The value of Energy Supply Security in Austria

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Energy Institute at the Johannes Kepler University Linz

16.02.2012

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Motivation for research on Energy Supply Security (ESS)

- **Goal I:** Elicitation of damage costs (firms) and WTP to avoid power cuts (households)⇒ relevant for (energy) policy making
- **Goal II:** Value of ESS necessary for benefit-cost analyses
- Important for energy policy decisions
  - E.g. Important for infrastructure investment analyses

ESS valuation is challenging & requires new approaches

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Methodology: ESS quantification for households & firms

3 Stage process (household⇒non-households⇒aggregation)

ESS is a different kind of good for firms and households

⇒Combined approach was chosen:

- *Contingent Valuation (CVM) for Households* ($n \approx 1,300$)
- *Value-added approach for Non-households* ($n \approx 300$)

- **Households' WTP**: Welfare losses represent only a part of the total power cut damages (ranging from **2%**[1] to **85 %**[2])
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  Outage costs computation for every $OENACE_{2008}$ sector:
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Current Level of electricity supply reliability in Europe

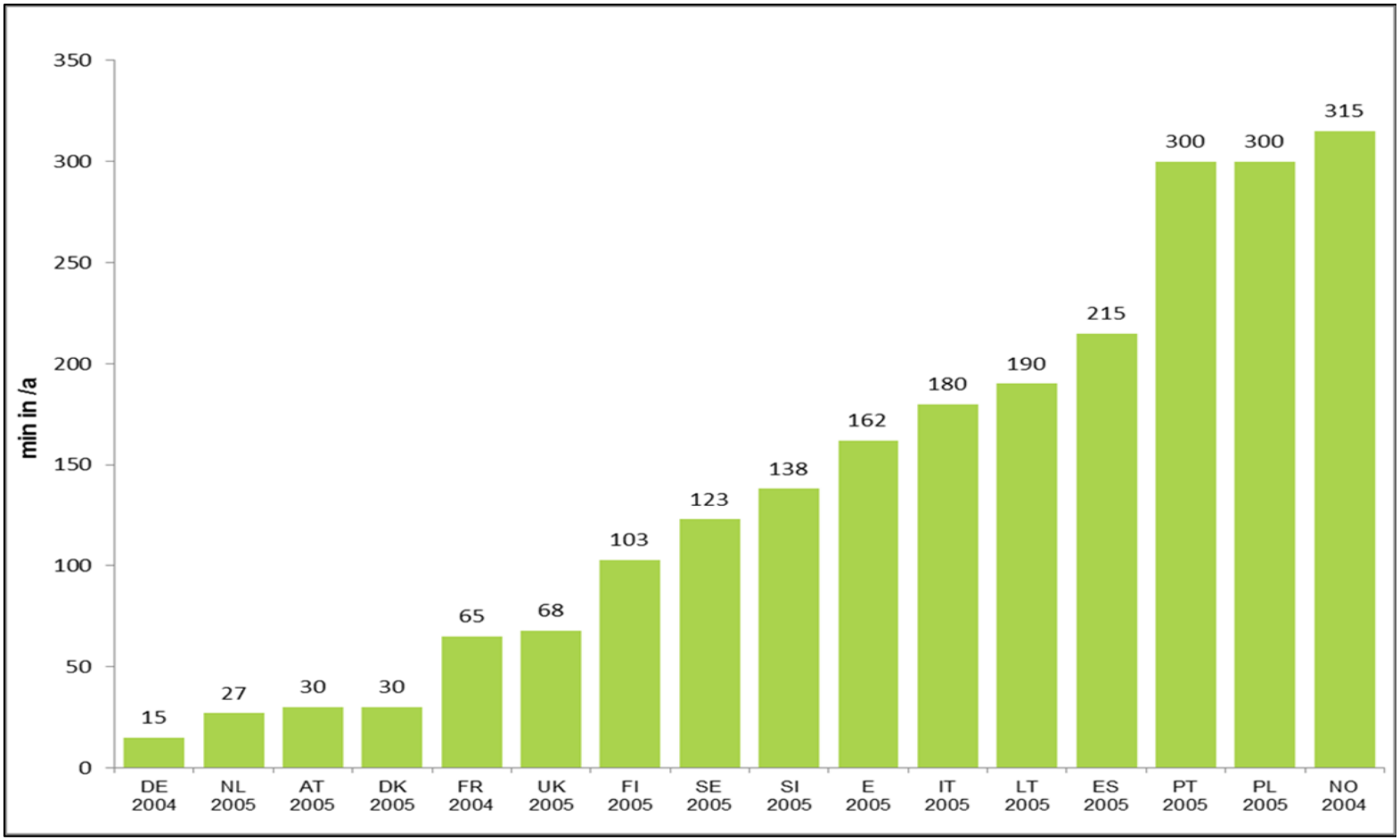

Figure: Customer Average Interruption Duration Index (CEER, 2008)

