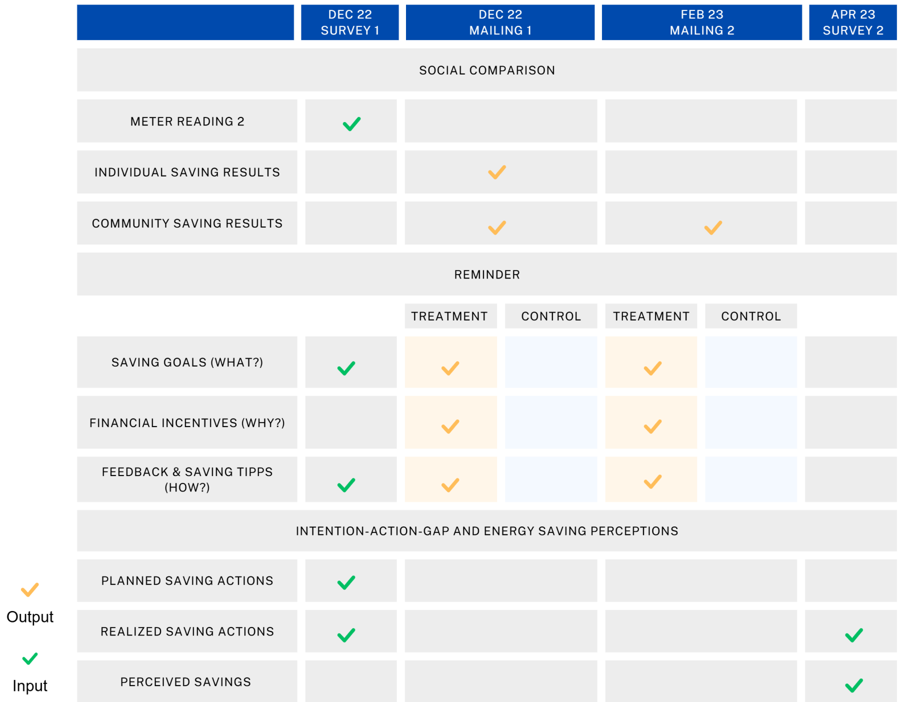


Fig. 2: Study overview

Note: Inputs refer to data collected from participants, i.e. survey responses and meter readings. Outputs represent the information and feedback provided to participants during the interventions.

First, both mailings informed each participant about the average mid-term community savings (34 %), as derived from Meter Reading 2. Further, in Mailing 1,

[3]National statistics for comparison: 41.9 % of households own their dwellings (2022), 33.5 % are two-person households (2022), 18.5 % hold a university degree (2019), the median net monthly household income is 3074 € (2024), and 23 % of the population are aged 65 years or older (2024) [19–23].

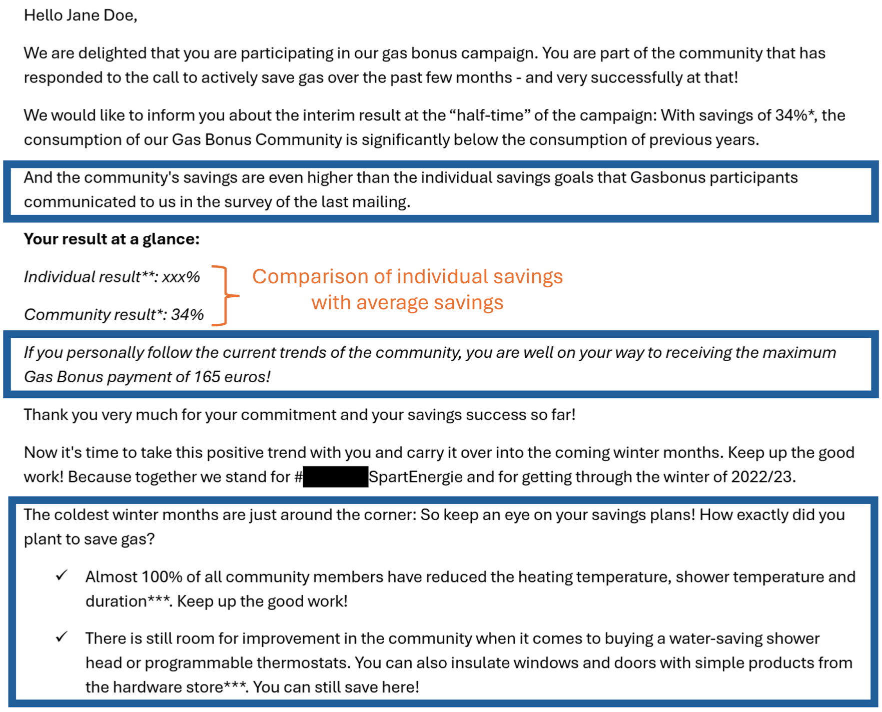
participants received feedback about their individual mid-term savings if they submitted Meter Reading 2. This comparison of individual and community savings provides the basis for the social comparison feedback. In our analysis, we distinguish participants who received positive feedback (i.e., individual savings exceeded community savings) from participants who received negative feedback [13].

Notably, this feedback includes a comparison to the descriptive social norm of savings, but does not include an injunctive norm feedback, such as smiling emoticons as in [14] and [15]. By contrast, our setting relies on the crisis environment that already entails a naturally occurring strong injunctive norm: saving gas was perceived as a top priority for the German society at this time. In an earlier study, [13] report a "boomerang effect" of social norm comparisons among above-average energy consumers if only a descriptive norm was communicated. This boomerang effect was eliminated once the descriptive comparison was accompanied with an injunctive social norm feedback. Yet, it is unclear whether the only-descriptive norm feedback turns effective when a strong societal norm is already present and common knowledge as in our setting. We therefore study whether a boomerang effect persists in the presence of an energy crisis, or whether the strong societal injunctive norm renders the descriptive norm feedback alone to be effective.

