# Willingness-to-pay for reducing greenhouse gas emissions: Differences between urban and rural areas*

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Willingness-to-pay (WTP) for reducing greenhouse gas emissions (GHG) likely depends on the socio-economics of respondents in valuation studies. The location of respondents and their housing situation are rarely taken into account. Based on a representative household survey in Austria, mean WTP to reduce GHGs in a choice experiment (CE) amounts to EUR 186 per ton. The results of this paper indicate that – ceteris paribus – respondents in rural areas exhibit a lower WTP of about EUR 164 per ton while urban respondents state a WTP of roughly EUR 204 per ton. The results suggest that differences have their origin in the different housing conditions of respondents. Single-family homes in rural areas exhibit a higher energy consumption (kWh per m²), compared to multi-unit residential dwellings in urban and densely populated areas. Furthermore, socio-economics (e.g. level of education, age) of urban and rural populations explain different WTP bids. The individual concern about effects of climate change, such as urban heat islands (UHI) and heat stress, is different between urban and rural households. In addition, respondents strongly preferred information campaigns, incentives and energy consumption standards as climate change mitigation policy instruments compared to environmental taxation.

** This paper is in the state of a working paper; the authors plan to revise the paper and re-estimate marginal WTP with more advanced statistical methods and approaches.*

## 1 Introduction and backround

Today, there is no doubt that anthropogenic GHG are the main cause of climate change (IPCC, 2014). While there are a lot of political and legally binding frameworks[1] to reduce GHG, the atmospheric abundance of CO2 increased since pre-industrial time from 277ppm (1750) to more than 400 ppm in 2017 (WMO, 2018; Le Quéré et al., 2018). Austria's level of GHG emissions did not decrease either since 1990 (Umweltbundesamt, 2019). To reach the goal of limiting temperature increase to 2°C, or even 1,5°C, above pre-industrial levels (UNFCC, 2015), it would be necessary to implement effective and substantial short-term mitigation policies (IPCC, 2018). These policies employ different classes of environmental policy instruments such as economic incentives (taxes, subsidies), regulation (e.g. standards and mandatory norms for energy performances), information and education (e.g. energy audits und assessments; public information campaigns) and institutional frameworks (e.g. rights and obligations of property owners and tenants; see Laes et al., 2018). All of these are considered to have a positive impact on national GHG emissions (WIFO, 2007; Böhm and Getzner, 2016; Ó Broin et al., 2015; Laes et al, 2018).

The implementation of a carbon tax in Austria, for example, could reduce GHG emissions by at least 3 to 10% per year, depending on the level of the tax rate (carbon price) and the use of revenue (WIFO, 2018). Recent debates about the realization and the extent of CO2 taxes as well as the need to have sufficient information about the benefits of GHG emission mitigation policies spurred ambi-

[1] E.g: Paris Agreement (UNFCCC, 2015); Kyoto Protocol (United Nations, 1998), 2020 climate and energy package of the European Union (European Comission, 2008).

tions to estimate the economic value of GHG. One way to determine the economic welfare of mitigation policies and, thus, the economic value of reducing GHG emissions is to ask respondents for their willingness to pay for these policies in discrete choice experiments (Alberini et al., 2018; Johnston et al. 2017).

This paper examines preferences of Austrian households regarding GHG mitigation policies in the field of housing, and the willingness-to-pay (WTP) to reduce GHG emissions in this sector using a discrete choice experiment. While there is evidence that WTP is, of course, driven by income (Alberini et al., 2018; Gupta, 2016; Tyllianakis and Skuras, 2016) and other socio-economic characteristics of respondents such as the level of education (Sundt and Rehdanz, 2015; Diederich and Goeschl, 2014), the effects of the location of the respondent's residence and his/her housing conditions (e.g., multi-story apartment blocks vs. single homes; owner-occupied vs. rented flats; rural vs. urban environments) on WTP is rarely observed. This fact is interesting as the housing conditions have strong impacts on the households' levels of GHG emissions (Tukker et al., 2010; Druckman und Jackson, 2008). Furthermore, the costs of abating GHG emissions are different owing to the available technologies of retrofitting different kinds of buildings.

For this reason, we investigate how different degrees of urbanization and housing conditions affect individual WTP to reduce GHG emissions as well as preferences for environmental policy instruments. A recent study, which estimated WTP in Italy and the Czech Republic (Alberini et al., 2018) served as starting for this paper. This facilitates to ascertain not only differences within Austria depending on socio-economics of respondents, but also an international comparison of WTP values. The novelty of this paper is therefore how WTP is driven by specific spatial factors, like different degrees of urbanization and housing situations.

The structure of the paper is as follows: A brief literature review on the methodology and empirical evidence of WTP for reducing GHGs is presented in Section 2. The empirical survey and the choice experiment are presented in Section 3. Descriptive and econometric results are discussed in section 4, while in Section 5, the results are summarized and conclusions are drawn.