Socio-demographics of the survey sample

- Four groups to control for survey effects (sample $n \approx 1,300$):
  - face-to-face vs. online survey
  - test vs. control group (smart meter data vs. no information)
  - with and without incentive

Table: Descriptive statistics of the household sample

Household income	EUR 2,311
City	47 percent
Age of participants	40.54 years
Presence of children	22 percent
Education=Matura	60 percent
Male Participants	58 percent

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Realization of discrete choice setting in the questionnaire

Scenario 1: Overnight winter power outage in three states in Austria with prior warning

Outage area: Upper Austria, Lower Austria, Salzburg

Advance warning: Yes, 3 days in advance

Time of year: from December to February

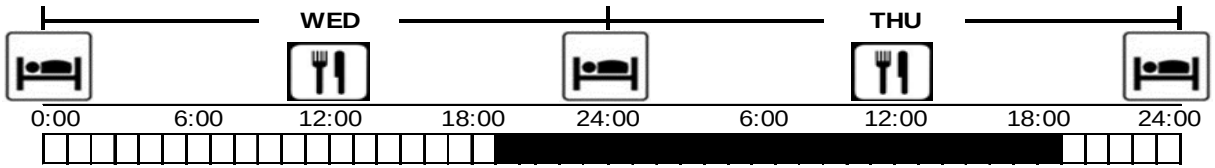
The power cut listed here will be avoided if you agree to pay the one time-fee	**Costs for the next 2 years**	**Willing to pay?**
Begins: 7 p.m. **Ends:** 7 p.m. 	17 €	☐ YES ☐ NO

Figure: Questionnaire implementation of discrete choice scenarios

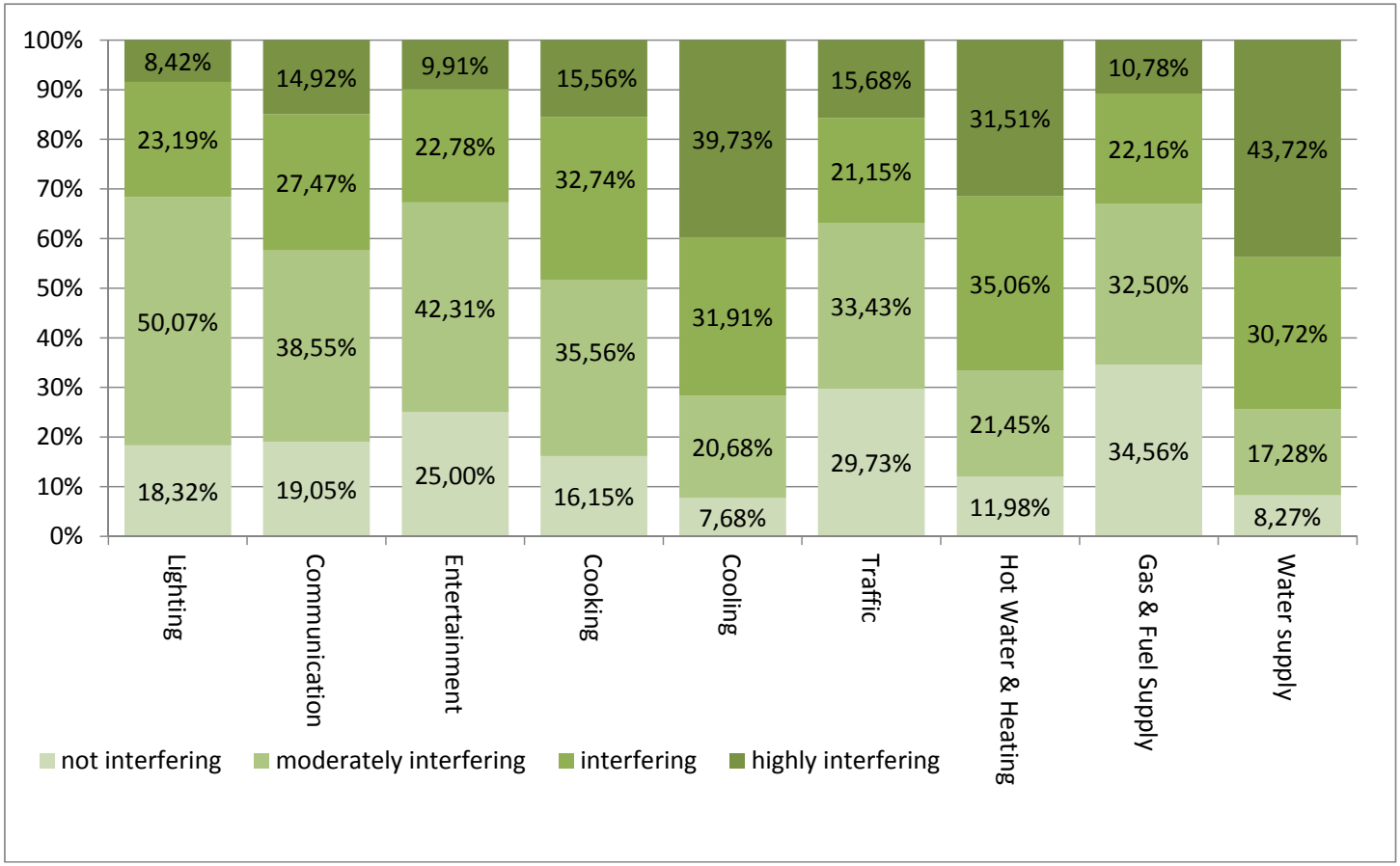
Housholds' satisfaction with their level of supply security