Second, both mailings included a reminder of individuals' plans to save gas [16, 18]. Reminder assignment was randomized, such that a control group received the standard mailing (N = 1,199) and a treatment group receiving an altered mailing (N = 1,183). The altered mailing added three elements (see blue highlights in Figure 3): 1) we reminded participants of planned energy savings as elicited in Survey 1 (the 'what'); 2) we stressed the financial motif to save natural gas (the 'why'); 3) we highlighted specific energy saving actions using information from Survey 1 (the 'how'). We distinguish between actions that are already implemented (e.g., reducing room temperature) and actions, which show potential for further improvement (e.g., buying a low-flow showerhead).

The design of the reminder treatment aligns with best practices of the plan-making and inattention literature [17, 18, 24]. In the presence of present-biased [25] participants, the actual implementation of saving actions during the winter season, such as reducing room temperature, might fall short of the saving plans as pledged during the sign-up phase in the summer before. As a result, participants may have reduced their saving ambitions and started to neglect, or forget, their initial plans. One of the reasons why feedback is so crucial in these settings [18], is that the feedback acts as a reminder and thereby maintains salience of the saving plan. [26] reviews the literature on reminders that are designed to address inattention, or the 'forgetting' of actions. Further, [16] show that plan-making, or goal-setting, is more effective if the plans come with specific actions to be undertaken to fulfill the plan.

In a third step, we use surveys to explore a potential intention-action-gap [27] in participants' adoption of energy saving measures. In Survey 1, we elicited the energy saving actions participants had already done or were planning to do. In Survey 2, we again elicited the energy saving actions participants had already done. A difference in planned (or already implemented) measures in Survey 1 and implemented measures in Survey 2 serves as a instrument for an intention-action gap. In addition, we investigate


Hello Jane Doe,

We are delighted that you are participating in our gas bonus campaign. You are part of the community that has responded to the call to actively save gas over the past few months - and very successfully at that!

We would like to inform you about the interim result at the "half-time" of the campaign: With savings of 34%*, the consumption of our Gas Bonus Community is significantly below the consumption of previous years.

And the community's savings are even higher than the individual savings goals that Gasbonus participants communicated to us in the survey of the last mailing.

Your result at a glance:

*Individual result**: xxx%*

Community result: 34%*

If you personally follow the current trends of the community, you are well on your way to receiving the maximum Gas Bonus payment of 165 euros!

Thank you very much for your commitment and your savings success so far!

Now it's time to take this positive trend with you and carry it over into the coming winter months. Keep up the good work! Because together we stand for #[redacted]SpartEnergie and for getting through the winter of 2022/23.

The coldest winter months are just around the corner: So keep an eye on your savings plans! How exactly did you plant to save gas?

- ✓ Almost 100% of all community members have reduced the heating temperature, shower temperature and duration***. Keep up the good work!
- ✓ There is still room for improvement in the community when it comes to buying a water-saving shower head or programmable thermostats. You can also insulate windows and doors with simple products from the hardware store***. You can still save here!

Fig. 3: December mailing with highlighted nudges

misperception in the effectiveness of the different energy saving measures [28, 29]. This allowed us to elicit participants' expected savings of different energy saving actions and compare them to engineering estimates of savings.

4 Limited effectiveness of nudges during high-price periods

We start our analysis by investigating the impact of social comparison feedback on savings. Figure 4a plots the difference in individual-level savings of natural gas consumption (in percentage points) between the first and second meter reading (sign up - Dec 22) and the second to third meter reading (Dec 22 - Apr 23) against the type of feedback received. Participants who learned in Mailing 1 that their individual savings are larger than the community average (i.e., who received positive feedback), are depicted in the green and red area (54.2 %, N=842). Participants, who learned that their savings are lower than the average (i.e., negative feedback), are depicted in the yellow and blue areas (46.8 %, N=712). On the y-axis, a positive value (i.e., the yellow and green areas) denotes an increase in individual savings after Mailing 1 (25.5

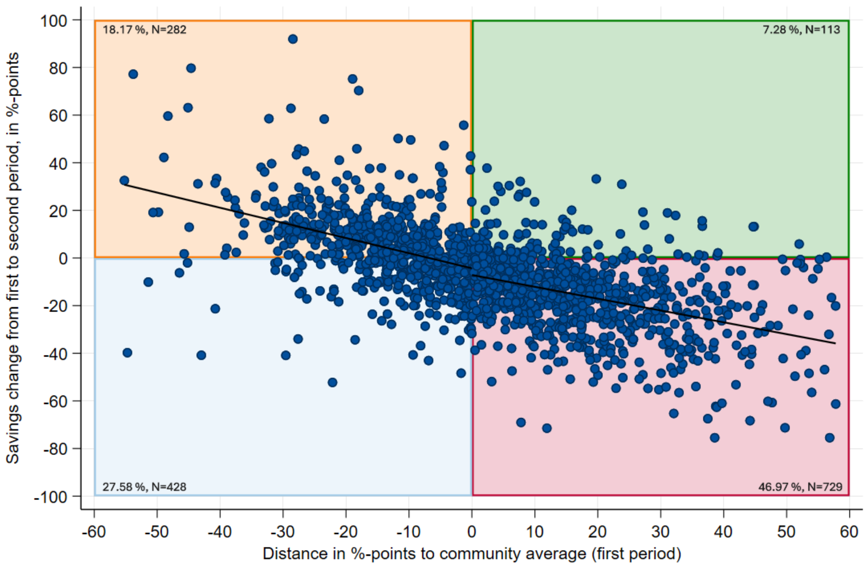
%, N=397). A negative value (i.e., the blue and red areas) denotes a decrease in savings after Mailing 1. The large majority of participants is located in these blue and red areas (74.5 %, N=1,157).

Figure 4a displays a difference in saving efforts depending on the feedback received. Participants who received a positive signal in Mailing 1, lowered their saving efforts in the second phase (86.7 %, N=729). In contrast, a considerable fraction of participants who received a negative feedback increased their savings (39.7 %, N=282). These descriptive results suggest the presence of a boomerang effect: While negative feedback enhances saving efforts, positive feedback tends to backfire and decrease saving efforts. This finding is confirmed in a two-sided two-sample t-test indicating a statistically significant negative effect of positive feedback on the change in savings (t = 23.56, $p < 0.001$, N=1,552).

