Evaluation of Households' Preferences for the Planned Hydropower Station in Graz-Puntigam using a Choice Experiment

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Kurzfassung: In this paper we use a choice experiment to estimate public preferences for the construction of a new hydropower plant in the city of Graz (Austria). The econometric results point out that people have in general a positive attitude towards the construction of the new hydropower plant. The provision of green electricity, as well as the creation of new possibilities for recreation, are valued positively by the public, and therefore they exhibit a positive "Willingness To Pay" (WTP). However, the realisation of the new hydropower plant must come along with a small environmental impact in order to gain a significant welfare increasing impact. In addition to the choice experiment, we explain the differences in respondents' WTP for hydropower expansion in Austria using a Tobit model. The results show that WTP is determined by four socio-economic characteristics, namely sex, age, residential area as well as respondent's attitude towards hydroelectric power.

Keywords: Hydropower, choice experiment, willingness to pay, Tobit model

1 Introduction

Hydropower plays a substantial role in the Austrian energy sector. Currently 58.5 percent of total electricity produced in Austria comes from hydroelectric power stations; this corresponds to an amount of 41,572 annual gigawatt hours (GWh; ENERGIE-CONTROL AUSTRIA, 2011a). Moreover, gross electric hydropower generation has nearly doubled since 1970 (ENERGIE-CONTROL AUSTRIA, 2011b). The total number of hydropower plants in Austria is 2,598, with an entire installed capacity of 12,920 megawatts (MW). Of these, 672 are river and 111 are storage power plants. In addition, there exists a large number of small-scale hydropower plants (1,815) with a capacity lower than 1 MW[1] (ENERGIE-CONTROL AUSTRIA, 2011c).

Although about 60 percent of the total electricity produced already comes from hydropower installations, there is still substantial potential for new hydropower facilities, especially for small-scale hydropower. According to the hydropower potential study of PÖYRY ENERGY GMBH (2008), the reduced techno-economic potential, which is effectively exploitable, is estimated at 13,000 GWh.[2]

[1] These small-scale hydropower plants cannot be distinguished between river and storage power plants.

[2] This value does not include reductions due to the possible restrictions imposed by the European Water Framework Directive (WFD).

The Austrian master plan for the expansion of hydropower utilisation was presented in 2008 and envisages an increase of hydropower utilisation by 7,000 GWh (VEÖ, 2008). In the Austrian energy strategy, hydropower plays a substantial role too. It stipulates a realizable hydropower expansion of 3,500 GWh[3] and considers the intensified use of renewable energy sources as the core element of a sustainable and future-oriented energy policy (LEBENSMINISTERIUM, 2010). In total, 100 new hydropower plants are currently in the stage of planning, whereas 70 of these projects are small-scaled with a capacity of less than 15 MW. In the province of Styria, 22 new hydropower stations are planned to be built, among them the project "Graz-Puntigam" along the river Mur (UMWELTDACHVERBAND, 2010a and 2010b).

The construction of the hydropower station Graz-Puntigam, with a total capacity of 16 MW, is planned within the city limits of Graz. The overall investment volume is € 87 Mio. The construction works are scheduled to start in autumn 2013 and will be finished by the end of 2015. The power station will be able to generate an electricity amount of 74 GWh per year. Hence, about 20,000 households can be provided with "green" electricity (PISTECKY, 2010; DOBROWOLSKI AND SCHLEICH, 2009; ENERGIE STEIERMARK, 2010).

Generally, the use of hydropower implies a considerable conflict potential. On the one hand, there are the targets of protecting the climate with a non-Carbon Dioxide emitting energy policy (e.g. reduction of greenhouse gas emissions, intensified use of renewable energy sources) and on the other hand, there are the objectives of nature and water protection, as for instance, the Water Framework Directive (WFD). Positive effects from the use of hydropower especially involve the emission-free generation of electricity and the associated CO_2 avoidance. In addition, hydropower projects can have positive impacts on the local economy (especially employment effects). Furthermore, new hydropower stations can contribute to domestic energy security. Important environmental concerns related to the operation of hydropower plants are the visual impact of a power plant on the surrounding (natural) environment, erosion, sedimentation and oxygen-deficiency problems due to the alteration of the water flow in the river, and correspondingly, the impacts of these changes on fish and other water-dependent wildlife. Hence, all these social, economic and environmental impacts have to be taken into consideration, if socially-optimal investments are to be made.

The aim of this paper is to examine the public's perception and preferences for the hydropower project "Graz-Puntigam" in Styria. Therefore we estimate the public's willingness to pay (WTP) for increasing the amount of green electricity, preserving the natural environment around the power plant, as well as for increasing the opportunities for some added recreational activities. We will also use the model results to calculate the total consumer surplus for different policy scenarios. Finally, we analyse the determinants of respondents' WTP for the extension of hydropower use in Austria.

2 Theoretical background and previous research

The costs and benefits associated with new hydropower plants are estimated conducting a choice experiment study. Choice experiments belong to the family of stated preference techniques. Within the scope of such an experiment, respondents are asked to choose between a selection of different alternatives in a hypothetical setting. The alternatives are described

[3] This target value considers ecological requirements, as well as economic aspects.

by a number of attributes which vary between different alternatives. Usually the respondents are asked to make a sequence of choices. Based on that information, it is possible to estimate the probability of an alternative being chosen in terms of the value attached to the attributes used to describe the alternatives. Such models provide information on the willingness of respondents to make trade-offs between the individual attributes, and in further consequence it is possible to obtain willingness to pay measures for the different attributes used in the choice experiment (for reviews see ALPIZAR ET AL., 2001; BENNETT AND BLAMEY, 2001; LOUVIERE ET AL., 2000).

