FINNISH METEOROLOGICAL INSTITUTE

COST-BENEFIT ANALYSIS:
underground cabeling of power distribution networks as a climate change adaptation measure

Väinö Nurmi
Finnish Meteorological Institute

BACKGROUND

This study was undertaken in ELASTINEN project, which is part of the implementation of the 2015 Government plan for Analysis, Assessment and Research (www.tietokayttoon.fi/en). The producers of the information are responsible for its content and it does not necessarily represent the views of the Government.

As an example of how to use economic analysis methods to analyse climate change adaptation measures, cost-benefit analysis of Electricity Market Act 2013 was conducted. – *Policy support – not a thorough academic study*

Electricity Market Act 2013 requires that in **rural areas** (excluding premises without permanent residents), blackouts **shall not last over 36 hours**, and in **urban areas** blackouts **shall not last over 6 hours.**

Electricity distribution companies are therefore required to improve the reliability of their networks. Transition period lasts until 2029, and mid-term goals have to be reached by 2019 and 2023.

AIM AND STUDY AREA

Analyse the costs and benefits of the requirements of the Electricity Market Act

Specifically:

i) Is the price paid by consumers higher than the benefits obtained due to improved network reliability

ii) How thorough was the analysis done prior to the renewal of the Act (e.g. Partanen ym., 2012)

iii) What is the reliability of the analysis, considering data availability

Region: Pirkanmaa, and surrounding areas where electricity distribution companies operating in Pirkanmaa also operate

Altogether **1,1 million customers**; approximately 31% of the entire electricity distribution network in Finland

Division of different user groups	Agriculture	Industry	Services and construction	Households	Sum
Share %	0.6	0.6	0.6	98.2	100
Amount	6 600	6 600	6 600	1 080 200	1 100 000

DATA

BENEFITS

- Economic damage (*in willingness-to-pay as the customer pays the bill*) due to blackout accrued to consumers and companies
- Current length of blackouts and assumed length after the required reliability stated in the Act is achieved
- Blackout data acquired from Enease Oy that collects them from electricity distribution companies

COSTS

- Electricity distribution network in the area (Energiavirasto)
- Current share of underground cables in the area (Energiavirasto)
- Required share of underground cables (Partanen et al. 2012)
- Costs of underground cabling in urban and rural areas (Energiavirasto and interviews)

Economic damage from blackouts to consumers and companies

CONSUMERS: Willingness-to-pay

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Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)    9.8702     5.3269   1.853    0.101
KestoTuntia   10.1395     0.3138  32.314 9.17e-10
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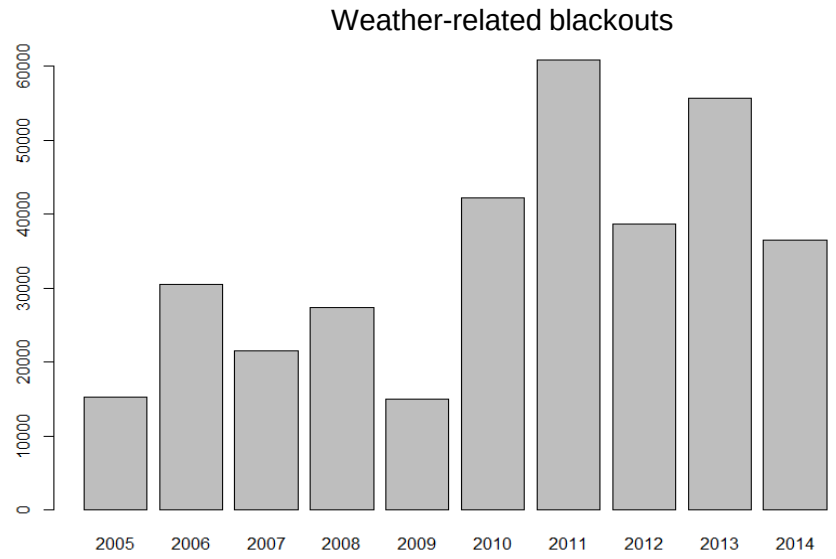
WTP
Winter: 1.7 € (1 second) to 368.7 € (36 h)
Summer: 1.8 (1 second) to 366.5 € (36 h)
No statistical difference

Approximated from surveys conducted in Finland.
Meta-analysis was conducted for international literature; values close to the values in Finland.
High disparity between WTP and WTA, behavioural anomalies? Income elasticity of WTP on average 18 – not realistic

COMPANIES: lost profit

- Usually estimated by Lost value of production and translated into ”KAH-values (per lost kWh)

CURRENT LENGTH OF BLACKOUTS AND ASSUMED REDUCTION



Blackouts are assumed to reduce according to the requirements stated in the Act.