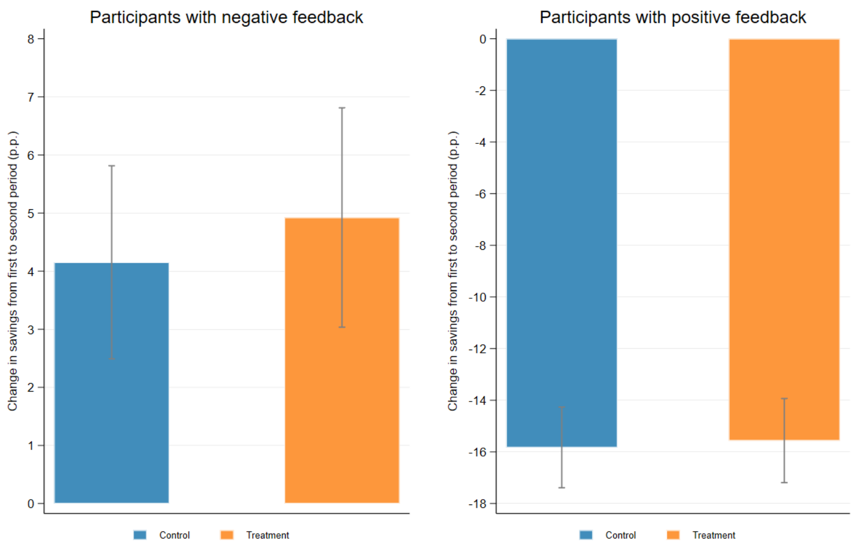
While the finding is in line with [13], it is yet surprising given the strong injunctive norm of saving gas in winter 2022/2023. One potential explanation lies in the easing gas shortage situation in early 2023. The reduced perceived societal pressure on individual saving efforts may have attributed to individuals perceiving a less salient injunctive norm of saving gas. Another potential explanation may be a statistical regression to the mean. We provide evidence against such a purely statistical explanation in the Methods section.

We next turn to investigating the impacts of the randomized reminder treatment on savings. Figure 5 depicts the distribution of gas savings for the treatment (in orange) and control group (in blue) using a Kernel Density plot. The savings distribution of the treatment group appears to be slightly rightward shifted, indicating a positive effect of the reminder on gas savings. However, a two-sided two-sample $t-$test fails to confirm a statistically significant difference in savings ($t = -1.129$, $p = 0.259$, N=2,338). Likewise, when we test for a significant treatment effect using a regression model and including control variables (see Methods and Table B1), the estimated treatment coefficients of all main econometric specifications point towards the anticipated direction, i.e., reduced consumption levels and increased savings in response to the nudge, but are not statistically significant from zero.

To adjust for a potential impact of outlier observations (see Figure 5), we refine the regression analysis and (i) run a quantile regression that compares the median savings across groups, (ii) introduce a binary indicator for savings above the median level and for savings of more than 15 % and (iii) truncate the upper and lower fifth percentile of the savings distribution. In these refined specifications, we observe robust, statistically significant treatment effects (see Table B2). The reminder treatment increases median savings by 1.5 percentage points ($p = 0.028$; 95% CI = 0.002, 0.029; specification 1), tends to increase the likelihood of exhibiting savings above the median value ($p = 0.050$; 95% CI = 0.000, 0.081, specification 3), and increases average savings by 1.1 percentage points ($p = 0.033$; 95% CI = 0.001, 0.022, specification 5) in the truncated data set. We further identify heterogeneous reminder effects, specifically showing that the reminder increases average savings by 1.5 percentage points (one-sided t-test, $p = 0.0337$, 95% CI = 0.001, 0.031) for households with above-median baseline consumption.



(a) Change in gas savings by feedback.



(b) Change in gas savings by feedback and reminder treatment

Fig. 4: Change in gas savings: Positive vs. negative feedback

Note: Error bars in Panel b) represent 95 % confidence intervals.

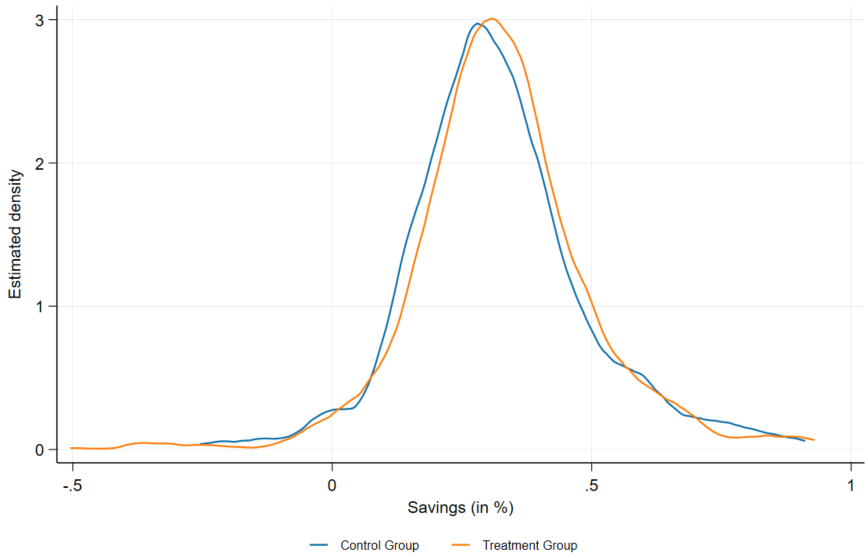


Fig. 5: Smoothed Kernel-density of gas savings by treatment.

Note: Data truncated at the lower and upper first percentile of the savings distribution.

In Figure 4b, we explore the interaction of the feedback effect and the reminder. The left panel corresponds to the left-hand-side of Figure 4a, i.e., zooms-in on the treatment and control participants with negative feedback. The right panel focuses on the treatment and control participants with positive feedback (i.e., the green and red quadrants of Figure 4a). Both for the negative and positive feedback, we do not observe a statistically-significant different response to the reminder treatment. Most notably, the reminder treatment is not able to counterbalance the boomerang effect of the participants with a positive feedback.

