Gutenberg School of Management and Economics

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Discussion Paper Series

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Andreas Gerster, Manuel Frondel, Kathrin Kaestner, Michael Pahle and Puja Singhal

20th March 2025

Discussion paper number 2504

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# Premium Programs for Energy Conservation: Evidence from a Randomized Controlled Experiment

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**Abstract**

Premium programs are seen as a politically attractive substitute for Pigouvian taxes to establish incentives for energy conservation, particularly when energy prices are high. Using an incentive-compatible survey experiment with almost 4,500 participants, this paper analyzes consumers' uptake of a savings premium paid when a household reaches a pre-defined energy conservation target. We find that the financial benefit of a savings premium motivates only 11 percent of households to opt for it. 42 percent of households never take part, irrespective of generous premium payments of up to 1,500 euros. The remaining households prefer the conditional payment under the premium program to an equally large unconditional amount, which indicates that they use the premium program as a commitment device. Our findings challenge the view that premium programs and taxes are equivalent resource conservation policies. In particular, they imply that generous premium programs will be largely ineffective.

**JEL Codes:** D12, D91, Q41

**Keywords:** Energy conservation, commitment devices, goal setting, savings premium

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# 1 Introduction

In times of both climate change and recent energy crises, the conservation of fossil fuels is high on the political agenda. The standard approach to conservation in economics is to tax the use of resources. However, this policy measure frequently encounters heavy resistance, in particular when energy prices are perceived as high, as documented by the Yellow-Vest demonstrations in France, for example (see e.g. Douenne and Fabre, 2020). Carbon pricing is also well-known to be regressive in that it burdens poor households relatively more than wealthier households (Grainger and Kolstad, 2010; Pizer and Sexton, 2019; Goulder et al., 2019).

In the aftermath of Russia's attack on Ukraine, fears about gas shortages have increased the importance of alternative measures to induce household savings. Numerous economists (e. g. MCC, 2022), as well as the German Federal Government (2022), recommended the introduction of an energy savings premium as a politically viable alternative to Pigouvian pricing. The idea is to establish similar incentives for research conservation by paying out a premium if a pre-determined energy savings target is reached.[1] A key question for policymakers implementing such programs is whether consumers indeed react similarly to premium programs and taxes. On the one hand, both taxes and equivalent conservation premia introduce (opportunity) cost on resource use and should therefore – following neoclassical arguments – induce the same behavior. On the other hand, premium programs may appeal to different (non-financial) motivations to conserve resources, e.g. through goal setting (Locke and Latham, 1990; Allcott and Mullainathan, 2010; Andor and Fels, 2018).

Drawing on data from the German Heating and Housing Panel (GHHP), this paper disentangles consumer's financial and non-financial motivations for resource conservation induced by an energy savings premium. In particular, we tailor an incentive-compatible survey experiment to identify three groups of consumers. First, consumers

[1] Although such a premium has not been introduced by the German government yet, numerous energy providers set up premium programs for their customers.

who are motivated by financial gains to take part in a premium program. Borrowing from the program evaluation literature (Angrist and Pischke, 2009), we denote these consumers as "compliers", i.e. as individuals who only participate in the presence of financial gains. Second, consumers who never take part in a premium program, not even at the highest premium level, who we denote as "never-takers". And, third, consumers who choose to participate in a premium program even in situations where the premium program offers no financial benefit relative to an alternative certain payment (denoted henceforth as "always-takers").

The experiment was conducted between late September and early November 2022 among 4,500 household heads who took part in the GHHP survey and heated with gas. Households could choose between two options: either an unconditional payment of 100 euros, irrespective of any gas savings efforts, or the participation in a savings program, where the randomly drawn savings premia ranged from 100 to 1,500 euros. Obtaining the premium was conditional on reaching a randomly assigned gas savings target ranging from 700 to 4,200 kilowatt-hours (kWh), which correspond to around 5 to 30% of the average gas consumption of private households, respectively (BDEW, 2022). The resulting net premium corresponds to a subsidy per kWh of between zero and 2 euros and thus covers the range of politically feasible implicit subsidy values. Incentive compatibility was ensured by informing participants that their choice of either 100 euros or the randomly assigned savings premium would be paid out to a single randomly selected participant – who would be notified after the survey ended – at the end of the heating period, provided that the savings goal was actually met.

Our empirical results suggest that private households are largely unresponsive to monetary incentives given by the savings premia. First, across all savings targets, only 11 percent of participants are "compliers" and opt for the premium program as the potential financial gains increase from zero euros to 1,500 euros. Second, around 42% of the participants of the experiment are "never-takers" in the sense of deciding against the savings premium even with a very high premium of 1,500 euros. Third, almost half of the participants of the experiment across all savings targets are what we call "always-takers" and sign up for the premium program at a premium of 100 euros, even though this does not imply any financial advantages over the unconditional payment of 100 euros.[2]

Taken together, our findings demonstrate that the behavioral response to premium programs differs markedly from the responsiveness to taxes in two main respects. First, higher premia are largely ineffective in inducing more households to enroll in a premium program. In fact, we quantify that the implicit cost of households to accept more stringent targets is on average as high as 0.92 euros per kWh saved, which amounts to more than 200% of the actual gas price. For less affluent households, the required premia to accept more stringent savings targets are even higher, likely because those households have less room to further reduce their energy consumption. Hence, achieving substantial resource conservation through premia is unlikely, even for very generous (and costly) programs. Second, the fact that many consumers prefer the conditional prospect of a premium over a same-sized unconditional payment suggests that premium programs appeal to non-financial motivations to conserve energy, by for example enabling households to use energy conservation targets as a commitment device to save energy (Harding and Hsiaw, 2014). Premium programs that leverage such motivations with small stakes may thus be a highly cost-effective policy to achieve *some* resource conservation.

Our results contribute to three main strands of the literature. First, we add to the extensive body of empirical research examining consumer responsiveness to energy taxes, which reports a wide range of price elasticities for electricity (see e.g. Espey and Espey, 2004; Krishnamurthy and Kriström, 2015; Frondel and Kussel, 2019) and gas demand (Alberini et al., 2011, 2019). The responsiveness of electricity and gas demand to price changes has been found to depend on households' attentiveness to energy prices

[2] Preferring the randomly given savings premium over the unconditional payment implies opportunity costs, making the choice of the conditional payment of 100 euros rational only if the household is intrinsically motivated to meet a randomly assigned savings target.