## 2 Empirical and methodological overview: Willingness-to-pay for reducing greenhouse gas emissions

Several studies have recently estimated citizens' willingness-to-pay (WTP) for reducing GHG emissions in different countries (Table 1). As can be seen from the range of countries of the selected studies, there is no recent paper that has estimated WTP for reducing GHG emissions in Austria. There are, of course, different methods and approaches to elicit WTP and estimate benefits of climate policies that reduce GHGs. One approach is the Social Cost of Carbon (SCC), which estimates the monetary value of (reducing) damages of GHG and is associated with a one-metric-ton reduction in carbon dioxide (CO2) (Pizer et al., 2014; Johnston, 2016).

The existing literature shows a broad range of SCC. Tol (2018) and Wang (2019) recently provided a meta-analysis that suggested that there are big differences between estimated SCC values. Mean SCC ranges from 44$/tC (3% PRTP[2]) to 677$/tC (0% PRTP), while the mode is between 28$/tC (3% PRTP) and 220$/tC (0% PRTP) (Tol, 2018). Wang (2019) reviewed 58 studies with 589 estimates, where the average SCC is clearly higher with 200$/tC (3% PRTP).

Another approach to estimate the monetary value of mitigation policies are stated preference methods (SPM) such as contingent valuation (CVM) and discrete choice experiments (DCE). SPM are the only methods that can estimate values for non-use values of public goods such as environmental services (Johnston et al., 2017). Many studies (e.g. Alberini et al., 2018; Carlsson et al., 2012; Longo et al., 2012) used SPM to valuate environmental services. A lot of papers applying DCEs do not estimate the value of one ton of GHG directly, but measure WTP for a certain precentage reduction of GHG emissions (e.g. Carlsson et al. 2012), or set emission reductions in context to emissions of other sectors, like cars (e.g. Chalak, et al., 2012). To make results comparable, Table 1 presents an overview of selected papers that estimated WTP for reducing GHG directly from DCE or CV, and therefore ascertained the monetary value for (the reduction of) one metric ton of CO2 or GHGs (measured as CO2-equivalent). The overview shows that WTP values differ within a certain range, depending on the proposed climate change mitigation policy, and the country context (e.g., income).

In comparison to prices of GHGs that are traded on markets, the elicited WTP values are on average much higher. Based on the European Union's Emissions Trading System (EU ETS), prices for one ton CO2 are currently about EUR 25€/t CO2 (February 2020; see European Emission Allowances, 2020). Actual CO2 taxes of the non-ETS sector differ greatly among EU-countries (OECD, 2018). However, market prices and tax rates of carbon taxes implemented are determined by political and economic contexts, and cannot readily be compared to WTP elicited in SPM. Furthermore, many tax schemes in European countries pose taxes on energy consumption (especially fossil fuels) which may only loosely be linked to carbon emissions, and thus may only include an implicit price of carbon.

[2] PRTP= pure rate of time preference.

| *Author(s)* | *Country* | *Year of survey* | *N of participants* | *Environmental policy context* | *Method* | *WTP (EUR, mean, per capita, per ton of GHG emissions)* |
|---|---|---|---|---|---|---|
| *Alberini et al. (2018)* | *Italy / Czech Republic* | *2014* | *1,005<br>1,394* | *Public policies which reduce GHG from dwellings* | *DCE* | *133€<br>94€ (2014)* |
| *Holm et al. (2015)* | *Germany* | *2015* | *178* | *Different procedures to reduce GHG* | *CV* | *-161€ to 644€ (2015)* |
| *Diederich and Goeschl (2013)* | *Germany* | *2010* | *1,640* | *Voluntary climate action* | *DCE* | *6.30€ (2010)* |
| *Achtnicht (2011)* | *Germany* | *2007<br>2008* | *600* | *GHG reduction in car manufacturing. Survey of potential car buyers* | *DCE* | *89€ to 256€ (2008)* |
| *Longo et al. (2008)* | *United King-dom* | *2005* | *300* | *Program that promo-tes the production of renewable energy* | *DCE* | *967$ (2005)* |
| *Schwirplies et al. (2019)* | *Germany* | *2014* | *1,005* | *Offset GHG-Emissions from travelling* | *DCE* | *53€ for a bus travel<br>11€ for a plane travel (2014)* |
| *Brouwer et al. (2008)* | *Netherlands* | *2006* | *400* | *Air travel passengers at Schipol Int. Compensa-tion of GHG-emissions during flight.* | *CV (DB)*double bounded dichotomous choice* | *41€ (Europe)<br>17€ (NAmerica)<br>10€ (Asia)<br>25€ (*World)* |

**Table 1:** Overview of recent papers on the willingness-to-pay (WTP) to reduce greenhouse gas (GHG) emissions

Source: Authors' collection and assessment of selected papers.

# 3 The empirical survey

## 3.1 Survey and questionnaire administration

This paper presents the results of a representative Austrian household survey eliciting WTP for reducing one ton of GHG-emissions; and preferences for climate mitigation policy instruments. WTP values are elicited by using a discrete choice experiment (DCE) implemented as a web-based survey of 1,500 respondents in Austria. The survey was conducted as a nationwide representative survey with a randomized quota sample by a certified market research company (Marketagent) in April 2019. The sample was representative in terms of age (between 18 and 69), gender, and regional dispersion (at levels of federal states and different degrees of urbanization according to criteria of the European Commission (Eurostat, 2019)). As the summary statistics show, participants with a lower level of education and a below-average household income were slightly underrepresented (Table 2).