5 Nudges do not close the gap between intention and actions or alleviate misperception of energy savings

A question that emerges from our analysis is why the behavioral instruments only show limited effectiveness at encouraging gas savings. Using our survey data, we explore two candidate answers.

First, we explore the role of an intention-action gap. Table 2 shows that across all measures, the motivation to implement actions is high, but decreases with the financial costs of the measures. For example, in December 2022, 99 % of respondents have either already reduced their room temperatures or are planning to do so, while 38 % plan to insulate the building. Intentions for smaller-scale investment measures lie in-between, with, e.g., 77 % of participants planning to buy a water-saving showerhead. However, the actual implementation is lower compared to the plans for all measures.

The gap between intention and actual implementation is smallest for reduced room temperature (–3 percentage points) and largest for buying an water-saving showerhead (–38 percentage points). The intention-action-gap is significant for all measures, and, while the size of the gap appears rather small for the energy saving behaviors, the gap increases for the investments.

Table 2: Intention-Action Gap

Action	Mean: Survey 1	Mean: Survey 2	Difference	Pearson Chi	p-value
Reduce room temperature	0.9858	0.9578	0.0280	4.8556	0.028
Lower heating	0.9119	0.8511	0.0608	5.9101	0.015
Heat fewer rooms	0.8949	0.8247	0.0702	6.8123	0.009
Change shower behavior	0.9062	0.8350	0.0712	7.5407	0.006
Ventilate intermittently	0.9943	0.9065	0.0879	28.5114	0.000
Use thermostat	0.4773	0.2718	0.2055	29.4373	0.000
Hydraulic balancing	0.4091	0.1258	0.2833	66.1335	0.000
Install new windows/doors	0.4290	0.1392	0.2898	66.6556	0.000
Insulate building	0.3807	0.0680	0.3127	89.6465	0.000
Insulate windows/doors	0.6335	0.2839	0.3496	80.9033	0.000
Change showerhead	0.7664	0.3883	0.3781	97.0395	0.000

Note: Survey 1 on completed actions and intentions (N=352). Survey 2 on completed actions (N=308-310).

Particularly notable is the intention-action-gap for purchasing programmable thermostats, small-scale insulation of windows and doors, and purchasing an energy-saving showerhead, as these actions were explicitly encouraged in the reminder treatment (see Figure 3). We further do not see that the reminder treatment significantly increased the likelihood of implementing these actions ($p = 0.233$ for use thermostat, $p = 0.100$ for insulate windows/doors, $p = 0.811$ for change showerhead). The reminder nudge thus did not succeed in closing the gap for these actions, which corresponds to the insignificant treatment effects we have observed for energy savings. For the actions that the reminder treatment mentions as having high completion rates, the intention-action-gap is indeed small, but the reminder treatment did not significantly contribute to these success rates ($p = 0.180$ for reduce room temperature, $p = 0.232$ for change shower behavior).

As a second mechanism, Figure 6 maps the perceived and factual effectiveness of five gas saving actions. The factual savings stem from engineering estimates that are reported on websites that provide energy saving tips. As these websites use different assumptions, we report intervals for the engineering estimates (see Methods). Notably, participants overestimate the savings from most actions. The only exception are the savings from installing a water-saving showerhead, which are underestimated. Perceptions are about accurate for commissioning a hydraulic balancing.

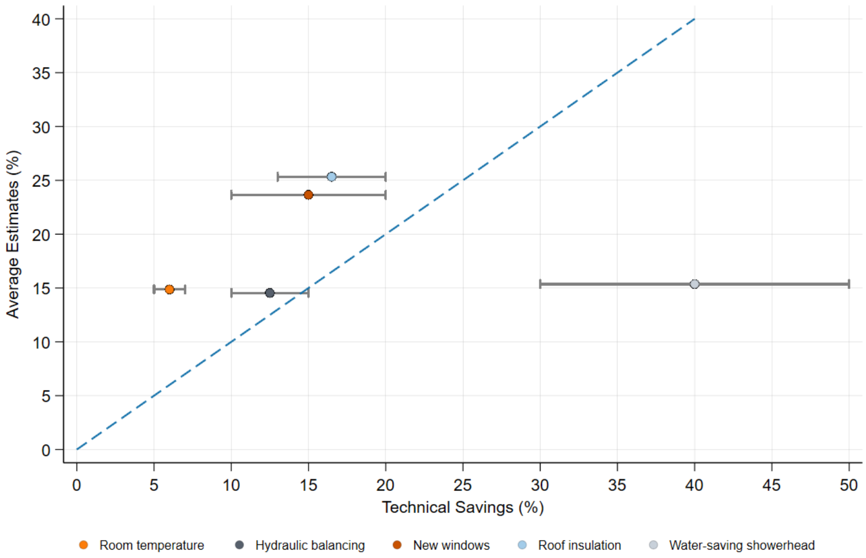


Fig. 6: Estimated and technical natural gas savings per measure

The existence of such misperception gives room for behavioral nudges to interfere, e.g., by motivating participants to seek information about the savings of different actions. Yet, we do not see robust evidence that the reminder nudge decreased misperception, i.e., increased the likelihood of reporting an estimate that falls within the engineering estimate intervals. Pearson χ^2-tests are mostly not statistically significant from zero (reduce room temperature: $\chi^2(1) = 0.011$, $p = 0.918$, $N = 366$; change showerhead: $\chi^2(1) = 3.467$, $p = 0.063$, $N = 366$; hydraulic balancing: $\chi^2(1) = 0.539$, $p = 0.463$, $N = 363$; insulate roof: $\chi^2(1) = 2.1$, $p = 0.147$, $N = 366$). An exception marks the installation of new windows. The reminder treatment significantly increases the likelihood of reporting a correct estimation by 12 percentage points ($\chi^2(1) = 4.92$, $p = 0.027$, $N = 366$).