(Frondel and Kussel, 2019), to income (Frondel et al., 2019), and to self-reported energy conservation behavior (Krishnamurthy and Kriström, 2015). Our study fills a gap in the literature on subsidy program effectiveness, which has received less attention than energy taxes. Ito (2015) examines a U.S. electricity rebate program, finding that only consumers near the target consumption level significantly reduce usage, leading to weaker incentives than a Pigouvian tax. Dertwinkel-Kalt et al. (2024) provide the first field evidence on the ineffectiveness of a German utility's savings premium program during the energy crisis, suggesting households responded more to crisis-related communication than economic incentives. With our experimental study, we are, to our knowledge, the first to quantitatively disentangle the financial and non-financial motivations behind energy conservation premia.

Second, we contribute to the large body of literature on goal setting, which has demonstrated the motivating power of goals even when they are nonbinding and no financial rewards are tied to achieving them. Goal setting has been shown to be effective in several fields, such as education (Clark et al., 2020) and energy conservation – see Allcott and Mullainathan (2010), Fraser (2023) and Andor and Fels (2018) for an overview. While it has been found that goals need to be challenging and attainable (Locke et al., 1968; Agarwal et al., 2022). Our results suggest that savings premium programs trigger similar behavior as externally set goals and are perceived by many individuals as a way to self-commit to resource conservation.

Third, we contribute to a literature that has explored the additionality of programs, that is, the question whether a given program induces additional consumers to adopt a desirable behavior or only benefits consumers who would also have adopted it in the absence of a program. For energy efficiency programs, there is a concern that the share of participants who would have undertaken an energy efficiency investment even in the absence of a government program is high, which implies that such programs may be highly cost-ineffective (Boomhower and Davis, 2014; Houde and Aldy, 2017; Alberini et al., 2016). We contribute to this literature by exploring additionality in the context of energy savings premia. In particular, we show that increasing the generosity of a premium program induces only few additional households to sign up for it, but strongly increases program cost.

We proceed as follows. In Section 2, we develop a conceptual model to explain the behavior of households who can opt for a savings premium program, followed by a description of our experimental design and data. Section 4 presents the results, Section 5 explores how higher or lower premia change the cost-effectiveness of premium programs. The last section summarizes and concludes.

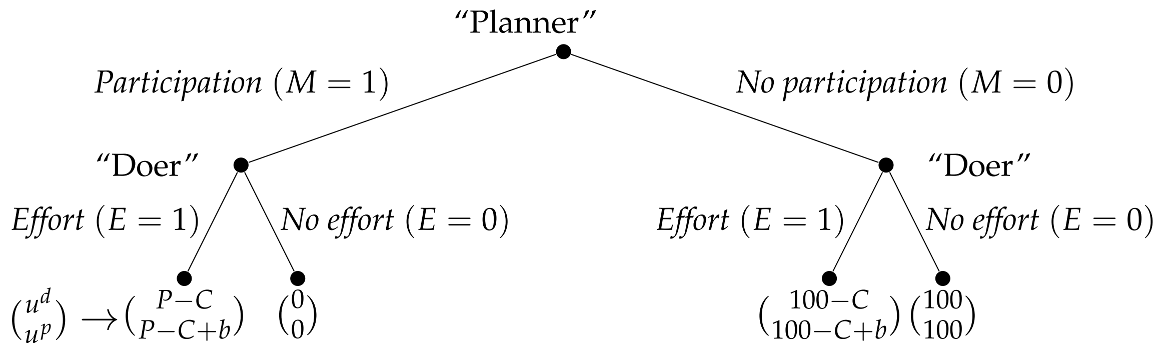
## 2 Conceptual Model

In this section, we model the behavior of a household who can choose to participate in a savings premium program by an intra-personal two-stage game between a "planner" and a "doer" (Thaler and Shefrin, 1981).

In the first stage, the household acts as a planner who chooses either to participate in the premium program, denoted by $M = 1$, or not: $M = 0$ (Figure 1). If the household chooses to participate, the household obtains a premium of $P$ euros conditional on reaching a given energy savings target $S$. Otherwise, the household obtains an unconditional payment, which we for consistency with our experiment set to 100 euros. The unconditional payment serves to create opportunity cost of choosing the savings premium, which ensures that only households with intentions to reach the goal will participate in the program.

In the second stage, the household acts as a doer who decides on whether or not to exert the effort $E$ required to meet the savings target. If the household does ($E = 1$), the household incurs the money-metric effort cost $C$ of reaching the target. If the household does not ($E = 0$), these cost are zero. The effort cost $C$ is assumed to be positive and heterogeneously distributed across the population of individuals with a continuous cumulative distribution function $F_C$ and density function $f_C$.

Figure 1: **A Model of Commitment through a Savings Premium Program**




*Note*: $u^d$ and $u^p$ denote the utility of the "doer" and the "planner", respectively.

If the household participates in the savings premium program, $M = 1$, the utility of the doer is given by $u^d(M = 1) = \mathbb{1}(E = 1)(P - C)$, where $\mathbb{1}(.)$ is an indicator function. If the planner does not commit to any savings, $M = 0$, the utility of the doer is given by $u^d(M = 0) = 100 - \mathbb{1}(E = 1)C$. The planner's utility is given by $u^p = u^d + \mathbb{1}(E = 1)b$, where $b$ denotes any – pecuniary or non-pecuniary – benefit from exerting effort, i.e., saving energy, which is not sufficiently taken into account at the time of decision-making about effort provision, for example through present-focus or inattention.

We solve the model by backward induction. When the planner does not participate, i. e. $M = 0$, the doer prefers to not exert any effort, as the effort cost $C$ is positive and, hence, $100 > 100 - C$. If the planner does sign up to the premium scheme, i. e. $M = 1$, the doer will only exert any effort if the effort cost are lower than the premium: $C < P$.

Anticipating such behavior, the planner will choose to participate in the premium program only if the payout realized after signing up exceeds the payout from not participating: $P - C + b > 100$. Hence, a necessary condition for participation is:[3]

$$C < P - 100 + b, \tag{1}$$

that is, the effort cost $C$ are lower than the sum of the net premium $P - 100$ and the

[3] The condition is necessary and sufficient if $b$ is weakly smaller than the outcome from not participating.

value of exerting effort $b$.