There exist only a very limited number of studies using choice experiments to value the costs and benefits of hydropower use. An investigation from SUNDQVIST (2002a) provides an attempt to place a value on the environmental impacts arising from hydroelectric production by non-residential electricity consumers (small and medium sized firms) using the choice experiment approach. The main objective of the study was to analyse Swedish non-residential attitudes towards green electricity from hydropower. On the one hand, the water-related attributes such as *downstream water level, erosion and vegetation,* as well as *impacts on fish life,* were included in the choice experiment. In order to obtain willingness to pay measures for these attributes, the price attribute was defined as an *increase in electricity price per kilowatt hour (KWh).* The results show that respondents are willing to incur extra costs for environmental improvements, like the reduction of erosion and vegetation, or the preservation of fish species. The analysis also indicates that environmental improvements must be provided at a low cost, since firms are sensitive to price increases. The same choice experiment was applied to a random sample of households (SUNDQVIST, 2002b). This investigation principally yields the same results as in the case of non-residential electricity consumers. KATARIA (2009) examined the willingness to pay of Swedish households for environmental improvements in hydropower regulated rivers. The choice experiment contains the attributes: *fish stock, living conditions for birds, species richness, vegetation and erosion,* as well as an unspecified *additional annual cost.* The results show that people are principally willing to pay for ecological improvements, for instance, for an increased fish stock or an improvement of living conditions for birds. Furthermore, there exist a limited number of valuation studies focusing on other renewable energy sources, mainly wind power (see e.g. ALVAREZ-FARIZO AND HANLEY, 2002; EK, 2005; MEYERHOFF ET AL., 2008). Other choice experiment studies focus on the valuation of costs and benefits of renewable energy investments in general, and not especially on hydropower investments (see e.g. BERGMANN ET AL., 2004; BERGMANN ET AL., 2008; LONGO ET AL., 2006).

3 Study design

3.1 The choice experiment

In order to examine public preferences for the described hydropower facility in Styria, a questionnaire was developed over a 2-3 month time period based on a series of pre-tests, as well as two discussion rounds with external experts on an advisory board.[4] Special attention was paid to the choice experiment and how understandable the experiment and its design were to

[4] The group of experts ("Advisory Board") consisted of people from the electricity industry and different federal and provincial government departments.

lay people. The final questionnaire consisted of 43 questions divided into three main parts. The first section contained questions about the respondent's general perception and attitudes towards renewable energy, electricity and hydropower use. In the second part, respondents were asked to state their choices using six different choice sets. The choice experiment was followed up by a number of debriefing questions related to the perceived complexity of the experiment, as well as the possible presence of protest responses. The final part of the questionnaire focused on respondents' demographic and socio-economic status. The attributes used in the choice experiment are presented in Table 1.

Table 1: Attributes and attribute levels used in the choice experiment

Attributes	*Description*	*Levels*
Market size	Number of households that can be provided with green electricity from the new hydropower plant	5000, 10000, 15000 households
Nature and landscape	Impact of the new hydropower plant on the natural environment and the landscape	small impact, strong impact
Recreational activities	Creation of new possibilities for recreation	yes, no
Cost	Increase in monthly electricity bill	€ 3, 6, 9, 12, 15, 18

The main advantage of the installation of a new hydropower plant is the emission-free generation of electricity. The planned hydropower project in Graz can provide electricity for approximately 20,000 households (DOBROWOLSKI AND SCHLEICH, 2009; VERBUND AUSTRIAN HYDRO POWER, 2009). In view of a conservative estimate, the levels for the *household attribute* were fixed between 5,000 and 15,000 households. However, both the construction, as well as the operation of a new hydropower plant, always come along with negative impacts on the water body and its surrounding environment. Consequently there is a trade-off between emission-free electricity generation from hydropower and nature conservation. Negative effects related to a new hydropower plant are visual impacts on the landscape, as well as negative consequences for the ecosystem state of the water body. These impacts range from the disruption of the consistency of the water stream, the alteration of flow conditions and the associated sedimentation, the increase of the water temperature and the related oxygen-deficiency, and the reduction of the water level downstream of the hydropower plant. Altogether these changes seriously affect fish and other water-dependent wildlife (KNÖDLER ET AL., 2007; MEYERHOFF AND PETSCHOW, 1997; BUNGE ET AL., 2001; WURZEL AND PETERMANN, 2006). In order to minimize these ecological impacts, hydropower plants can be planned in an environmentally friendly way. Thereby, measures like the restoration of riverbanks into a near-natural state, as well as the preservation of the water body continuity using such methods as the installation of fish ladders, play an important role (KNÖDLER ET AL., 2007).[5] We decided to use two levels for the *nature and landscape attribute*, namely a

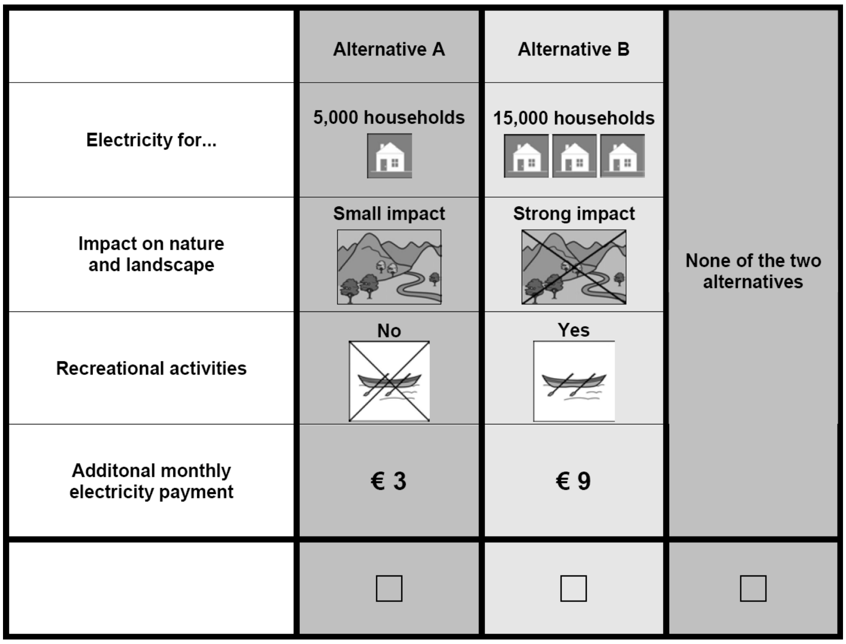
[5] The Water Framework Directive represents a legal framework to ensure that new hydropower plants do not lead to a deterioration of the water body status. Measures like the installation of fish ladders are obligatory when new hydropower stations are built.