In sum, we do not see robust evidence of alleviated misperception. Further, since participants mostly *over*estimate savings, seeking information due to the reminder nudge would only reduce estimated savings, and, thus, reduce the implementation of energy saving actions. An interesting case marks the water-saving showerhead. Participants underestimate the savings of buying such a showerhead, and, despite being explicitly encouraged in the reminder treatment, the saving misperception persists.

6 Conclusion

In this study, we use field experiments and surveys to investigate the potential of social comparison feedback and reminders to reduce residential gas consumption during the European Energy Crisis. Our analysis shows two main results: First, we find that there is a risk of a boomerang effect from the social comparison feedback. Participants who realized halfway through the program that their savings were greater than those of the program community reduced their savings efforts. Second, we find a small reminder effect (about 1 percentage point), which could be cost-effective in a high-price, high-stakes environment. However, this effect is not statistically-significant in our main specifications, but it is significant in alternate models refining for potential outliers. One possible reason for this finding is that reminders neither close the gap between stated intentions and realized energy-saving measures, nor do they adequately alleviate energy saving misperception even during high-price periods.

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Methods

Program implementation and participants. The recruitment campaign included direct mailings, distribution of posters and flyers throughout the city, and social media promotions. Figure A1 displays one of the posters. The energy provider initially limited sign-up to 1,500 participants. However, as this limit was already reached by the end of August 2022, the energy provider announced an extension of the limit to 3,000 participants. For sign-up, participants had to provide their previous two household natural gas bills, their current meter reading, information on their gender and housing type.

An important feature of the campaign was that participation was neither restricted to being a customer of the energy supplier nor to any geographical regions. Still, the large majority of 75 % of program participants live in the city districts of where the energy provider operates, 25 % live in surrounding counties. Further, 89 % of GBP participants are customers of the energy provider and 11 % are supplied by another energy provider. The GBP energy provider supplies gas to approximately a total of 54,000 households in and around the city. Consequently, the participants who joined the GBP represent 5 % of the total gas consuming customer base.

In January 2023, the energy provider implemented a gas price increase. The individual-level saving incentive corresponds to 19 % of that average price increase.

Data collection. The primary outcome of our study is the weather-adjusted natural gas savings, both in absolute terms (kWh) and relative terms (savings in %).

To accurately measure gas savings during the program period, consumption data was collected from participating households. To enable this, participants were asked to submit a meter reading upon sign-up. In early December 2022, they were invited to submit an interim reading to track mid-program progress. Finally, at the end of the program period (April 2023), participants submitted a final meter reading. To verify the reported gas consumption, energy providers use algorithms that predict gas consumption based on weather and historical data. If the reported consumption deviates from the predicted consumption, households are contacted by the energy providers, which either request a photo from the gas meter or send an employee to the customer to verify the reported value. This manual meter reading process was necessary for two reasons. First, in Germany, the diffusion of smart meters is among the lowest in Europe [30], leading to manual meter readings being the norm for how energy providers bill gas consumption. Second, households are usually billed for their gas consumption only on an annual basis, which is why extra meter readings are required to observe the 6-month gas consumption of the GBP period.

The utility calculates gas savings by taking the difference between the gas consumption from October 2022 to March 2023 (kWh_{GBP}) and some reference level of gas consumption (kWh_{ref}). Thereby, kWh_{ref} represents the weather-adjusted gas consumption of the two prior billing periods. More specifically, the utility defines kWh_{ref} as

$$kWh_{ref} = \frac{kWh_{t-1} + kWh_{t-2}}{HDD_{t-1} + HDD_{t-2}} \cdot HDD_{10/22-3/23},$$

whereby kWh_{t-1} and kWh_{t-2} represent the gas consumption of the last billing period $(t-1)$ and of the second-to-last billing period $(t-2)$, HDD_{t-1} and HDD_{t-2} the heating degree days of the same time frame and $HDD_{10/22-3/23}$ represents the heating degree days of the GBP period from October 2022 to March 2023. Heating degree days are determined by the difference between the daily average outdoor temperature and a reference temperature.[4] In an alternate measure, we use the savings in percentage terms, calculated as $1 - \frac{kWh_{GBP}}{kWh_{ref}}$.

Surveys. The study includes two online surveys, administered at different points in time. The baseline survey was distributed in early December 2022 to all GBP participants via email invitation , resulting in N = 469 survey responses, approximately 18 % of all signed-up GBP participants. Survey participants had the chance to win a 50 Euros shopping voucher for a local clothing shop. Participation in the survey was voluntary.

The survey questions were divided into four sets: (1) household and individual characteristics, (2) energy-related beliefs, (3) crisis-related beliefs, and (4) motivational beliefs for saving energy.

In mid April 2023, after the end of the GBP, the endline survey was sent out to all participants. This second wave resulted in N = 383 responses. A subset of N = 67 participants completed both the baseline and the endline surveys.

Experimental Design and Interventions. As part of the intervention, reminder emails were sent in two randomized waves: in mid-December 2022 (Mailing 1) and early February 2023 (Mailing 2). Participants were randomly assigned to a treatment (N = 1,183) or a control group (N = 1,199). The baseline balance was checked across a range of covariates, such as pre-program consumption, survey participation, gender, and home ownership. The reminder emails included three behavioral components: a reminder of saving goals, a reference to the financial incentives available, and suggested energy-saving actions based on prior survey responses. Mailing 2 (see Figure A4) is a slightly shorter version of Mailing 1 but still contained the same three behavioral components. The average open rate of Mailing 1 was 74.5 %, based on provider tracking. Participants who submitted their interim meter reading in December (N = 1,647) received individualized social comparison feedback indicating whether their interim savings exceeded or fell below the community average. This feedback was not randomized and served as a descriptive social norm intervention.

Analysis and Empirical Strategy. All analyses were conducted using Stata 18 SE. We constructed a comprehensive data set that merged reported gas consumption data with survey responses at both baseline and endline. To reduce the influence of extreme values, we truncated the distribution of gas savings for the entire program period from October 2022 to March 2023 by trimming the top and bottom 1 percentile. This cleaned dataset serves as the basis for all subsequent analyses.

[4]The energy provider submitted us both the prior gas consumption, the heating degree days and the kWh_{ref}.