Question: *How satisfied are you with the number and duration of supply interruptions in your household?*

Table: Satisfaction with electricity supply security

Level of satisfaction	percentage
Very satisfied	75.5
Satisfied	21.3
Moderately satisfied	2.1
Not satisfied	1.2

Adverse effects due to power cuts (affected services)



Households' experience with power outages

Question: *Have you ever experienced a power outage?*

Table: Households' experience with power outages

Duration of outage	share of participants
Never experienced one	6.8 percent
Less than 5 minutes	5.0 percent
Up to 1 hour	23.7 percent
Up to 4 hours	36.5 percent
Up to 8 hours	15.4 percent
To 24 hours	5.8 percent
Longer than 24 hours	6.8 percent

Personal perception of power outages (Level of Interference)

Question: *How disturbing/interfering is a power outage in the summer for you (in percent)?*

Table: Level of disturbance of outages dependent on their duration

	Immediately	after one hour	after 4 hours	after 24 hours
Not interfering	58.6	35.0	14.4	4.0
Moderately interfering	27.9	46.4	37.9	15.0
Strongly interfering	8.1	12.4	31.0	27.3
Very strongly interfering	5.3	5.9	16.7	53.8

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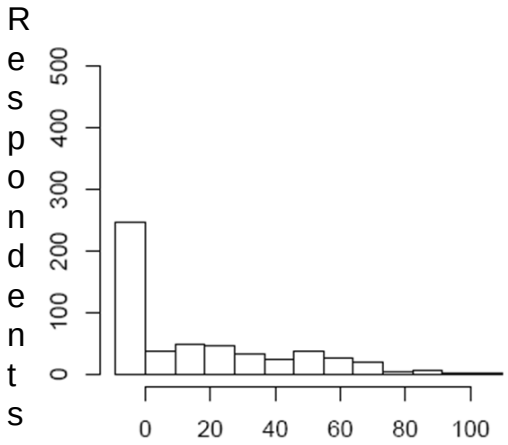
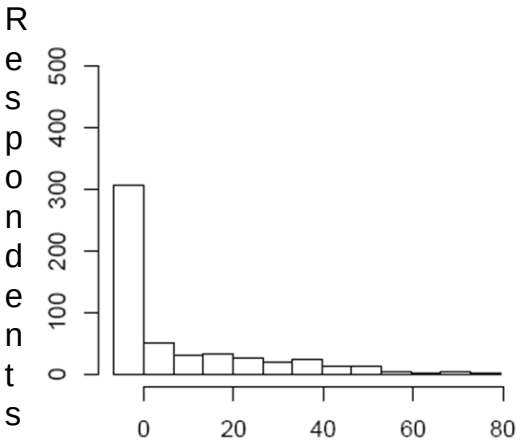
Willingness to Pay to avoid Power Outages



WTP for a 24-hours outage



WTP for a 12-hours outage

24h: WTP €17,3

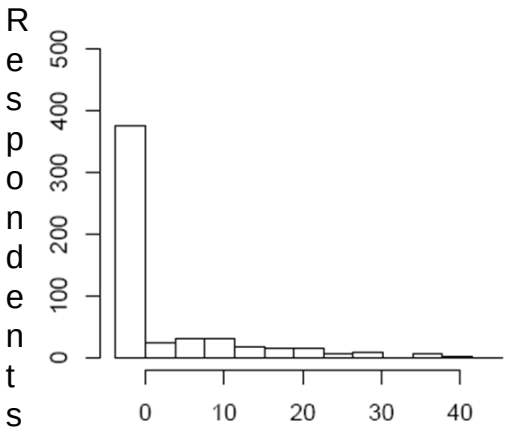
(41% have WTP=0)

12h: WTP €9,9

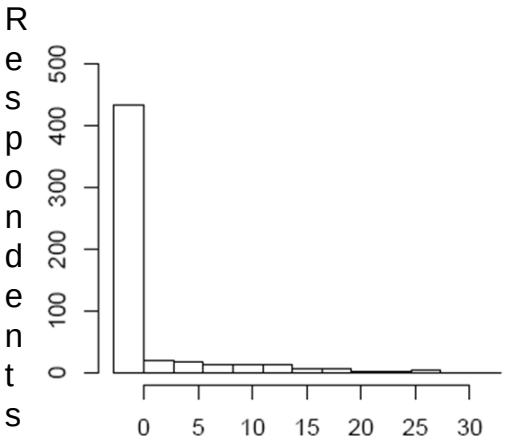
(56% have WTP=0)