small and strong impact. With a strong impact, only the minimum requirements predetermined by the Water Framework Directive are fulfilled.[6] A small impact implies that higher environmental standards to minimize the impact of the hydropower plant on the landscape and the natural environment are fulfilled. The third attribute included in the choice experiment is concerned with possible future recreational activities like biking, boat trips or canoeing that can be created when new hydropower plants are built. Finally, the monetary attribute was specified as an increase in respondents' monthly electricity bill. The payment levels ranged between € 3 and € 18.

In the questionnaire, all choice attributes and their levels were explained in easy terms to the respondents. In order to improve the comprehensibility of the questionnaire, various pictograms were used to introduce the choice experiment attributes.

Choice sets were created using a D-efficient design in the software package Sawtooth. Each choice set consisted of three alternatives, including an opt-out alternative referred to as "none of the two alternatives". This opt-out alternative was included in all choice sets. The design was finally blocked into 30 versions, each containing six choice tasks. An example of a choice card is presented in Figure 1.

Figure 1: Choice card example



Respondents who chose six times the opt-out alternative were asked to explain why. They were confronted with a series of statements based on the pre-test results (e.g. "I am strictly against the construction of the hydropower station", "The current situation is already satisfactory", or "I cannot afford additional monthly payments") in order to identify and categorise protest bidders. Altogether we were able to identify 12 protest votes (5.7 percent) in the sample. These protest votes were excluded from the analysis.

[6] For new hydropower plants, the Water Framework Directive stipulates a mandatory installation of fish ladders, as well as a minimum amount of residual water (STIGLER ET AL., 2005).

3.2 Sample characteristics

In June 2011, the survey was implemented by a professional survey company using a web-based survey. The sample consists of people living in the city of Graz and the surrounding communities. For a pre-test, 103 people completed the web-based questionnaire in May 2011. In the final survey, 959 people were invited to participate. The response rate was 22.0 percent meaning that 211 respondents completed the survey.[7]

Table 2 displays the socio-demographic characteristics of the sample group, as well as the distribution in the total population from which the sample was drawn. The gender of respondents is very close to the Styrian average with 50.6 % men and 49.4 % women. The age structure corresponds in principle to that of the total population in Styria. However, the age category older than 59 years is proportionally low compared to the total population. The same applies to the age group 18-19 years old, which is also slightly underrepresented in the sample. In contrast, respondents aged between 20 and 29 years are stronger represented in the sample compared to the total population. The mean age is 40.9 years.

Table 2: Socio-demographic characteristics of respondents

	Graz (n=199)	*in %*	*Total population[a]*
GENDER			
Male	103	51.8 %	50.6 %
Female	96	48.2 %	49.4 %
AGE			
18-19 years	4	2.0 %	3.2 %
20-29 years	52	26.1 %	17.5 %
30-39 years	38	19.1 %	18.3 %
40-49 years	46	23.2 %	22.5 %
50-59 years	36	18.1 %	17.8 %
60-69 years	19	9.5 %	15.1 %
>69 years	4	2.0 %	5.6 %
REGION			
Graz	151	75.9 %	78.1 %
Surrounding communities	48	24.1 %	21.9 %

Source: [a]Statistik Austria (2010), (2011a)

In total, Graz (including the surrounding communities[8]) has about 330,000 inhabitants. 21.9 % of them are living in one of the surrounding communities and 78.1 % have their residence within the city limits. This distribution is also reflected in the sample. The respondents from the area around Graz are thereby equally allocated among all surrounding communities.

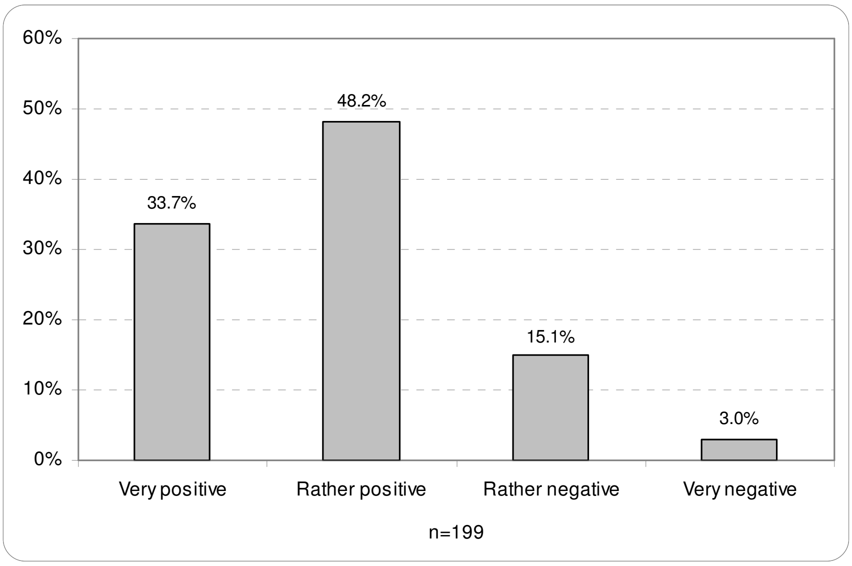
[7] Due to the exclusion of protest votes, the sample size for further analyses is reduced to 199.
[8] Graz has in total 19 surrounding communities.

