Institut für Höhere Studien Kärnten Institute for Advanced Studies Carinthia

Economic Valuation of Electrical Service Reliability – Experiences from Austrian

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Lisbon, 12 September 2008

Introduction

- Since 2001, the Austrian electricity market has been completely liberalised.
- Transmission and distribution networks represent a natural monopoly and must also be regulated.
- Since 2006, incentive regulation scheme (price-cap regulation).
- Price and quality are strong correlated. Economic theory predicts that where utilities are subjected to a price-cap it is profitable for them to reduce costs by cutting down on quality; a higher service reliability usually costs more money.
- In order to prevent a service quality deterioration you need a quality regulation scheme.

→ Problem: What is the optimal level of service quality?

Interruption costs as ‚reliability worth'

COST of providing quality and continuity of electric supply

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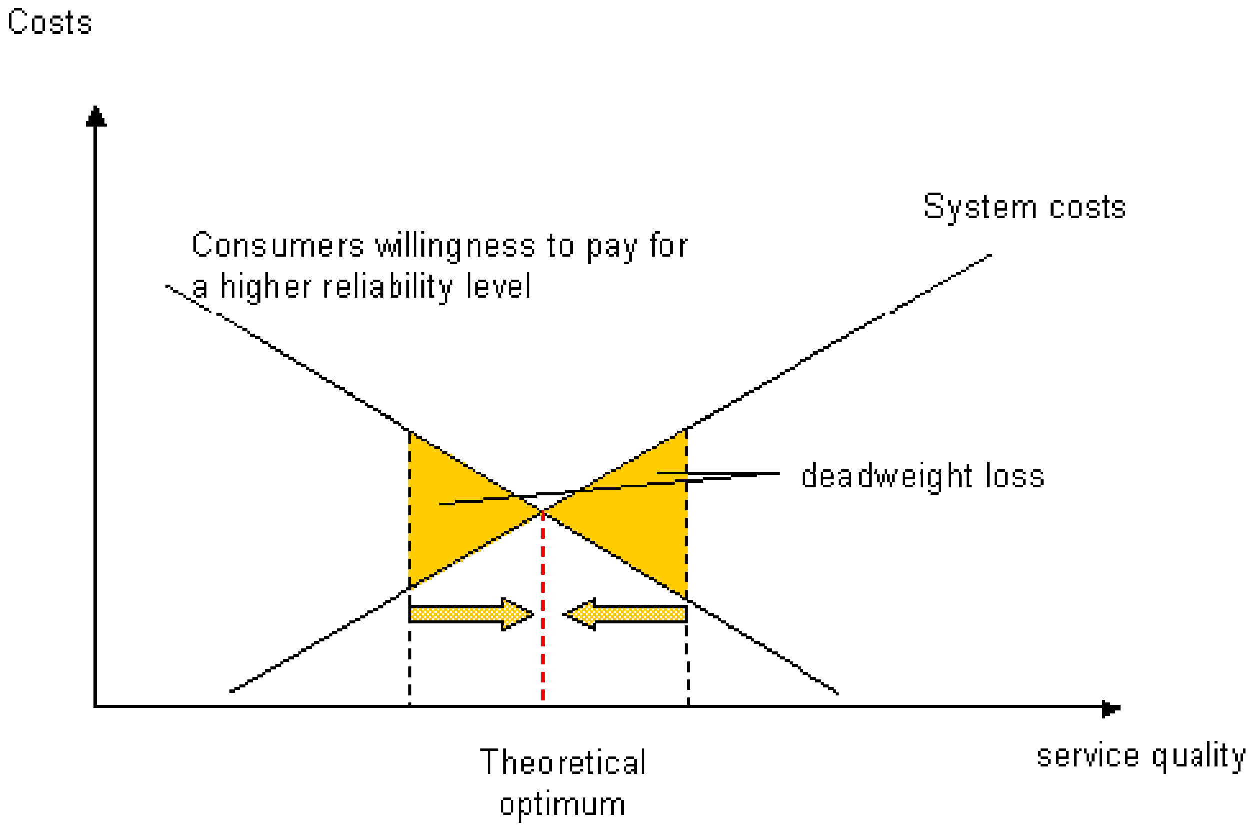
BENEFIT of having a certain quality level and continuity of electric supply



Informational problems

Reaching this superior outcome is limited by different information problems:

1. Problem of measuring quality levels (most common measures are the so-called SAIDI and SAIFI).
2. Lacking information on consumer demand (expectations) for quality.
3. Lack of information on the (efficient) costs required to produce optimal quality.