4h: WTP €3,8

(71% have WTP=0)



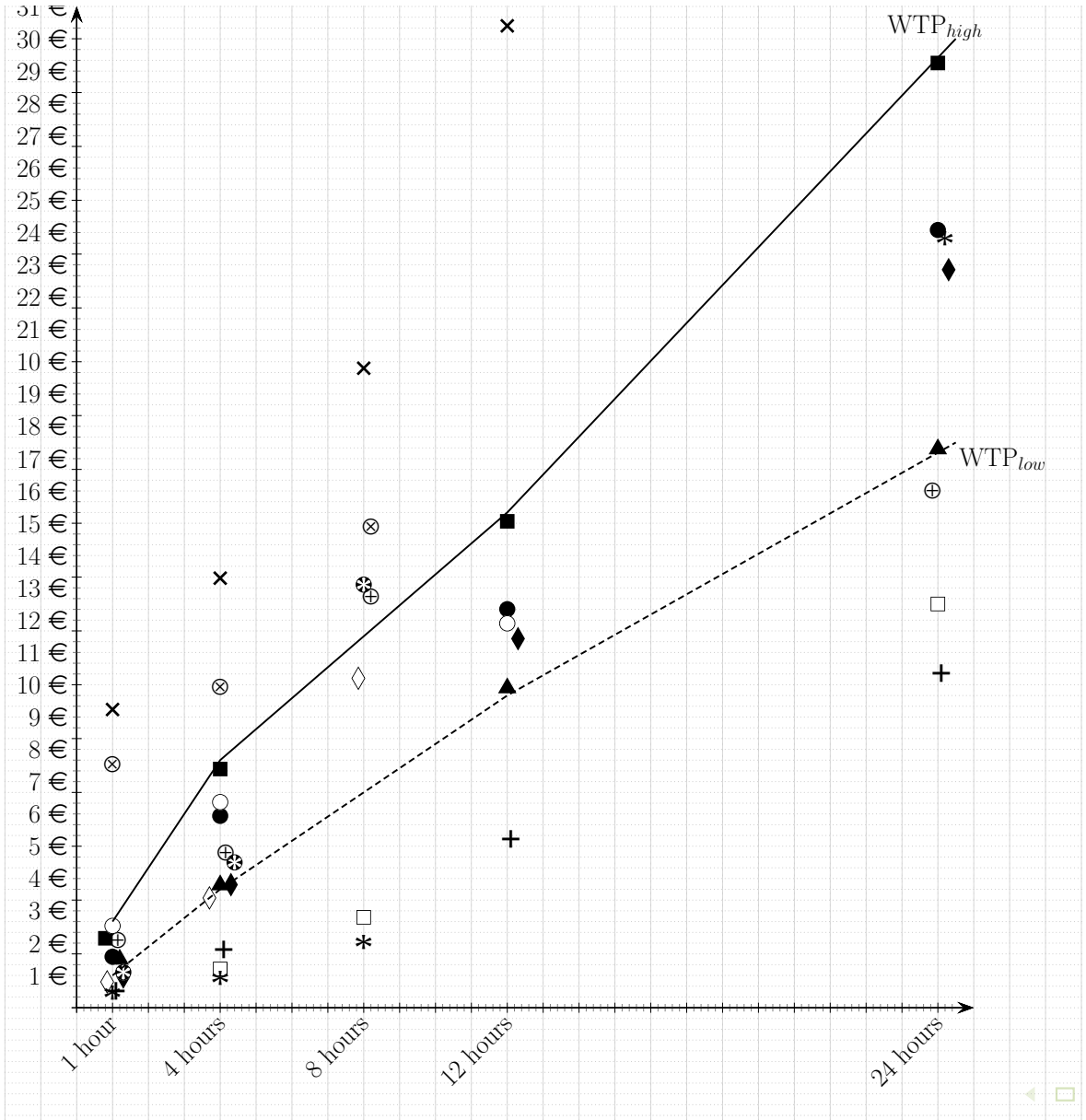
WTP for a 4-hours outage



WTP for a one-hour outage

1h: WTP €1,4

(83% have WTP=0)



- ■ Austria, RE-Probit
- ● Austria, RE-Logit
- ▲ Austria, Bayes
- \+ Austria, $WTP_{open2.5}$
- ♦ Austria, WTA_{open}
- × Woo, USA1991
- ◇ Sweden, planned Carlsson, 2008
- □ Sweden, weekend Carlsson, 2008
- ⋆ Sweden, unplanned Carlsson, 2008
- ⊕ Austria, Reichl, 2006
- ⊗ USA, winter Doane et al., 1990
- ∗ USA, Summer Sangvhi et al., 1983
- ○ Austria, workday Bliem, 2007

