Valuing the appearance of an Alpine landscape: the costs and benefits of underground cabling of high-voltage power lines

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Abstract

High-voltage power lines are crucial for the security of electricity supply, and also necessary for regional renewable electricity production. However, power lines cause damage especially to human health (electric smog, noise), and to sensitive ecosystems.

The fragmentation and impaired appearance of Alpine landscapes has raised major opposition towards the planning of new power lines in Austria. An alternative, though very costly, to the erection of new lines is underground cabling. The current study presents the costs and benefits of underground cabling in a major Austrian tourist resort in the Tyrolean Alps; tourists were asked to value improvements of the appearance of the landscape with two approaches. The first presented respondents with manipulated pictures of the landscape with the existing and without power lines, and asked for the potential change of the frequency of trips to the area. The second ascertained the respondents' willingness-to-pay for a nature conservation fund financing underground cabling.

While 60% of respondents would positively change their travel behavior with an improved appearance of the landscape, and also stated a positive willingness-to-pay for underground cabling (on average about EUR 9 to 13), the additional costs of underground cabling would not be outweighed by the tourists' willingness-to-pay. For the purpose of planning new power lines, it is thus important to explore the full range of benefits of underground cabling including the willingness-to-pay of Austrian residents which might be much higher than that of tourists alone, and not only concentrate on the significance of a pristine Alpine landscape for tourism.

Keywords: Alpine Landscape, transformation of landscapes, high-voltage power lines, economic valuation, underground cabling.

1. Introduction and background

The Alpine landscape in Austria has been transformed into a cultural landscape over the past centuries. Even the remaining natural areas such as national parks or Natura 2000 areas are affected by human use. For the Austrian Alps, tourism is, of course, one of the major and large-scale land uses. Especially in areas of ski resorts, all kinds of infrastructure (e.g., ski lifts, cable cars, hotels) may impair the typical appearance of the landscape. Besides such infrastructure, high-voltage power lines (transmission lines) are considered to lead to major negative effects on the landscape not only in terms of visual disamenities but also owing to their manifold negative effects on human and ecosystem health. A range of spatial planning instruments (e.g., land use and zoning plans prescribing a certain distance from power lines to residential areas) have thus been implemented to reduce direct land use conflicts (Kirschner et al., 2007). For instance, high-voltage power lines are subject to a comprehensive environmental impact assessment.

While the negative environmental effects of high-voltage transmission lines are well documented (e.g., Battaglini and Bätjer, 2015; Jorge and Hertwich, 2013), such power lines are also essential for transporting energy from the sites of production to the sites of consumption. Even more so, the current development of producing larger amounts of renewable energy sources (e.g., by means of wind turbines) has led to planning efforts of new transmission lines and energy storage infrastructure in order to connect the locations of production and consumption across Europe (Kishore and Singal, 2014).

An alternative to overhead high-voltage transmission lines is underground cabling. While many negative effects on human or ecosystem health are substantially reduced by underground cabling, this technological option is very costly. Costs of underground cabling depend on the concrete technology and on the necessities given the topography of the landscape and are up to 12 times higher than the costs of overhead cabling (Lang, 2014).

However, public (citizens') opposition to overhead high-voltage power lines is significant in current planning efforts for new transmission lines in Austria (e.g., Österreichisches Parlament, 2012). Often, the demand for underground cabling is reasoned by the negative effects of overhead transmission lines on the appearance of the landscape, and consequently, on (eco-) tourism since tourists expect an unobstructed view on the alpine landscape when visiting Austria.

Against this background, the aim of this paper is to shed more light on the effects of overhead transmission lines on tourists' perception of the landscape, and to ascertain tourists' willingness-to-pay for underground cabling to secure an unobstructed view of the alpine landscape. In particular, the purpose of this paper is to find answers to the following questions:

- How do tourists in the case-study area of the prominent ski resort of St. Anton am Arlberg (Tyrol) perceive overhead transmission lines?
- Were tourists aware of transmission lines crossing the landscape when booking their holidays?
- How would tourists change their travel behavior if overhead transmission lines were removed?
- Do tourists have a willingness-to-pay to fund underground cabling?