3.3 Perceptions of the hydropower project

The perceptions of the respondents for renewable energy and hydropower use in Austria, and especially Styria, were elicited through a series of questions. A majority of respondents (165 or 82.9 percent) answered that the use of renewable energy sources is very important to meet future energy-related targets. Moreover, 16.1 percent stated that it is rather important to further increase electricity generation from renewable sources like hydropower, wind power or solar power in the future.

In principle, most respondents have a very positive (43.2 percent) or rather positive (52.3 percent) attitude toward hydropower utilisation in Austria. When respondents were asked if they heard about the plan to construct new hydropower plants along the river Mur, 86.9 percent answered this question with “yes”. Furthermore, about half of the respondents (48.2 percent) have a positive attitude toward the construction of new hydropower plants along the Mur. The proportion of people with a very positive attitude is 33.7 percent. Only a minority (18.1 percent) is, in principle, against the construction of new hydropower plants along the Mur (see Figure 2).

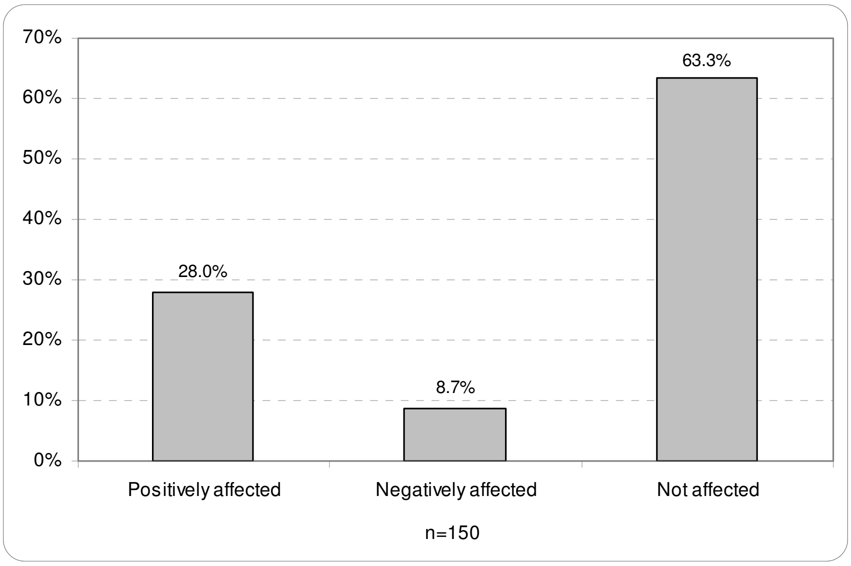
Figure 2: Public attitudes towards the expansion of hydropower use along the Mur



Generally, the survey results show that the hydropower project Graz-Puntigam is well known. About three quarters (75.4 percent) of the respondents in the sample know that there are plans to build a new hydropower station.

People who heard about the new hydropower project were asked to state the approximate distance between the location of the hydropower plant and their home. In the sample, this distance is on average 10.8 km (median: 9.0 km). Furthermore, a relatively high number of respondents (95 or 63.3 percent) reported not to be affected by the new hydropower project. At the same time, 8.7 percent of the sample population indicated to feel negatively affected, while 28.0 percent feel positively affected (see Figure 3).

Figure 3: Individual concernment by the new hydropower project



4 The econometric model

Choice experiments belong to the family of stated preference techniques and are based on traditional microeconomic theory. They combine Lancaster's characteristics theory of value, as well as random utility theory (RUT). First, Lancaster's theory states that consumers derive utility from the properties or characteristics of a good (LANCASTER, 1966). Thus, the value of a new hydropower station can be expressed by its characteristics, such as the number of households that can be provided with electricity, or the impact on the landscape and the natural environment. Moreover, choice theory is based on the assumption that individuals are acting rationally, meaning that they compare alternatives and choose the one which gives the highest level of utility (HENSHER ET AL., 2005).

"RUT postulates that utility is a latent construct that exists (if at all) in the mind of the consumer, but cannot be observed directly by the researcher" (BENNETT AND BLAMEY, 2001, p. 15). Instead, it is possible to explain a significant proportion of the unobservable consumer utility, but some part of the utility will always remain unobserved. That is:

$$U_{in} = V_{in} + \varepsilon_{in} \qquad (1)$$

V_{in} represents the systematic or observable component of the utility held by consumer *n* for choice alternative *i.* The factor ε_{in} refers to the random or unobservable component of utility (BENNETT AND BLAMEY, 2001). For the unobserved component of utility, we have to make assumptions about the distribution. Usually the random part is assumed to be independently and identically distributed (IID), with an extreme value type 1 (EV1) distribution (LOUVIERE ET AL., 2000).[9]

In the classical multinomial or conditional logit (MNL) model, the observed component of utility V_{in} from equation (1) is assumed to be linear additive in the attributes and parameters.

[9] This distribution is also referred to as Gumbel distribution. The assumption that the unobserved part of the utility function is independently and identically distributed further results in the independence from irrelevant alternatives (IIA) property. IIA states that the relative probabilities of two options being selected are unaffected by the introduction or removal of additional alternatives.

Thus, each parameter is a single fixed parameter (HENSHER ET AL., 2005). Consequently, the MNL model cannot capture preference heterogeneity not embodied in the individual characteristics of respondents (GREENE AND HENSHER, 2005; HENSHER AND GREENE, 2002). Therefore, we draw on more complex choice models, namely mixed logit. In the mixed logit model, parameters are not fixed, but random, meaning that they are allowed to vary across individual respondents. Furthermore, the model can be extended to allow for variance heterogeneity in the random parameters, by the use of error components (BEVILLE AND KERR, 2009; HENSHER AND GREENE, 2002).