Determinants of Respondents' WTP

- Characteristics of Outage
  - Origin (bad weather event *vs.* malicious attack)
  - Geographical extent of outage (residential street *vs.* 3 states)
  - Premonition (no premonition *vs.* 3 days ahead)
  - Season (winter *vs.* summer)
  - Daytime (working hours *vs.* spare time)
- Characteristics of the Respondents
  - Income
  - Sex
  - Age
  - Education
  - Size of residential area
  - Children below 14 in household
  - Experience with longer outages

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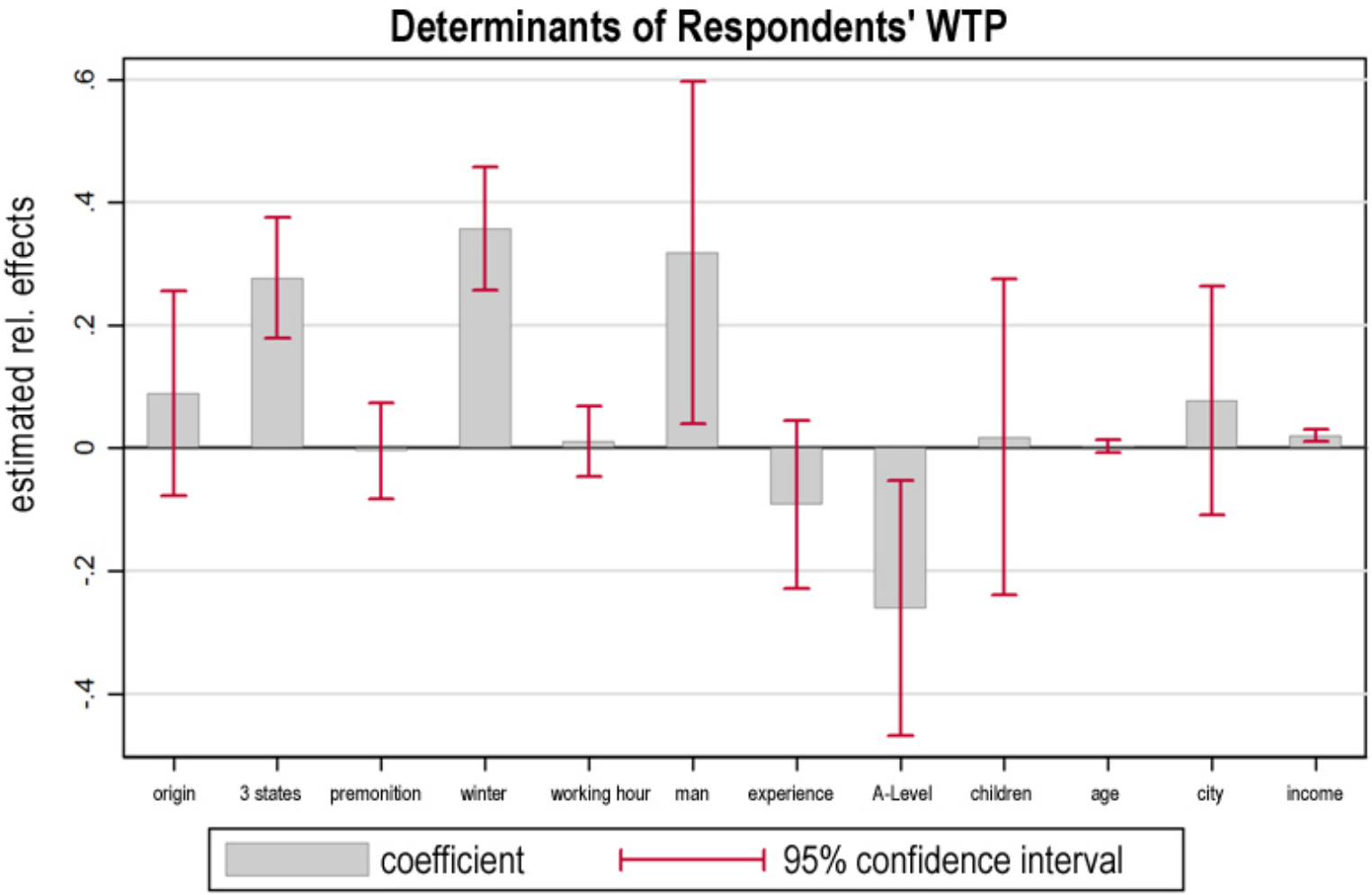
Determinants of Respondents' WTP