Using this model, we classify individuals into either of three groups. The first group consists of those who opt for the premium even when the net premium is zero ("always-takers"). Because effort cost $C$ are by definition positive, Equation (1) implies that, for this group of households, $b > 0$ (as $0 < C < b$). Hence, there must be a disagreement between the doer and the planner about the value of exerting effort. It implies a commitment benefit, i.e., the planner has an incentive to act in a way that commits the doer towards putting effort by for example signing up to the program. The second group consists of the "compliers": Those who choose to participate only if the premium is at the maximum premium level that is politically feasible, but not in the absence of financial gains from participating. The third group comprises individuals who do not opt for the premium even if it reaches its highest level $\bar{X}$: $M(P = \bar{X}) = 0$, and thus can be called "never-takers". These households have either a very high effort cost $C$ and/or a very low disagreement about the value of exerting effort, $b$. The primary goal of our study is to empirically quantify the shares of these three groups in our study population.

Beyond that, we aim to quantify the implicit compensation that individuals need to obtain to commit to more stringent targets. To do so, we now investigate a situation where a policy maker may decide to change the magnitude of the savings target $S$ that has to be reached in order to receive the premium $P$. Let $D(P, S) := \int M(P, c, S) f_C(c) dc$ denote the demand for commitment across all households. To determine how households trade off the stringency of the target relative to the premium, we take the total derivative of $D$ with respect to $P$ and $S$ and set it equal to zero. After rearranging, we obtain:

$$\frac{dP}{dS} = -\frac{\partial D/\partial S}{\partial D/\partial P}. \tag{2}$$

In our empirical analysis, we can thus identify the implicit compensation from estimates on the market demand response to changes in the premium level $P$ and the savings target $S$.

# 3 Data and Experimental Design

To analyze the effect of a savings premium on household energy consumption, we embedded an incentive-compatible experiment in the 2022 survey of the German Heating and Housing Panel (GHHP), a panel established in 2021 in cooperation with the survey institute forsa to assemble a comprehensive database on the building stock and heating energy consumption of private households. A unique feature of the panel is that, in addition to heating and building infrastructure data, socio-economic characteristics of the households that reside in the buildings are available. The 2022 survey was conducted from late September to early November 2022, coinciding with the start of the heating season, which typically begins in October in Germany.

Survey participants are drawn from forsa.omninet, forsa's household panel. Members of forsa.omninet are recruited via telephone and selected such that the panel is representative of the German-speaking online population aged 14 and older. To obtain meaningful answers on energy-related topics, the GHHP includes only household heads, defined as those individuals who typically make the financial decisions for the household, and deliberately overweights homeowners (67%) relative to tenants (33%). In the end, 15,321 household heads completed the questionnaire of the 2022 survey.

The invitation to participate in the survey reached the household heads via email. In addition to the link to the questionnaire, the invitation contained a short introduction to the topic of the survey. For finishing the survey, participants received a small compensation in the form of bonus points, which could be exchanged with moderate incentives, such as an amazon voucher, a lottery ticket for a German charity organization, or a donation to UNICEF.

The questionnaire started with a detailed elicitation of building characteristics, such as the construction year of the building, building substance and floor size. After inquiring about the households' heating costs incurred during the previous heating period, as well as the respondents' expectations about future energy costs and their intention to save energy in the upcoming winter of 2022/2023, for our experiment, we selected all those households that reported using natural gas for heating. Our focus on these households is due to the former wide-spread fear about gas shortages in the winter following Russia's gas export stop in September 2022. Among other measures to save gas, Germany's government contemplated offering a premium to private households for their efforts in natural gas savings. Ultimately, though, such a premium has never been introduced.

A total of 7,386 household heads, that is, about half of the sample, heat their home with natural gas, mimicking the share of natural gas users in the German population (Destatis, 2024). When asked whether they wanted to participate in the experiment, 2,740 respondents did not want to participate in the experiment. Of the other household heads, 206 individuals were unable to choose between either of the alternatives presented in the experiment and ticked the option "Don't know". In the end, the remaining 4,440 household heads opted in and build the estimation sample for the following analysis.

The overwhelming majority of about 71% of these 4,440 individuals consists of homeowners (Table 1). A large share of about 43% of the sample has a college degree. Both these shares are higher than in the German population, where only about half are homeowners and the share of individuals with a college degree only amounts to about 23% (Destatis, 2021). Among the reasons for these discrepancies between the sample and the population is the intentional oversampling of homeowners in the GHH panel.

Almost 70% of the estimation sample lives in single-family houses and about 14% owns a solar thermal system with which water is heated. With a share of about 91%, almost all sample subjects state that they plan a reduction of their heating energy consumption in the winter 2022/2023. Given the timing of our experiment in the midst of the energy crisis, this share is not surprising. Similarly, a vast majority of 90% of respondents agrees with the statement that energy cost in Germany are high, and 95%

Table 1: Summary Statistics for the Estimation Sample

| | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|
| **Socio-economic characteristics of the household head:** | | | | |
| Homeowner | 0.71 | – | 0 | 1 |
| Age | 56.2 | 13.7 | 18 | 91 |
| Female | 0.38 | – | 0 | 1 |
| College degree | 0.43 | – | 0 | 1 |
| **Household and building characteristics:** | | | | |
| Household size | 2.32 | 1.06 | 1 | 5 |
| Monthly household net-income, in euros | 3,894 | 1,432 | 700 | 5,950 |
| Floor area, in $m^2$ | 121.3 | 50.9 | 15 | 903 |
| Built after 2002 | 0.15 | – | 0 | 1 |
| Single-family house | 0.68 | – | 0 | 1 |
| Solar thermal system | 0.14 | – | 0 | 1 |
| Photovoltaic system | 0.15 | – | 0 | 1 |
| **Heating characteristics and attitudes of the household head:** | | | | |
| Annual cost for heating and warm water, in euros | 2,340 | 1,841 | 0 | 6,800 |
| Planned reduction of heating consumption | 0.91 | – | 0 | 1 |
| Agreed: High energy cost in Germany | 0.90 | – | 0 | 1 |
| Agreed: Heating energy cost will increase | 0.95 | – | 0 | 1 |
| Agreed: Ability to control energy consumption | 0.58 | – | 0 | 1 |

of respondents agree with the statement that the cost for heating and warm water will increase in the future.

Household heads who participated in the experiment chose among two options. One was an unconditional payment of 100 euros, irrespective of any gas savings efforts (see the original and translated version of the experiment in Appendix B). The other option was a premium payment that varied randomly between 100 and 1,500 euros, contingent on achieving a randomly assigned energy savings target. These savings targets were set at 700, 1,400, 2,800, or 4,200 kWh per year, corresponding to approximately 5%, 10%, 20%, and 30% of the average annual gas consumption of private households, respectively (BDEW, 2022). Because of the unconditional payment of 100 euros, opting for the savings premium implies opportunity costs. This design feature ensure that choosing the savings premium reflects actual energy saving intentions.