To find answers to these questions, an empirical survey was undertaken in the internationally well-known alpine resort of St. Anton am Arlberg (Tyrol). Tourists during the 2014 winter season were surveyed with respect to their preferences for pristine landscapes and their willingness-to-pay for underground cabling of power lines which currently have significant negative effects on the appearance of the landscape. In addition, tourists' potential changes of trip frequency were elicited depending on the hypothetical changes of the landscape if the power lines were put underground.

The structure of the paper is as follows: In Section 2 there is a brief overview of literature on valuing landscape changes, and of studies on the costs and benefits of underground cabling of power lines. In Section 3 the experimental setting and the survey is presented. In Section 4.1 the descriptive results of the study are discussed, while Section 4.2 includes the econometric results of the survey. Section 4.3 presents the costs and benefits of underground cabling in light of the survey results. Finally, in Section 5, the results are summarized, and conclusions are drawn.

2. Costs and benefits of high-voltage power lines: a short review

Environmental economics offers a wide range of methods for valuing changes of a natural landscape. Direct valuation approaches such as contingent valuation or choice experiments present respondents (residents, visitors, tourists, general public) different scenarios which may include management options for developing an area. Presenting such scenarios to respondents is often done by means of pictures that show the original landscape, and are then manipulated to emphasize possible changes, e.g., by inserting new infrastructure or a higher number of visitors. Usually, two measures of benefits are ascertained. One the one hand, respondents may be asked to state their frequency of trips (visits) to an area based on the current and potential future appearance of the landscape, thus combining revealed and stated preferences. The difference between these may then be assessed by differences in consumer surplus based on travel demand models (e.g., Whitehead et al., 2000; Hoyos and Riera, 2013). This approach can value the recreation benefits of different scenarios. On the other hand, non-use values can be ascertained by comparing willingness-to-pay bids of respondents given different development scenarios (e.g., Lienhoop and Ansmann, 2011; Getzner and Svajda, 2015).

Such techniques of presenting respondents development scenarios are, of course, also used in urban and regional planning in order to highlight potential changes of the appearance not only of natural but also residential (urban) environments (cf. Zech, 2013; Tisma et al., 2012).

One of the earlier valuation studies on visual disamenities owing to overhead transmission lines was done by Harrison (2002). He compared costs of overhead and underground power lines; while the costs of the latter were about twice the cost of the first, politicians decided on burying the power line due to the significant impacts on the environment valued, among others, by losses in ecotourism, and residential property values.

With respect to the valuation of power lines, changes to the landscape, and underground cabling, Tempesta et al. (2014) have recently published a study on costs and benefits of underground cables. While there is a majority of respondents who would be in favor of underground cables, willingness-to-pay is only larger than the costs associated with underground cabling in certain specific areas, especially in natural mountainous areas and nature parks. This results points to an important aspect also for this paper since high-voltage power lines might be generally accepted in flat landscapes or intensively used areas, but less in the natural environment.

Another study in Finland by Soini et al. (2011) ascertained preferences of respondents for different types of infrastructure such as high-voltage power lines in comparison to other infrastructure that might impair the visual appearance of the landscape. Respondents in their study stated a diverse spectrum of preferences and perceptions especially emphasizing preference heterogeneity.

Devine-Wright and Batel (2013) tested whether the appearance of the pylons carrying the transmission wires would gain a differentiated acceptance by respondents in their UK study. The authors find that several forms of pylons in fact are preferred to others, but that even the most 'appealing' pylon would not be preferred to underground cabling of power lines (cf. for different energy infrastructures also Cohen et al., 2014).

3. The study site, and testable hypotheses

In order to answer the basic research questions of the current study, 140 tourists were surveyed during the Easter holidays in 2014. The case-study area chosen for this survey was the surroundings of the village of St. Anton am Arlberg, a prominent and internationally visited prime tourism resort. Especially during the winter season, the resort is fully booked. The village is connected to the Austrian highway network, and the Austrian railway company has a stop of international trains at St. Anton. However, since the village is geographically located along the major East-West corridor of inner-Austrian infrastructure, major high-voltage power lines cross the area. Some of the power lines are very near the village, and also stretch over several ski slopes.