Determinants of respondents' WTP

- Geographical extent of outage (residential street *vs.* 3 states)
  Increase of WTP of 28%
  - larger extent reduces options to "escape" the outage
  - lost recreation value increases
- Season (winter *vs.* summer)
  Increase of WTP of 36%
  - electric is required earlier for lighting in winter
  - more substantial applications in winter, e.g. heating
- Income
  Increase of WTP of 2% per 100€
  - in economic terms: electricity is a *normal* good (demand for inferior goods↓ as income↑, e.g. wine in Tetra Pak)
  - recreational activities demand more electricity as incomes↑

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Determinants of Respondents' WTP

- Sex
  Increase of WTP of 32% for men
  - recreational activities of men are more electricity-demanding
  - men have higher income
- Education (general qualification for university entrance)
  Decrease of WTP of 26%
  - adaptation is easier for higher educated persons "reading instead of watching TV"
  - higher overall feeling of safety of higher educated persons
- Experience with outages of more than 4 hours
  Decrease of WTP of 9%
  - adverse effects discussed in literature
  - adaptation to recurring events
  - "overestimation" of true limitations of unexperienced persons

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Elicitation of vulnerabilities of Non-Households

Survey as individual vulnerability assessment $\Rightarrow$ Implemented in damage costs analysis based on value-added

Table: Attributes of participating Non-households

Size of the participating companies	percent
Small companies 1 to 10 employees	35 percent
Small companies 11 to 50 employees	21 percent
Medium companies 51 to 250 employees	23 percent
More than 250 employees	21 percent

Characteristics of participating Non-households

Table: Firms' knowledge about their electricity consumption

Yes, the exact amount of electricity consumed per year (kWh) is known.	36%
Yes, the approximate magnitude of the annual amount of electricity consumed (in kWh) is known.	14%
Yes, the exact annual cost of electricity (in €) are known.	23%
Yes, the approximate magnitude of the annual expenditure on electricity (in €) is known.	14%
Neither quantity nor expenses are known.	12%

Entry page: Information about the outage

APOSTEL allows to simulate the effects of power outages

Date of outage start	16.02.2012
Starting time of power supply interruption	10:00
Duration of power supply interruption (in hours)	10
Regional scale of the power outage (state level)	Styria
Date check	The day the power outage occurs is a workday. .

Figure: APOSTEL entry page - Information

Distribution of monetary damages to economic sectors

	Sector Code according to ÖNACE 2008	Energy not supplied (in MwH)	Total damage (in 1,000 Euro)
Primary sector	A, B	392	1.316
Secondary sector	C, D, E, F	7.119	23.431
Tertiary sector	G,H,I,J,K,L,M,N,O,P,Q,R,S,T,U	2.744	27.059
	Sum	**10.256**	**51.806**

