ECONOMICAL EVALUATION OF THE AESTHETIC ASPECT OF PUTTING CABLES UNDERGROUND

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ABSTRACT

This work aims to evaluate the aesthetic perception of the benefits of residential customers for the conversion of overhead lines to electric wires underground in the city of São Paulo. This article presents the results of a Willingness to Pay (WTP) survey employing the Contingent Valuation Method to quantify the environmental benefits of residential customers. The aggregated WTP in the neighborhood was found to be near 30% the projected investment for the conversion.

INTRODUCTION

Converting an existing aerial electricity distribution system into an underground one is a much-discussed subject in many countries: the large costs of such works require a deep analysis of costs and benefits for society in the short and long term. Such a large-scale conversion, requiring a restructuring of the electricity and communications networks, has several economic merits, such as a reduced frequency of outages and real estate appreciation. Other benefits tied to the perceived aesthetic benefits have been acknowledged, but deemed very difficult to estimate [2,3].

Former studies indicate that the direct and indirect economic benefits of the underground networks do not compensate for the costs, usually they are estimated almost ten times greater than those of an aerial system.

The main goal of this work is to quantify the added externality costs of this conversion, meaning the social and aesthetical value of putting the cables underground. In this study, residents were inquired on their preferences regarding the conversion of the electric system into an underground network in the neighborhood; and their Willingness to Pay (WTP) has been determined using the contingent valuation method.

METHODS

This work opted to explore the environmental economic valuation methodology, which as a principle considers total economic value of goods; meaning that it must account for all externalities in economic valuation of goods and services.

Underground conversion clearly has a use value, derived from reduced frequency of interruptions on power grid-dependant services, as well as indirect use values such as real estate appreciation in the neighborhood, and an existence value, associated to aesthetic and environmental aspects attributed by the people, even those that do not benefit directly from these actions.

Urban economic valuation uses many techniques to assess economic value of environmental assets. Among valuation methods, Contingent Valuation stands out. This method has been used to evaluate several phenomena, such as changes in water quality, decrease in mortality risk of nuclear accidents, landscape amenities, endangered species preservation, urban visibility, etc. In the electric power sector, other studies have employed contingent valuation.

The contingent valuation method aims to extract personal preferences for goods and services from sample surveys, calculating the costumer's maximum willingness no pay (WTP) and/or their minimum willingness to receive (WTR). This estimate may be interpreted as the perceived value of the variable studied, and this method has been widely used to valuate non-market goods, such as environmental and aesthetic issues.

The basic principle consists of presenting to the individual, preferably in face-to-face interviews, a hypothetical market for the goods being valued. The presentation of this hypothetical scenario is central for the study: the estimates will be conditional to this market, and the interviewer must make sure that the customer is well-informed on the needed background information. In order to determine the WTP, use of an open-ended question ("How much would you be willing to pay?") has been criticized by specialists on the field for being too vague, introducing a bias as a result. A more appropriate approach for public goods valuation is to use a referendum-like question with a yes/no answer ("Would you be willing to pay X?").

The in-depth interviews were supported by a focus group responsible for earlier qualitative exploration. Pilot surveys have also been run in advance, in order to evaluate the performance of the whole process and to train the interviewers, allowing for some adjustments before the final survey.

RESULTS

Sampling and procedures

This work of determining WTP was focused on regions with good energy supply quality of the city of São Paulo and near major commercial corridors, which made them natural candidates for the process of conversion into an underground network. Three indexes, evaluated in a previous survey, were used to determine the best neighborhoods. Following an analysis of the data and some field visits, five zones were selected as best candidates for such a project. All of those correspond to important commercial corridors of São Paulo.

The person interviewed was the head of the family or spouse, resident within the area of the commercial corridor, 18 to 70 years old. In each of the five areas, data was collected from 100 face-to-face home interviews, resulting in 500 questionnaires total.

In the first part of the questionnaire, both open-ended and objective questions sought to understand the client's perception on the quality of the energy supply and their understanding on underground networks, as well as to establish the interviewee's socioeconomic profile.

After this first part, the interviewer presented detailed information on underground networks, supported by maps and pictures. Previous implementations of the underground wiring system in other districts of São Paulo were presented, as well as the conversion plans and expected changes in the neighborhood. An example of the scenario shown could be viewed in the Figure 1.The demand for extra investments and the institutional context were also highlighted.

After this exposition, the second part of the interview aimed to estimate the customer's willingness to pay. In the scenario presented, an extra cost would be charged on the customer's electricity bill for a two-year period, in order to fund the necessary work. In the preliminary focus group, open-ended questions were asked in order to find adequate baseline values for a yes/no question. After the first estimates, the pilot survey used a double-bounded format, where two yes/no questions were asked: if the customer admits its WTP to the first value presented, the second question proposes a higher value; otherwise, it proposes a lower value. This allowed a better understanding of the distribution of the WTP function.