5 Results

5.1 The choice model

The final best fit econometric model of this study has the following indirect utility form:

$$
\begin{aligned}
U_{in} = \alpha + \beta_1 Households_{in} + \beta_2 Nature_{in} + \beta_3 Leisure_{in} + \beta_4 Cost_{in} + \\
\beta_5 Payment * Cost + \beta_6 Donator * Nature + \beta_7 Age + \varepsilon_{in}
\end{aligned}
\qquad (2)
$$

In equation (2), α represents the alternative specific constant (ASC) and β_1 to β_4 refer to the coefficients related to the attributes of the choice model, namely the number of households that can be provided with electricity from the new power station (Households), the impact on landscape and natural environment (Nature), the impact on recreational activities (Leisure) as well as the additional electricity payment per month (Cost). The attributes Households and Cost represent linear effects, while Nature and Leisure are dummy coded. The baseline category of Nature is small impact. In the case of Leisure, the base consists of no recreational activities. Furthermore, two interaction terms were included in the choice model. The dummy variable payment indicates whether the electricity bill in the respondent's household is paid by another person[10], and was then subsequently interacted with the cost attribute. The variable Donator is also dummy coded and shows whether the respondent (or someone else in his or her household) is a donator to environmental organisations.[11] Together with the nature attribute, this variable represents the second interaction term. Finally, Age was included in the econometric model as the only socio-demographic characteristic. No further socio-economic characteristics were found to be statistically significant. This includes household income, which is usually a strong predictor of stated willingness to pay.

First, in a set of models not presented here, a variety of variables including socio-demographic characteristics like sex, income or education level, as well as interaction terms between these characteristics and choice attributes, were included in the model specification. However, these variables did not show up to be statistically significant in the estimated models. The statistically best fit models are presented in Table 3.[12] The results of the standard multinomial logit model, as well as the estimates of the mixed logit model with error components, are reported below. Looking at the multinomial logit estimates, all coefficients are in-

[10] More precisely, the variable Payment takes the value 1 if another person in the respondent's household pays the electricity bill and 0 if the respondent pays.
[11] The variable Donator equals 1 if the respondent or someone else in his household is a donator to environmental organisations and 0 if this is not the case.
[12] NLOGIT 4.0 econometric software was used to estimate the models.

deed significant, at least at the 5 % confidence level, and have the expected signs, but ignore so-called taste differences, which are captured by the mixed logit model. As can be seen from Table 3, the derived standard deviations of random parameter distributions are all statistically significant at the 1 % level. The presence of significant parameter standard deviations indicates the presence of preference heterogeneity in the sampled population (HENSHER AND GREENE, 2002). Hence the mixed logit error components model is more appropriate than a standard multinomial logit model.

Table 3: Model estimates

Variable	*Multinomial Logit*	*Mixed Logit Error Comps.*
ASC	1.972*** (0.000)	3.537*** (0.000)
Households	0.035*** (0.002)	0.055*** (0.001)
Nature impact strong	-1.339*** (0.000)	-2.405*** (0.000)
Recreational activities yes	0.646*** (0.000)	1.040*** (0.000)
Cost	-0.150*** (0.000)	-0.253*** (0.000)
Donator*Nature	-0.529*** (0.007)	-1.445*** (0.004)
Payment*Cost	0.027** (0.045)	0.059** (0.029)
Age	-0.017*** (0.000)	-0.026* (0.070)
Std. dev. Households		0.087*** (0.001)
Std. dev. Nature		3.772*** (0.000)
Std. dev. Leisure		1.767*** (0.000)
Std. dev. random effects (error component)		2.309*** (0.000)
Log likelihood	-1,038.690	-868.042
McFadden Pseudo R^2		0.338
AIC	1.753	1.474
BIC	1.787	1.525
Number of respondents	199	199
Number of observations	1,194	1,194

p-values in parentheses

Significance: *** 1 % level ** 5 % level *10 % level

Looking at the mixed logit model estimates, it can be seen that the coefficients of the four choice attributes, the interaction terms and age have the expected signs and are all statistically significant. The alternative specific constant (ASC) can be interpreted similarly to the constant in a regression model and represents on average the effect of all factors that are not included in the model (HENSHER ET AL., 2005; TRAIN, 2003). Thus the positive ASC indicates that the respondents have some inherent propensity to choose for one of the power plant alternatives over the opt-out (none of the two alternatives) for reasons that are not captured in the estimated model. The attributes *households* and *recreation* have positive signs which imply that respondents have preferences for alternatives where more households can be supplied with electricity by the new hydropower stations and where recreational activities are possible. In contrast, alternatives with a strong impact on landscape and natural environment are less preferred compared to those with only a small or no impact. This relationship is captured by the negative sign of the coefficient on the attribute *nature*. Furthermore, the effect of the strong nature impact is enhanced if the respondent (or someone else in his or her household) is a donator to environmental organisations. The negative sign of the cost attribute indicates that respondents prefer lower electricity bills. However, if the electricity bill is not paid by the respondent himself, but instead by another household member, the negative effect of cost diminishes, suggesting lower price sensitivity. Finally, older people are less willing to choose one of the hydropower plant options. Instead they rather tend to choose the opt-out alternative.

5.2 Willingness to pay

In the next step, we calculated implicit prices (willingness to pay), as well as the corresponding standard deviations and confidence intervals (see Table 4).[13] These values are based on a ceteris paribus assumption, that is, all other parameters are held constant, except for the attribute for which the implicit price is being calculated. As can be seen from Table 4, respondents are willing to pay around € 0.25 on top of their monthly electricity bill for the supply of 1,000 additional households with electricity from the hydropower plant.

Table 4: Estimates of implicit prices (willingness to pay)

Variable	Measurement	Graz-Puntigam
Households	per 1,000 households	€ 0.246 (0.234, 0.258)
Nature impact	from small to strong	€ -9.811 (-10.352, -9.260)
Leisure activities	from no recreation to recreation	€ 4.200 (4.065, 4.335)
95 % confidence intervals in parentheses		

[13] In order to account for the given preference heterogeneity, implicit prices and the corresponding standard deviations have been estimated by calculating the implicit price for each respondent and taking the mean and standard deviation of these simulations. This approach is in line with HENSHER ET AL., 2005, p. 686 ff.