Figure: Distribution of monetary damages to economic sectors

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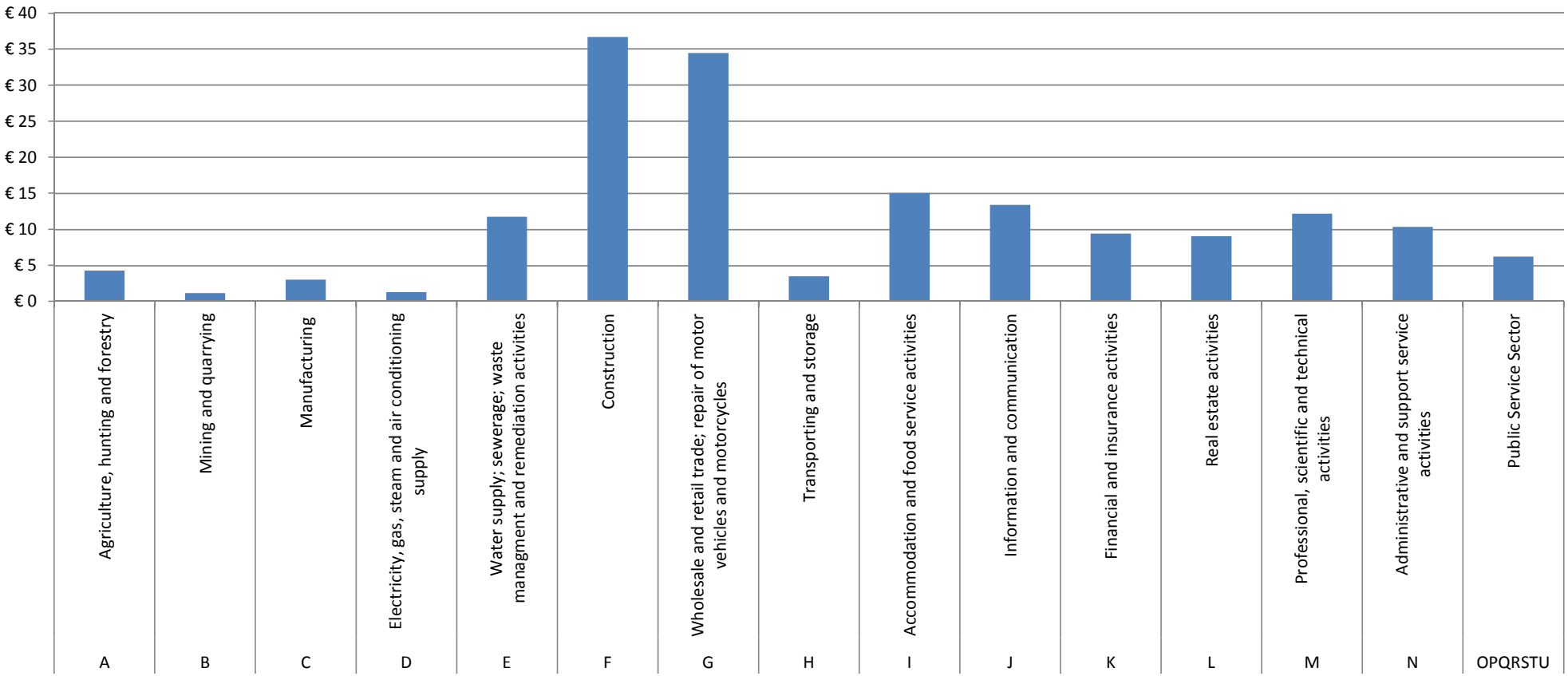
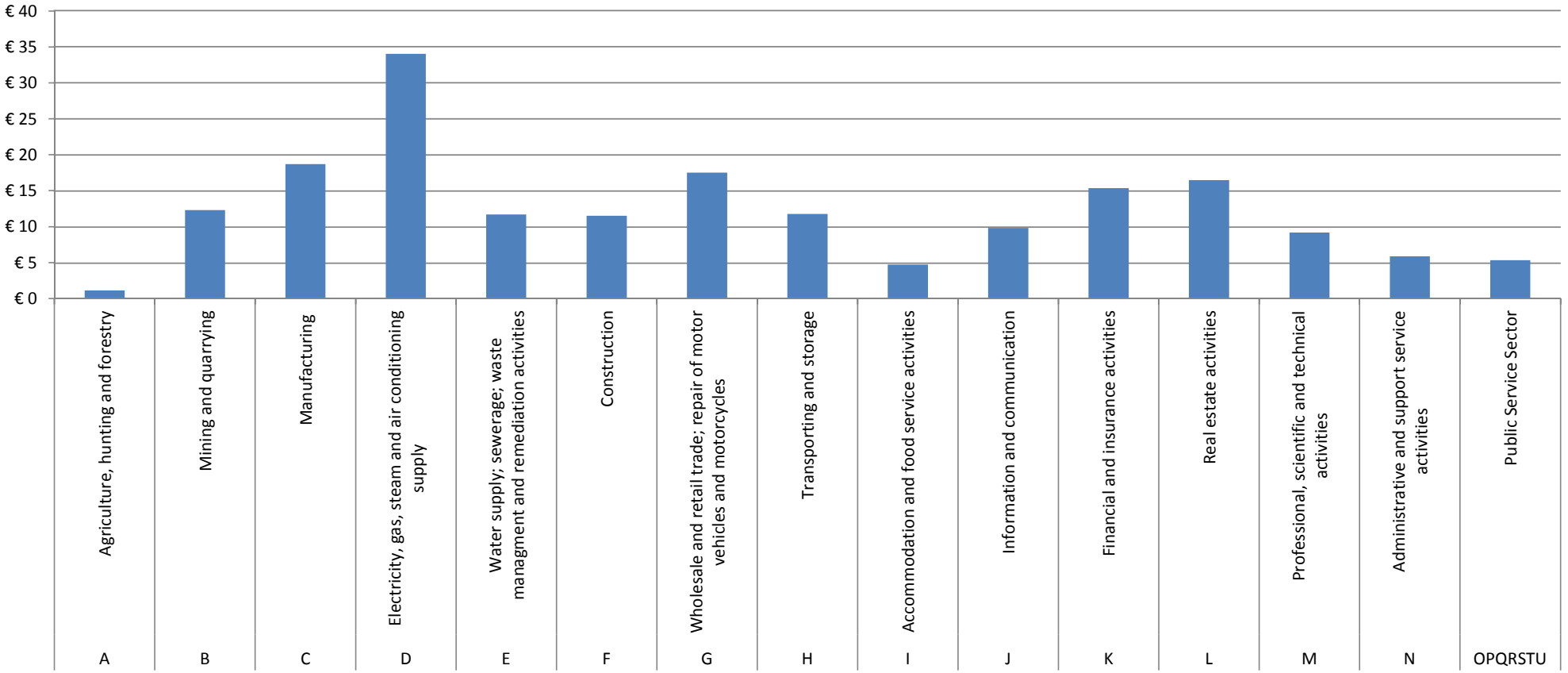
Damage per kWh unserved - VOLL