For the purpose of the current study, data was collected on the perception and preferences of tourists in St. Anton am Arlberg with respect to overhead power lines, and the tourists' trip frequency both in the status quo and in the case one of the scenarios were to become reality. In addition, respondents stated their willingness-to-pay for the improvement of the appearance of the landscape by means of two scenarios of underground cabling. *Figure 1* presents the status quo (current appearance of the landscape), and two potential scenarios of underground cabling differing in the extent (partial vs. complete underground cabling).

Figure 1: Status quo and potential changes of the appearance of the landscape at the St. Anton ski resort in the Austrian Alps

Status quo: current appearance of the landscape at St. Anton am Arlberg

Scenario 1: Partial underground cabling of one of the high-voltage power lines crossing the area

Scenario 2: Complete underground cabling of both high-voltage power lines crossing the area

Source: Authors' pictures (original and manipulated).

Table 1 presents an overview and description of all variables used in the empirical estimations of both trip frequency, and willingness-to-pay of respondents for the two scenarios of underground cabling.

Table 1: Variables of the empirical estimation

Variable name	*Description*
Dependent variables	
Travelfrequency	Frequency of travels to the St. Anton skiing area
WTP	Willingness-to-pay of respondents for scenario 1 or scenario 2 (EUR, ln)
Explanatory variables	
T_i	
Travelcost	Travel costs of respondents for their visits to an alpine pasture landscape (EUR)
G_i	
Scenario1	=1 for scenario 1
Scenario2	=1 for scenario 2
S_i	
Income	Income of respondent (net monthly income, per household, EUR, ln)
P_i	
Disturb	=1 for respondents who perceived overhead high-voltage transmission lines as disturbing
Aware	=1 for respondents who were aware that transmission lines would cross the area
View	=1 for an unobstructed view of an alpine landscape to be a major motive of repondents to visit the area
Alpine	=1 for respondents who came to the area to enjoy a high-alpine landscape
Lift	=1 for respondent stating that their major motive to visit the area is a dense lift network

Our main hypotheses to be tested are:

H_1: $\text{Tripfrequency}_{i,\text{Status quo}} < \text{Tripfrequency}_{i,\text{Scenario 1}} < \text{Tripfrequency}_{i,\text{Scenario 2}}$

H_2: $\text{WTP}_{i,\text{Scenario 1}} < \text{WTP}_{i,\text{Scenario 2}}$

The two hypotheses are developed based on the research questions of the current paper. First, we hypothesize that tourist in fact have a preference for underground cabling owing to a reduction of visual disamenities given the rather prominently located high-voltage power lines which crosses the ski slopes. Second, we test whether tourists in fact will be willing to pay a higher contribution for a hypothetical landscape conservation fund to finance underground cabling near the tourism resort.

4. Empirical results[1]

4.1 Descriptive survey results[2]

In order to ascertain preferences of respondents (tourists) for the different scenarios presented above, *Table 2* sums up some details of the descriptive survey results. One important aspect of the choice of the holiday resort is – besides the prices of accommodation, transport, offers for sports and leisure activities – the variety of landscape amenities and attributes of the tourism offers in the region. The upper part of the table shows that one major advantage of the ski resort lies in the extensive lift network and the length of ski slopes. Other landscape amenities such as high-alpine landscapes, or open landscapes with long-distance view, are of minor importance.

As the ski resort is not only a nationally prominent resort but is also visited by international tourists, the duration of transport, as well as the means of transport, are certainly specific to the area. About one fourth of respondents came by plane, and about one fifth of respondents used the intercity railway connection directly to the St. Anton train stop.