Incentive compatibility of the experiment was ensured by announcing that either the unconditional payment or the savings premium would actually be paid out to one randomly selected participant of the experiment. To obtain it, the participant had to send in the heating bills of the previous and the current heating period as soon as the current heating period ends. Participants were also told that they would be notified of being selected directly at the end of the survey.[4]

In detail, the premium levels amounted to 100, 150, 200, 300, 400, 500, 600, 800, 1,000, 1,200, and 1,500 euros (see Figure A1). Hence, if the premium option is chosen, rather than the unconditional payment of 100 euros, the additional amount to be gained by the premium lies between 0 and 1,400 euros. The implicit subsidy rates corresponding to this premium scheme range from a maximum rate of 2 euros per kWh if the randomly assigned net premium is the maximum of 1,400 euros and the randomly assigned minimum savings target of 700 kWh is met, to 0 euros per kWh if the premium is 100 euros and thus the minimum net premium of 0 euros is obtained for achieving any of the savings targets.

# 4 Empirical Results

To investigate the respondents' choice between the savings premium and the unconditional payment of 100 euros, we estimate a Linear Probability Model (LPM). The dependent variable is binary and equals one if the respondent chooses the savings premium and zero otherwise. In a first specification, we regress the dependent variable on three dummy variables, excluding the constant. The first dummy variable is one if the household obtained the lowest premium level of 100 euros and the second dummy variable that the premium was above 100 and below 1,500 euros. The third dummy variable equals one if the premium reached its maximum 1,500 euros. The resulting estimates, presented in Column 1 of the upper Panel A of Table 2, identify the groups

[4]Since the heating season in Germany ends at the end of April, and our survey ended in November of the previous year, the selected participant would still have some time to reach a savings target after being notified of the draw. In 2023, we paid 800 euros to one of the participants of the experiment who reached the assigned savings target of 700 kWh.

Table 2: Linear Probability Estimation Results for the Choice of a Randomly given Energy Savings Premium

| **Panel A: Responsiveness of Uptake to Premium and Savings Targets Levels** | | | | |
|---|---|---|---|---|
| | All Premia | | Targets + Premia | |
| | Coeff. | Std. Err. | Coeff. | Std. Err. |
| **Premium:** | | | | |
| €100 | 0.468*** | (0.025) | 0.565*** | (0.027) |
| €150 – €1,400 | 0.552*** | (0.008) | 0.658*** | (0.014) |
| €1,500 | 0.582*** | (0.024) | 0.698*** | (0.027) |
| **Savings target:** | | | | |
| 1,400 kWh | – | – | -0.061** | (0.020) |
| 2,800 kWh | – | – | -0.144*** | (0.020) |
| 4,200 kWh | – | – | -0.240*** | (0.021) |
| Number of observations | 4440 | | 4440 | |

| **Panel B: Implicit Subsidy Rate** | | |
|---|---|---|
| | Coeff. | Std. Err. |
| (1) Savings premium difference, in 1000 EUR | 0.074*** | (0.017) |
| (2) Savings target difference, in 1000 kWh | -0.068*** | (0.005) |
| Constant | 0.651*** | (0.017) |
| Number of observations | 4440 | |
| Equivalent premium: (2)/(1), in EUR/kWh | 0.92 | |

Notes: Robust standard errors are in parentheses. Savings premium difference denotes the difference of the observed savings premium relative to the lowest premium of 100 EUR, in 1000 EUR. Savings target difference denotes the difference of the observed savings target relative to the lowest target of 700 kWh. ***, ** and * denote statistical significance at the 0.1 %, 1 % and 5 % level, respectively.

of always-takers, compliers, and never-takers as follows.

First, the estimate for the premium of 100 euros represents the percentage of "always-takers", i.e., of individuals who opt for the savings premium when the premium is just as large as the unconditional payment of 100 euros. We find that this group of individuals consists of as many as 46.8% of subjects across all savings targets. Second, the estimates for the premium groups represent the sign-up rate to the program for the respective financial premia across all savings targets. Overall, we find that higher premia lead to higher uptake. In particular, if the premium amounts to the maximum premium of 1,500 euros, 58.2% of households presented with this premium choose to participate in the premium program. Hence, 41.8% (100-58.2%) of participants are "never-takers" as they do not participate regardless of the financial stakes, not even at the highest premium level. Third, the remaining 11.4% (100-46.8-41.8%) constitute the group of "compliers", i.e., those who participate if the financial gains are sufficiently high, but not otherwise.

Taken together, the high share of always-takers suggests that for many individuals the primary motivation for participating in premium programs is a non-financial benefit of signing up to a premium program. One explanation is that they view savings target as a commitment device, that is, as a mechanism to implement prevalent intentions and overcome potential present biases (Harding and Hsiaw, 2014). Furthermore, the low percentage of compliers and the high percentage of never-takers suggests that only few individuals follow financial motivations when participating in premium programs.

Next, we explore the implicit premium needed for individuals to sign up to more ambitious saving targets. As a first step, we explore how the sign-up rates differ by the stringency of the targets by additionally including three dummy variables for the savings targets into the LPM (Column 2 in Panel A in Table 2). As predicted, the sign-up rates for a premium program decrease as the targets that need to be reached become more stringent (a graphical presentation of the sign-up rates for all savings targets and premium levels can be found in Figure A1 in Appendix A). We then quantify the implicit subsidy by estimating the response of the sign-up decision to changes in the premium and the savings target. Because both features are randomly attributed in our study, we can causally estimate these responses by a LPM, where we regress the sign-up decision on the magnitude of the net-premium, $P - 100$ euros, and of the relative stringency of the savings target compared to the lowest target of 700 kWh, $S - 700$ kWh (see the lower Panel B of Table 2).

We find that – on average – increasing the target by 1,000 kWh reduces take-up by 6.8 percentage points. Furthermore, a 1,000 euros increase in the premium increases take-up by 7.4 percentage points. Hence, using Equation (2), we estimate that the savings premium has to be as high as 0.92 euros per kWh, on average, to spur the financially motivated "compliers" to accept more ambitious savings targets (see Panel B in Table 2). It bears noting that 0.92 euros per kWh was roughly 4.5 times the gas price for households at the end of December 2022 (BDEW, 2022).