Aims of the Thesis

- Apply stated preference methods to estimate the value of service reliability.

- The results of the survey were used to develop a regulation scheme that explicitly takes into account reliability of supply as the main quality dimension. How strongly will the Q-factor affect tariffs? The close relationship between actual performance level, the reference level and tariff was explored in detail by analysing some real-life examples.

Sample

- In order to guarantee a representative sample the survey covered all regions (districts) of Austria.

- Separate survey for households and companies.

  - Households: Sample was randomly generated using the electronic telephone book. → Sample size : **2,500 households**.

    Sample was weighted to reflect relevant socio-economic characteristics (age, gender, household size, etc.).
  - Business (SMEs and industry): Database Aurelia (Vienna University of Economics and Business Administration); Allocation of sample according to the number of companies in the Austrian “Bundesländer”.
  - No sectoral classification. → Sample size : **1,500 companies.**

Questionnaire Logistics and Response Rate

- Postal survey in combination with a web-based survey was chosen.
- 2 Pre-tests in autumn 2006
- Final survey December 2006 - February 2007
- Recruitment-Screening for business customers: The challenge was to find a person who is responsible for the electrical service reliability and has the knowledge to appraise how the company would be affected by an outage.
- Incentive for households: successful use of a lottery!
- Total budget for the survey: € 6,000.-
- Funded by E-Control to cover direct costs for call centre, printing etc.; no personnel cost!

Table: Response Rate

	Sample	Responses	Response rate (%)
Households	2500	421	16.84
Business	1500	396	26.40
Total	4000	817	20.43

Questionnaire Design

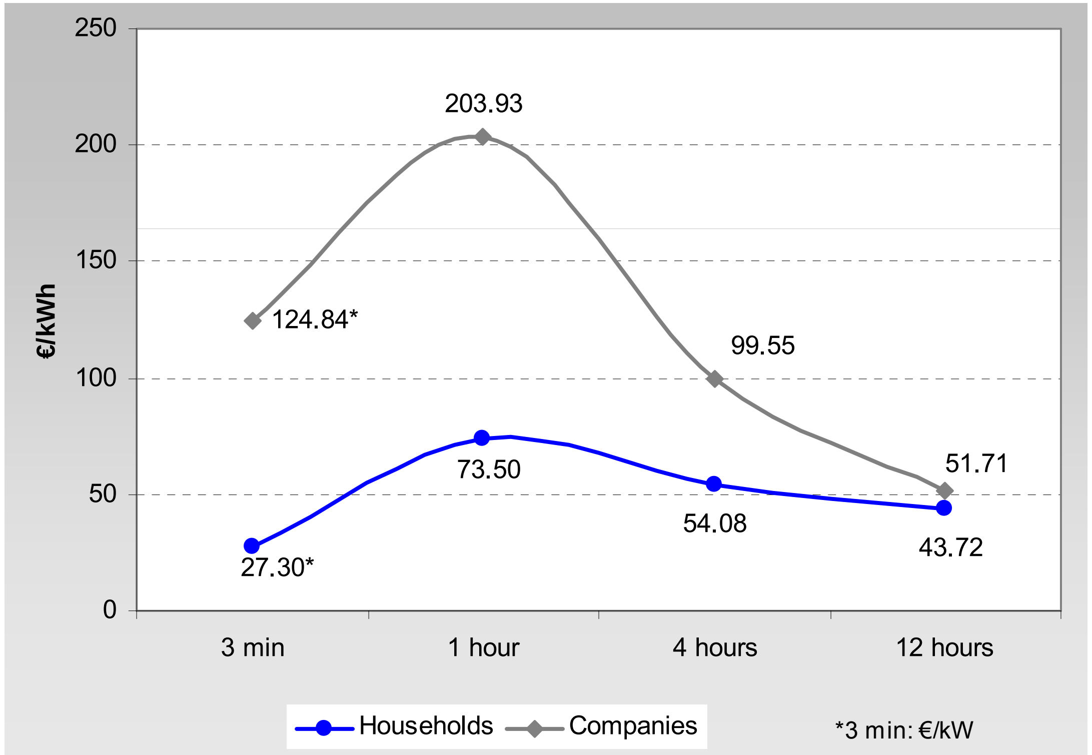
The questionnaire was developed to obtain information about:

