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The German Heating and Housing Panel (GHHP): Survey Data for the Heating Transition from 2021

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Manuel Frondel, Kathrin Kaestner, Marielena Krieg, Colin Vance*

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Abstract

Numerous measures have been taken in recent years to achieve climate protection targets in Germany's building sector. With the newly established Ariadne German Heating and Housing Panel (GHHP), the prerequisite for a well-founded evaluation of the effectiveness, distribution effects, and acceptance of climate policy measures in the heating sector has been created for the first time. Funded by the Federal Ministry of Education and Research (BMBF) as part of the Kopernikus project Ariadne, the GHHP is a series of annual surveys on the heating transition. It comprises around 15,000 participating households in Germany, 65% of which are owner-occupied households with the remaining 35% renters. In addition to eliciting detailed information on the building stock, existing heating systems, heating costs and the socio-economic characteristics of the households, the survey examines energy modernization measures that have already been carried out or are planned. The survey also records households' perception and acceptance of policy instruments in the building sector that are being discussed and have already been introduced. The first survey took place in 2021, with subsequent surveys to be continued annually until 2026.

JEL-Codes: Q3, Q4

Keywords: Household panel, heating transition, rate of modernization, acceptance

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1 Introduction

It is often alleged that the energy-efficient renovation rate of the existing building stock in Germany, which hovers at about 1% per year (BMWK 2014; Stede et al. 2020), is too low to achieve the greenhouse gas reduction targets in the building sector. Therefore, as early as 2010, policymakers set the goal of increasing this rate to 2% per year (BMWK 2010). A variety of measures have been taken to achieve this goal, including tax incentives for energy modernization. Just recently, the debate in Germany heated up after the Green party, a member of the governing coalition, announced plans to ban the installation of new fossil-fueled heating systems as of next year (The Federal Government 2023). A sound evaluation of the effectiveness and distributional impacts of these and other policy measures has so far been stymied by the lack of information on the linkage between the building stock, final energy demand, and the socioeconomic characteristics of households. The present paper describes a new initiative funded by the German Federal Ministry of Education and Research to close this data lacuna: the Ariadne German Heating and Housing Panel (GHHP).

By collecting data on the building stock, the heating energy costs of private households, the acceptance of policy instruments, and the socioeconomic characteristics of respondents in repeated systematic surveys, the GHHP establishes the foundation for a sound empirical analysis of the heating sector in Germany. The longitudinal nature of the Ariadne GHHP enables the identification of general trends, such as in modernization activity and energy demand patterns, allowing the analysis of barriers to modernization as well as the distributional effects of climate change mitigation instruments and public acceptance thereof (Frondel et al. 2021). In addition, the Ariadne GHHP establishes a comprehensive database on the building stock and energy efficiency, one that supports the application of modern panel-econometric methods to the modeling of household energy demand.

This paper provides a brief overview of the first wave of the Ariadne GHHP and how, over the longer term, this dataset will fill an important gap in the analysis of climate protection instruments. The following section 2 explains the process and methodology of the data collection and section 3 describes the socioeconomic features of the sample. Section 4 presents an application example. Information on how the data can be accessed can be found in section 5. A codebook is annexed.

2 Data Collection

Between July 23 and September 2, 2021, the first survey of the GHHP was conducted as part of the Kopernikus project "Ariadne - Evidence-based Assessment for the Design of the German Energy Transition", funded by the German Federal Ministry of Education and Research (BMBF), see https://ariadneprojekt.de/. The survey was designed by the RWI – Leibniz Institute for Economic Research (RWI) in cooperation with the project partners Potsdam Institute for Climate Impact Research and the German Economic Institute. The survey was implemented in collaboration with the opinion research institute forsa using its forsa.omninet panel, a panel with approximately 100,000 members. Panel members are recruited as part of forsa.omniTel, a multi-topic telephone survey conducted by forsa in which 500 people are interviewed daily. Recruitment is designed to ensure that the forsa.omninet panel is representative of the German-speaking online population aged 14 and older. The panel members were randomly selected for the survey and invited by a short e-mail. In addition to the link to the questionnaire, the invitation contained a brief introduction to the overarching theme of the survey and stated the (moderate) reward that participants receive if they complete the questionnaire in full, which is paid out in the form of vouchers or a raffle ticket for "Aktion Mensch". Alternatively, the amount can be donated to UNICEF.