In a subsequent step, we explore how the implicit subsidy rates vary by household income (see Table A1 in the Appendix for details). Dividing participants into three equally sized groups of monthly net household income, we see that lower income is associated with higher premium levels. For this group, the average premium would have to be as high as 2.44 euros per kWh to induce financially motivated households to accept more ambitious savings targets. In contrast, the average premium for the middle income group would be 0.92 euros, and for the highest income group it would be 0.72 euros. This result suggests that it is more difficult for lower-income households to save energy because they may already be close to their lowest possible consumption level, which is consistent with findings in the literature that lower-income households have a lower energy price elasticity (Pothen and Reaños, 2018).

Overall, our evidence suggests individuals regard a savings premium program predominantly as a means to achieve their own energy saving ambitions and, hence, as commitment devices. Such type of programs, which motivate individuals through goal setting and the possibility of self-commitment, rather than monetary incentives, have been proposed in the behavioral economics literature for many years (see e. g. Andor and Fels, 2018). By contrast, our evidence speaks against the efficacy of generous premium programs for achieving resource conservation.

# 5 Marginal Costs of Energy Savings

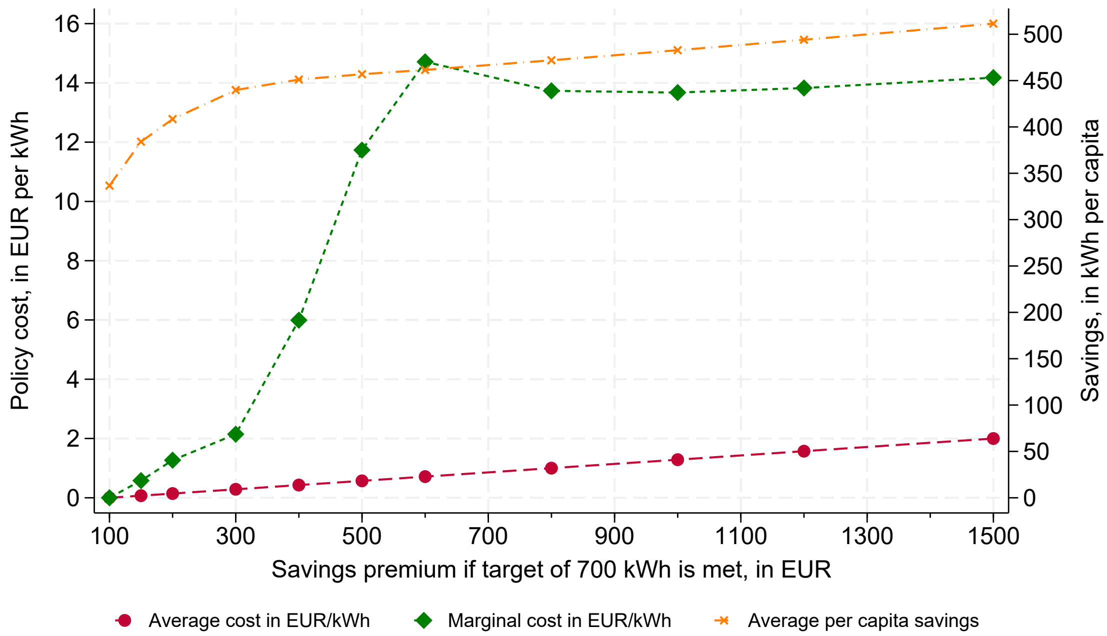
The low proportion of financially motivated participants found in our experiment suggests that generous premium programs are not cost-effective. In this section, we investigate the optimal design of premium programs in more detail and calculate the average and marginal cost per kWh saved. For simplicity, we present the results for a 700 kWh savings target in the main text (the results for the other savings targets are provided in Table A2 in the Appendix).

We obtain the average cost of the program by dividing the total premium payments by the savings the program induces. For simplicity, we smoothen premium adoption rates by employing a kernel-weighted local polynomial regression of degree 1 (see Figure A2 in the appendix). To quantify savings, we assume that all participants who enroll in the program achieve their respective savings goals. This reflects that our experimental design ensures that opting for the savings goal is only rational if a household expects to reach it. As shown in Figure 2, the average savings amount to about 340 kWh for the lowest premium of 100 euros and increase only slightly thereafter, reflecting the slight increase in adoption rates. The average cost increase slowly and reach about 1 euro per kWh when the savings premium reaches 800 euros. For premium levels as low as about 200–400 euros, the average cost amount to 0.14 to 0.43 euros per kWh. These values exceed the estimated external cost from carbon emissions associated with burning gas of 0.036 euros per kWh (European Commission and Trinomics, 2020), but may well be in the ballpark of the total social cost when taking externalities from security of supply into account. While estimates for such externalities are unavailable for gas, they are estimated at around 2 euros per kWh (Baik et al., 2020) in the context of electricity blackouts.[5]

However, for optimal program design, the question is not whether the costs are equal to the benefits on average, but at what point the marginal cost of setting up a more generous subsidy scheme exceed its marginal gains. We explore this issue by calculating the marginal cost of increasing the premium from one of the premium levels in our experiment to the next (Figure 2). Dividing these marginal cost by the marginal increase in gas savings then allows us to determine the marginal costs for each kWh of gas that is saved in response to an increase in the premium. As can be seen from

[5]We use this value as a conservative estimate of the security of supply externality from consuming gas during times of gas shortage. As gas can be stored more easily than electricity, the value for gas is likely lower.

Figure 2: Marginal Cost per Kilowatt-hour (kWh) for the Savings Target of 700 kWh




the green line in Figure 2, the marginal cost are very low for small savings premium levels, but rise strongly when the premium exceeds 200 euros. This cost explosion is largely driven by the fact that inframarginal participants, who would have signed up already for a lower premium, receive an unnecessary high premium, whereas the share of marginal participants is very small at each premium level. We also see that the marginal cost exceed 2 euro per kWh as soon as the premium level exceeds about 300 euros. Hence, premium programs with premia above that value are highly unlikely to yield social benefit.

# 6 Summary and Conclusions

Our experimental results suggest that private households react much less to savings premia than is often assumed: Even with a very high net-premium of up to 1,400 euros, which is equivalent to up to 2 euros per kilowatt-hour saved, an average of around 42% of the participants of the experiment decide against the savings premium. Instead, these individuals opt for an unconditional payment of 100 euros that is paid out irrespective of whether any savings target is reached. However, almost half of all participants of the experiment choose the savings premium even if this would not imply any financial advantages over the unconditional payment of 100 euros.

