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

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# The role of hydropower in Austria

- Hydropower plays a substantial role in the Austrian energy sector. Currently (2010) 58.5 % (41,572 GWh) of total electricity produced in Austria comes from hydroelectric power stations.

- Moreover gross electric hydropower generation has nearly doubled since 1970.

- The total number of hydropower plants in Austria is 2,598 with an entire installed capacity of 12,920 MW.

- 2,441 of these hydropower plants are small-scaled with a capacity less than 10 MW. Furthermore river power plants play – compared to storage power plants – a more important role in Austria (Energie-Control Austria, 2011, online).

# Hydropower expansion plans

- Although about 60 % of the total electricity produced already comes from hydropower installations, there is still substantial potential for new hydropower facilities, especially for small-scale hydropower. The *hydropower potential study* (Pöyry Energy GmbH, 2008) provides a value of 13,000 GWh, which is effectively exploitable.
- The *Austrian master plan* for the expansion of hydropower envisages an increase of hydropower utilisation by 7,000 GWh until 2020 (VEÖ, 2008). In the *Austrian energy strategy* hydropower plays a substantial role too; it stipulates a realizable hydropower expansion of 3,500 GWh by 2020 (Lebensministerium, 2010).
- Nationwide about 100 new hydropower plants are currently in the stage of planning; 70 of these projects are small-scaled with a capacity 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).

# Hydropower plant „Graz-Puntigam“

- Hydropower plant within the city limits of Graz.
- Total capacity amounts to 16 MW.
- The overall investment volume is € 87 million.
- The power station will be able to generate an electricity amount of 74 GWh per year.
- Construction works are scheduled to start in autumn 2013 and will be finished by the end of 2015 (Pistecky, 2010; Dobrowolski and Schleich, 2009; Energie Steiermark, 2010).

# Conflict potential

- Generally, the use of hydropower implies a considerable conflict potential.
- On the one hand there are the targets of climate and energy policy like the reduction of greenhouse gas emissions or the intensified use of renewable energy sources.
- On the other hand there are the objectives of nature and water protection as for instance the European Water Framework Directive (WFD) from the EU.
- Accordingly, the installation of new hydropower stations is associated with both benefits as well as costs $\longrightarrow$ „Trade-off“ (Bunge et al., 2001; Meyerhoff and Petschow, 1997; Wurzel and Petermann, 2006).

# Benefits and costs of a new hydropower plant

+ Emission-free generation of electricity ($\rightarrow CO_2$-avoidance).
+ Positive impacts on the local economy (especially employment effects).
+ Improvement of domestic energy security ($\rightarrow$ energy self-sufficiency).
+ Recreational area
– Visual impacts on the landscape.
– Negative consequences for the ecosystem of the water body (e.g. disruption of the water stream consistency,...).
– Impacts on fish and other water-dependent wildlife.

$\rightarrow$ *Trade-off between emission-free electricity generation and nature conservation.*

# Research question and methodological approach

- The aim of this study is to examine public perception and preferences for the new hydropower project in Graz. → Evaluation of positive and negative effects associated with the hydropower plant.

- The costs and benefits of the new hydropower station can be estimated by conducting a Choice Experiment (CE) study.

- Choice experiments belong to the family of stated preference techniques and are based on traditional microeconomic theory (*Random Utility Model*).

- The underlying assumption of the choice experiment approach is that the value of a good can be expressed by its characteristics (*attributes*). → People derive utility from the properties of a good and not from the good per se (Lancaster, 1966).

# Methodological approach (1)

*In the CE of this study the new hydropower plant is described by four attributes*:

1. Number of households that can be provided with green electricity from the new hydropower plant. *Levels:* 5,000, 10,000 and 15000 households.
2. Impact of the new hydropower plant on landscape and natural environment. *Levels:* small impact, strong impact.
3. Creation of new possibilities for recreational activities. *Levels:* yes, no
4. Increase in monthly electricity bill. *Levels:* € 3, 6, 9, 12, 15 and 18

*Through combination of these attribute levels different alternatives are generated (CE design). Respondents are then asked to choose between a selection of different alternatives in a hypothetical setting (choice card).*