Overhead transmission lines do not seem a major disturbance of tourists: While about 13% of respondents already have power lines close to their home, and information levels are not high with respect to potential effects of overhead high-voltage transmission lines, 55% of all respondents were well aware that there would be overhead power lines close to the ski resort. Most respondents knew from the existence of these power lines because of past visits, but some also said that they expected power lines crossing the area based on pictures from the resort prior to their journey.

[1] The entire questionnaire and further descriptions of the experiment, all the data and empirical assessments, including econometric estimations, can be obtained from the authors on request.

[2] Owing to limits of space, only the most important results will be presented. Some more descriptive analysis can be found in Lang (2014).

Table 2: Descriptive survey results: attractiveness of the ski resort, modes of transport, and perception of existing power lines

The ski resort of St. Anton am Arlberg (Tyrol) is attractive because of... (mean points on a 5 point Likert scale, 1=most important)	
Number of lifts and extension of the ski slopes networks	1.36
High-alpine landscapes	1.44
Appearance of the landscape	1.60
Transport connections	1.85
Open landscape with long-distance views	1.92
Activities and events	2.13
Local urban center	2.15
Solitude	2.79

	Mean	*Std. Deviation*
Duration of traveling to the area (hrs.)	6.30	32.20
Distance to the area (km)	768.00	402.45
Length of stay in the area (days)	6.58	2.69

Mode of transport (multiple answers, % of respondents)	
Car	74.30%
Air	25.00%
Train	22.10%
Bus	10.00%

Transmission lines near the home of the respondent (% of respondents)	12.90%
Information level about high-voltage transmission lines (mean on a 5 point Likert scale, 1=very well informed)	3.96
Respondents were aware, that transmission lines are crossing the area (% of respondents)	55.00%
... owing to the experience during the last visit (% of respondents)	50.00%

Transmission lines are disturbing because of the ...	
… pylons	54.30%
… transmission cables	27.10%
… noise	22.90%

Table 3 presents the descriptive survey results with respect to the different scenarios (cf. *Figure 1*). The upper part of the table includes the respondents' perception of the status quo and the two scenarios; in most cases, the scenario 1 with its partial underground cabling does not seem to add much improvement to landscape amenities. For instance, the scenario 1 is not perceived differently in comparison to the status quo with respect to the diversity of the landscape. However, scenario 2 (complete underground cabling) improves the landscape significantly, for instance, with respect to natural landscapes, unimpaired views, or the uniqueness of the view. 93.6% of respondents preferred scenario 2 to the status quo and to scenario 1.

Table 3: Descriptive survey results: Preferences for scenarios, change of travel frequency, and willingness-to-pay

Perception and valuation of scenarios (mean on a 5-point Likert scale, 1=best value)	*Status quo*	*Scenario 1*	*Scenario 2*
Natural landscape	3.50	3.36	2.64
Diversity of the landscape	3.14	3.13	2.75
Area used	2.39	2.90	3.67
Unimpaired view	3.52	3.15	2.40
Uniqueness of the view	3.19	3.03	2.55

Will ski lifts still be disturbing after underground cabling?	
Very disturbing	17.90%
Somewhat disturbing	20.70%
Not disturbing	34.30%

Frequency of vacations in the area during the last five years or in the next five years if scenario 1 (2) were to be realized	*Mean*	*Std. Deviation*
Status quo	5.56	6.31
Scenario 1	5.42	5,22
Scenario 2	6.23	5,28

WTP for…	*Mean*	*Std. Deviation*
… scenario 1	3.54	9.34
… scenario 2	7,81	13,66

It is, however, interesting to consider that the pylons of the ski lifts which are still very visible in the pictures (both status quo and scenarios) are not perceived as disturbing by the majority of respondents. Only about 18% of respondents still perceived lift pylons as very disturbing.

Table 3 also includes the respondents' assessments of the status quo and the scenarios. While travel frequency would not change if scenario 1 were to be realized, there is a significant, though somewhat small, stated increase of trip frequency in scenario 2 (complete underground cabling). This result indicates that respondents do not perceive a partial improvement of the landscape view in scenario 1 to be sufficient to increase trip frequency. However, even in the case of complete underground cabling, trip frequency would not change dramatically.