The questionnaire was developed between October 2018 and February 2019 by the authors; several experts and focus groups were asked for their assessment of the questionnaire regarding clarity and completeness (e.g., psychologists, sociologists, other members of the Institute of Spatial Planning, student groups) and pre-tested in the field with a sample of 129 respondents in March 2019. In the pre-test the questionnaire was checked for comprehensibility and the DCE for plausibility as well as dominant choice cards. As pre-test results showed no abnormalities, the survey was cleared to be carried out subsequently. The combination of choice cards and policy programs was computed by using the NGENE ® software with the aim to produce N-efficient designs (see section 3.2).

To accomplish a clear and reliable questionnaire and spot potential biases several experts and focus groups were asked for their assessment of the questionnaire before the pre-test was conducted in the field. To make sure participants understood the task of the DCE a separate sheet (as a pdf file) with explanations of the attributes and levels was placed previous to the DCE.

The questionnaire was inspired by the one used in Alberini et al. (2018) and divided into several parts. Furthermore, the original questionnaire was extended and adapted to include questions specific for housing and the location of the residence of respondents. The survey started with questions about the individual living conditions and

| Variable | Densely populated area | Intermediate density areas | Thinly populated areas | Total sample | Austrian Average |
|---|---|---|---|---|---|
| Observations | 487 | 491 | 522 | 1.500 | |
| Gender | | | | | |
| Male | 48,9% | 48,7% | 52,3% | 50,0% | 50,8% |
| Female | 51,1% | 51,3% | 47,7% | 50,0% | 49,2% |
| Education | | | | | (2016) |
| Compulsory school | 12,5% | 11,8% | 12,3% | 12% | 26% |
| Apprenticeship | 32,4% | 41,1% | 41,8% | 38% | 32% |
| School for Intermediate Vocational Education | 10,7% | 14,9% | 16,3% | 14% | 14% |
| High school diploma | 25,1% | 19,3% | 19,7% | 21% | 15% |
| University or similar | 19,3% | 12,8% | 10,0% | 14% | 13% |
| Income[4] | | | | | (2017) |
| < 1.250 | 12% | 13% | 8% | 14% | 20% |
| 1.250 - 2.000€ | 22% | 16% | 15% | 22% | 30% |
| 2.001 – 2.500€ | 13% | 13% | 9% | 14% | 20% |
| 2.501 – 3.600€ | 19% | 19% | 24% | 26% | 20% |
| > 3.600€ | 16% | 18% | 22% | 24% | 10% |
| Missing income (refused) | (18%) | (21,2%) | (22,2%) | (20,3%) | 0% |

**Table 2:** Socioeconomics of respondents

Source: Authors' calculations, and Statistik Austria, 2019a and 2019b.

the respondent's household energy consumption and GHG-emissions. The DCE and questions about attitudes towards climate change were placed roughly in the middle of the questionnaire. The questionnaire ended with general questions about environmental policy approaches and also elicited the respondent's assessment of the causes and consequences of climate change.

## 3.2 Structure of the choice experiment

In contrast to CVM, where respondents are asked if they would vote for a certain policy change at specific costs, participants in choice experiments have to make a choice between at least two multi-attribute alternatives (programs) in an experimental setting based on their preferences. As several attributes describe every alternative, it is possible to rate every alternative individually (Johnston et al., 2017).

Like Alberini et al. (2018) we investigated public preferences for climate mitigation policies in the context of energy use in dwellings. To do so, respondents had to indicate their preference among three alternative policy packages. Every alternative was described by four attributes whose levels differed between the alternatives. Respondents were asked to choose between the status quo and two hypothetical policies, which would reduce GHG-emissions of private households. The CE-design of Alberini et al. (2018) served as a blueprint for our DCE to make our results comparable to results of Italy and the Czech Republic. As in their study, our alternatives were described by four attributes, a) the goal of the policy, b) the approach of the policy, c) GHG-emission reductions per household per year, and d) the costs of the policy to the respondent's household per year. Attributes a) and b) were included to measure preferences towards mitigation policies, while c) and d) were needed to estimate WTP for reducing GHG-emissions.

[3] Precentage values are calculated without missing values. Categories were summarized to be comparable to Statistik Austria.

| *Attribute* | *Attribute levels* |
|---|---|
| *Goal of the policy* | *- Higher share of renewable energy*<br>*- Improvement of energy efficiency* |
| *Approach* | *- Taxes*<br>*- Incentives*<br>*- Mandatory regulations*<br>*- Information* |
| *GHG Reduction (per household for each of 10 years)* | *- 0.25 tons (-5%)*<br>*- 0.5 tons (-10%)*<br>*- 1.0 tons (-25%)*<br>*- 1,65 tons (-33%)* |
| *Costs of the policy (per household for each of 10 years)* | *- 0.25 tons (-5%)*<br>*- 0.5 tons (-10%)*<br>*- 1.0 tons (-25%)*<br>*- 1,65 tons (-33%)* |

**Table 3:** Attributes and attribute levels of the choice experiment

Source: Authors' draft

Every attribute was set at an average of 5 tons GHG emissions per household and year conforming to current direct household emissions in Austria[4]. The levels (GHG-reduction and costs) as well as the baseline of GHG reduction were also taken from Alberini et al. (2018) to make results comparable. Compared to the mentioned study where respondents had to answer five choice sets, participants had to respond to six choice sets in our questionnaire.