The sample for the Ariadne GHHP was composed of two subsamples: One subsample consisted of respondents who had previously participated in the "German Residential Energy Consumption Survey" (GRECS) conducted by RWI and forsa, so that the data from the GHHP can be partially linked to the existing data from GRECS (https://www.rwi-essen.de/forschung-beratung/weitere/forschungsdatenzentrum-ruhr/datenangebot/mikrodaten/rwi-grecs-german-residential-energy-consumption-survey). The other part of the sample was drawn from the general forsa sample "Private households in the Federal Republic of Germany". The survey explicitly targets "heads of households" who are defined as those individuals who typically make the financial decisions for the household. Since heads of household usually also have the best overview of the building stock, energy costs and investments made, they are particularly well-suited to answer the survey. As many of the research questions are primarily relevant to owners, they were overweighted in the sample: 64.9% of households surveyed live in owner-occupied properties, while only 35.1% rent. Of these, 18.8% of respondents rent a house or apartment. Due to the intentional overweighting of owners, the ownership rate in the sample is significantly higher than in Germany, which was 46.5% in 2018 according to the Supplementary Microcensus Survey (Destatis 2019). To reach the advised final sample size of 15,000 households, forsa sent the invitation link for the survey to roughly 20,700 households from the forsa.omninet panel. With 1,487 abandoned interviews and a response rate of 74.5%, this resulted in a net sample of 15,416 respondents with complete data.

The questionnaire consists of several sections (see overview in Table 1). Module 1 collects data on the participants' housing situation and building characteristics. This information can be used to calculate the final energy demand of the building as a measure of energy efficiency. This first section of the questionnaire is followed by a section on households' heating costs and a module on past and planned building retrofits. This information will be asked repeatedly in every survey wave. The query of building characteristics and heating technology is based on the structure of

the renovation configurator of the Federal Ministry for Economic Affairs and Energy (BMWK 2015) and the "Short Procedure Energy Profile for the Simple Energy Evaluation of Buildings" of the Institute Living and Environment (Loga et al. 2005) (see also https://www.iwu.de/forschung/energie/kurzverfahren-energieprofil/). In the first survey wave, this module is followed by an experiment on the acceptance of bearing additional costs due to carbon pricing (Module 2). For this purpose, the respondents were randomly divided into three groups that differed in the carbon price level and revenue use information presented to the respondents. A subset of homeowners did not participate in Module 2 but instead participated in an experiment on heating optimization decisions (Module 3). The survey ended with a section on psychological variables, attitudes towards the environment, time preferences as well as socioeconomic features.

The data for wave 1 is offered in two separate data sets that can be merged via the household identifier "key". The first dataset ("ghhp_w1_buildingchars_eng") contains all building characteristics. All remaining survey data is included in the data set "ghhp_w1_experiments_eng". An accompanying tool to estimate the final energy demand of the respective houses based on their technical characteristics will soon be made available to interested researchers and professionals via RWI.

Table 1: Sections contained in the first wave

Section	Content
a & ist	Building & household characteristics
san	Passed and planned energetic renovations
ea & bel	Energy certificates and beliefs regarding energy retrofits
Eg	Experimental groups carbon pricing (Module 2)
Co	(Experimental) Assessment of statements about policy measures
Es	Experiment on heating optimization decisions (Module 3)
pk & altru	Psychological/environmental control variables
So	Socio-economic data
Calc	Calculated values needed for experiment in Module 2