Finally, the table also presents mean willingness-to-pay figures. Respondents were willing to pay EUR 3.54 per person per stay for the realization of scenario 1 (corresponding to about EUR 0.54 per person per day). For scenario 2, willingness-to-pay is much higher, with about EUR 7.81 per person per day (EUR 1.52 per person per day). These rather low figures suggest that respondents do not hold strong preferences for the removal of transmission lines; in order to explore preferences further, the next section provides econometric evidence regarding recreation benefits and willingness-to-pay.

4.2 Travel frequency and willingness-to-pay for removing power lines

In order to answer the hypothesis H_1 presented in section 3, travel frequency of visitors (tourists) is estimated econometrically by means of a count data model. Such estimation procedure hypothesizes that trip frequency foremost depends on travel costs associated with travelling to (visiting) an area. In addition, we test whether trip frequency would change in the case if a scenario were to become reality. Furthermore, additional variables are included in the empirical estimation in order to ascertain potential additional explanatory variables of trip frequency. *Table 4* presents an econometric estimation of the frequency of travels to the area.

Table 4: Determinants of the respondents' travel frequency depending on potential scenarios of landscape changes

Variable	*Coefficient*	*z-Stat*	*Sign.*
Constant	0.3368	1.0584	
Travelcost	-0.0104	-6.9339	***
Scenario1	-0.0524	-0.9768	
Scenario2	0.0972	1.8822	**
Income	0.0909	2.3331	**
Disturb	0.1894	3.3925	***
Aware	0.7928	15.598	***
View	-0.1049	-2.1915	*
Alpine	0.4378	8.8753	**
Lift	0.0592	1.1796	***
Adj. R²	0.2415		
S.E. of regression	4.9930		
Log likelihood	-1,163.742		
n	383		

Dependent variable: Travelfrequency
*** p<0.01, ** p<0.05, * p<0.1
Count data model (Poisson).

First, our basic hypothesis that trip frequency depends on travel costs is highly supported with a significantly negative coefficient for the variable 'Travelcost'. Based on the estimation and the coefficient for travel costs (-0.0104), the consumer surplus per trip amounts to over EUR 129 per stay; given the average length of stay in the area (about 6.6 days), consumer surplus measured by travel costs amounts to about EUR 19.5 per person per day.

The coefficient of the variable 'Scenario1' is not significantly different from Zero. This means that respondents would not change their travel frequency if this scenario would be realized. This result can be expected since the change of the landscape is marginal, and there still would remain the other high-voltage power line. However, the coefficient for the variable 'Scenario 2' is highly significant indicating that respondents would in fact be sensitive to major improvements of the visual appearance of the landscape, and would increase the number of trips to the area slightly. Given the coefficient of 0.0972, consumer surplus of the realization of scenario 2 amounts to EUR 138 per person per trip; given the difference between the status quo and the scenario 2, consumer surplus would increase by EUR 9.35 per person per trip. Assuming the average length of stay, respondents value the reduction of visual disamenities of the high-voltage power lines by at least EUR 1.42 per person per day.

While the estimation so far has only included travel costs and the appearance of the landscape as explanatory variables, we also included several other factors influencing trip frequency. As a central socio-economic variable, we assume that trip frequency is directly connected with the income (net of taxes) of the respondent's household. The estimation clearly indicates that trip frequency depends positively on income.

Furthermore, there are a number of variables that additionally determine trip frequency. On the one hand, the variable 'Disturb', denoting the respondents' perception of transmission lines as disturbing, adds to the explanatory power of the model. This variable is closely connected to the variable 'Aware' denoting the awareness of respondents prior to the journey that power lines are close to the ski resort. Both variables taken together implicitly acknowledge that respondents who were aware of transmission lines exhibit a higher trip frequency than other respondents; they might thus be regular visitors of the area who "got used" to the appearance of the landscape.