In the final questionnaire, a single yes/no question was asked, followed by inquiring the reasons for that choice. The value proposed to each participant was chosen randomly among six possible values, ranging between 1 and 30 Brazilian reais, marked as R$. In São Paulo, one kWh costs R$0,30 plus taxes (about USD 0,18).

Client's Perception Results

These results were collected before the presentation of detailed information on the impact of converting the network. The survey inquired on the consumer's satisfaction with three aspects of energy supply quality:

Figure 1: An example of scenario shown to householders: before conversion (above) and after conversion (below)

frequency of interruptions, duration of interruptions, and voltage fluctuations. 91.2% of the people interviewed were satisfied or very satisfied with the low frequency of interruptions, while 69.6% were satisfied or very satisfied with their duration when they occurred., and 87.4% had a positive opinion on the stability of the voltage supplied. When customers were asked to grade from 0 to 10 the quality of those services, the results were similar, with average grades of 8.23 for frequency, 7.19 for duration of outages, and 8.02 for voltage fluctuations.

It has been noted that 49% of customers declared they had heard about underground networks before this survey. There seems to be no correlation between the spatial proximity of underground networks and resident's knowledge of them: the questionnaires indicate that most people have learned of underground wiring through indirect means, and that zones close to previously-converted neighborhoods are no more likely to be well informed in this matter than areas further away. People that had heard of underground networks before were asked where they had heard about them, with the results shown in Figure 2.

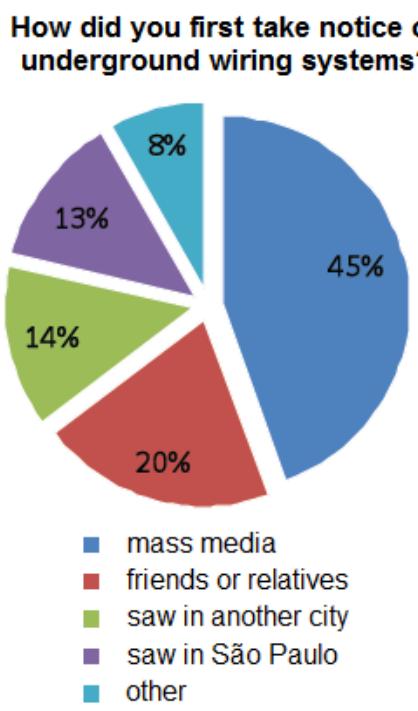

Figure 2: most-cited sources for hearing about underground cabling (spontaneous)

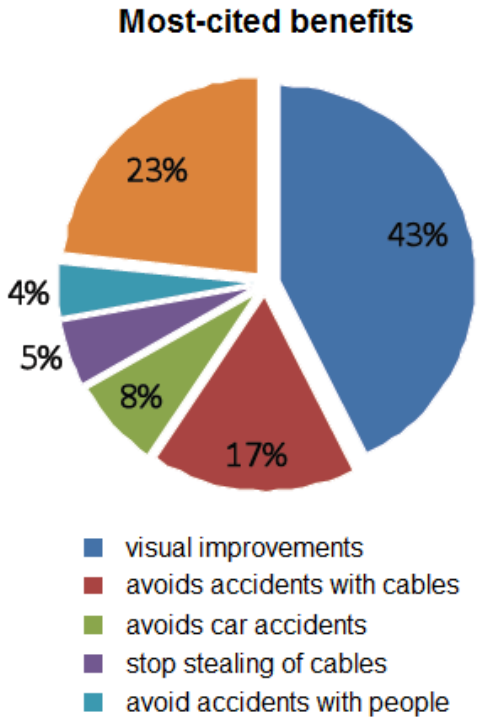

Figure 3: most-cited benefits obtained from underground cabling (spontaneous)

Only 29% of the clients interviewed could name a region in the city where underground cables had been implemented. Even though several of the city major commercial corridors have had underground wiring systems for a long time, most clients perceived Oscar Freire St., which was converted only recently in a project that received a lot of media attention. Other zones that have had underground electrical systems for decades have been noticed by remarkably few residents. It is believed that the presence of aerial wiring for trolleybus lines hamper the public's perception in this case.

When inquired whether or not the investments in underground network implantation works brought benefits to the public, 80% answered affirmatively, 16% answered negatively, and 4% couldn't answer. People that answered yes were asked to spontaneously name those benefits, resulting in the data shown in Figure 3. When stimulated with a list of nine main benefits and asked to rank them, 23.8% of participants cited embellishment and aesthetic reasons as number one, while 21% preferred the reduced frequency of outages and 19.2% ranked the reduced risk of accidents highest.

In contrast, when inquired whether or not the conversion brought any inconveniences, 88% replied there were none, while 3% couldn't answer and only 9% replied there were. Most of the disadvantages pointed were consequence of the installation work: 31.9% cited increased traffic jams, 27.7% cited the noise and 17.0%, the dirt on the streets.