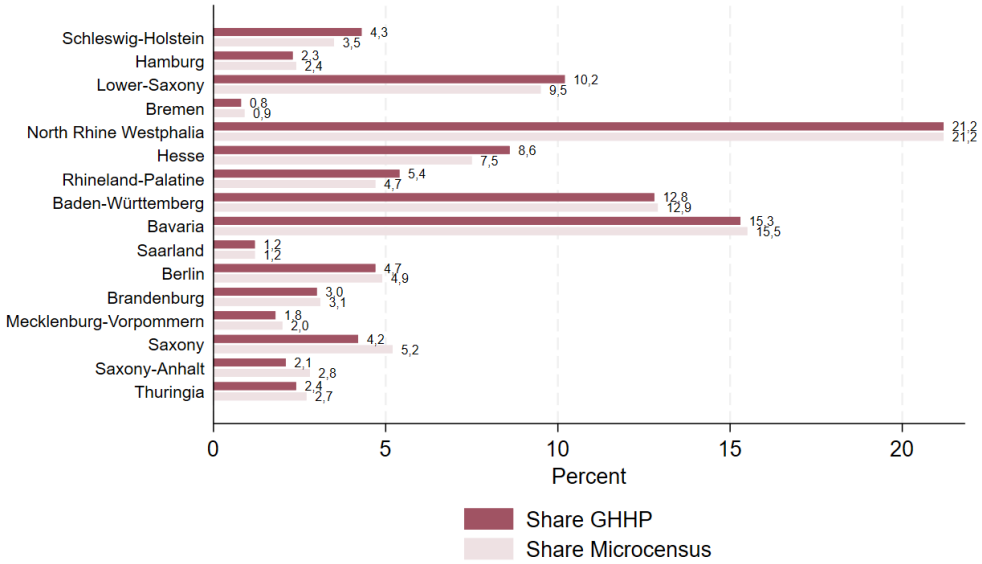
It is important to note that due to the deliberate overweighting of homeowners, it is not possible to make direct statements representative of the German population based on the raw data set. For this purpose, the data set contains weighting factors calculated by forsa that weight the study representatively according to household size and the ratio of owning vs. renting in the German population. The survey was not designed to infer statistics at the municipal level.

3 Socioeconomic Features of Surveyed Households

In the following, we summarize the most important socioeconomic characteristics of the surveyed households in the GHHP and compare them with households from the German population, as represented in the Microcensus 2020 compiled by the Federal Statistical Office of Germany (Destatis 2021).

The distribution of households across the federal states largely aligns with the distribution of households according to the Microcensus 2020. The three federal states with the largest share are North Rhine-Westphalia (21.2%), Bavaria (15.3%) and Baden-Württemberg (12.8%) (Table 2 and Figure 1).

Figure 1: Distribution of households across the states in the GHHP and in Germany according to Microcensus 2020. Source: Destatis (2021)