To analyze the effect of the social comparison feedback, we compute three measures of gas savings: (1) savings between the first and second meter reading (sign-up to December), (2) savings between the second and third reading (December to end of program), and (3) the change in savings between these two periods. The savings used in this part of the analysis are calculated in line with the utility's methodology as described above. Reference consumption (kWh_{ref}) is based on the two preceding billing periods and adjusted using heating degree days specific to the respective subperiods.

For the graphical representation (see Figure 4a), we truncate extreme values to reduce the visual impact of outliers. Specifically, on the x-axis (distance to community average), we exclude the top and bottom percentiles. On the y-axis (change in savings), we remove observations with changes below -100 or above $+100$ percentage points. The underlying data set used for Figure 4a is identical to the one used in 4b.

An alternative explanation of the observed "boomerang effect" may be that the associations between feedback and savings occur due to a statistical regression to the mean. Against such a pure statistical artifact speak two observations. First, changes in savings are asymmetrical between positive and negative feedback. If the decrease in savings following positive feedback were purely statistical, that savings decrease should be symmetric to the savings increase experienced by participants with negative feedback. Yet, participants with positive feedback react more strongly than participants with negative feedback. Second, the gas consumption of the two prior billing periods is strongly correlated (Pearson's $r = 0.965$, $p < 0.001$). This suggests that gas consumption is primarily determined by (stable) household characteristics and choices, as opposed to random shocks. Therefore, we see limited room for random fluctuation, including regression to the mean, influencing gas consumption.

To analyze the reminder treatment, we run the following regression that estimates the average treatment effect of the nudge,

$$Y_i = \gamma_0 + \gamma_1 Treat_i + \gamma_2 \boldsymbol{X}_i + \mu_i.$$

In this regression, Y_i summarizes different measures of gas consumption and savings during program period. We use (1) consumption in kWh, (2) the logarithm of consumption in kWh, (3) weather-adjusted ("corrected") consumption in kWh, (4) the logarithm of weather-adjusted ("corrected") consumption in kWh, (5) savings in kWh and (6) savings in %. The use of logarithms of both actual and weather-adjusted assumption should reduce the influence of outliers in our data, and is commonly done in the literature (e.g., [17]).

We denote the treatment group by the indicator $Treat_i$. The indicator equals 1 for the treatment group and 0 for the control group. The coefficient γ_1 thus gives the treatment effect of the reminder nudge.

We add control variables, described by the vector $\boldsymbol{X_i}$, to reduce the variance of the outcome. Most importantly, we control for the gas consumption in prior years. This means, we control for the kWh-consumption of the two prior billing periods for outcome specification (1), for the logarithm of the kWh-consumption of the prior years in (2), for a weather-adjusted average of the prior consumption in (3) and for the logarithm of the weather-adjusted average of prior consumption in (4). As prior consumption is already implicit in the outcomes of specifications (5) and (6), we do not further control for it.

We additionally control for information that was provided during the sign-up process. This includes the sign-up date, gender (female=1), and residential type (1=family house). We also control for survey participation (yes=1). Finally, the parameter μ_i denotes the error term.

To evaluate participants' perceptions of energy-saving actions, we compare their stated estimates of gas savings with technical reference values based on publicly available engineering estimates. Given that these estimates vary depending on specific assumptions, we present them as intervals that reflect the plausible range of savings for each measure: 5 - 7 % for reducing room temperature [31], 10 - 15 % for hydraulic balancing [32], 10 - 20 % for installation of new windows [33], 13 - 25 % for insulate roof [34, 35] and 30 - 50 % for water-saving showerhead [36].

Additional Information. Our study is pre-registered at the AEA RCT Registry as trial AEARCTR-0010890. We thank the Fritz-Thyssen-Stiftung (10.25.2.021W) and ZEW-Förderkreis Wissenschaft und Praxis e.V. for their financial support.

Appendix A Extended Data

A Figures

Fig. A1: Recruitment campaign: Poster

Hello Jane Doe,

We are delighted that you are participating in our gas bonus campaign. You are part of the community that has responded to the call to actively save gas over the past few months - and very successfully at that!

We would like to inform you about the interim result at the “half-time” of the campaign: With savings of 34%*, the consumption of our Gas Bonus Community is significantly below the consumption of previous years.

Your result at a glance:

*Individual result**: xxx%*

Community result: 34%*

Thank you very much for your commitment and your savings success so far!

Now it's time to take this positive trend with you and carry it over into the coming winter months. Keep up the good work! Because together we stand for #[redacted]SpartEnergie and for getting through the winter of 2022/23.

Are you looking for ways to optimize your energy consumption even further? Then take part in one of our web seminars.

Next webinar on 10.01. (18.30-19 h) - Topic: Saving energy

Registration link: [link]

Or come and visit us and the [redacted] at our [redacted] E.forum. You can easily book an appointment online at [link]. We look forward to seeing you!

Do you want to keep an eye on your gas consumption and measure yourself against the savings targets set by Germany and the EU? Then use our new gas consumption check in our online services. Not yet registered? Then simply register at [link].

We wish you and your loved ones a Merry Christmas and a healthy and happy New Year.

Your [redacted]

*The interim meter readings of approx. 63% of participants in the Gas Bonus Community form the basis.
**The reporting of an individual result presupposes a reported interim meter reading. Positive results reflect a decrease in consumption and negative results reflect an increase in consumption.
***Based on a survey among Gas Bonus participants in the previous mailing.

Fig. A2: December mailing of control group

Hello Jane Doe,

In December, many member of the Gas Bonus Community shared their interim meter readings with us. The result: together we saved 34% gas consumption per household. That is more than double of the national average savings (14%). A strong performance!

This means that you, too, have made a significant contribution to averting the gas shortage this winter and ensuring that Germany gets through the winter of 2022/23 in good shape. Currently, the gas storage levels are still around 75%*, which gives us justified hope that we can start the next winter with a cushion.

Let us continue to ensure this by actively saving gas.

Did you know, for example, that around 15% of the energy used by Germany households each year is used to heat water, e.g., for showering? If you reduce the duration of your shower by half, you will directly save 50% of this energy and also save money.