- Direct economic interruption costs.
- The willingness to pay (WTP) to avoid a power outage of a certain duration.
- A choice experiment was carried out to identify the preferences that both groups of consumers have for improvements/deterioration in some service quality aspects.

Empirical Results - Direct Costs

In the survey, the respondents were asked to state their direct economic interruption costs of a certain duration at 2 pm on a working-day in summer. → scenario was chosen because it represents a worst case!

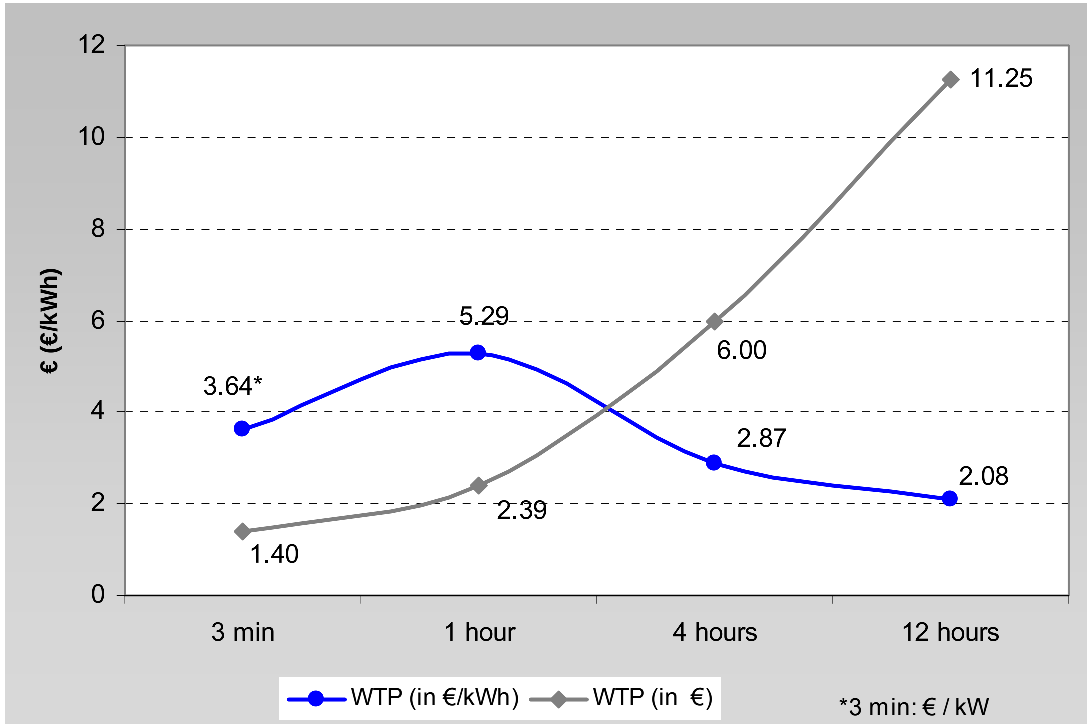
Figure: Direct costs (values are normalized with regard to the energy not supplied (€/kWh))