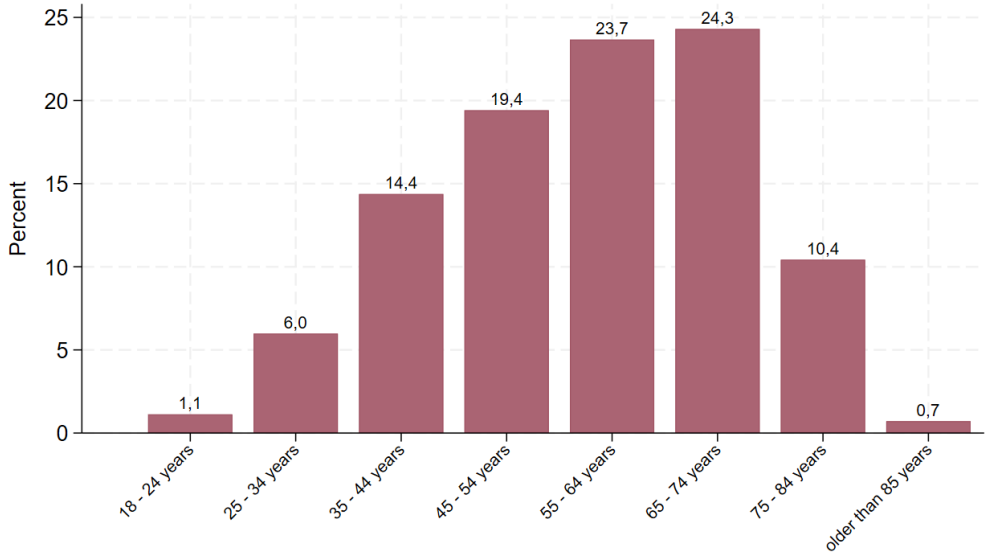


The study participants in the GHHP are between 18 and 93 years old. Respondents between the ages of 65 and 74 form the largest age group, with a share of 24.3%, while the age group between 55 and 64 has a slightly lower share of 23.7% (Figure 2). Comprising a total of 48%, persons aged between 55 and 74 are thus overrepresented when compared with the 35.6% share in the Microcensus 2020 (Destatis 2021). Conversely, with a share of 6%, persons between the ages of 25 and 34 are underrepresented compared with the 12.8% figure in the Microcensus. Since younger persons tend not to make household decisions, this can be attributed to the fact that the survey was explicitly aimed at heads of household.

Table 2: Distribution of households across states in the GHHP and in Germany according to Microcensus 2020. Source: Destatis (2021)

Federal State	Number of households in GHHP	Share of households in GHHP	Share in Germany according to Microcensus 2020
Baden-Württemberg	1,969	12.8%	12.9%
Bavaria	2,359	15.3%	15.5%
Berlin	729	4.7%	4.9%
Brandenburg	449	2.9%	3.1%
Bremen	118	0.8%	0.9%
Hamburg	364	2.4%	2.4%
Hesse	1,339	8.7%	7.5%
Mecklenburg-Vorpommern	266	1.7%	2.0%
Lower Saxony	1,544	10.0%	9.5%
North Rhine-Westphalia	3,263	21.2%	21.2%
Rhineland-Palatine	813	5.3%	4.7%
Saarland	185	1.2%	1.2%
Saxony	652	4.2%	5.2%
Saxony-Anhalt	323	2.1%	2.8%
Schleswig-Holstein	673	4.4%	3.5%
Thuringia	371	2.4%	2.7%
Total	**15,416**	**100%**	**100%**

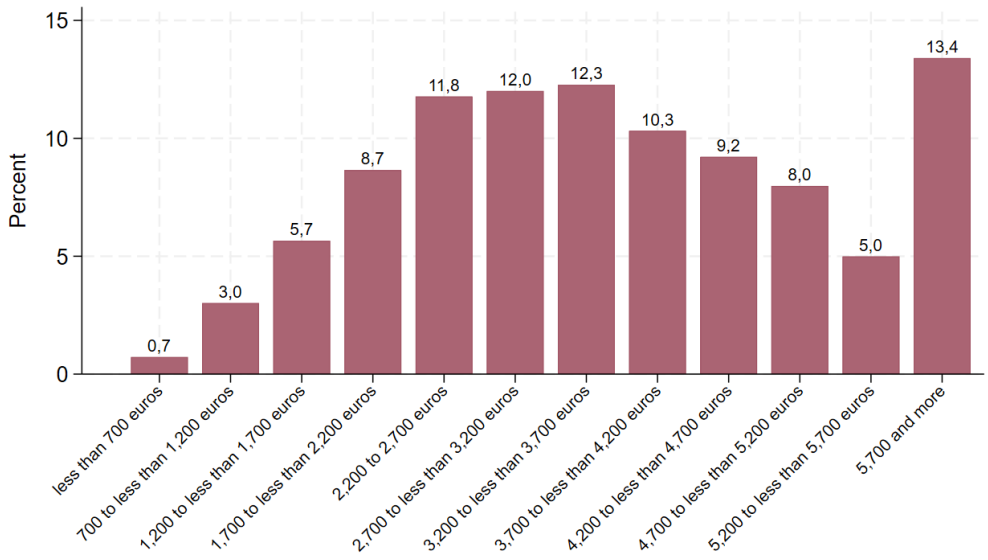
Figure 2: Age distribution of surveyed household heads



40.7% of respondents are women, while 59.3% are men. This also does not correspond to the distribution in the population, where the proportions are almost equal, with 49.5% male and 50.5% female (Destatis 2021). Here, too, the unequal distribution likely owes to the explicit survey of heads of household.