BENEFITS FOR HOUSEHOLDS

- **On average 34 360 weather related blackouts per year in the study area**
- **Average blackout concerns 107 customers**
- **Altogether, consumers face approx. 3 642 000 blackouts per year**
- **Average length 3h 20 min**
- **Thanks to linearity in the damage per hour, a straighforward multiplication**

In urban areas (no electricity blackouts):
16-32 million euro per year

In rural areas (frequency halved and no blackouts over 36 hours):
28-55 million euro per year

BENEFITS FOR INDUSTRY – ONLY SMEs INCLUDED

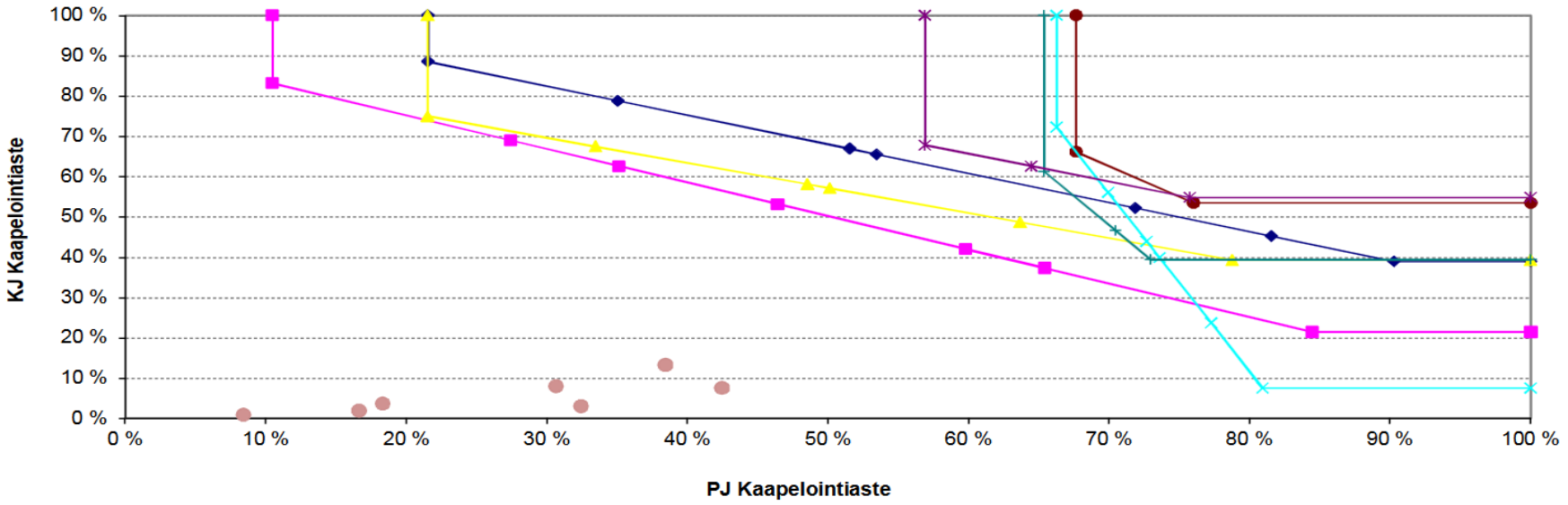
	Chemical industry	Paper and wood industry	Metal industry	Mining
Number of firms	600	300	1 500	150
Number of blackouts / year / firm	3.3	3.3	3.3	3.3
Length of blackouts / blackout (hours)	3,37	3,37	3,37	3,37
Yearly damage / firm (€)	2 090	1 770	1 560	350
Yearly damage, sector (€)	1 260 000	530 000	2 300 000	50 000
Yearly benefit, sector (€)	630 000	270 000	1 150 000	25 000
Uncertainty range(€)	410 000–840 000	180 000–360 000	770 000 – 1 560 000	17 000 – 34 000

BENEFITS - AGRICULTURE

- Yearly damage to an average farm: 110 euro
- Total damage to agriculture 600 000 euro
- Assume that blackout frequency halves, benefit 300 000 €

How much cabling is necessary?

- In urban areas, both low and medium voltage network 100% cabling required
- In rural areas, the required share of cabling researched by Partanen et al. (2012)



COSTS

Total investment cost in urban areas: 350-400 mil €:
Increasing the share of medium voltage power lines to 100%: 160-182 mil €
Increasing the share of low voltage power lines to 100%: 190 mil €

Total investment cost in rural areas: 550-1 150 mil €:
Medium voltage power lines 200-800 mil € (depends on the final share of underground cables: 20-50% required)
Low voltage power lines (80% share cabled): 350 mil €

Sensitivity analysis

- **Due to the WTA-WWTP disparity**, it is not clear which value from the surveys is closer to the 'true' value of welfare loss due to one-hour blackout → **50-100% sensitivity analysis for WTP-value**

- **Discounting (3% and 5 %)**:
  - Both beneftis and costs paid by the customers;
  - the initial costs are transferred to pricces over a longer time period → return-on-investment is added to the prices
  - WACC 3.2–4.5 % in 2014; has been declining since – now around 3%
  - Time preference considered with higher discount factor since the initial costs are transferred to prices before all benefits are realised – sensitivity analysis also with 5%

RESULTS

	Urban 3 %	Urban 5 %	Rural 3 %	Rural 5 %	Agriculture & industry 3 %	Agriculture & industry 5 %	Total 3 %	Total 5 %
Benefit (mil. €)	440–880	300–600	660–1 230	450–910	40–90	30–60	1 140–2 200	780–1 570
Cost (mil. €)	350–400	350–400	550–1 150	550–1 150	-	-	900–1 550	900–1 550

CONCLUSIONS

3 % Discount rate: Net Present Expected Value is positive
5 % Discount rate: Net Present Expected Value is negative

Cost-efficiency of the requirements stated in the Act depends on the assumptions used in the analysis: estimated economic damage and discount factor

Estimated economic damage (WTP) should have been studied more carefully prior to the Act → Requirements in the Act might be too strict -> spatial analysis

From the economic perspective, **a thorough CBA should have been conducted prior to the Act**