Figure 1: Choice card example

| | Möglichkeit A | Möglichkeit B | |
|---|---|---|---|
| Strom für... | 5.000 Haushalte  | 15.000 Haushalte  | |
| Eingriff in Natur und Landschaftsbild | Gering  | Stark  | Keine der beiden Möglichkeiten |
| Freizeitmöglichkeiten | Nein  | Ja  | |
| Zusätzliche Stromkosten pro Monat | € 3 | € 9 | |
| | ☐ | ☐ | ☐ |

*Source:* Own depiction

# Methodological approach (2)

- Usually respondents are asked to make a sequence of choices, in our case six choice tasks.
- It is assumed that individuals are acting rationally, meaning that they compare alternatives and choose that one which gives the highest level of utility.
- The sequence of choice outcomes enables the analyst to model the probability of an alternative being chosen.
- Furthermore it is possible to estimate willingness to pay (WTP) measures for the different attributes used in the CE.[1]

[1] For reviews see Alpizar et al., 2001; Bennett and Blamey, 2001; Hensher et al., 2005 or Train, 2003.

# Questionnaire design

The CE is embedded in a questionnaire on the general subject of hydropower/renewable energy. The questionnaire consits of 43 questions divided into three main parts.

1. Perception and attitudes towards renewable energy, electricity and hydropower use

2. Choice tasks and follow-up questions

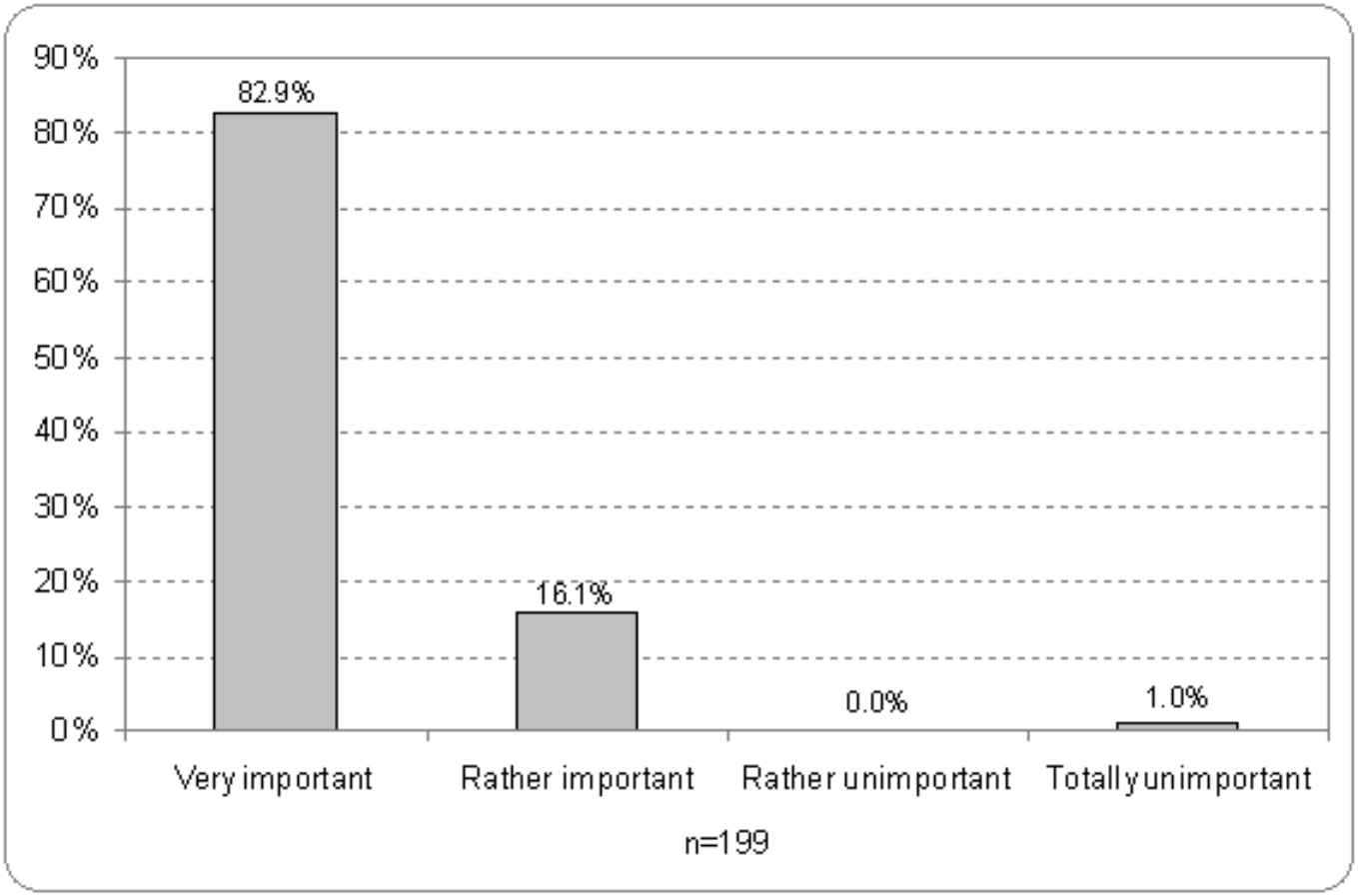
3. Demographic and socio-economic status of respondents