Our results add to previous findings that households use energy-saving premium programs as a commitment device to save energy (Harding and Hsiaw, 2014). Our experimental evidence suggests that energy-saving incentive programs should be designed to encourage this group of households, that is, those who already have energy saving intentions but fail to commit to their goals. This can be achieved by offering relatively low premia and the possibility to track the progress of self-set goals. By contrast, our evidence speaks against offering high premia: Only an average of 11% of participants in our experiment are motivated to save more energy with increasing premia and, at an average of 0.92 euros per kilowatt-hour saved, program costs are high. As shown in a calculation of the marginal cost of each additional kWh saved due to an increase in the premium, the cost is high because the proportion of marginal participants is small and generates little additional savings, while inframarginal participants who would have participated at lower premium levels also receive the now higher premium.

In summary, our results raise doubts about the cost-effectiveness of generous premium programs. Against this background, it appears reasonable that policymakers in Europe have not launched such premium programs during the recent energy crisis. Nevertheless, the proposal could well be put up for discussion again in the future. If so, our findings suggest that energy saving targets with small financial rewards are optimal because they enable motivated households to set targets and commit to them, while avoiding large inframarginal payments to consumers who intend to save energy anyways. Finally, our findings suggest that lower-income households require significantly higher premia to accept ambitious savings targets. Thus, energy savings programs have regressive distributional effects, which policymakers may want to consider in the optimal design of premium programs.

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# A Appendix

Table A1: OLS Regression Results for choice of Energy Saving Target with Continuous Savings and Premium Difference According to Income

| | Low income | | Medium income | | High income | |
|---|---|---|---|---|---|---|
| | Coeff. | Std. Err. | Coeff. | Std. Err. | Coeff. | Std. Err. |
| (1) Savings premium difference, in 1000 EUR | 0.018 | (0.030) | 0.096** | (0.030) | 0.103*** | (0.030) |
| (2) Savings target difference, in 1000 kWh | -0.044*** | (0.010) | -0.088*** | (0.010) | -0.074*** | (0.010) |
| Constant | 0.563*** | (0.030) | 0.704*** | (0.031) | 0.708*** | (0.030) |
| Number of observations | 1431 | | 1320 | | 1367 | |
| Equivalent premium: (2)/(1), in EUR/kWh | 2.44 | | 0.92 | | 0.72 | |

Notes: Robust standard errors are in parentheses. Savings premium difference denotes the difference of the observed savings premium relative to the lowest premium of 100 EUR, in 1000 EUR. Savings target difference denotes the difference of the observed savings target relative to the lowest target of 700 kWh. ***, ** and * denote statistical significance at the 0.1 %, 1 % and 5 % level, respectively.

Figure A1: Share of Respondents who Choose the Savings Premium

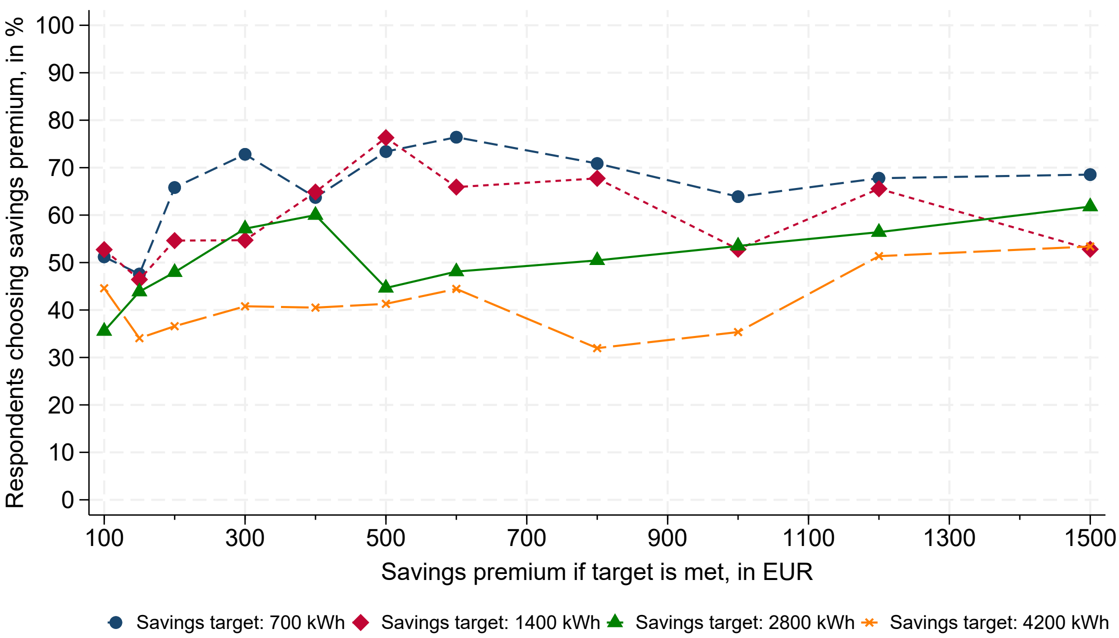
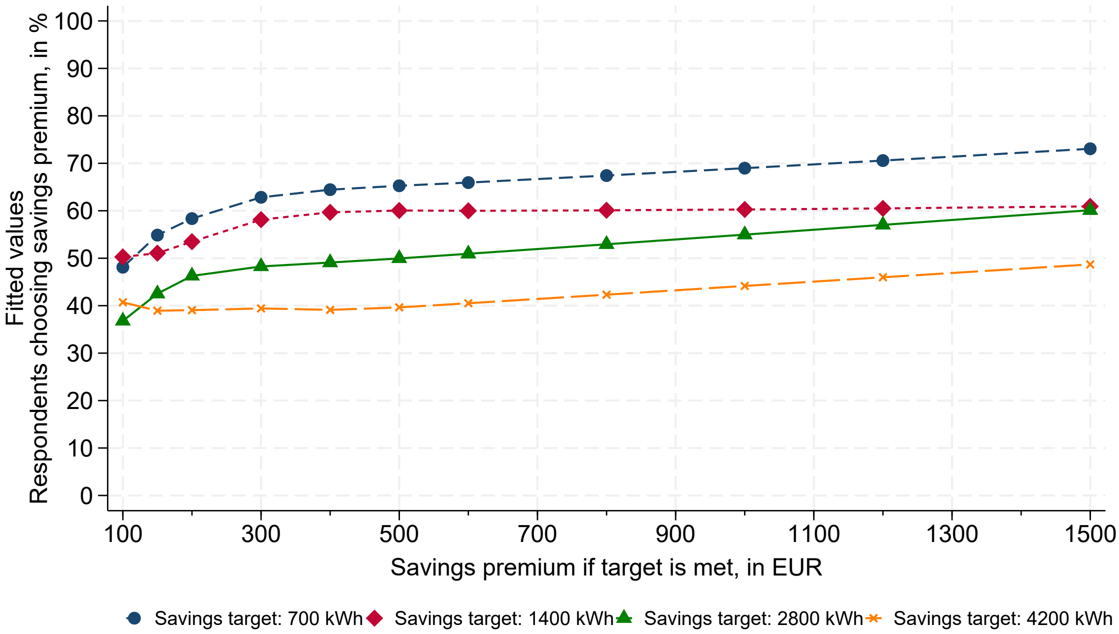