„Value of Lost Load" (VOLL) measures the damage costs per unserved kWh electricity



Damage per hour of outage and employee

New definition of classification figure aimed at overcoming some drawbacks of the ,,Value of Lost Load" figure (VOLL)



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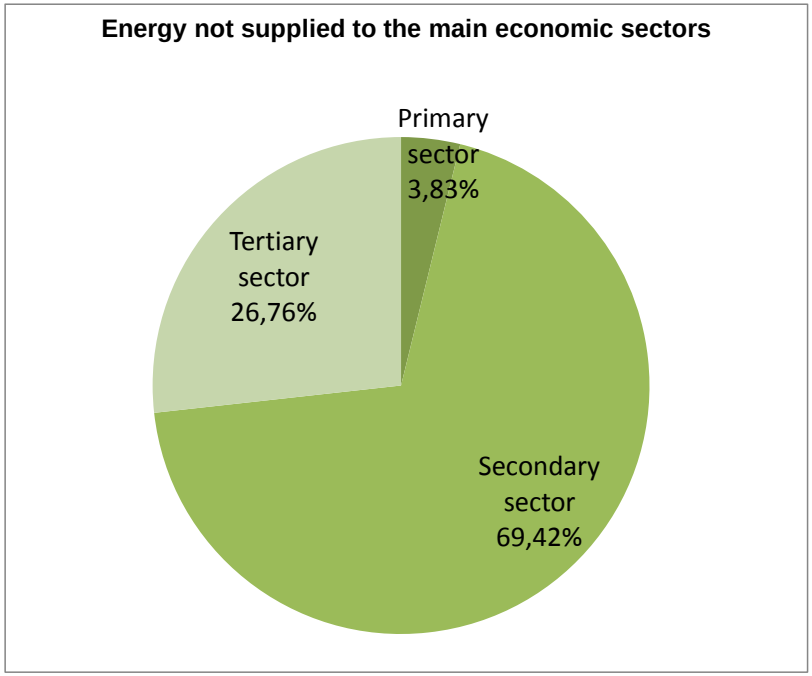

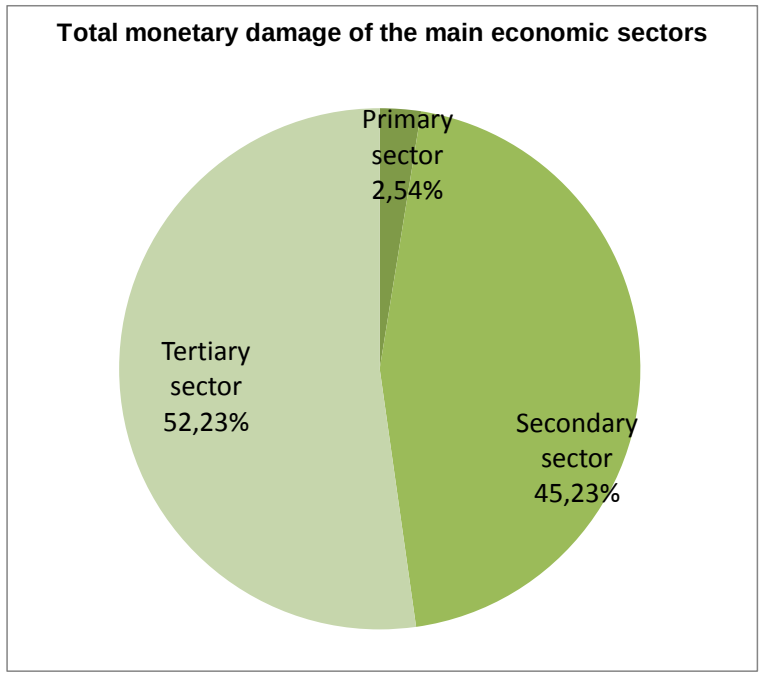

Figure: Distribution of monetary damages to economic sectors

Assessments of households

Summary of affected households, energy not supplied and Willingness to pay to avoid the specified outage scenario

Number of households in the area of the outage	500.921
Number of Inhabitants in the area of the outage	1.195.300
Number of adversely or strongly adversely affected households	210.387
Number of adversely or strongly adversely affected inhabitants	502.026
Energy not supplied (in MWh)	3.288
WTP to avoid the outage (in 1,000 €)	4.732
VOLL (in €/kWh)	1,44

Figure: Assessments of affected households

Summary of main findings

- Different models for WTP applied ⇒ **Very Similar Results!!**
- Total costs of a 10h Blackout in Austria: **EUR 502 Mio.**
- ⇒Central Finding: Value Of Lost Load **(VOLL)** for a power cut of 1h on a summer workday morning is **EUR 17.1/kWh.**
- The **value of a secure energy supply** by far **exceeds the price of one unit of electricity** (factor $n \approx 100$)

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Thank you for your attention

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