# The survey

- The questionnaire was developed in the course of several discussion rounds. For a pre-test 103 people completed the questionnaire in May 2011.
- In June 2011 the final survey was implemented by a professional survey company using a web-based survey. We asked only people from Graz and its surrounding communities.
- In total 959 people were invited to participate in the survey. The response rate was 22.0 % meaning that 211 respondents completed the survey.[2]
- Gender distribution of respondents is very close to the Styrian average. Moreover the age structure corresponds (in principle) to that of the total population in Styria.
- The population distribution of Graz and surroundings is also reflected in the sample.

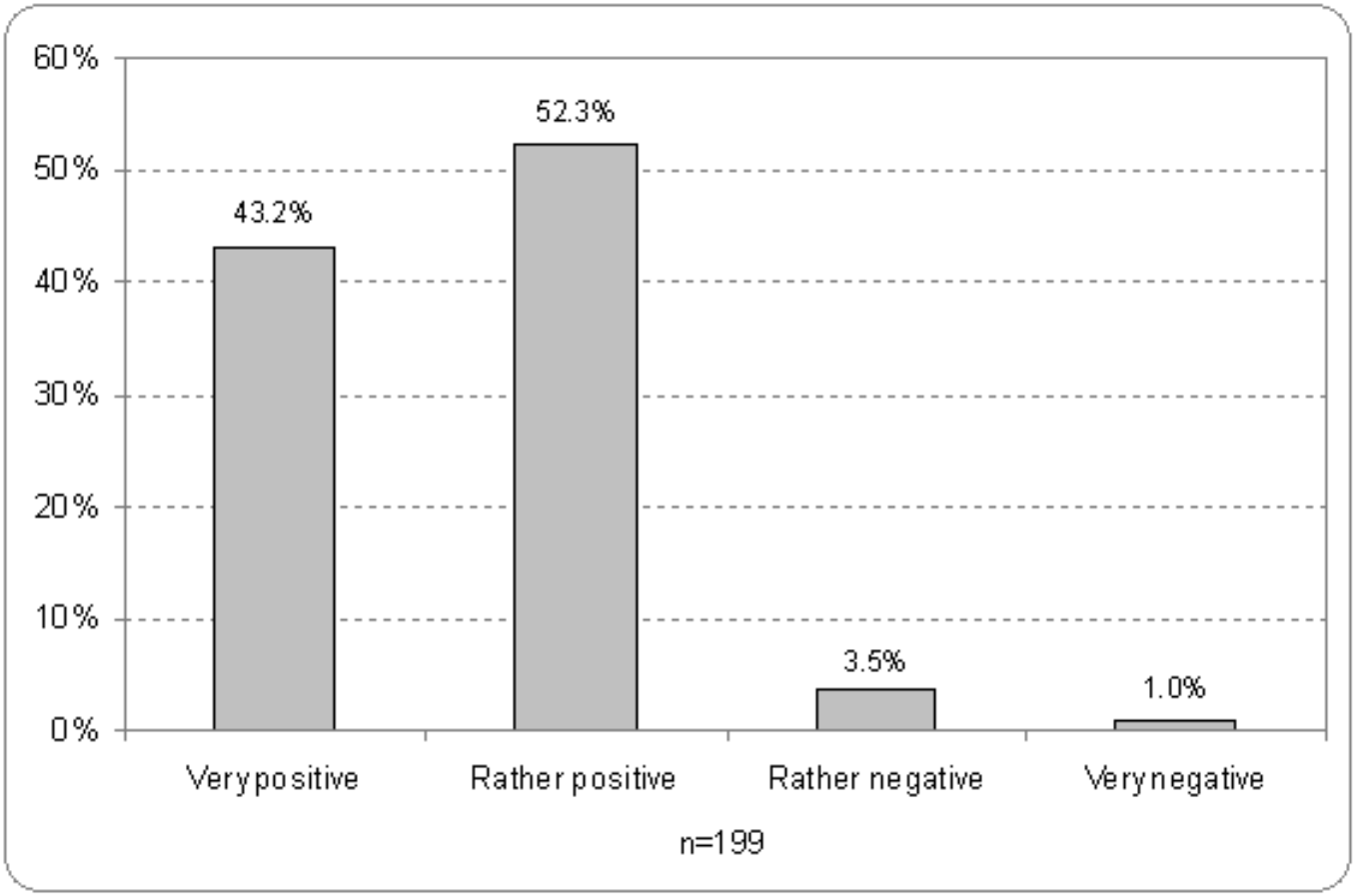
[2] Due to the exclusion of protest votes the sample size was reduced to 199 for further analyses.