Due to the different attribute values more than 16,000 different choice set combinations are possible. To exclude dominant choice cards and define reasonable choice sets the most efficient combinations were computed by using NGENE ®, a software for designing choice experiments. In a final step, twelve computed choice sets were reviewed for plausibility and slightly adapted. In the survey, the sample was divided into two sub-samples, each with six choice sets based on the NGENE calculations. Every block was answered by 750 respondents, to reduce the impact of single choice sets on the results. Table 4 shows an exemplary choice set.

## 3.3 Description of the Conditional Logit Model

Conditional Logit models, often also called Multinomial Logit models (MNL), are the most widely used method to model individual choices in research fields, such as environmental, urban and health economics as well as marketing, transportation and many others. Both models belong to the family of Random Utility Maximization mod-

4 Annual GHG emissions per houshold and year range from 2.1 tons (Umweltbundesamt, 2018) to 6.82 tons (CO2 Rechner, 2018). Own calculations based on data of Statistik Austria (2017) resulted in about 4.5 tons GHG emissions per HH and year.

| ***Attribute*** | ***Policy A*** | ***Policy B*** | ***Status quo*** |
|---|---|---|---|
| **Goal of the policy** | **Higher share of renewab-le energy** | **Improvement of energy efficiency** | **-** |
| **Approach** | **Taxes** | **Mandatory regulations** | **-** |
| **GHG Reduction** (per household for each of 10 years) | **-1.00 tons of GHG year** (-20%) | **-0.25 tons of GHG/year** (-5%) | **No reduction** (Still 5 tons GHG-emissions/ year) |
| **Costs of the policy** (per household for each of 10 years) | **100€/year** | **50€/Year** | **0€/year** |
| **Which policy would you prefer:**<br>**a) Policy A**<br>**b) Policy B**<br>**c) Status quo** | | | |

**Table 4:** Exemplary Choice Set Source: Authors' draft (translated from the German original).

els (RUM) (Sarrias and Daziano, 2017). McFadden (1974) indicated that individual choices among different alternatives are driven by nonstochastic, observable parameters as well as stochastic, idiosyncratic (unobservable) ones. Individuals would choose the one alternative, which maximizes his or her utility (Hauber et al., 2016). The utility function can be written in the form:

$$U_{ij} = V_{ij} + \varepsilon_{ij},$$

where the individual *i*'s utility (U) from alternative *j* derives from *V*, which depends on observable parameters (attributes of the alternative), and *ε*, an error term that marks specific (unobservable) individual factors.

In our case the utility of the presented mitigation policy (*U*) derives from the goal of the program (*G*), the approach of the policy (*A*), the GHG-emission reduction per household delivered by the program (*GHG*) and the costs of the mitigation policy (*C*). The coefficients $\alpha_{1\ldots4}$ describe the marginal utility of the attributes of the programs:

$$U_{ij} = V_{ij} + \varepsilon_{ij} = \alpha_1 G + \alpha_2 A + \alpha_3 GHG + \alpha_4 C + \varepsilon_{ij}$$

The relative contribution of the attribute levels to the programs utility that interviewees assign to an alternative is represented by each estimated coefficient, which serve as preference weights (Hauber et al., 2016).

The error term *ε* is assumed to follow an independently and identically distributed type 1 extreme- value (i.i.d) distribution in conditional logit models, making the probability (PR) to choose one alternative (*k*) out of a set of alternatives (*j*) look like:

$$PR(k) = e^{V_k} \Big/ \sum\nolimits_{J=1}^{3} e^{V_j}$$

in our example. As a result of the model a coefficient and a corresponding standard error are estimated for all but one omitted level of each attribute (Hauber et al., 2016).

After coefficients for all attribute levels are estimated, one can calculate individual's willingness to pay (WTP) for certain attributes. To do so the coefficient of the attribute to be valued must be divided by the coefficient, which obtains the monetary value. In our case WTP for reducing GHG-emissions is estimated by $\alpha_3/\alpha_4$

This paper focuses on differences between urban and rural regions regarding WTP for reducing GHG Emissions and preferences towards climate mitigation polices. To compare different regions CL-models were estimated for every degree of urbanization[5] individually in sub-samples of the above-sketched models.

# 4 Descriptive and econometric results

## 4.1 Descriptive results

In addition to the DCE, respondents were asked about their attitudes towards climate change, and whether they believe that GHG emissions would have an impact on climate change. 87% of the respondents stated that they felt a change in climate in the last few years. Regarding this question differences between respondents living in municipalities with different degrees of urbanization occurred. While 43% of participants who lived in highly density areas experienced a clear change in climate conditions, only 33% of respondents in intermediate density areas and 31% of rural interviewees felt accordingly. A reason might be the urban heat islands (UHI) effect, resulting in higher temperatures in cities in comparison to the countryside, especially at night.

Furthermore, 41% of respondents stated that GHG-emissions have a very strong impact on global warming, while 47% acknowledged that they have at least a certain impact on climate change. On the other side only 2% of the participants believed that GHG-emissions have no influence on climate change. Respondents who lived in urban areas (46%) rather believed that climate change is driven by anthropogenic GHG-emissions, compared to participants living in intermediate density areas (41%) and rural areas (36%).