Find out how to reduce your heating costs with a few simple measures in our free web seminar on March 7:

> *(Teaser with picture:)*
> *Saving energy is that easy*
> *Web seminar on heating costs on March 7*

Together with the [redacted] Climate Protection Agency, we will be providing useful tips on how you can save heating energy:

Registration link: [link]

We would be delighted to see you there.

Best regards

Your [redacted]

*Source: Gas Infrastructure Europe - AGSI (gie.eu)

Fig. A3: February mailing of control group

Hello Jane Doe,

In December, many member of the Gasbonus Community shared their interim meter readings with us. The result: together we saved 34% gas consumption per household. That is more than double of the national average savings (14%). A strong performance!

This means that you, too, have made a significant contribution to averting the gas shortage this winter and ensuring that Germany gets through the winter of 2022/23 in good shape. Currently, the gas storage levels are still around 75%*, which gives us justified hope that we can start the next winter with a cushion.

Let us continue to ensure this by actively saving gas.

As you know: it takes a lot of staying power to achieve our common goal. That is not always easy. Many are familiar with this from New Year's resolutions, the implementation of which we often lose sight of after just a few weeks. So, stick with it now, keep an eye on your saving plans and the maximum gas bonus payment of 165 euros. What gas saving measures did you set out to take? How can you continue to implementing them?

Did you know, for example, that around 15% of the energy used by Germany households each year is used to heat water, e.g., for showering? If you reduce the duration of your shower by half, you will directly save 50% of this energy and also save money.

Find out how to reduce your heating costs with a few simple measures in our free web seminar on March 7:

(Teaser with picture:)
Saving energy is that easy
Web seminar on heating costs on March 7

Together with the [redacted] Climate Protection Agency, we will be providing useful tips on how you can save heating energy:

Registration link: [link]

We would be delighted to see you there.

Best regards

Your [redacted]

*Source: Gas Infrastructure Europe - AGSI (gie.eu)

Fig. A4: February mailing with highlighted nudges

B Tables

Table B1: Gas savings by treatment

	(1) Consumption	(2) log (consumption)	(3) Corrected consumption	(4) log (corrected consumption)	(5) Savings (in kWh)	(6) Savings (in %)
Treat	-209.8	-0.006	-236.3	-0.012	294.1	0.008
	(186.8)	(0.014)	(172.1)	(0.013)	(279.9)	(0.007)
Last year kwh	0.220*					
	(0.125)					
2nd last year kwh	0.310***					
	(0.067)					
Sign-up date	-3.529	-0.000	1.322	-0.000	13.74	0.000
	(4.381)	(0.000)	(4.209)	(0.000)	(9.964)	(0.000)
Participation survey	-386.2**	-0.013	-357.0**	-0.018	-118.1	0.018**
	(173.7)	(0.017)	(169.7)	(0.016)	(231.4)	(0.009)
Female	3.025	0.004	-20.37	-0.008	-364.1	0.005
	(203.4)	(0.017)	(197.5)	(0.014)	(289.1)	(0.008)
Living in family house	-555.2***	0.002	-484.0***	0.015	-219.4	-0.008
	(169.1)	(0.015)	(152.4)	(0.014)	(350.6)	(0.008)
log(last year kWh)		0.749***				
		(0.121)				
log(2nd last year kWh)		0.293***				
		(0.107)				
Corrected past kWh			0.612***			
			(0.125)			
log(corrected past kWh)				1.087***		
				(0.012)		
Constant	82567.6	2.002	-28615.5	6.031	-309337.5	-0.447
	(100956.2)	(10.11)	(96428.5)	(8.861)	(227846.8)	(4.869)
Observations	2338	2336	2338	2338	2338	2338

Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors in parentheses.

Table B2: Gas savings by treatment: Alternate specifications

	(1) Savings (in %)	(2) Savings (in kWh)	(3) Savings $\geq$ p50	(4) Savings $\geq$ 15%	(5) Savings (in %)
Treat	0.0152**	14.43	0.041**	0.023**	0.011**
	(0.007)	(144.2)	(0.021)	(0.013)	(0.005)
Model	Quantile: p50	Quantile: p50	Dummy	Dummy	Cut $\leq$ 5p & $\geq$ 5p
Controls	Yes	Yes	Yes	Yes	Yes
Observations	2338	2338	2338	2338	2144

Note: * p < 0.1, ** p < 0.05, *** p < 0.01. Robust standard errors in parentheses.

References

[1] Bundesnetzagentur: Gasversorgung in Deutschland. URL: https://www.bundesnetzagentur.de/DE/Gasversorgung/aktuelle_gasversorgung/start.html (Retrieved: 01/26/2024) (2024)

[2] BDEW: BDEW-Gaspreisanalyse Dezember 2023. URL: https://www.bdew.de/service/daten-und-grafiken/bdew-gaspreisanalyse/ (Retrieved: 01/26/2024) (2023)

[3] Ahlvik, L., Kaariaho, T., Liski, M., Vehviläinen, I.: Household-level responses to the european energy crisis. CEPR Discussion Paper (2025)

[4] Deryugina, T., MacKay, A., Reif, J.: The long-run dynamics of electricity demand: Evidence from municipal aggregation. American Economic Journal: Applied Economics **12**(1), 86–114 (2020)

[5] Alberini, A., Khymych, O., Ščasnỳ, M.: Responsiveness to energy price changes when salience is high: Residential natural gas demand in ukraine. Energy Policy **144**, 111534 (2020)

[6] Behr, S.M., Köveker, T., Kücük, M.: Understanding energy savings in a crisis: The role of prices and non-monetary factors. DIW Discussion Papers 2112 (2025)

[7] Dertwinkel-Kalt, M., Feldhaus, C., Ockenfels, A., Sutter, M.: Household reduction of gas consumption in the energy crisis is not explained by individual economic incentives. Proceedings of the National Academy of Sciences **121**(48), 2411740121 (2024)

[8] Amberg, M., Kalkuhl, M., Koch, N., Ockenfels, A., Tiedemann, S.: Beyond experimental settings: Large-scale evidence of residential natural gas savings through financial rewards. mimeo (2024)

[9] Gerster, A., Frondel, M., Kaestner, K., Pahle, M., Singhal, P.: Premium programs for energy conservation: Evidence from a randomized controlled experiment.