Respondents who primarily prefer unobstructed views of the landscape (variable 'View') are less likely to visit the area while respondents seeking a high-alpine mountainous landscape (variable 'Alpine') exhibit a higher trip frequency as especially St. Anton offers such landscapes above the valleys and the potentially disturbing infrastructures. Finally, respondents who enjoy a dense lift infrastructure (variable 'Lift') state a higher trip frequency.

All in all, the model exhibits a rather high explanatory power given the limited number of respondents even if the observations for each respondent [n=140] are pooled resulting in a total number of observations of 383.

Table 5: Determinants of the respondents' willingness to pay to prevent landscape changes considered to be unfavorable

Variable	*Coefficient*	*z-Stat*	*Sign.*
Constant	-2.6617	-2.6632	***
Scenario2	0.6016	3.8281	***
Income	0.271	2.1738	**
Disturb	0.3487	1.6008	*
Aware	-0.0474	-0.2936	
View	0.3769	2.1358	**
Alpine	-0.2012	-1.2097	
Lift	-0.3398	-1.8962	*
Adj. R²	0.1954		
S.E. of regression	0.5414		
Log likelihood	-421.8708		
n	256		

Dependent variable: WTP
*** p<0.01, ** p<0.05, * p<0.1
Baseline is the WTP for preventing scenario 1.
GLM (maximum likelihood) estimation (Poisson distribution assumed, log link).

Table 5 presents the econometric estimation of the determinants of willingness-to-pay of respondents for the realization of scenario 1 or 2. As discussed above, mean willingness-to-pay amounted to EUR 3.54 per person per stay to promote scenario 1 (partial underground cabling) while scenario 2 attracted a mean willingness-to-pay of EUR 9.34 per person per stay; given the average length of stay, daily willingness-to-pay amounts to EUR 0.54 per person (scenario 1) to EUR 1.52 per person (scenario 2). Interestingly, the latter figure is quite close to the gain of consumer surplus computed above by means of the travel demand model.

The WTP estimation broadly includes – for the purpose of comparability – the same variables as the estimation presented in *Table 4*. Given the WTP for scenario 1 as the baseline, the estimation clearly indicates that willingness-to-pay of respondents is significantly higher for scenario 2. In addition, the income variable is significantly positive indicating that willingness-to-pay of respondents for the improvement of the landscape appearance is positively correlated with income as suggested by economic theory.

Furthermore, we find that willingness-to-pay of respondents who feel disturbed by high-voltage transmission lines is above-average. Moreover, respondents who prefer an unobstructed view of the landscape – as a measure for the strength and intensity of preferences – state a higher willingness-to-pay for underground cabling. Finally, respondents who positively value the density of ski lifts at the St. Anton ski resort state a lower willingness-to-pay, presumably because they are more used to the impaired view of the landscape.

4.3 Costs and benefits of underground power lines

The last section has provided some econometric evidence towards recreation benefits of underground cabling, and the respondents' (tourists') willingness-to-pay for the removal of overhead transmission lines. In order to test whether the benefits of tourists with respect to the removal of power lines is sufficiently high to at least match the costs of underground cabling, a cost-benefit analysis on a (hypothetical) removal project for underground cabling in the village of St. Anton am Arlberg is presented in the following.

For this project, we assume that over a certain stretch, the existing transmission lines are removed from the surface; as there are three major power lines crossing the area with different voltages (110 and 380 kV), we assume that our hypothetical project includes a tunnel for the underground cables. For this purpose, the tunnel to remove the overhead cables is 13,972 meters long; given the costs of removal of about EUR 15,700 per meter, total investment costs sum up to EUR 176 million (for all underlying data and details, see Lang, 2014). Under the assumption that the existing overhead power lines have to be renewed anyway, and that the cost ratio between overhead and underground cabling is 12.4, we arrive at differential costs for the underground cabling of around EUR 161 million.