The vast majority of respondents (more than 80%) believed that the sectors industry and mobility (traffic) are responsible for emitting most GHG-emissions. Concerning this statement, it seems legit that 89% of respondents stated that it would be the duty of industry and companies to reduce GHG-emissions. At the same time 87% of participants felt personally constrained to make a contribution to climate protection, while only 21% of the respondents actually made a carbon offset (e.g., emissions compensation of flights) in the last 5 years.

Regarding the consequences of climate change in Austria, 80% of respondents were afraid that global warming will lead to an increase in extreme weather. Most participants also believed that climate change has negative effects on economic development (76%), winter tourism (82%) and agriculture (62%). Generally, effects of climate change were perceived negatively among participants.

## 4.2 Econometric results

To fit the CL-model one omitted attribute-level had to be determined for every attribute (Hauber et al., 2016). The status quo was the omitted level for the goal of the policy,

[5] Corresponding to criterias of the European Commission (Eurostat, 2019) .

| | | coef | se(coef) | signif |
|---|---|---|---|---|
| **Goal** (status quo) | Higher share of renewables | 0,2948492 | 0,0754855 | *** |
| | Improvement of energy efficiency | 0,4883171 | 0,0822932 | *** |
| **Approach** (taxes) | Incentives | 0,5710338 | 0,0551756 | *** |
| | Mandatory regulations | 0,5297658 | 0,0544143 | *** |
| | Information | 0,6323510 | 0,1775969 | *** |
| **Reduction** | GHG-emissions reductions | 1,0148659 | 0,0460606 | *** |
| **Cost** | Cost of the policy | -0,0054709 | 0,0007665 | *** |
| Signif. codes: 0 '***' 0,001 '**' 0,01 '*' 0,05 '.' 0,1 ' ' 1 | | | | |
| N= 1.500; n of observations = 27.000; n of events = 9.000 | | | | |
| Concordance= | 0,703 (se=0,005) | | | |
| Likelihood ratio test= | 2672 on 7 df, p=<2e16 | | | |
| Wald test= | 2132 on 7 df, p=<2e16 | | | |
| $R^2$(McFadden)= | 0,1351375 | | | |
| $R^2$adjusted (McFadden)= | 0,1344295 | | | |
| Log Likelihood at start= | -9887,511 | | | |
| Log Likelihood at convergence= | -8551,337 | | | |

**Table 5:** Econometric estimation results – full sample

Source: Authors' calculations.

while taxes were the omitted level for the approach of the policy.

With respect to the full sample without differentiating between urban and rural respondents, the results of the DCE indicate that respondents preferred climate mitigation policies to reduce GHG-emissions in dwellings rather than the status quo. Regarding the policies, strategies which result in a higher share of renewable energy were favored over an improvement of energy efficiency. Both dummy coefficients were positive and strongly significant. Taxes were perceived as the most unpopular approach for reducing GHG-emissions, as coefficients of the remaining dummy levels were positive and highly significant. The dummy of information-based approaches had the highest magnitude.

Furthermore, the coefficient of the GHG-reduction dummy is positive and highly significant, indicating that participants preferred policies which resulted in higher GHG-emission reductions, while a higher level of costs had significantly negative effects on choosing a policy (see Table 5).

The WTP for reducing one ton of GHG-emissions is 185.5 Euro for the whole sample and is higher than WTP in Italy (133€) and the Czech Republic (94€) estimated in Alberini et al. (2018). The Austrian result might be explained because of the positive effect of higher income on WTP, as the average household income in Austria is higher than in Italy and the Czech Republic (OECD, 2019). Respondents with higher income were usually willing to pay more for environmental services than participants with lower income (Duan et al., 2014; Gupta, 2016; Tylliankis & Skuras, 2016; Alberini et al., 2018; etc.). The effect of income and the level of education on WTP was also determined in this study[6]. WTP of households with an income of less than 1.250 Euro per month was nearly 50% lower than in households with a monthly income of more than 3.200€ (see Appendix A).

To determine differences between urban and rural areas regarding preferences towards climate mitigation policies and WTP for reducing GHG-emissions, CL-models were estimated for every degree of urbanization[7] individually. As before, the status quo was the omitted level for the goal of the policy and taxes were the omitted category for the approach of the strategy. Table 6 presents the results of the CL-models.

The results presented in Table 6 strongly suggest that there are significant differences between various degrees of urbanization. Coefficients of the renewables dummy and energy efficiency dummy were positive and significant for highly density areas and intermediate density areas, indicating that climate mitigation policies were preferred over the status quo in these areas. The acceptance of these policies was lower in thinly populated areas, where only the renewables dummy was significantly positive.

[6] A seperate CL-model was estimated for different levels of income(income not reported, less than 1.250€/month, 1.251-2.000€/month, 2.001-3.200€/month, more than 3.200€/month) and education (corresponding to the levels presented in Table 2). All results are shown in Appendix A and B.