Net incomes are classified in 500-euro increments ranging from "under 700 euros" to "5,700 euros and more." Households with a net income of more than 5,700 euros form the largest income group in the sample, with a share of 13.4% (Figure 3).

Figure 3: Distribution of monthly household net income in the GHHP.



Answer to the question: "What is the total monthly net income of your household? This refers to the sum of wages, salary, income from self-employment, pension or retirement benefits, in each case after deduction of taxes and social security contributions. Please also add income from public assistance, income from renting, leasing, housing allowance, child benefit and other income."

When comparing the sample distribution of the GHHP with the income distribution in the population according to the Microcensus, it is noticeable that the lower income strata are clearly underrepresented in the sample, while the higher income strata are strongly overrepresented. For example, the income group from 2,700 to 5,200 euros has a share of 51.8% in the sample (Table 3), while incomes between 2,500 and 5,000 euros have a share of 36.7% in the population according to the Microcensus 2020 (Destatis 2021). This difference is related to the deliberate oversampling of homeowners in the sample. Note here that the median income of renters in the sample is in the category of 2,700 to 3,200 euros, but the median income of homeowners is in the category of 3,700 to 4,200 euros.

Table 3: Comparison of the distribution of household incomes between the GHHP and the German population according to the 2020 Microcensus. Source: Destatis (2021).

Share in GHHP		Share in Microcensus 2020	
Under 700 Euro	0.7%	Under 500 Euro	1.8%
700 – 1,200 Euro	3.0%	500 – 1,250 Euro	13.7%
1,200 – 2,700 Euro	26.2%	1,250 – 2,500 Euro	33.4%
2,700 – 5,200 Euro	51.8%	2,500 – 5,000 Euro	36.7%
Over 5,200 Euro	18.4%	Over 5,000 Euro	13.6%

At 48.3%, households with two persons are the largest group in the GHHP, a far larger share than the 34.0% recorded by the Microcensus 2020 (Table 4). Single-person households are the

second largest group in the sample (23.6%), but the largest group within the Microcensus (40.6%).

Table 4: Distribution of household size in the GHHP and according to the Microcensus 2020. Source: Destatis (2021).

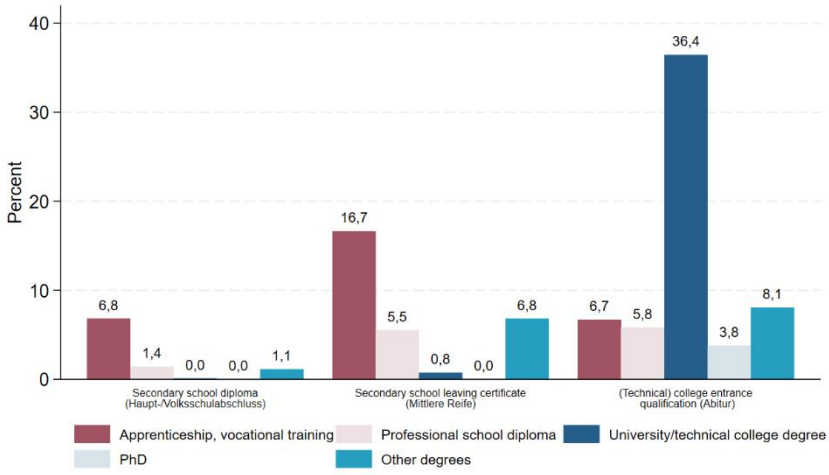
Household size	Share in GHHP	Share in Microcensus 2020
1 Person	23.6%	40.6%
2 Persons	48.3%	34.0%
3 Persons	13.2%	12.1%
4 Persons	11.2%	9.8%
5 and more persons	3.9%	3.5%