The implicit price for the nature attribute is negative, reflecting the fact that people do not desire alternatives with a strong environmental impact. Negative values of WTP imply a reduction in utility. So, overall WTP decreases by € 9.8 with a strong environmental impact. Finally, respondents' WTP for the creation of recreational activities amounts to € 4.2 per month.

5.3 Welfare analysis

Although implicit prices (i.e. marginal willingness to pay) are useful to policy makers, they do not represent valid welfare measures to be used, for instance, in Cost-Benefit-Analysis (CBA). Therefore, based on the statistically best fit model, a number of policy scenarios were simulated and their welfare implications estimated, changing the attribute levels simultaneously. Generally, the assessment of economic welfare involves the investigation of utility differences associated with a baseline alternative compared to some other alternative. Accordingly, the compensating surplus (CS) can be written as follows (BENNETT AND BLAMEY, 2001):

$$CS = -\frac{1}{\beta_{cost}}(V_1 - V_0) \qquad (3)$$

where β_{cost} is the marginal utility of income. V_0 and V_1 represent observed utility associated with linear combinations of attribute levels in the current situation, and a new policy scenario, respectively. Welfare values and the results of CS comparisons are therefore contingent on the scenarios chosen. The estimated welfare measures for three different policy scenarios are presented in Table 5. The standard errors needed to calculate the 95 percent confidence intervals are estimated using the delta method. Scenario (1) represents the "worst case scenario" and yields a very low CS, amounting to € 0.9 per respondent and month. Improving all attributes ("best case scenario"), CS increases substantially to € 18.2 per person and month. However, if we compare scenario (2) with scenario (3), CS decreases considerably from € 18.2 to € 7.8, due to the deterioration of nature and landscape. This result illustrates how important it is to hold the environmental impact of a new hydropower plant as small as possible.

Table 5: Estimates of welfare measures for different policy scenarios (per respondent/month)

	Policy scenario			CS
	Households	Nature/landscape	Leisure activities	Graz
(1)	10,000	Strong impact	No	€ 0.947 (0.803, 1.091)
(2)	20,000	Small impact	Yes	€ 18.246 (17.948, 18.544)
(3)	20,000	Strong impact	Yes	€ 7.774 (7.511, 8.037)

95 % confidence intervals in parentheses

In order to get a measure of total economic surplus for the region Graz and its surroundings, the calculated CS values per person and month can be aggregated. In total, 329,458 people are living in Graz and its surrounding communities, whereas a share of approximately 74 percent (243,667 people) is aged between 18 and 75 years. Multiplying the calculated CS per person with the total number of inhabitants in this age group gives an approximate aggregation of total economic surplus (see Table 6). This welfare measure amounts to only € 230,753 if the new hydropower plant provides 10,000 households with green electricity, causes a strong impact on the landscape and natural environment and creates no possibilities for recreation. Compared to that, the same hydropower plant, supplying twice as many households with green electricity, causing only a small environmental impact and creating new possibilities for recreational activities, yields a total economic surplus of approximately € 4.4 million. Starting from this policy scenario, a strong environmental impact would cause a significant decrease in welfare from € 4.4 million to € 1.9 million in scenario (3).

Table 6: Total economic surplus of the hydropower project Graz-Puntigam

Policy scenario	Graz
(1) 10,000 households / strong environmental impact / no recreation	€ 230,753
(2) 20,000 households / small environmental impact / recreation	€ 4,445,948
(3) 20,000 households / strong environmental impact / recreation	€ 1,894,267

5.4 Determinants of willingness to pay

In addition to the choice experiment, an open ended question was included in the questionnaire asking directly how much people are willing to pay for the expansion of hydropower in Austria, on top of their monthly electricity bill. As shown in Table 7, the mean WTP for hydropower expansion in Austria is € 9.2. Due to the existence of outliers, the median WTP (€ 5.0) is considerably lower than the mean. Median WTP corresponds to 7.3 % of respondents' current electricity bill, meaning that people are willing to pay a share of 7.3 % over what they pay at the moment. The maximum monthly WTP amounts to € 95.0. In total, there are 12 respondents which stated a WTP of more than € 20.0. In contrast, 21 respondents have a zero WTP for hydropower expansion in Austria.

Table 7: Maximum WTP for the expansion of hydropower in Austria

Mean WTP	€ 9.2
Standard deviation	€ 12.6
Median	€ 5.0
Minimum WTP	€ 0.0
Maximum WTP	€ 95.0
Number of observations	199

In the next step, we wanted to find out which socio-demographic variables determine respondent's WTP for an expansion of hydropower in Austria. WTP datasets usually contain a number of "zero" bids as in this paper. In this case, the Tobit model represents a theoretically correct model to explain the variance in stated WTP amounts. Generally, the Tobit model is a regression model for censored distributions, i.e. for distributions where there are no observations beyond a certain censoring point (in our case below zero). If there are a large portion of observations at this censoring point, ordinary least squares (OLS) estimation may result in biased estimates. The Tobit model assumes that whenever the dependent variable has the value zero or is negative for an individual respondent, this is an observation for which the dependent variable is not observed. The model can be written as follows (for reviews see BROUWER AND SPANINKS, 1999; GREENE, 2007; LONG, 1997 or MADDALA, 2003):

$$\begin{aligned} WTP_i &= \alpha + \beta X_i + \varepsilon_i && \text{if } WTP^* > 0 \\ WTP_i &= 0 && \text{if } WTP^* \leq 0 \end{aligned} \tag{4}$$

where X_i is the matrix of explanatory variables. The error term ε_i is assumed to be normally distributed with zero mean and variance σ^2. The estimates for the regression coefficients are obtained through maximum likelihood estimation and are presented in Table 8.[14]