USAEE Working Paper Series (25-644) (2025) https://doi.org/10.2139/ssrn.5188361

[10] Khanna, T.M., Baiocchi, G., Callaghan, M., Creutzig, F., Guias, H., Haddaway, N.R., Hirth, L., Javaid, A., Koch, N., Laukemper, S., *et al.*: A multi-country meta-analysis on the role of behavioural change in reducing energy consumption and co2 emissions in residential buildings. Nature Energy **6**(9), 925–932 (2021)

[11] Mertens, S., Herberz, M., Hahnel, U.J., Brosch, T.: The effectiveness of nudging: A meta-analysis of choice architecture interventions across behavioral domains. Proceedings of the National Academy of Sciences **119**(1), 2107346118 (2022)

[12] Chlond, B., Goeschl, T., Kesternich, M., Werthschulte, M.: Transporting behavioral insights to low-income households: A field experiment on energy efficiency investments. AWI Discussion Paper Series No. 755 (2024)

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

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

[15] Andor, M.A., Gerster, A., Peters, J., Schmidt, C.M.: Social norms and energy conservation beyond the us. Journal of Environmental Economics and Management **103**, 102351 (2020)

[16] Rogers, T., Milkman, K.L., John, L.K., Norton, M.I.: Beyond good intentions: Prompting people to make plans improves follow-through on important tasks. Behavioral Science & Policy **1**(2), 33–41 (2015)

[17] Löschel, A., Rodemeier, M., Werthschulte, M.: Can self-set goals encourage resource conservation? field experimental evidence from a smartphone app. European Economic Review **160**, 104612 (2023)

[18] Agarwal, S., Fang, X., Goette, L., Schoeb, S., Sing, T.F., Staake, T., Tiefenbeck, V., Wang, D.: Goal-setting and behavioral change: Evidence from a field experiment on water conservation (2022)

[19] Destatis: Eigentumsquote. URL: https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Wohnen/Tabellen/tabelle-eigentumsquote.html (Retrieved: 10/28/2025) (2024)

[20] Destatis: Haushalte nach Haushaltsgrößen im Zeitvergleich. URL: https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Bevoelkerung/Haushalte-Familien/Tabellen/1-3-privathaushalte-neuer-zeitvergleich.html (Retrieved: 10/28/2025) (2025)

[21] Destatis: Bevölkerung im Alter von 15 Jahren und mehr nach allgemeinen und beruflichen Bildungsabschlüssen nach Jahren. URL: https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Bildung-Forschung-Kultur/Bildungsstand/Tabellen/bildungsabschluss.html (Retrieved: 10/28/2025) (2020)

[22] Destatis: Einkommen und Einkommensverteilung. URL: https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Einkommen-Konsum-Lebensbedingungen/Lebensbedingungen-Armutsgefaehrdung/Tabellen/einkommen-einkommensarten.htmlfussnote-4-1369566 (Retrieved: 10/28/2025) (2025)

[23] Destatis: Ältere Menschen. URL: https://www.destatis.de/DE/Themen/Querschnitt/Demografischer-Wandel/Aeltere-Menschen/bevoelkerung-ab-65-j.html (Retrieved: 10/28/2025) (2025)

[24] Harding, M., Hsiaw, A.: Goal setting and energy conservation. Journal of Economic Behavior & Organization **107**, 209–227 (2014)

[25] Laibson, D., List, J.A.: Principles of (behavioral) economics. American Economic Review **105**(5), 385–390 (2015)

[26] Gabaix, X.: Behavioral inattention. In: Handbook of Behavioral Economics: Applications and Foundations 1 vol. 2, pp. 261–343. Elsevier, ??? (2019)

[27] Sheeran, P., Webb, T.L.: The intention–behavior gap. Social and Personality Psychology Compass **10**(9), 503–518 (2016) https://doi.org/10.1111/spc3.12265

[28] Attari, S.Z., DeKay, M.L., Davidson, C.I., Bruin, W.: Public perceptions of energy consumption and savings. Proceedings of the National Academy of Sciences **107**(37), 16054–16059 (2010)

[29] Attari, S.Z.: Perceptions of water use. Proceedings of the National Academy of Sciences **111**(14), 5129–5134 (2014)

[30] BNetza, BkartA: Monitoringbericht 2023. Technical report, Bundesnetzagentur, Bundeskartellamt, Bonn (2023)

[31] Umwelt, E.u.A. Klima: Acht einfache Tipps zum Heizkosten sparen in der Energiekrise. URL: https://www.moinzukunft.hamburg/alltags-tipps/nachhaltiger-konsum/energiespartipps-785394 (Retrieved: 10/28/2025) (n.d.)

[32] Enercity: Heizenergie sparen mit dem hydraulischen Abgleich. URL: https://www.enercity.de/magazin/mein-leben/hydraulischer-abgleich (Retrieved: 10/28/2025) (2023)

[33] Energieberatung, V.: Fenstertausch. URL: https://verbraucherzentrale-energieberatung.de/sanieren-bauen/daemmen/fenstertausch/ (Retrieved: 10/28/2025) (2023)

[34] co2online: Dachdämmung 2025: Methoden, Kosten Förderung. URL: https://www.co2online.de/modernisieren-und-bauen/daemmung/dachdaemmung/ (Retrieved: 10/28/2025) (2025)

[35] Verbraucherinformation, F.: Warum Du Dein Dach dämmen solltest. URL: https://www.finanztip.de/energetische-sanierung/dachdaemmung/ (Retrieved: 10/28/2025) (2025)

[36] EnBW: Wassersparende Duschköpfe im Vergleich. URL: https://www.enbw.com/blog/wohnen/energie-sparen/wassersparende-duschkoepfe-im-vergleich/ (Retrieved: 10/28/2025) (2023)

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