[7] Corresponding to criterias of the European Commission (see Eurostat, 2019).

| **Densely populated areas (Typ 1)** n=8766; n of events= 2922 | | | | |
|---|---|---|---|---|
| | | coef | se(coef) | signif |
| **Goal** (status quo) | Higher share of renewables | 0,4082636 | 0,1357496 | ** |
| | Improvement of energy efficiency | 0,5732174 | 0,1484892 | *** |
| **Approach** (taxes) | Incentives | 0,5511502 | 0,0999284 | *** |
| | Mandatory regulations | 0,3863326 | 0,0972944 | *** |
| | Information | 0,3729832 | 0,3176293 | |
| **Reduction** | GHG-emissions reductions | 1,1306308 | 0,0829640 | *** |
| **Cost** | Cost of the policy | -0,0055308 | 0,0013760 | *** |
| Concordance= | 0,732 (se=0,009) | | | |
| Likelihood ratio test= | 1060 on 7 df, p=<2e16 | | | |
| Wald test= | 822,6 on 7 df, p=<2e16 | | | |
| $R^2$(McFadden)= | 0,165175 | | | |
| $R^2$adjusted (McFadden)= | 0,1629944 | | | |
| Log Likelihood at start= | -3210,145 | | | |
| Log Likelihood at convergence= | -2679,909 | | | |
| **Intermediate density areas (Typ 2)** n=8838; n of events=2946 | | | | |
| | | coef | se(coef) | |
| **Goal** (status quo) | Higher share of renewables | 0,33520364 | 0,12920183 | ** |
| | Improvement of energy efficiency | 0,55241939 | 0,14018691 | *** |
| **Approach** (taxes) | Incentives | 0,41212804 | 0,09385782 | *** |
| | Mandatory regulations | 0,50007579 | 0,09353278 | *** |
| | Information | 0,49446361 | 0,30730729 | *** |
| **Reduction** | GHG-emissions reductions | 0,93114304 | 0,0789071 | *** |
| **Cost** | Cost of the policy | -0,00486964 | 0,00132232 | *** |
| Concordance= | 0,698 (se=0,009) | | | |
| Likelihood ratio test= | 805,3 on 7 df, p=<2e16 | | | |
| Wald test= | 650,4 on 7 df, p=<2e16 | | | |
| $R^2$(McFadden)= | 0,1244114 | | | |
| $R^2$adjusted (McFadden)= | 0,1222486 | | | |
| Log Likelihood at start= | -3236,512 | | | |
| Log Likelihood at convergence= | -2833,853 | | | |
| **Thinly populated areas (Typ 3)** n=9396; n of events=3132 | | | | |
| | | coef | se(coef) | |
| **Goal** (status quo) | Higher share of renewables | 0,14955660 | 0,12820578 | |
| | Improvement of energy efficiency | 0,34550975 | 0,14011033 | * |
| **Approach** (taxes) | Incentives | 0,74691528 | 0,09400553 | *** |
| | Mandatory regulations | 0,69797705 | 0,09270648 | *** |
| | Information | 1,01921279 | 0,30020131 | *** |
| **Reduction** | GHG-emissions reductions | 0,99937276 | 0,07830869 | *** |
| **Cost** | Cost of the policy | -0,00608207 | 0,00129284 | *** |
| Concordance= | 0,689 (se=0,005) | | | |
| Likelihood ratio test= | 854,7 on 7 df, p=<2e16 | | | |
| Wald test= | 690,3 on 7 df, p=<2e16 | | | |
| $R^2$(McFadden)= | 0,1241945 | | | |
| $R^2$adjusted (McFadden)= | 0,1221601 | | | |
| Log Likelihood at start= | -3440,854 | | | |
| Log Likelihood at convergence= | -3013,519 | | | |
| Signif. codes: 0 '***' 0,001 '**' 0,01 '*' 0,05 '.' 0,1 ' ' 1 | | | | |
| N= 1.500; n of observations = 27.000; n of events = 9.000 | | | | |

**Table 6:** Econometric estimation results – sub-samples of different degrees of urbanization
Source: Authors' calculations.

| *Area* | *MWTP* | *95% confidence interval of WTP* | |
|---|---|---|---|
| | | *Lower bound* | *Upper bound* |
| *High density areas* | *204,43€/t* | *144,33€/t* | *341,64€/t* |
| *Intermediate density areas* | *191,12€/t* | *132,41€/t* | *339,15€/t* |
| *Thinly populated areas* | *164,31€/t* | *121,31€/t* | *250,57€/t* |

**Table 7:** Willingness-to-pay for reducing GHG emissions between urban and rural populations

Source: Authors' calculations.

Regarding the approach of the policies, taxes were viewed as the most unpopular strategy to reduce GHG-emissions in all types of area. Differences emerged in respect of the most popular approach in between the different degrees of urbanization. While the information dummy was strongly significant and positive in thinly populated areas, the same dummy was not significant in the others. In rural regions information was perceived as the most popular approach to reduce GHG-emissions in dwellings, whereas the mandatory regulations dummy has it highest magnitude in intermediate density areas, while in cities, incentives were regarded as the most popular instrument to reduce GHG-emissions.