Table 8: Tobit regression results

Variable	*Definition*	*Measurement*	*Coefficient*
	Dependent variable : willingness to pay (WTP) in €		
Constant	-	-	9.040** (0.019)
Sex	Sex of respondent	Dummy (1=female, 0=male)	4.018* (0.056)
Age	Age of respondent	Continuous variable	-0.176** (0.013)
Region	Residence of respondents	Dummy (1=Graz, 0=surroundings)	4.046* (0.086)
Hydro	Most preferred renewable energy source	Dummy (1=hydropower most preferred, 0=other energy source most preferred)	5.006** (0.019)
Income	Income of respondent	Dummy (1=income higher € 2,250, 0=income below this limit)	0.078 (0.972)
σ	Disturbance standard deviation	-	13.372*** (0.000)
Observations	185		
Positive Obs.	167		
Log likelihood	-685.034		
X^2 (5)	15.439		
Prob. > X^2	0.009		

p-values in parentheses
Significance: ***1 % level **5 % level *10 % level

As expected, standard socio-economic variables play a significant role in explaining differences in stated WTP. First, we were able to find a significant relationship between sex and WTP. The positive coefficient in the table shows that female respondents are willing to pay

[14] Due to the fact that the income question was voluntary, the number of observations is only 185, instead of the 199 in the total sample.

more for an expansion of hydropower. Next, the age coefficient is significant at the 5 % level and shows a declining WTP with an increase in age. Furthermore, the residential area of respondents plays a significant role in explaining WTP differences. People living in the urban area of Graz are willing to pay more for hydropower expansion than people living in one of the surrounding communities of Graz (rural area). Additionally, respondents' attitude towards different renewable energy sources helps to explain differences in the WTP. In the questionnaire, people have been asked which renewable energy source they prefer most for future electricity generation. People who stated hydropower to be the most preferred technology have a higher WTP than people who stated another energy source to be the most preferred one. Finally, income level, which is usually a strong determinant of WTP, does not show any significant impact. This result may be attributable to the small sample size of only 185 observations. The outcome of the likelihood ratio test (X^2 in Table 8) shows that the model is highly significant, meaning that we can convincingly reject the null hypothesis of zero slopes for all explanatory variables.

6 Conclusions

The aim of this paper was to explore the various costs and benefits of a new hydropower project in Graz (Austria). The main question to answer was whether people have, in general, a positive attitude towards the construction of the new hydropower plant and how they value the costs and benefits of a specific hydropower project. To answer these questions, a random sample of people living in Graz and its surrounding communities was surveyed using a choice experiment.

The main findings of the choice model are as follows:

- All variables (choice attributes, interactions and sociodemographic characteristics) have a statistically significant impact on choice with the expected signs.
- Respondents have some propensity to vote in favour of the construction of the new hydropower plant over the opt-out alternative (no hydropower plant).
- The supply of additional households with “green” electricity from the new hydropower plant is valued positively, although the marginal willingness to pay for the provision of 1,000 extra households is quite low and amounts to merely € 0.25 monthly.
- Alternatives which create new possibilities for recreational activities are preferred over alternatives where leisure activities are not possible. Hence, people exhibit a positive WTP, amounting to € 4.2 per month for power plant constructions with new possibilities for recreation.
- In principle, people don't favour the construction of a hydropower station which causes a strong impact on the surrounding nature and landscape. Therefore, WTP is negative, in the amount of monthly € 9.8.
- Total economic surplus of a power plant which can provide 20,000 households with green electricity, keeps the environmental impact small, and creates new possibilities for recreation is approximately € 4.4 million. A strong environmental impact would decrease this surplus value substantially to € 1.9 million. Thus, it is very important to hold the environmental impact of a new hydropower plant to be as small as possible.

Finally, we tried to explain the differences in stated WTP for the expansion of hydropower in Austria by socio-demographic characteristics. In the random sample, median WTP amounts to € 5.0 per month, on top of the monthly electricity bill. Generally, WTP is determined by sex, age and residential area of respondents. Additionally, respondents' attitude towards hydropower significantly helps to explain the differences in WTP.

7 References

ALPIZAR, F., CARLSSON, F. AND MARTINSSON, P. (2001): Using Choice Experiments for Non-Market Valuation. Working Papers in Economics no. 52. Department of Economics: University Göteborg.

ALVAREZ-FARIZO, B. AND HANLEY, N. (2002): Using conjoint analysis to quantify public preferences over the environmental impacts of wind farms. An example from Spain. In: Energy Policy 30 (2002), pp. 107 – 116.

BENNETT, J. AND BLAMEY, R. (2001): The Choice Modelling Approach to Environmental Valuation. Edward Elgar Publishing: Cheltenham.

BERGMANN, A., HANLEY, N. AND WRIGHT, R. (2004): Valuing the Attributes of Renewable Energy Investments. University of Glasgow.

BERGMANN, A., COLOMBO, S. AND HANLEY, N. (2008): Rural versus urban preferences for renewable energy developments. In: Ecological Economics 65 (2008), pp. 616 – 625.

BEVILLE, S. AND KERR, G. (2009): Fishing for more understanding: a mixed logit-error component model of freshwater angler site choice. University: Lincoln.

BROUWER, R. AND SPANINKS, F. (1999): The Validity of Environmental Benefits Transfer: Further Empirical Testing. In: Environmental and Resource Economics 14 (1999), pp. 95-117.

BUNGE, T., DIRBACH, D., DREHER, B., FRITZ, K., LELL, O., RECHENBERG, B., RECHENBERG, J., SCHMITZ, E., SCHWERMER, S., STEINHAUER, M., STEUDTE, C. AND VOIGT, T. (2001): Wasserkraftanlagen als erneuerbare Energiequelle – rechtliche und ökologische Aspekte. Umweltbundesamt: Berlin.

DOBROWOLSKI, P. AND SCHLEICH, U. (2009): Zielobjekt Mur. In: Frontal 14/2009, pp. 10-14.

EK, K. (2005): Quantifying the Preferences over the Environmental Impacts of Renewable Energy: The Case of Swedish Wind Power. University of Technology: Luleå.