On the benefit side, we present two options for valuation which are very close to each other. *Table 6* presents the present value of both the valuation of recreation benefits by means of the consumer surplus, as well as willingness-to-pay of respondents for the removal of overhead power lines. Given the average annual number of tourists in the region (in total about 1.2 million overnight stays), and the average consumer surplus and WTP, respectively, we arrive at additional recreation benefits of about EUR 53 million (present value over 40 years, d=1%). As the table shows, the value of recreation benefits is highly sensitive to the discount rate varied from 0% to 5% over a planning period of 40 years which is the usual technical lifespan of high-voltage power lines.

Table 6: Consumer surplus based on trip frequency, and willingness-to-pay for realizing underground cabling

Average number of tourists (overnight stays) during the winter season 2012/2013 at St. Anton am Arlberg	1,013,187	
Average number of tourists (overnight stays) during the summer season 2013 at St. Anton am Arlberg	123,202	
	Scenario 1	*Scenario 2*
Consumer surplus per person per stay (difference to the status quo if scenario 2 would be realized)* (EUR)		9.350
Consumer surplus per person per day (difference to the status quo if scenario 2 would be realized)* (EUR)		1.417
Aggreated annual consumer surplus for visitors (scenario 2) (EUR)		1,609,884
Average WTP for the realization of scenario 1 (2) (EUR)	3.540	9.340
Average WTP per person per day (EUR)	0.536	1.415
Aggregated annual WTP of respondents based on total overnight stays (EUR)	609,518	1,608,163
Discounted benefits of underground cabling		
Discounted total consumer surplus (d=0%, 40 years) (EUR)		64,395,377
Discounted total WTP (d=0%, 40 years) (EUR)	24,380,709	64,326,505
Discounted total consumer surplus (d=1%, 40 years) (EUR)		53,388,650
Discounted total WTP (d=1%, 40 years) (EUR)	20,213,457	53,331,550
Discounted total consumer surplus (d=3%, 40 years) (EUR)		38,328,475
Discounted total WTP (d=3%, 40 years) (EUR)	14,511,529	38,287,482
Discounted total consumer surplus (d=5%, 40 years) (EUR)		29,005,353
Discounted total WTP (d=5%, 40 years) (EUR)	10,981,706	28,974,331

* As there is no significant difference between scenario 1 and the status quo in terms of trip frequency, additional consumer surplus is Zero (cf. Table 4).

In addition to recreation benefits (or WTP) of tourists at the ski resort, underground cables avoid some of the external effects of overhead power lines such as noise, electromagnetic fields, and fragmentation of ecosystems owing to the transmission route. Furthermore, underground cables are connected with a reduced loss of voltage (line losses) compared to overhead transmission lines. Valuing the reduced losses of underground cables with reasonable input data (loss per kilometer, valued at electricity costs), we arrive at benefits of underground cables (compared to overhead power lines) of around EUR 11.7 to 27.2 million over the lifespan of the power lines (depending again on the discount rate over the whole period). *Table 7* presents the comparison between costs and benefits of underground cabling.

Table 7: Costs and benefits of underground cabling: results for scenario 2 (complete removal of overhead power lines, construction of underground cabling)

	Discount rate			
	0%	1%	3%	5%
Additional cost (one-off investment) for underground cabling (EUR) including marginal maintenance costs	161,810,000			
Additonal benefits owing to the reduction of transmission losses (EUR, present value)	27,165,312	22,299,113	15,698,000	11,653,299
Recreation benefits (consumer surplus) for scenario 2 (present value) (EUR)	64,326,505	53,331,550	38,287,482	28,974,331
Benefit-cost ratio (consumer surplus)	0.340	0.290	0.216	0.167
WTP for scenario 2 (present value) (EUR)	64,395,377	53,388,650	38,328,475	29,005,353
Benefit-cost ratio (WTP)	0.341	0.291	0.217	0.168

The results of the cost-benefit analysis suggest that the costs involved for underground cabling in the case-study region are not offset by the benefits of reduced losses, and by the tourists' willingness-to-pay for removing overhead power lines since the benefit-cost ration is clearly below 1 for all assumptions.