## Figure 2: Importance of renewable energy expansion



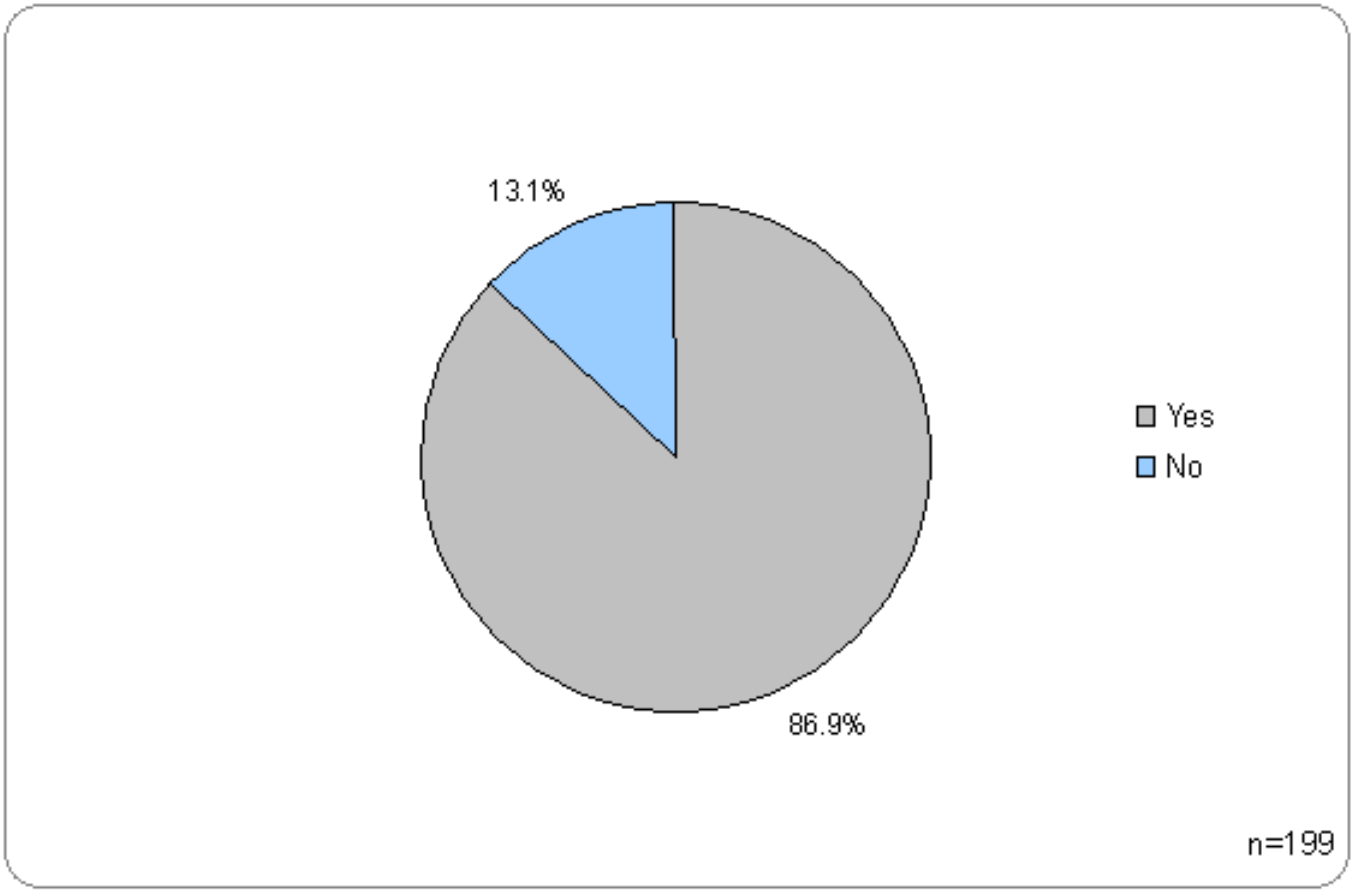

*Source:* Own calculations

## Figure 3: Attitude of respondents towards hydropower use



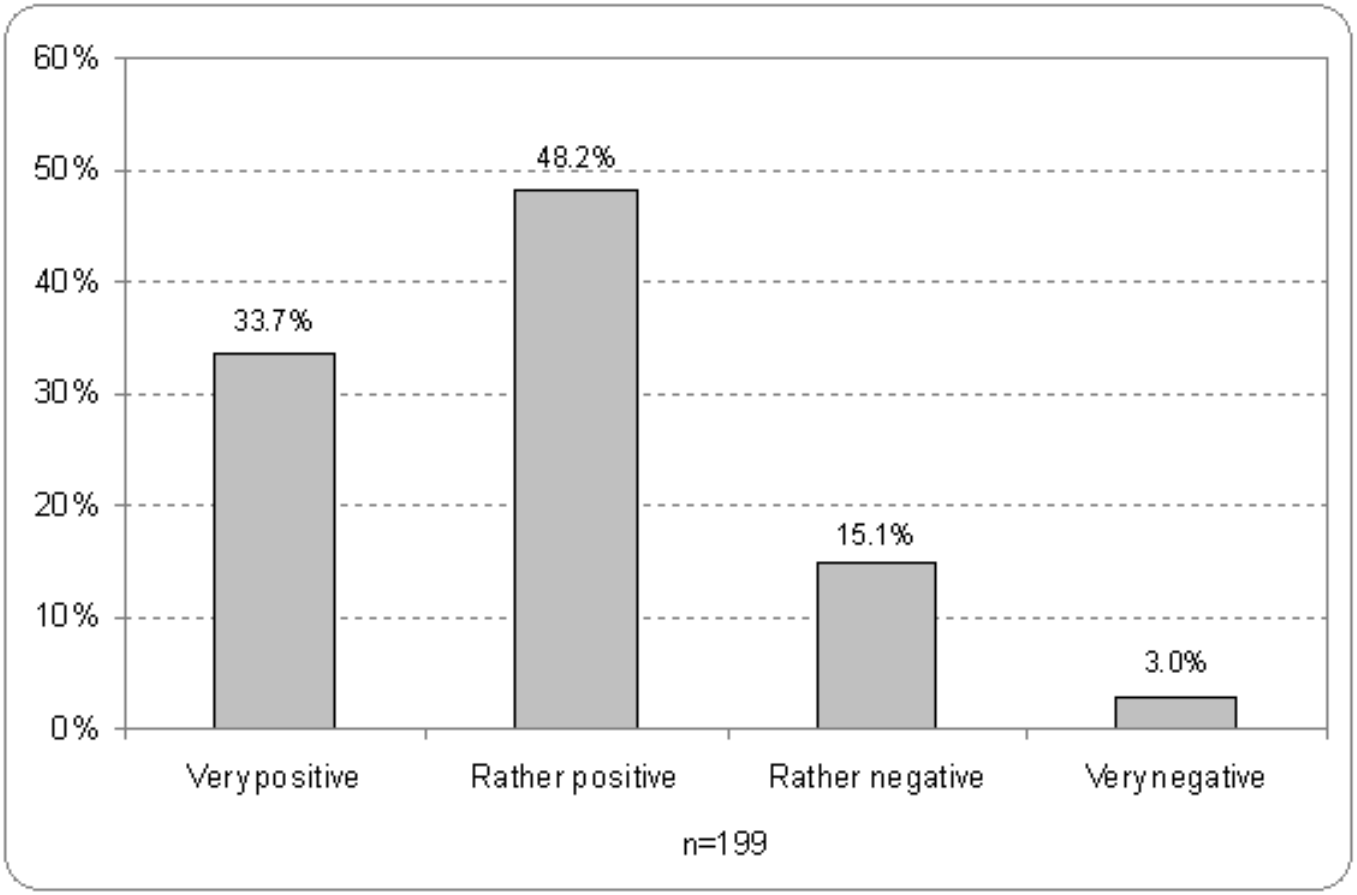

*Source:* Own calculations

## Figure 4: Proportion that heard of hydropower expansion plans along the Mur



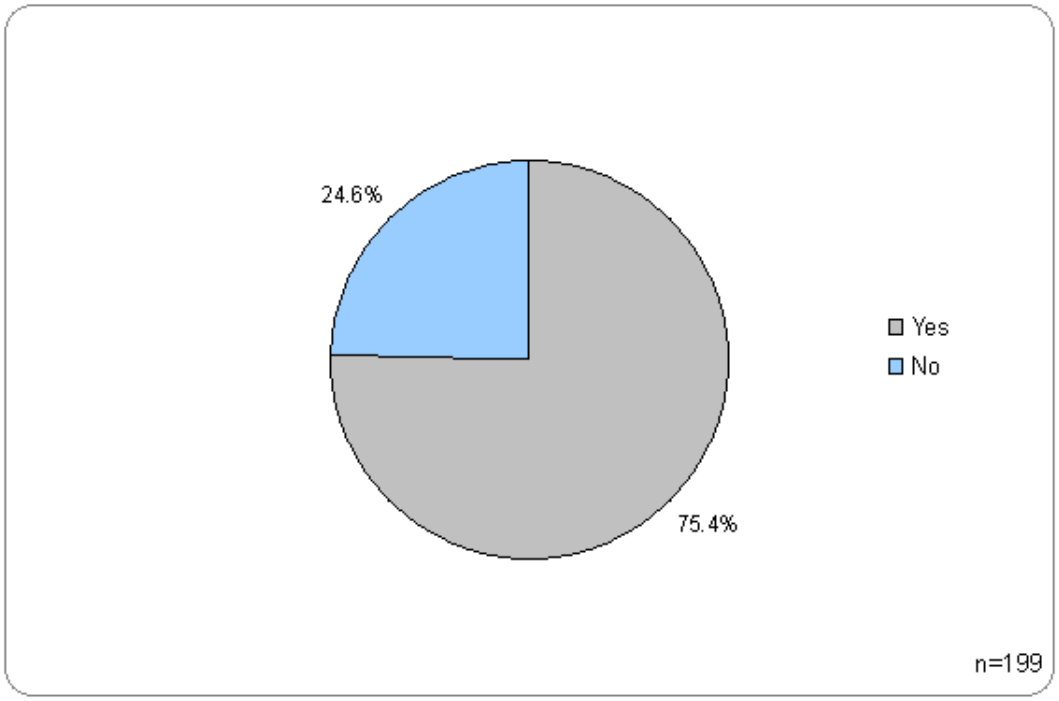

*Source:* Own calculations

Figure 5: Attitude of respondents towards hydropower expansion along the Mur




*Source:* Own calculations

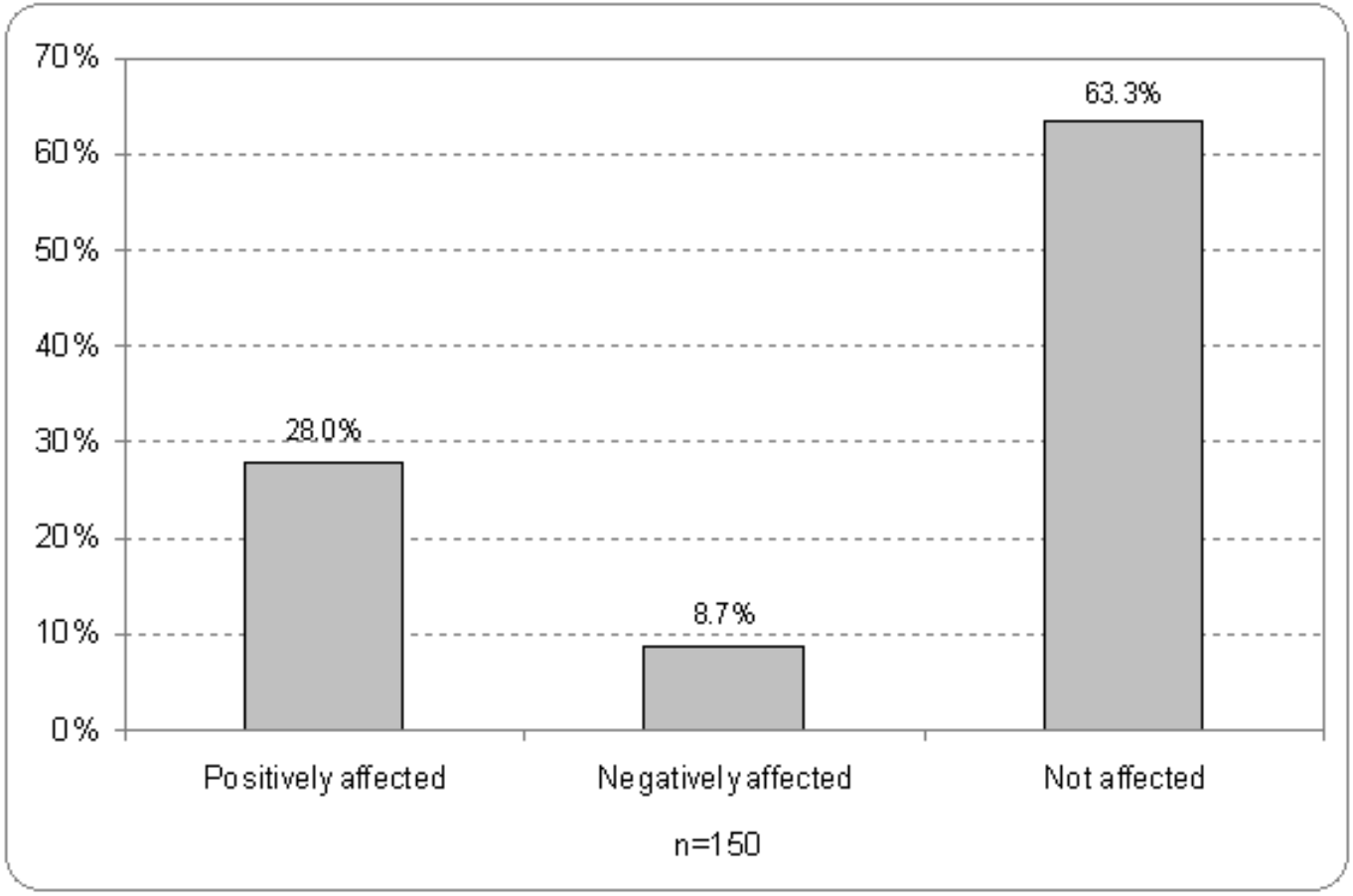