ENERGIE-CONTROL AUSTRIA (2011a): Gesamte Versorgung – Kalenderjahr 2010 (Datenstand: August 2011). Monatliche Erzeugungsstruktur (brutto / netto). Available under *http://www.e-control.at/de/statistik/strom/betriebsstatistik/betriebsstatistik2010*. Download 04.10.2011.

ENERGIE-CONTROL AUSTRIA (2011b): Gesamte Versorgung. Erzeugung elektrischer Energie in Österreich. Available under *http://www.e-control.at/de/statistik/strom/betriebsstatistik/betriebsstatistik2010*. Download 04.10.2011.

ENERGIE-CONTROL AUSTRIA (2011c): Kraftwerkspark in Österreich. Stichtag: 31. Dezember 2010. Available under *http://www.e-control.at/de/statistik/strom/betriebsstatistik/betriebsstatistik2010*. Download 04.10.2011.

ENERGIE STEIERMARK (2010): Murkraftwerk Graz. Technik. Available under *http://www.e-steiermark.com/wasserkraft/murkraftwerkgraz/technik/index.htm*. Download 10.10.2011.

GREENE, W.H. (2007): Econometric Analysis. 6th Edition. Prentice Hall International: London.

GREENE, W.H. AND HENSHER, D.A. (2005): Heteroscedastic Control for Random Coefficients and Error Components in Mixed Logit. Working paper of the Institute of Transport and Logistics Studies: Sydney.

HENSHER, D.A., ROSE, J.M. AND GREENE, W.H. (2005): Applied Choice Analysis. A Primer. University Press: Cambridge.

HENSHER, D.A. AND GREENE, W.H. (2002): The Mixed Logit Model: The State of Practice. Working paper of the Institute of Transport and Logistics Studies: Sydney.

KATARIA, M. (2009): Willingness to pay for environmental improvements in hydropower regulated rivers. In: Energy Economics 31 (2009), pp. 69-76.

KNÖDLER, M., HIMPEL, K. AND BARBI, K. (2007): Wasser hat Energie – Wasserkraft unter der Lupe. Büro am Fluss e.V.: Plochingen.

LANCASTER, K.J. (1966): A New Approach to Consumer Theory. In: The Journal of Political Economy, 74/2, pp. 132-157.

LEBENSMINISTERIUM – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (2010): EnergieStrategie Österreich. Vienna.

LONG, J.S. (1997): Regression Models for Categorical and Limited Dependent Variables. Sage Publications: Thousand Oaks.

LONGO, A., MARKANDYA, A. AND PETRUCCI, M. (2006): The Internalization of Externalities in the Production of Electricity: Willingness to Pay for the Attributes of a Policy for Renewable Energy. Fondazione Eni Enrico Mattei (FEEM): Milan.

LOUVIERE, J.J., HENSHER, D.A. AND SWAIT, J.D. (2000): Stated Choice Methods. Analysis and Applications. University Press: Cambridge.

MADDALA, G.S. (2003): Introduction to Econometrics. 3rd Edition. John Wiley & Sons.

MEYERHOFF, J. AND PETSCHOW, U. (1997): Umweltverträglichkeit kleiner Wasserkraftwerke. Zielkonflikte zwischen Klima- und Gewässerschutz. Institut für ökologische Wirtschaftsforschung GmbH: Berlin.

MEYERHOFF, J., OHL, C. AND HARTJE, V. (2008): Präferenzen für die Gestaltung der Windkraft in der Landschaft – Ergebnisse einer Online Befragung in Deutschland. Working Paper on Management in Environmental Planning 24/2008. Technische Universität: Berlin.

PISTECKY, W. (2010): Murkraftwerk Graz. Einreichprojekt zum UVP-Verfahren. Juni 2010. Ingenieurbüro Pistecky: Wien.

PÖYRY ENERGY GMBH (2008): Wasserkraftpotentialstudie Österreich. Commissioned by the VEÖ. Vienna.

STATISTIK AUSTRIA (2010): Demographisches Jahrbuch 2009. Wien.

STATISTIK AUSTRIA (2011a): Demographische Indikatoren 1961 – 2010 für Steiermark. Wien.

STATISTIK AUSTRIA (2011b): Statistisches Jahrbuch 2011. Wien.

STIGLER, H., HUBER, C., WULZ, C. AND TODEM, C. (2005): Energiewirtschaftliche und ökonomische Bewertung potenzieller Auswirkungen der Umsetzung der EU-Wasserrahmenrichtlinie auf die Wasserkraft. Technische Universität: Graz.

SUNDQVIST, T. (2002a): Quantifying Non-Residential Preferences over the Environmental Impacts of Hydropower in Sweden: A Choice Experiment Approach. University of Technology: Luleå.

SUNDQVIST, T. (2002b): Quantifying Household Preferences over the Environmental Impacts of Hydropower in Sweden: A Choice Experiment Approach. University of Technology: Luleå.

TRAIN, K.E. (2003): Discrete Choice Methods with Simulation. University Press: Cambridge.

UMWELTDACHVERBAND (2010a): Aktuelle Wasserkraftwerks Projekte der österreichischen E-Wirtschaft (in Planung). Wien.

UMWELTDACHVERBAND (2010b): Umweltdachverband präsentiert top-aktuelle Wasserkraftwerksliste und zeigt auf: E-Wirtschaft blockiert Gewässerschutz. Wien.

VERBUND AUSTRIAN HYDRO POWER (2009): Wasserkraftwerk Gratkorn. Kurzbeschreibung des Vorhabens. Wien.

VEÖ – Verband der Elektrizitätsunternehmen Österreichs (2008): Zukunft Wasserkraft. Masterplan zum Ausbau des Wasserkraftpotenzials. Vienna.

WURZEL, A. AND PETERMANN, R. (2006): Die Auswirkungen erneuerbarer Energien auf Natur und Landschaft. In: Schriftenreihe des Deutschen Rates für Landespflege 79 (2006).