Coefficients of the reduction dummy were positive and strongly significant in all areas, implying that the higher GHG-emission reduction the more attractive the policy. The cost dummy was negative and strongly significant across all samples, indicating that the higher the costs the lower the probability for choosing an alternative. The different magnitude of booth dummies suggests that WTP varies between the different degrees of urbanization (Table 7).

WTP for reducing one ton of GHG-emissions was about 164€ in thinly populated areas and increased with a higher degree of urbanization from 191€ in intermediate density areas to more than 204€ in densely populated areas. A reason to explain differences in between various degrees of urbanization is that values are often assumed to decline by a higher distance to the valued object (Wamberg-Broch et al., 2013). This is consistent to findings of Campbell et al. (2009), who determined an increase of WTP for landscape improvements with lower population density in Ireland and results of this paper as effects of climate change are perceived stronger by participants living in cities than in rural areas (see 4.2). Furthermore, education level of respondents living in highly density areas is higher than in less densely areas (see Table 2). WTP for environmental services also depends on participants' level of education (Adaman, 2010; Bliem and Getzner, 2012). This effect was also estimated in this study (see appendix). As level of education was higher in densely areas than in thinly populated areas it seems plausible that the determined WTP is lower in rural areas than in cities.

# 5 Discussion, summary and policy conclusions

We estimated respondents' willingness-to-pay (WTP) for reducing GHG emissions in the context of energy use in private households in Austria applying a DCE. The DCE was part of a nationwide representative survey with a randomized quota sample. The sample was representative in terms of gender, age and regional dispersion at levels of federal states as well as different degrees of urbanization according to criteria of the European Commission. Results show that a substantial WTP for reducing GHG in the housing sector exists.

Average WTP for respondents is about 186€ per household and ton of reduced GHG-emissions in context of energy use in dwellings. This value is much higher than existing energy or carbon taxation, especially with respect to Austrian energy taxation (OECD, 2018). In comparison to other studies our WTP is higher than estimated WTP in Italy and the Czech Republic (Alberini et al., 2018) and is also nearer to the average of studies estimating the social costs of carbon (SCC; see Wang, 2019). The comparatively higher WTP in our study might be owing to higher household income in Austria in comparison to other countries. Like in other studies (Adaman, 2010; Alberini et al., 2018; Carlsson, 2012; Duan et al., 2014) our estimations show that a higher income and a higher level of education both have a positive effect on respondent's WTP. Households with low income and a low level of education, however, were slightly underrepresented in our sample, indicating that actual WTP could be higher.

Regarding the research question whether WTP is driven by specific spatial factors such as different degrees of urbanization, our results indicate that substantial differences between urban and rural areas may exist. WTP in high density areas (e.g., larger cities, regional centers) was more than 204€ per ton of avoided GHG-emissions in context of energy use in dwellings. WTP decreased with a lower degree of urbanization from 191€ per ton in intermediate density areas to 164€ per ton in thinly populated areas. A possible explanation is the higher level of education of respondents living in urban areas compared to rural areas. Furthermore, effects of climate change (urban heat islands [UHI], heat stress) are perceived much stronger among respondents living in highly density areas. This is consistent to findings that WTP is often assumed to decline with a higher distance to the valued object (Wamberg-Broch et al., 2013), and that WTP should also correlate with respondent's information and experience. Although respondents' income was higher in rural than in urban areas, WTP increased with a higher degree of urbanization, indicating that WTP in these areas is driven rather by the level of education and perception of climate change than by income.

In addition, different policy instruments to reduce GHG emissions in dwellings were preferred between urban and rural regions. While taxes were generally perceived as the most unpopular instrument to reduce GHG emissions, the most preferred approach varied between different degrees of urbanization. Providing more information to reduce emissions was the most popular approach to reduce GHGs in rural areas, whereas mandatory regulations were favored in intermediate density areas, and economics incentives (subsidies) were preferred in cities. We therefore find substantial preferences heterogeneity not only with respect to the socio-economics, but also in regard to the place of residence of respondents.

Although taxes were perceived as the most unpopular instrument to reduce private households' GHGs among participants in Austria, environmental taxation (carbon taxes) is, of course, absolutely necessary to reduce GHG emissions on a national level. The results of this study strongly suggest that it is important to respect that discrepancies between urban and rural areas exist. Besides showing a different WTP, the avoidance costs of mitigating carbon emissions differ between rural and urban regions. Costs for retrofitting single homes are higher than for retrofitting multi-dwellings (per m²), and a larger dependence on private transport (cars) in thinly populated areas results in a substantially higher fuel consumption, and lower share of public transport use. Furthermore, socio-economics such as income and education are different between urban and rural areas. It should be noted that the sample was representative for Austrian households. The random sample was not specially adapted and drawn for the different degrees of urbanization, what could bias results. Results were only estimated by using CL-models and not verified with other models, like mixed logit models or weighted log likelihoods. Furthermore, results concerning differences in WTP between varying degrees of urbanization were not checked for confounding variables.

As a general conclusion of this paper, spatially responsive policy instruments, at least over the first couple of years should be introduced. Such policies need to tackle the characteristics of rural areas, and, for instance, support the expansion of public transport, or result in a subsidy scheme for retrofitting buildings. However, the problem of conserving carbon-intensive infrastructures and settlement structures as well as commuting has to be solved at another policy level (national and European). In addition, information campaigns are necessary to raise awareness on environmental topics like climate change but not sufficiently strong to change behaviors to an extent needed for achieving emission reduction goals. The results of this study also indicate that renewable energy is much more accepted among respondents than increasing energy efficiency. But without a significant increase in energy efficiency (or energy sufficiency), climate goals will not be met.