Figure A2: Share of Respondents who Choose the Savings Premium: Estimates from a kernel-weighted local Polynomial Regression of Degree 1



## Table A2: Policy Cost

| Premium, in EUR | Share of participants, in pp | Share of marg. participants, in pp | Average per capita savings, in kWh | Average per capita cost, in EUR | Average cost, in EUR/kWh | Marg. savings, in kWh | Marg. cost, in EUR | Marginal cost, in EUR/kWh |
|---|---|---|---|---|---|---|---|---|
| **Saving goal: 700 kWh** | | | | | | | | |
| 100 | 0.48 | 0.48 | 337 kWh | €0 | €0.00 | 337 kWh | €0 | €0.00 |
| 150 | 0.55 | 0.07 | 384 kWh | €27 | €0.07 | 47 kWh | €27 | €0.58 |
| 200 | 0.58 | 0.03 | 409 kWh | €58 | €0.14 | 24 kWh | €31 | €1.27 |
| 300 | 0.63 | 0.05 | 440 kWh | €126 | €0.29 | 31 kWh | €67 | €2.14 |
| 400 | 0.64 | 0.01 | 451 kWh | €193 | €0.43 | 11 kWh | €68 | €5.99 |
| 500 | 0.65 | 0.01 | 457 kWh | €261 | €0.57 | 6 kWh | €68 | €11.73 |
| 600 | 0.66 | 0.01 | 462 kWh | €330 | €0.71 | 5 kWh | €69 | €14.71 |
| 800 | 0.67 | 0.01 | 472 kWh | €472 | €1.00 | 10 kWh | €142 | €13.73 |
| 1000 | 0.69 | 0.02 | 483 kWh | €621 | €1.29 | 11 kWh | €149 | €13.67 |
| 1200 | 0.71 | 0.02 | 494 kWh | €776 | €1.57 | 11 kWh | €156 | €13.83 |
| 1500 | 0.73 | 0.02 | 512 kWh | €1,023 | €2.00 | 17 kWh | €247 | €14.18 |
| **Saving goal: 1400 kWh** | | | | | | | | |
| 100 | 0.50 | 0.50 | 704 kWh | €0 | €0.00 | 704 kWh | €0 | €0.00 |
| 150 | 0.51 | 0.01 | 715 kWh | €26 | €0.04 | 11 kWh | €26 | €2.28 |
| 200 | 0.53 | 0.02 | 749 kWh | €54 | €0.07 | 34 kWh | €28 | €0.83 |
| 300 | 0.58 | 0.05 | 814 kWh | €116 | €0.14 | 65 kWh | €63 | €0.97 |
| 400 | 0.60 | 0.02 | 835 kWh | €179 | €0.21 | 22 kWh | €63 | €2.91 |
| 500 | 0.60 | 0.00 | 841 kWh | €240 | €0.29 | 6 kWh | €61 | €11.23 |
| 600 | 0.60 | – | 840 kWh | €300 | €0.36 | – | €60 | – |
| 800 | 0.60 | 0.00 | 841 kWh | €421 | €0.50 | 1 kWh | €121 | €84.54 |
| 1000 | 0.60 | 0.00 | 844 kWh | €542 | €0.64 | 2 kWh | €122 | €49.84 |
| 1200 | 0.60 | 0.00 | 847 kWh | €666 | €0.79 | 3 kWh | €123 | €38.61 |
| 1500 | 0.61 | 0.00 | 853 kWh | €853 | €1.00 | 6 kWh | €187 | €31.89 |
| **Saving goal: 2800 kWh** | | | | | | | | |
| 100 | 0.37 | 0.37 | 1,030 kWh | €0 | €0.00 | 1,030 kWh | €0 | €0.00 |
| 150 | 0.43 | 0.06 | 1,191 kWh | €21 | €0.02 | 161 kWh | €21 | €0.13 |
| 200 | 0.46 | 0.04 | 1,296 kWh | €46 | €0.04 | 105 kWh | €25 | €0.24 |
| 300 | 0.48 | 0.02 | 1,351 kWh | €97 | €0.07 | 56 kWh | €50 | €0.90 |
| 400 | 0.49 | 0.01 | 1,375 kWh | €147 | €0.11 | 23 kWh | €51 | €2.20 |
| 500 | 0.50 | 0.01 | 1,399 kWh | €200 | €0.14 | 24 kWh | €53 | €2.17 |
| 600 | 0.51 | 0.01 | 1,426 kWh | €255 | €0.18 | 27 kWh | €55 | €2.00 |
| 800 | 0.53 | 0.02 | 1,482 kWh | €371 | €0.25 | 56 kWh | €116 | €2.06 |
| 1000 | 0.55 | 0.02 | 1,539 kWh | €495 | €0.32 | 57 kWh | €124 | €2.18 |
| 1200 | 0.57 | 0.02 | 1,597 kWh | €627 | €0.39 | 58 kWh | €133 | €2.31 |
| 1500 | 0.60 | 0.03 | 1,683 kWh | €842 | €0.50 | 87 kWh | €214 | €2.48 |
| **Saving goal: 4200 kWh** | | | | | | | | |
| 100 | 0.41 | 0.41 | 1,710 kWh | €0 | €0.00 | 1,710 kWh | €0 | €0.00 |
| 150 | 0.39 | – | 1,636 kWh | €20 | €0.01 | – | €20 | – |
| 200 | 0.39 | 0.00 | 1,641 kWh | €39 | €0.02 | 5 kWh | €20 | €3.96 |
| 300 | 0.39 | 0.00 | 1,656 kWh | €79 | €0.05 | 15 kWh | €40 | €2.61 |
| 400 | 0.39 | – | 1,643 kWh | €117 | €0.07 | – | €39 | – |
| 500 | 0.40 | 0.01 | 1,665 kWh | €159 | €0.10 | 22 kWh | €41 | €1.88 |
| 600 | 0.41 | 0.01 | 1,702 kWh | €203 | €0.12 | 37 kWh | €44 | €1.20 |
| 800 | 0.42 | 0.02 | 1,778 kWh | €296 | €0.17 | 76 kWh | €94 | €1.23 |
| 1000 | 0.44 | 0.02 | 1,855 kWh | €397 | €0.21 | 77 kWh | €101 | €1.31 |
| 1200 | 0.46 | 0.02 | 1,931 kWh | €506 | €0.26 | 77 kWh | €108 | €1.41 |
| 1500 | 0.49 | 0.03 | 2,045 kWh | €682 | €0.33 | 114 kWh | €176 | €1.54 |