Empirical Results - CV I

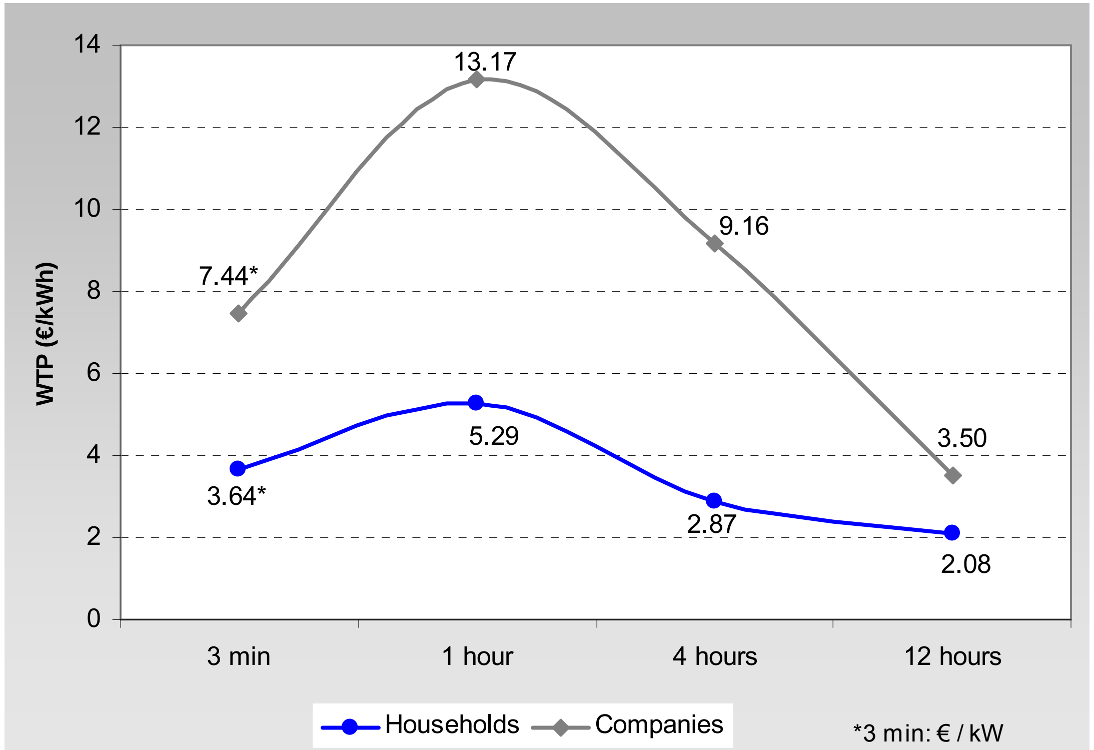
Households and commercial respondents were asked to state their maximum WTP for avoiding one power outage of a certain duration at 2 pm on a working-day in summer.

Figure: Normalized WTP for households



Empirical Results - CV II

Figure: WTP domestic and business electricity consumers (values are normalized with regard to the energy not supplied (€/kWh))



Comparison to existing studies I

Results are very similar to values for e.g. Italy or Sweden.

Table: WTP (€/kWh) for domestic and business electricity consumers in Austria and Italy (3 min. interruptions, €/kW)

	AUSTRIA		**ITALY***	
	Households	*Business*	*Households*	*Business*
3 min	3.64	7.44	1.38	4.90
1 hour	5.29	13.17	3.75	10.70
4 hours	2.87	9.16	2.25	6.63
8 hours	-	-	1.36	3.98
12 hours	2.08	3.50	-	-

*) Bertazzi, A.; Fumagalli, E. und Lo Schiavo, L. (2005). The Use of Customer Outage Cost Surveys in Policy Decision-Making: The Italian Experience in Regulating Quality of Electricity Supply. 18th International Conference on Electricity Distribution, Turin.

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Comparison to existing studies II

Table: WTP for domestic electricity consumers in Austria and Sweden (€/outage)

	AUSTRIA	SWEDEN**
3 min	1.40	-
1 hour	2.39	1.02
4 hours	6.00	4.04
8 hours	-	11.76
12 hours	11.25	-
24 hours	-	24.26

**) Carlsson, F. und Martinsson, P. (2007). Willingness to Pay Among Swedish Households to Avoid Power Outages, A Random Parameter Tobit Model Approach, The Energy Journal 28, 75-89.

Divergence between direct costs and WTP

- Respondents have no personal experience with (long) power outages → lead to overestimation of direct costs.
- Most households do not experience any tangible economic losses when an interruption occurs → direct cost values are based on subjective issues, subjective expectations, subjective well-being.
- Strategic response from the respondents → overestimate their costs in the hope of directing more investments towards quality problems.
- ???