9.6% of all participants have a secondary/elementary school diploma ("Haupt-/ Volksschulabschluss"), while 29.5% have a secondary school leaving certificate ("Mittlere Reife") (Table 5). The largest group, with a share of 60.4%, is made up of household heads with a technical or general higher education entrance qualification (Abitur). 36.4% of all respondents have a technical/higher education entrance qualification and also a university degree (Figure 4). 3.8% of respondents have a doctorate. Thus, with a total of 40.2%, the proportion of academics among the respondents is almost twice as high as in the Microcensus (22.7%). Respondents with a secondary school diploma (16.6%) were the most likely to report an apprenticeship as their highest vocational qualification. 5.5% of all respondents obtained a technical college degree after their intermediate secondary school leaving certificate. Among respondents with a lower secondary/elementary school leaving certificate, apprenticeship or vocational training is the most common degree (6.8%).

Table 5: Highest level of education in the sample and according to the Microcensus 2020. Source: Destatis (2021).

Highest school degree	Share in GHHP	Share in Microcensus 2020
Without school-leaving qualification / <7 years	0.2%	3.6%
Secondary / elementary school diploma	9.6%	28.1%
Secondary school leaving certificate (Mittlere Reife)	29.5%	30.0%
Technical / university entrance qualification / Abitur	60.4%	37.8%

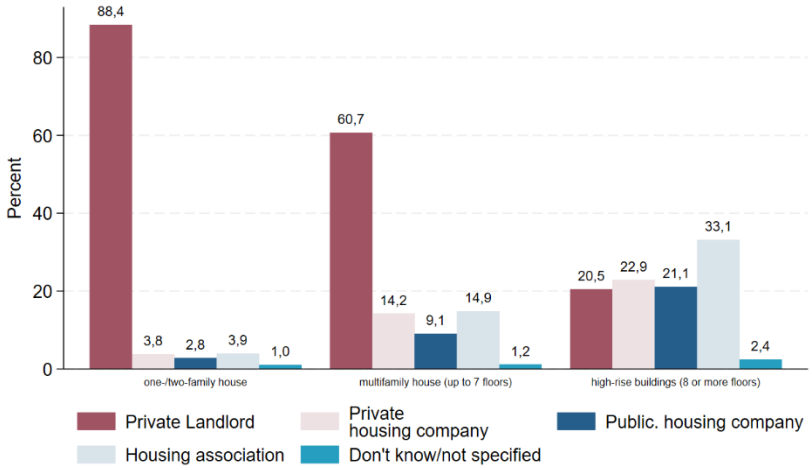
Figure 4: Distribution of the highest vocational training/(technical) college degree, broken down by highest school-leaving qualification.



Answer to the question, "What is your highest high school degree?"

64.9% of the surveyed households are homeowners, while 35.1% are tenants. Two-thirds of tenants report having a private individual as their landlord. The second most common rental type is (public) housing associations, with a much smaller share of 12.6%. The rest of the tenants surveyed rent from private (11.9%) or public housing companies (7.9%). When distinguished by building type, 88.4% of tenants in single/two-family houses rent from private individuals (Figure 5). In apartment buildings, 60.7% of respondents rent from private individuals, while in high-rise buildings only 20.5% rent from private individuals. Here, most respondents rent from housing associations (33.1%), followed by private (22.9%) and public housing associations (21.1%).

Figure 5: Type of landlord of people living for rent by building type.



If the respondent indicated living for rent, answer to the question, "What is true about your landlord/landlady?"

4 Examples for Applications

Besides the standard questions on building characteristics and heating technology, the focus of the first survey was on the energy-related building modernization activities of private households, as well as on the evaluation and acceptance of climate protection instruments in the building sector. Two publications presented below illustrate the variety of possibilities of working with the GHHP and how the data enhance the political and scientific dialog on the heating transition in Germany.