5. Discussion, summary and conclusions

The current paper has taken up the discussion on the importance of an unobstructed view on the Alpine landscape for tourism resorts. In order to test whether tourists indeed have a sufficient willingness-to-pay for the removal of overhead high-voltage power lines usually associated with negative effects both on the appearance of the landscape, and on human and ecosystem health, we conducted a survey of tourists visiting the prominent and internationally visited St. Anton holiday resort in the Tyrolean Alps.

In order to value the benefits of removing the overhead transmission lines, we employed two approaches; one approach asked tourists to state the current (status quo) and hypothetical frequency of trips to the holiday resort (for scenarios 1 and 2). If scenario 2 would be realized, about 60% of respondents stated that they would stay slightly longer or visit the region more often. Based on a recreation demand model (travel costs), additional consumer surplus amounts to about EUR 1.417 per person per day if scenario 2 (complete underground cabling) were to be realized. This amount is about the same size as the usual daily tourism tax charged for every overnight stay. Of course, the recreation benefits measured by the consumer surplus crucially depends on assumptions about travel costs (transportation and costs of travel time). The other approach measured benefits of an undisturbed landscape by means of the respondents' willingness-to-pay to finance underground cabling. It turned out that WTP per person per day of EUR 1.415 is almost equal to recreation benefits measured by the travel cost model. This result is interesting since economic theory would suggest that recreation benefits owing to the realization of a certain scenario measured by different methodological approaches should lead to the same order of magnitude which actually took place in this study.

Given the huge cost of underground cabling, however, the willingness-to-pay of visitors for such scenario as a measurement of benefits (either recreation benefits based on the travel cost method or benefits measured by the respondents' willingness-to-pay) does not outweigh these costs over the whole lifespan of transmission lines (40 years). Even if we assume that the discount rate of benefits would be Zero, the benefit-cost ratio is far from unity. The cost-benefit analysis of the overhead transmission lines removal project only includes the substantial reduction of transmission losses as a benefit of underground cabling as a proxy for potentially important other external effects of overhead power lines. These external effects may include noise and ecosystem fragmentation.

The results so far suggest that respondents were well aware that the area around the village of St. Anton am Arlberg is an intensively used area with tourism infrastructure, but that overhead high-voltage power lines are also close to the area. The majority of respondents stated that they knew that there were transmissions crossing the area, and that the disturbance is – on average – not very far-reaching. In addition, respondents thought that even after the removal of the transmission lines, the remaining lift pylons would also not be impairing their view on the landscape.

Of course, underground cabling may have a number of additional benefits; however, if (eco-) tourism is used as an argument in the debate on high-voltage power lines, one has to be aware that the results of this study indicate that the willingness-to-pay of visitors (respondents in a survey) is not sufficient to outweigh these costs. Thus, projects of underground cabling will need more specific argumentation besides (eco-) tourism. Some of these arguments may be:

- Residents and the general public may hold strong preferences for underground cabling in sensitive natural areas. As earlier studies show (see Section 2), however, preferences and willingness-to-pay could be regionally different, and may only be substantial in natural areas. In areas and regions that are already affected by numerous infrastructures (e.g., highways, railroads), underground cabling might not be economically efficient.
- Tourists hold differentiated preferences as well. As the current study shows, many respondents in our survey were well aware of the existence of power lines crossing the area. However, the removal of transmission lines in natural areas might attract new groups of visitors who might have spent their holidays in other resorts.
- If the tourism tax would indeed be increased to at least partially fund a project for underground cabling, demand for holidays in this Alpine region might be reduced as a reaction to higher prices of overnight stays. While this argument is well founded in demand modelling, it may also be assumed that the reduction of demand might not be significant since the additional costs in the form of increases of the tourism tax is only marginal compared to the average spending of tourists in the region (the St. Anton resort is certainly one of the most expensive resorts in the Austrian Alps).

All in all, for the purpose of planning new power lines, it is thus important to explore the full range of benefits of underground cabling including the willingness-to-pay of Austrian residents which might be much higher than that of tourists alone, and not only concentrate on the significance of a pristine Alpine landscape for tourism.

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