Choice Experiment Design and Application

• First step: Identify attributes; the range over which they vary must be set. The levels were presented as chances from the status quo!

• Second step: Define the monetary attribute to allow the estimation of WTP. Payment vehicle: Change in current electricity price.

• D-optimal design was used to combine the levels of the attributes into a number of alternatives (software JMP). The D-optimality criterion seeks to maximize the determinant of the information matrix, or to minimize the determinant of the variance-covariance matrix of the parameter estimators.

• 16 choice sets were randomly assigned to four blocks that a single respondent was confronted with four choice sets.

Attributes and Levels

Attribute	Level
duration (duration of outages in minutes/hours)	3 minutes, 30 minutes (current situation), 4 hours, 10 hours
frequency (number of outages per year)	0.5, 1 (current situation), 4, 10
time of day	Day, Night
day of the week	Tuesday, Sunday
advance notification of outage	None, yes
price (change in current bill)	No change, - 20 %, - 10 %, + 10 %

Choice Set Example

	Number of outages / year	Duration of outages	Day of the week	Time of day	Advanced notification	Change in current bill	I choose...
Option A	4 outages / year	4 hours	Tuesday	Night	no	-10 %	☐
Option B (Status quo)	1 outage / year	30 minutes	Tuesday	Day	no	No change	☐

In the choice experiment each choice set consisted of two options, one of which represented the ‘status quo’ (describing the current level of service reliability).

The level of the attributes included varied over all choice sets in alternative A, while alternative B represented the status quo.

Random-Effects-Probit Model – Households

Variable	Coefficient
Duration 3min	-0.114
	(0.117)
Duration 4h	-1.354**
	(0.165)
Duration 10h	-1.887**
	(0.153)
Frequency	-0.125**
	(0.014)
Price	-0.084**
	(0.007)
Time of day (night)	-0.061
	(0.119)
Day of the week (Sunday)	-0.617**
	(0.141)
Notification (yes)	0.237
	(0.124)
Working* frequency	-0.061*
	(0.027)
Working* Day of the week	0.325**
	(0.101)
Constant	0.220
	(0.128)
σ_v	0.725
ρ	0.344
Observations	1573
Number of nr	403
Wald Chi-squared(11) = 297.62	
* significant at 5%; ** significant at 1%	

Implicit Price - Households

Table: Implicit price estimates for households (in %)

Attribute	Coefficient	95 % Confidence Interval	
Duration 3min	-1.35	-4.05	1.33
Duration 4h	-16.07	-18.76	-13.37
Duration 10h	-22.38	-26.21	-18.55
Frequency	-1.49	-1.85	-1.12
Time of day (night)	-0.73	-3.46	1.99
Day of the week (Sunday)	-7.32	-9.94	-4.71
Notification (yes)	2.81	0.11	5.51

Random-Effects-Probit Model - Companies

Variable	Coefficient
Duration 3min	0.127
	(0.127)
Duration 4h	-0.272
	(0.162)
Duration 10h	-0.539**
	(0.142)
Frequency	-0.157**
	(0.028)
Price	-0.027**
	(0.006)
Time of day (night)	0.382**
	(0.142)
Day of the week (Sunday)	0.429**
	(0.148)
Notification (yes)	-0.056
	(0.137)
Precaution*duration	-0.096*
	(0.044)
satisfaction*frequency	0.035**
	(0.013)
Constant	-0.046
	(0.231)
σ_v	1.019
ρ	0.509
Observations	1468
Number of nr	367

Wald Chi-squared(10) = 143.94
* significant at 5%; ** significant at 1%

Implicit Price - Business

Table: Implicit price estimates for commercial respondents (in %)

Attribute	Coefficient	95 % Confidence Interval	
Duration 3min	4.64	-4.99	14.28
Duration 4h	-9.92	-19.30	-0.55
Duration 10h	-19.62	-30.85	-8.40
Frequency	-5.71	-8.81	-2.61
Time of day (night)	13.92	-0.44	28.30
Day of the week (Sunday)	15.64	-0.24	31.53
Notification (yes)	-2.03	-11.45	7.38

Some further considerations

• Results of the survey can be used to develop a regulation scheme that explicitly takes into account reliability of supply.