4.1 Descriptive analysis of acceptance and modernization

Frondel et al. (2022) use the data set from the first wave and descriptively analyze households' acceptance of different climate protection instruments in the building sector. While a ban on the installation of gas boilers and a building climate levy only meet with the approval of around 30% of respondents, a ban on the installation of oil boilers is welcomed by almost 70% of respondents. Surprisingly, only about 20% of those who reject the ban on the installation of oil boilers heat with oil, while this ban is rejected by a larger proportion of about 30% of those who heat with gas. Moreover, the authors find that almost half of all respondents report feeling rather uninformed about carbon pricing in Germany. Similarly, just over half of homeowners do not feel well-informed about energy-efficient refurbishments. To compare the modernization activity of the sample households with the frequently mentioned energy renovation rate of approximately 1% per year for Germany, the authors employ a methodology developed by Cischinsky and Diefenbach (2018) that weights the individual modernization rates of four modernization measures (insulation outer wall, roof, floor/basement ceiling and replacement of windows) by area to calculate the overall modernization rate. This results in an annual modernization rate for the sample of 1.03%, which is statistically indistinguishable from the rate calculated by Cischinsky and Diefenbach (2018).

4.2 Experimental evidence on cost-sharing of a carbon price

Kaestner et al. (2025) use a stated-choice experiment to analyze the support for different concepts to share the cost burden owed to carbon pricing between landlords and tenants. The building sector offers an important lever for reducing carbon emissions, with carbon pricing considered as one essential policy instrument to unleash this potential. Yet, carbon pricing in residential buildings faces challenges, particularly in rental housing, as the financial burden and thus the incentives to reduce carbon emissions may be distributed differently between landlords and tenants, presenting a principal-agent problem that can lead to conflict and low public support.

Using the extensive survey data from the GHHP in 2021, Kaestner et al. (2025) analyze drivers of the support for the following four burden sharing schemes: (1) where landlords or (2) tenants bear all the costs, as well as schemes where they are shared (3) equally or (4) based on the energetic quality of the building. The authors specifically examine the role of perceived cost, effectiveness, and fairness. Beyond analyzing these aspects in a correlational manner, they experimentally study the impact of revenue use and carbon price level on public preferences by randomly allocating three different carbon price levels and three different revenue use options to the about 12,000 participants in the experiment.

The results suggest that a sharing scheme that splits the additional cost of carbon pricing between landlord and tenants according to the building's energy efficiency level garners the highest overall support. Conversely, the status quo at time of the survey under which tenants bear all the costs is the least popular scheme. Notably, neither the kind of revenue use nor the carbon price level have a bearing on overall preferences. Yet, the authors detect that preferences largely reflect self-interest, as tenants strongly dislike the status quo, and landlords are more likely to disagree with a scheme that imposes all cost on them. Moreover, the authors find heterogeneity with respect to socioeconomic characteristics and especially with respect to respondents' attitudes toward carbon pricing. The results further indicate that fairness perceptions of the respective cost burden sharing scheme are more closely related to the overall support than perceived effectiveness for climate change mitigation.

5 Data Access

The data sets are available as a Scientific Use File at the FDZ Ruhr, the research data center at RWI – Leibniz Institute for Economic Research. The data access is only granted for scientific, non-commercial studies and to affiliate researchers of scientific institutions. It requires a signed data usage agreement that can be submitted on the FDZ website. The data can be obtained as a Stata ® dataset (.dta) or .csv file. Users are requested to cite the source and to inform FDZ Ruhr about publications with the data. When using the two available data sets of wave 1 of the GHHP, please cite the following two sources:

Frondel, Manuel; Gerster, Andreas; Kaestner, Kathrin; Pahle, Michael; Schwarz, Antonia et. al. (2023): The German Heating and Housing Panel (GHHP) - Wave 1. Building Characteristics. *German Heating and Housing Panel.* Version: 1. RWI – Leibniz Institute for Economic Research. Dataset. https://doi.org/10.7807/ghhp:building:v1

Frondel, Manuel; Gerster, Andreas; Kaestner, Kathrin; Pahle, Michael; Schwarz, Antonia et. al. (2023): The German Heating and Housing Panel (GHHP) - Wave 1. Socioeconomic Characteristics and Experiments. *German Heating and Housing Panel.* Version: 1. RWI – Leibniz Institute for Economic Research. Dataset. https://doi.org/10.7807/ghhp:experiment:v1

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