Notes: Missing fields indicate negative values, which we exclude by definition. Small inaccuracies may occur due to rounding of numbers.

# B Instructions

### Original German Version

*Hinweis: Angaben in Rot sind Programmierhinweise*

Alle Teilnehmende, die mit Gas heizen. Alternative A und B randomisieren (mal Option A 100 EUR, mal Option A Prämie mit Sparziel)

Ausprägungen von **YYY** und **XXX** randomisiert ziehen (mit derselben Wahrscheinlichkeit) aus den folgenden Ausprägungen:

| **XXX (in kWh)** | **YYY (in EUR** |
|---|---|
| 700<br>1400<br>2800<br>4200 | 100<br>150<br>200<br>300<br>400<br>500<br>600<br>800<br>1000<br>1200<br>1500 |

**Beginn Experiment**
In diesem Teil der Umfrage interessieren wir uns weiterhin dafür, inwiefern Sie bereit sind, Ihren Heizenergieverbrauch in der kommenden Heizperiode zu verringern.
Sie haben die Wahl zwischen zwei Optionen:

Bei **Option A** erhalten Sie **100 EUR** am Ende der kommenden Heizperiode ausbezahlt. Diesen Betrag erhalten Sie unabhängig davon, wie viel Gas Sie verbrauchen.

Bei **Option B** erhalten Sie **einen Bonus von mindestens 100 EUR** am Ende der Heizperiode ausbezahlt, falls Sie Ihren Gasverbrauch im Vergleich zum Vorjahr um mindestens **XXX kWh** senken. Zur Einordnung: Ein 4-Personenhaushalt in Deutschland verbraucht durchschnittlich **18.800 kWh** Gas pro Jahr.

**Ihre Entscheidung kann reale Auswirkungen haben.** Nach dem Abschluss dieser

Umfrage wird ein Teilnehmender zufällig ermittelt und informiert. Dieser Teilnehmende erhält entweder den Betrag von Option A oder den Bonus von Option B, falls die Einsparung erreicht wird. Bei beiden Optionen erfolgt die Auszahlung, wenn für beide Abrechnungsperioden die Gasrechnungen als Nachweis eingereicht werden.

Neue Seite
**Question Opt_out:** Falls Sie unter keinen Umständen an diesem Teil der Umfrage teilnehmen möchten, klicken Sie bitte auf das folgende Kästchen. Sie nehmen dann nicht teil. Klicken Sie bitte einfach auf „weiter", um teilzunehmen. Die Dauer der Umfrage wird dadurch nicht beeinflusst.

- Ich verzichte auf die Möglichkeit, einen Betrag von 100 EUR oder einen Bonus von mindestens 100 EUR bei Erreichung der Einsparung zu erhalten.
- Weiter

Falls kein „Opt_out" angeklickt
Neue Seite
**Question Bonus2:** Bitte treffen Sie nun Ihre Wahl, welche der beiden folgenden Optionen Sie wählen:

Option A und B je nach vorher randomisierter Zuordnung zu 100 EUR bzw. Prämie mit Sparziel programmiert

**Option A:** Betrag von **100 EUR**, unabhängig von Ihrem Gasverbrauch
**Option B:** Betrag von **YYY EUR**, falls Sie Ihren Gasverbrauch um mindestens **XXX kWh** senken.

**Ihre Wahl**:

- Option A
- Option B
- weiß nicht/keine Angabe

**Translated English Version**

*Note: Specifications in Red are programming instructions*

All participants who heat with gas. Randomize alternative A and B (sometimes option A 100 EUR, sometimes option A premium with savings target)

Randomly draw values of **YYYY** and **XXX** (with the same probability) from the following values:

| **XXX (in kWh)** | **YYY (in EUR** |
|---|---|
| 700<br>1400<br>2800<br>4200 | 100<br>150<br>200<br>300<br>400<br>500<br>600<br>800<br>1000<br>1200<br>1500 |

**Begin Experiment**

In this part of the survey, we are also interested in the extent to which you are prepared to reduce your heating energy consumption in the coming heating period.
You have the choice between two options:

With **Option A**, you will receive **100 EUR** at the end of the coming heating period. You will receive this amount regardless of how much gas you consume.

With **Option B**, you will receive **a premium of at least EUR 100** at the end of the heating period if you reduce your gas consumption by at least **XXX kWh** compared to the previous year. To put this into perspective: A 4-person household in Germany consumes an average of **18,800 kWh** of gas per year.

**Your decision can have real consequences**. After completing this survey, one participant will be randomly selected and informed. This participant will receive either the amount from option A or the premium from option B if the savings are achieved.

For both options, payment will be made if the gas bills for both billing periods are submitted as proof.

New page

**Question Opt_out:** If you do not wish to participate in this part of the survey under any circumstances, please click on the box below. You will then not take part. Simply click on "continue" to take part. This will not affect the duration of the survey.

- I waive the option of receiving an amount of EUR 100 or a premium of at least EUR 100 if the savings are achieved.
- Continue

New page

If „Opt_out" has not been chosen
New page

**Question Bonus2:** Please choose which of the following two options you would like to select:

Option A and B depending on previously randomized allocation to EUR 100 or premium with savings target programmed

**Option A:** Amount of **EUR 100**, regardless of your gas consumption
**Option B:** Amount of **YYY EUR** if you reduce your gas consumption by at least **XXX kWh**.

**Your choice**:

- Option A
- Option B
- do not know/no answer