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# 6 Appendix

## 6.1 Appendix A

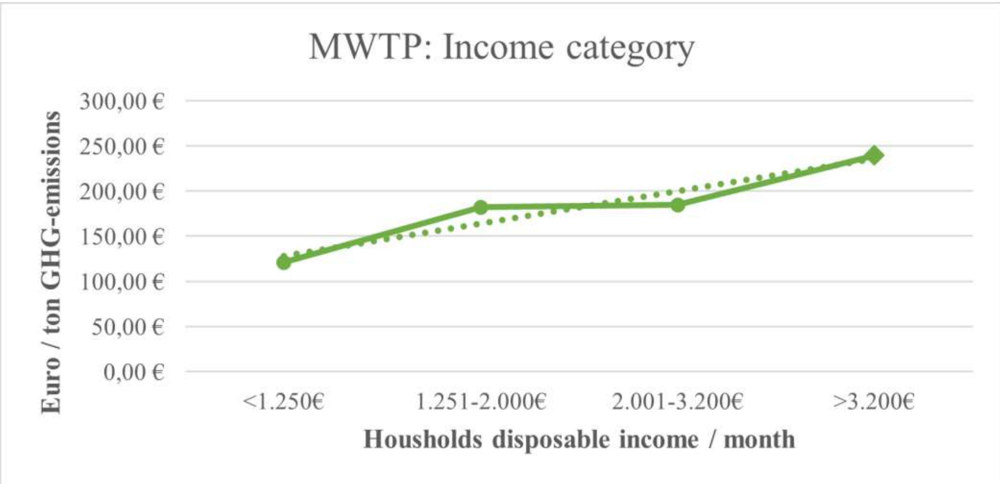
**Table A1:** MWTP regarding different income categories

Source: Authors' calculations.

| *Income Category* | *MWTP* | *95% confidence interval of WTP* | |
|---|---|---|---|
| | | *Lower bound* | *Upper bound* |
| *<1.250€* | *120,84€* | *58,05€* | *451,37€* |
| *1.251-2.000€* | *181,98€* | *107,43€* | *498,13€* |
| *2.001-3.200€* | *184,62€* | *118,36€* | *406,91€* |
| *>3.200€* | *239,51€* | *152,50€* | *523,79€* |
| *Income not reported* | *158,35€* | *98,22€* | *358,69€* |

**Figure A1:** Chart of WTP per houshold disposable income (per month)

Source: Authors' calculations.



## 6.2 Appendix B

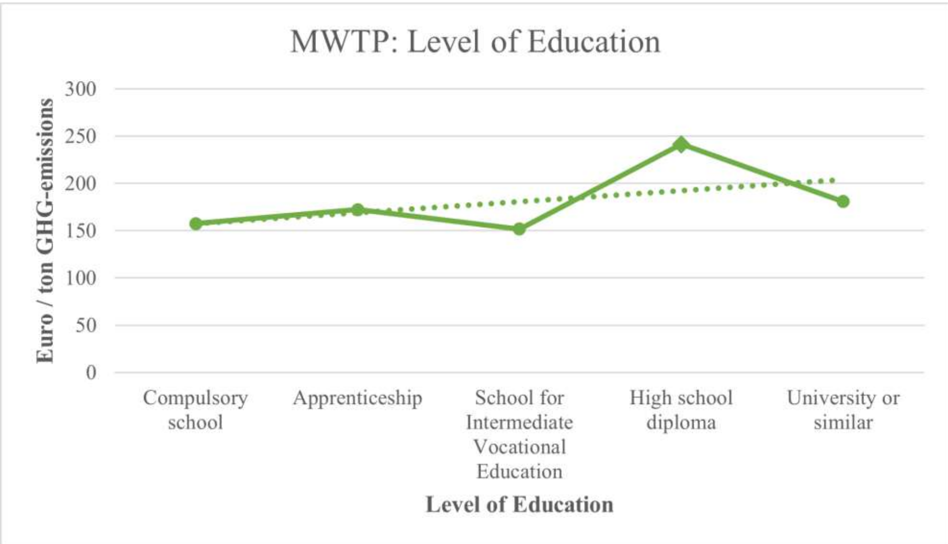
**Table B1:** MWTP regarding different levels of education

Source: Authors' calculations.

| *Levels of education* | *MWTP* | *95% confidence interval of WTP* | |
|---|---|---|---|
| | | *Lower bound* | *Upper bound* |
| *Compulsory school* | *157,48€* | *81,30€* | *591,78€* |
| *Apprenticeship* | *172,14€* | *112,74€* | *341,82€* |
| *School for Intermediate Vocational Education* | *151,79€* | *95,18€* | *335,84€* |
| *High school diploma* | *241,40€* | *144,14€* | *661,45€* |
| *University or similar* | *180,74€* | *115,30€* | *396,17€* |

**Figure B1:** Chart of WTP regarding respondents level of education

Source: Authors' calculations.

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