Quantitative Results

Among all clients interviewed with varying proposed values, in total 55% answered they were willing to pay the suggested price. Among residents asked whether they would be willing to pay R$1.00[1], 80% accepted the added cost. The same percentage was observed among clients proposed a R$2.00 increase in their bills, indicating that they are nearly indifferent between these two options. Similarly, the percentages of people willing to pay R$5.00 and R$10.00 were very close, at 50% and 55,6% respectively. While 28.9% would accept a R$20.00 increase in their bills, 37.1% accepted a R$30.00 increase.

Among participants that accepted the added cost, 33.4% cited visual improvements as their major motivation for doing so, followed by the reduction of risks and accidents (11.3%). Participants that declared themselves unwilling to pay cited that it was the electricity company's responsibility to finance the works (39.1%), that they pay many taxes already (15.6%), and that the light bill is already very expensive (11.3%), among other reasons.

If the work wouldn't be done on their own neighborhood, 43% of participants declared they would accept the extra charges on their light bill anyway, under the same conditions.

Social and economic profiles

In the family income survey, it has been noted that 44.6% of participants have a total household income superior to

[1] R$ 1,00 is about USD 0,59

10 minimum wages, 51.2% between 2 and 10 minimum wages, and 4.2% below 2 minimum wages. On average, the family income is 11.24 minimum wages, with an average of 3 people per household and an average residence surface of 150m^2.
In addition, 77.2% of residences are owned by the families interviewed, 97.2% are exclusively residential, and 63.4% are apartments.
The people interviewed were 51% male and 49% female, and 51 years old on average. Only 14.4% of them had not finished secondary education, 23.6% had completed high school, 47.8% had completed a university degree and 14.2% had begun university but not yet finished. Regarding occupation, 16.8% of them were independent workers, 9.2% were employees in the private sector, and 33.2% were retired.

Calculation of Willingness-To-Pay

The estimates on the WTP function were obtained with the maximum verisimilitude method [1]. A logistic distribution was assumed for the data, and the dependence on each parameter was supposed to be linear. The results obtained with this method are presented in Table 1.

	Coeffic	Error	Stat. t	Probab
Constant	3.113	9.36	0.33	0.74
Revenue	-1.417	0.56	-2.53	0.01
Schooling	1.377	0.57	-2.43	0.02
Age	-0.214	0.09	-2.45	0.01
City Perception	11.031	2.99	3.69	0.00
Benefit Perc.	6.628	3.76	3.76	0.08
Sigma (scale)	14.724	0.12	123.17	0.00

Table 1: Parameters and coefficients of the WTP function

Five variables proposed proved to be statistically significant: the household revenue (R), the schooling (S) and age (A) of the respondent, whether or not they had perceived the benefits in São Paulo beforehand (P), and whether or not they agree to the existence of benefits in an underground electric network (B). As expected, these last two variables carry the strongest positive effect in the willingness to pay of the customers. It is also interesting to note that age and income contribute negatively to the WTP: the richer and older the resident is, the less they accept to pay.
With the presented coefficients, it is possible to define the average willingness to pay for a representative client from the sample:

$$WTP = 3.113 - 1.416\,R + 1.377\,S - 0.214\,A + 11.031\,P + 6.628\,B$$

Using sampling averages for each of those variables, it has been found that, on average, households perceive the conversion to be worth an added cost of R$13.47 per month for a period of two years, which represents a total investment of R$ 323.28 per household (about USD 190,74).
The number of registered customers that would benefit from the conversion, obtained from the electricity company, is 153.456. This total was multiplied by the average contribution per household in order to obtain the quantified total benefit of the conversion as perceived by its neighbourhood, found to be of R$ 49,609,255.68 (about . USD 29,270,000.00). This is about 30 % of the total cost of conversion.

CONCLUSIONS

The participants' answers indicate that underground cabling is considered superior, and the customers are willing to pay for its implementation. The major incentive for this disposition is indeed the aesthetic aspect, backed up by safety and supply quality improvements. Since the interviewee's evaluation considers the whole of the benefits acquired, it has not been possible to decompose the WTP into the several expected benefits.
It is also observed that, as knowledge on these systems increases, mainly through mass media, willingness to pay also increases. It is noticeable that the total value obtained in this work, of nearly 50 million reais, is near 30% of the cost estimates for the project. This percentage is higher than shown in most former studies [2,3], and it may indicate that the public policy of converting the aerial wiring systems into underground ones is in agreement with the public expectations. It is also evidence that the perceived aesthetical benefits dwarf the economical expected revenue from the conversion into an underground cabling system, highlighting the importance of this parameter in cost/benefits analyses of such conversions. Future studies may evaluate this perceived appreciation for commercial and industrial clients.

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