## Figure 6: Proportion that heard of the new hydropower project in Graz




*Source:* Own calculations

Stated distance between the location of the hydropower plant and respondent's home: 10.8 km (mean), 9.0 km (median).

## Figure 7: Individual concernment by the hydropower project in Graz




*Source:* Own calculations

# Econometric model

The statistically best fit model has the following indirect utility form:

$$U_{in} = \alpha + \beta_1 Households_{in} + \beta_2 Nature_{in} + \beta_3 Leisure_{in} + \beta_4 Cost_{in} + \beta_5 Payment * Cost + \beta_6 Donator * Nature + \beta_7 Age + \epsilon_{in} \quad (1)$$

- In the classical multinomial logit (MNL) model the utility function is assumed to be linear additive in the attributes and parameters $\longrightarrow$ each parameter is a single fixed estimate.

- In order to account for preference and variance heterogeneity we draw on more complex choice models, namely mixed logit (with error components). In the mixed logit model parameters are allowed to vary across individual respondents.

# Table 1: Mixed Logit Error Component Model



| *Variable* | *Coefficient* | *Variable* | *Coefficient* |
|---|---|---|---|
| ASC | 3.537*** | Payment*Cost | 0.059** |
| | (0.000) | | (0.029) |
| Households | 0.055*** | Age | -0.026* |
| | (0.001) | | (0.070) |
| Nature impact (strong) | -2.405*** | Std. dev. Households | 0.087*** |
| | (0.000) | | (0.001) |
| Recreational activities (yes) | 1.040*** | Std. dev. Nature | 3.772*** |
| | (0.000) | | (0.000) |
| Cost | -0.253*** | Std. dev. Recreation | 1.767*** |
| | (0.000) | | (0.000) |
| Donator*Nature | -1.445*** | Std. dev. random effects | 2.309*** |
| | (0.004) | (error component) | (0.000) |
| Log likelihood | | -868.042 | |
| McFadden Pseudo-$R^2$ | | 0.338 | |
| Number of respondents | | 199 | |
| Number of observations | | 1,194 | |

