# Studies on Estimation of Costs due to Electricity Interruptions and Voltage Disturbances

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## Recent work

- In December 2010, CEER published **Guidelines of Good Practice on Estimation of Costs due to Electricity Interruptions and Voltage Disturbances,** supported by a consultant study, by SYNTEF. These GGP are intended as guidance for NRAs and other parties interested in how to design and develop nationwide cost-estimation studies.
- Several studies on the consequences of electricity disturbances have been conducted in European countries over the last few years. However most studies are focused on electricity interruptions, rather than voltage disturbances.

# Cost estimation methods

- CEER recommendations:
  - survey-based approach (questionnaires sent to a large and representative sample), and
  - case-based approach (direct interviews for few significant cases with high impact of interruptions or voltage disturbances).

- Different methods can be used, possibly in combination, including:
  - direct worth methods, which imply estimations of the consequences of voltage disturbances by the customer, and rarely takes properly into account non-monetary costs,
  - stated preference methods, based on the evaluation of Willingness to Pay and Willingness to Accept compensation.

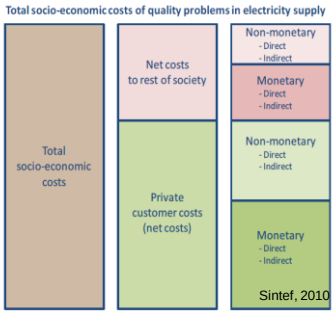


# Cost estimation methods

- In addition, as regards costs due to voltage disturbances, the CEER recommendations cover a few additional aspects, specifically for case-based VQ studies:
  - Deployment of measurement instruments,
  - Logging of events,
  - Analysis of log forms and measurement data.

# Determination of costs

- Even though they might be difficult to estimate, total socio-economic costs should be taken into account when designing regulatory measures, and not only private customer costs.






# Use of results

- Possible applications of cost-estimation studies of voltage disturbances include:
  - Input to investment decision-making process by means of contributions to cost-benefit analyses;
  - Setting of standards and reliability and security criteria.
- And further "regulatory" uses, such as:
  - Contribute to the regulatory approval of investment plans proposed by network companies;
  - Contribute to monitoring quality of supply and to assess customer expectations; understand VQ phenomena which impact more on customers, in order to prioritise VQ regulatory monitoring/treatment;
  - Contribute to monitoring/understanding customer satisfaction;
  - Contribute to designing incentive regulatory measures.

# Main conclusions from CEER GGP

- Customer costs due to voltage disturbances are important input when deciding where to focus regulation
- NRAs should ensure that nationwide cost-estimation studies on interruptions and voltage disturbances are performed
- A pre-study should define objectives, clarify country-specific characteristics, budget and consultancy needs, possible funding partners, timeline for the nationwide cost-estimation study
- Results and experiences from cost-estimation studies shall be disseminated among interested stakeholders



# Actual cost estimations for Voltage Dips

- Several recent studies provide cost-estimations for voltage dips:

France 2012 (RTE): 2.1 €/kW (Industry) - 2.8 €/kW (Large industry) - 7.1 €/kW (Commercial)

Norway 2002

| | NOK/kW | 10 NOK ~ 1.35 € €/kW |
|---|---|---|
| Industry | 30.4 | 4.1 |
| Large industry | 22.1 | 3 |
| Commercial | 5.6 | 0.8 |
| Public | 1.6 | 0.2 |
| Agriculture | 13.6 | 1.8 |
| Residential | - | - |

Italy 2010 (Delfanti et al.) and US 2005

**VOLTAGE DIPS AND V.S.I., DIRECT COST PER EVENT PER kW [€/kW-event, 2008]**

| Manufacturing sector (numb. observ. in IT survey) | Italy survey [1] Entire sample (sub-sample*) Median | Mean | Range | US survey [2] Range |
|---|---|---|---|---|
| Food products *(7)* | 0.6 | 6.1 | 0.2 – 31 | 2.6 – 4.3 |
| Textiles *(1)* | 3.3 | 3.3 | 3.3 | 1.7 – 3.4 |
| Paper *(11)* | 0.8 (0.9) | 0.9 (1.0) | 0.1 – 2.3 | 1.3 – 2.2 |
| Refined petroleum products *(1)* | 13.7 | 13.7 | 13.7 | 2.6 – 4.3 |
| Chemicals and artif. Fibres *(3)* | 0.6 (0.7) | 0.5 (0.7) | 0 (0.6) – 0.8 | 4.3 – 43° |
| Plastic products *(10)* | 1.9 | 2.3 | 0.1 – 4.3 | 2.6 – 3.9 |
| Glass and ceramic products *(4)* | 0.8 | 0.9 | 0.1 – 2.4 | 3.4 – 5.2 |
| Metals products *(3)* | 1.1 (5.1) | 3.4 (5.1) | 0 (1.1) – 9.0 | 1.7 – 3.4 |
| Electrical / electronics *(3)* | 9.6 | 10.9 | 0.2 – 23.1 | 6.9 – 10.3 |
| Auto and auto components*(2)* | 3.0 | 3.0 | 0.7 – 5.2 | 4.3 – 6.5 |
| **All observed sensible sectors** | **0.8 (1.1)** | **2.9 (3.4)** | **0 (0.1) - 31** | **n.a.** |

* *sub-sample: excluding values equal to zero, due for instance to CHP connected to the plant*
° *includes pharmaceutical*

*[1] Maurizio Delfanti, Elena Fumagalli* et al. *Towards Voltage Quality Regulation in Italy, IEEE Transactions on Power Delivery, 2010*
*[2] McGranaghan, M., Stephens, M., Roettger, B., 2005. The economics of voltage sag ride-through capabilities. EC&M, May 1, 2005. Available from: [www.ecmweb.com].*
Only for sake of convenience in comparison, results in $ (2005) have been converted in € (2008)

# Other voltage disturbances

- Very limited information is available on system-wide costs due to voltage disturbances, other than interruptions and voltage dips.
- The table below gathers "relative" impacts of voltage disturbances on the different categories of customers (Norway 1993-2010), i.e. consequences weighted individually for each customer category. For instance, regardless of the table, impacts of disturbances on Industry or Commercial services remain generally higher than impacts on Households.

| | Households | Commercial services (without "Infrastructure") | Governmental services (without "Infrastructure") | Industry (without "Large customers") | Large customers | Infrastructure |
|---|---|---|---|---|---|---|
| Frequency of the supply voltage | Low | Medium | Low | High | High | Medium |
| Supply voltage variations | Medium | Medium/high | Medium/high | Medium/high | Medium/high | Medium/high |
| Voltage dip | Medium | Medium | Medium | Medium/high | Medium/high | Medium/high |
| Voltage swells | Medium/high | Medium/high | Medium/high | Medium/high | Medium/high | Medium/high |
| Rapid voltage change | Low/medium | Low/medium | Low/medium | Low/medium | Low/medium | Low |
| Flicker | Medium | Medium | Medium | Medium | Medium | Low/medium |
| Transient over-voltages | High | High | High | High | High | High |
| Unbalance | Low/medium | Medium | Medium | Medium/high | Medium/high | Low/medium |
| Harmonic voltage | Medium | Medium | Medium | Medium/high | Medium/high | Medium |
| Interharmonic voltage | Low | Low | Low | Low/medium | Low/medium | Low |

Sintef, 2010



Thank you for your attention!

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