• In brief: the task of a penalty and reward system is to weight each temporal change of service reliability with consumers' marginal WTP thereby making it possible to internalize consumer preferences and WTP to avoid interruptions to the firm's decision-making-process.

• Utilities have the incentive to improve service reliability up to the point where the cost equals the consumers WTP for quality.

Proposal for a Quality Regulation Model

- Since 1 January 2006 Price-Cap Regulation (Systemnutzungstarife-Verordnung):

$$p_1 = p_0 \, (1 + NPI - X \pm Q)$$

where NPI is the net price index, X is the efficiency gain fixed by the regulator for a three year tariff period, and Q is a quality parameter.

- Currently, the Austrian Regulation Authority collects data on the frequency (SAIFI) and duration (SAIDI) of outages.

- Based on these statistics it is possible to derive an individual reference target for regulated utilities.

The Model I

- Yearly values of the parameter Q can be calculated, ex post, on the basis of company performances and relative financial incentives.

- Average reliability of network operator i over a period of M years, beginning in year T.

$$\overline{SAIDI}_{i,T,...,T+M-1} = \frac{SAIDI_{i,T} + ... + SAIDI_{i,T+M-1}}{M}$$

SAIDI…System Average Interruption Duration Index [min/a]
i…system (grid) operator
M…given period
T…first year
$\overline{SAIDI_i}$ ...moving average

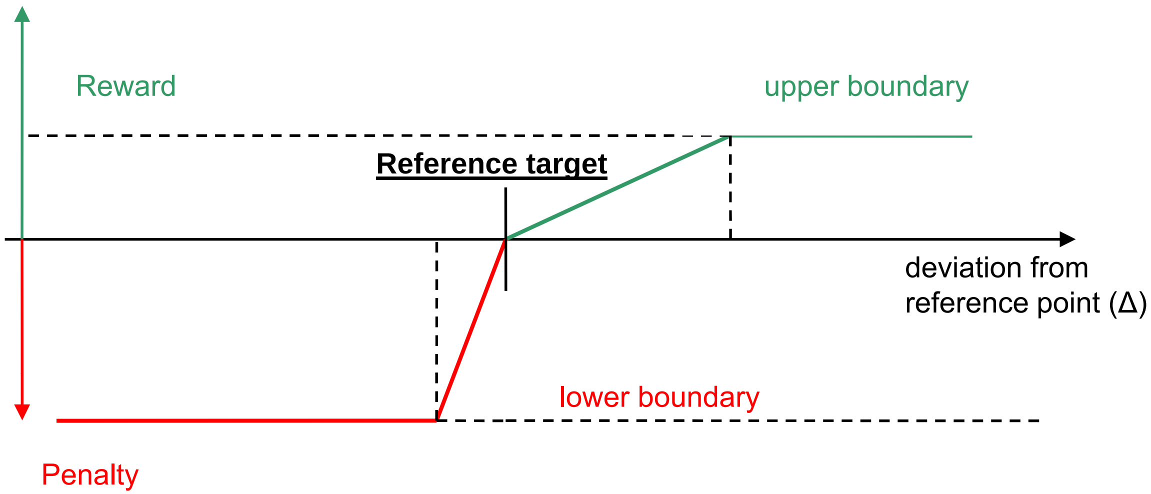
The Model II

- Quality-related company performances can be measured annually, as the difference (negative or positive) between the reference ($SAIDI_{ref}$) and a moving average of the measured SAIDI per each territorial district (Δ).

$$\Delta_{i,d} = SAIDI_{ref} - \overline{SAIDI}_{i,T,\ldots,T+M-1}$$

The Model III

Figure: Example of penalty or reward scheme



The level of reward or penalty depends on the deviation from the reliability target. If the actual level of reliability is higher than the individual reference target, the utility obtains a reward. If the actual level is lower than the reference target, the utility is penalised.

Thank you very much for your attention!

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