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

*Source:* Own calculations

# Econometric results (1)

- All coefficients are statistically significant and have the expected signs.
- The ASC indicates that respondents have some inherent propensity to choose for one of the power plant alternatives over the opt-out for reasons that are not captured in the estimated model.
- The two attributes households and recreation have positive signs. $\longrightarrow$ Respondents prefer alternatives where more households can be supplied with electricity and where recreational activities are possible.
- In contrast, alternatives with a strong impact on landscape and environment are less preferred compared to those with only a small impact. This relationship is captured by the negative sign of this coefficient.

# Econometric results (2)

- The negative effect of a strong environmental impact is enhanced if the respondent is a donator to environmental organisations.
- The negative sign of the cost attribute indicates that respondents prefer lower electricity bills. However, if the bill is paid by another household member, the negative effect of cost diminishes, suggesting lower price sensitivity.
- Older people are less willing to choose one of the hydropower plant options. They rather tend to choose the opt-out alternative.
- In order to give the estimated coefficients more meaningfulness we now consider willingness to pay (WTP) measures.

# Willingness to pay

**Table 2: Estimates of willingness to pay (WTP)**

| *Attribute* | *Measurement* | *WTP* |
|---|---|---|
| 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 | | |

*Source:* Own calculations

# Welfare analysis

**Table 3: Estimates of welfare measures for different policy scenarios**

| *Households* | *Nature/landscape* | *Leisure activities* | *Surplus* | *Aggregation* |
|---|---|---|---|---|
| 10,000 | Strong impact | No | € 0.947 | € 230,753 |
| | | | (0.803, 1.091) | |
| 20,000 | Small impact | Yes | € 18.246 | € 4,445,948 |
| | | | (17.948, 18.544) | |
| 20,000 | Strong impact | Yes | € 7.774 | € 1,894,267 |
| | | | (7.511, 8.037) | |

95 % confidence intervals in parentheses

*Source:* Own calculations

# Willingness to pay for hydropower expansion

In addition to the choice experiment, an open ended CV 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.

**Table 4: WTP for the expansion of hydropower in Austria**

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

*Source:* Own calculations

Determinants of respondents' WTP $\longrightarrow$ *Tobit model* for censored distributions.

# Table 5: Tobit regression results

| *Variable* | *Measurement* | *Coefficient* |
|---|---|---|
| | *Dependent variable:* WTP in € | |
| Constant | – | 9.040** |
| | | (0.019) |
| Sex | Dummy (1=female) | 4.018* |
| | | (0.056) |
| Age | Continuous variable | -0.176** |
| | | (0.013) |
| Region | Dummy (1=Graz) | 4.046* |
| | | (0.086) |
| Hydro | Dummy (1=hydropower most preferred) | 5.006** |
| | | (0.019) |
| Income | Dummy (1=income>€ 2,250) | 0.078 |
| | | (0.972) |
| Log likelihood | -685.034 | |
| Observations | 185 | |
| Positive obs. | 167 | |
| $\chi^2$ | 15.439 | |
| Prob. $> \chi^2$ | 0.009 | |

*Source:* Own calculations

# Determinants of WTP

*Standard socio-economic variables play a significant role in explaining WTP:*

- Female respondents are willing to pay more for an expansion of hydropower.
- The age coefficient shows a declining WTP with an increase in age.
- People living in Graz are willing to pay more for hydropower expansion than people living in one of the surrounding communities.
- People who stated hydropower to be the most preferred technology have a higher WTP than people who stated another renewable energy source to be the most preferred one.
- Income which is usually a strong determinant of WTP does not show any significant impact ($\longrightarrow$ problem: small sample size).

# Conclusions

- People have in general a positive attitude towards hydropower use in Austria and the construction of new hydropower plants along the Mur.
- The planned hydropower project in Graz is well known. Most of the people feel positively or not affected by the new hydropower plant.
- Principally, the new hydropower plant is valued positively. However, it is very important that the environmental impacts are as small as possible. Strong impacts would cause a decrease in welfare.
- Finally, people exhibit a positive WTP for hydropower expansion in Austria whereas WTP varies with socio-economic characteristics.

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