# SOCIO-ECONOMIC ASSESSMENT OF RELIABILITY CRITERIA


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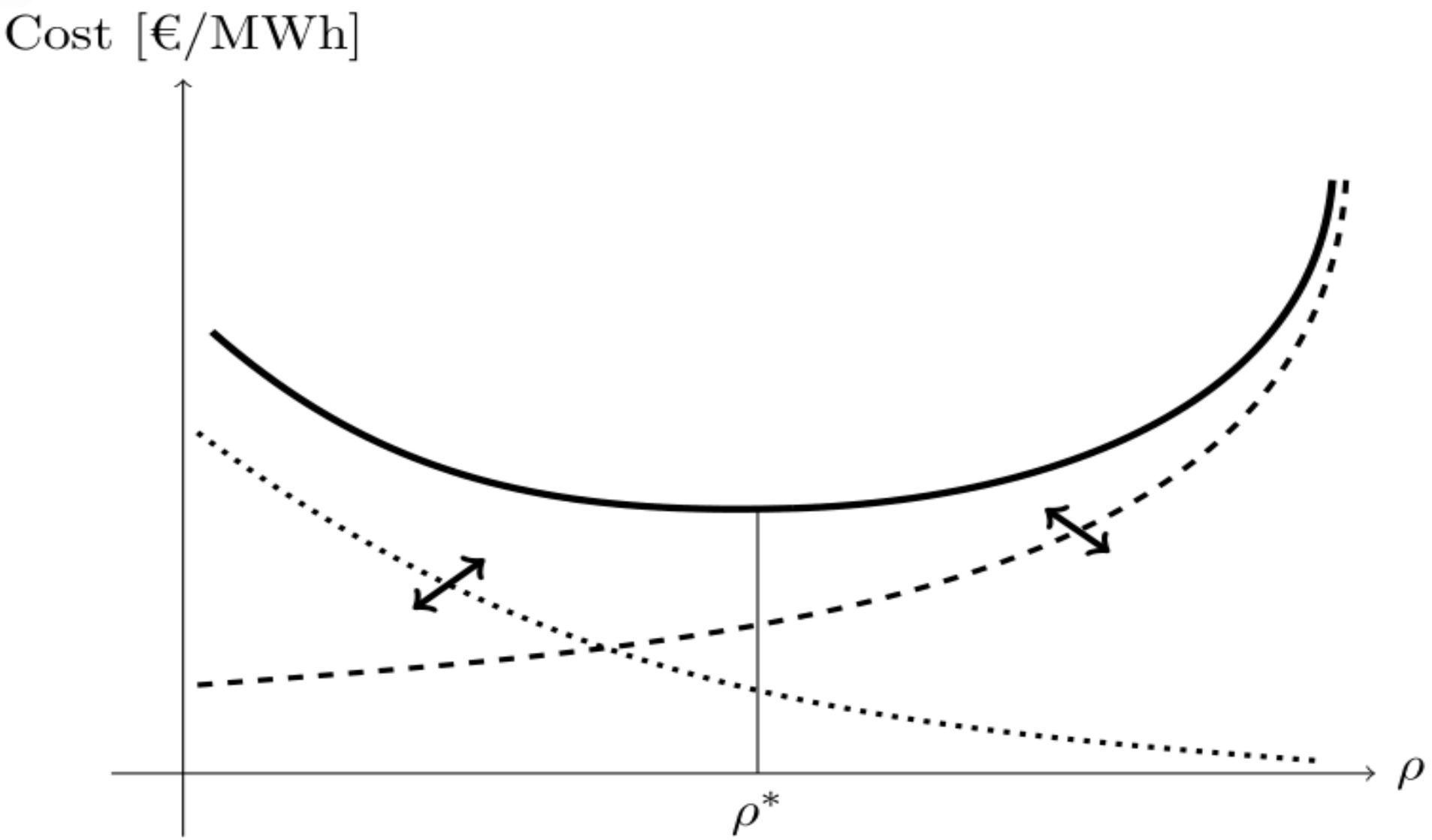
# The basic trade-off: benefits of reliability vs. costs of providing it



# OBJECTIVE

- **Develop methodology to quantitatively evaluate socio-economic impact of different reliability management approaches and criteria**

- **The Socio-Economic Impact Assessment (SEIA) methodology focuses on *socio-economic surplus* as the key economic measure of impact**

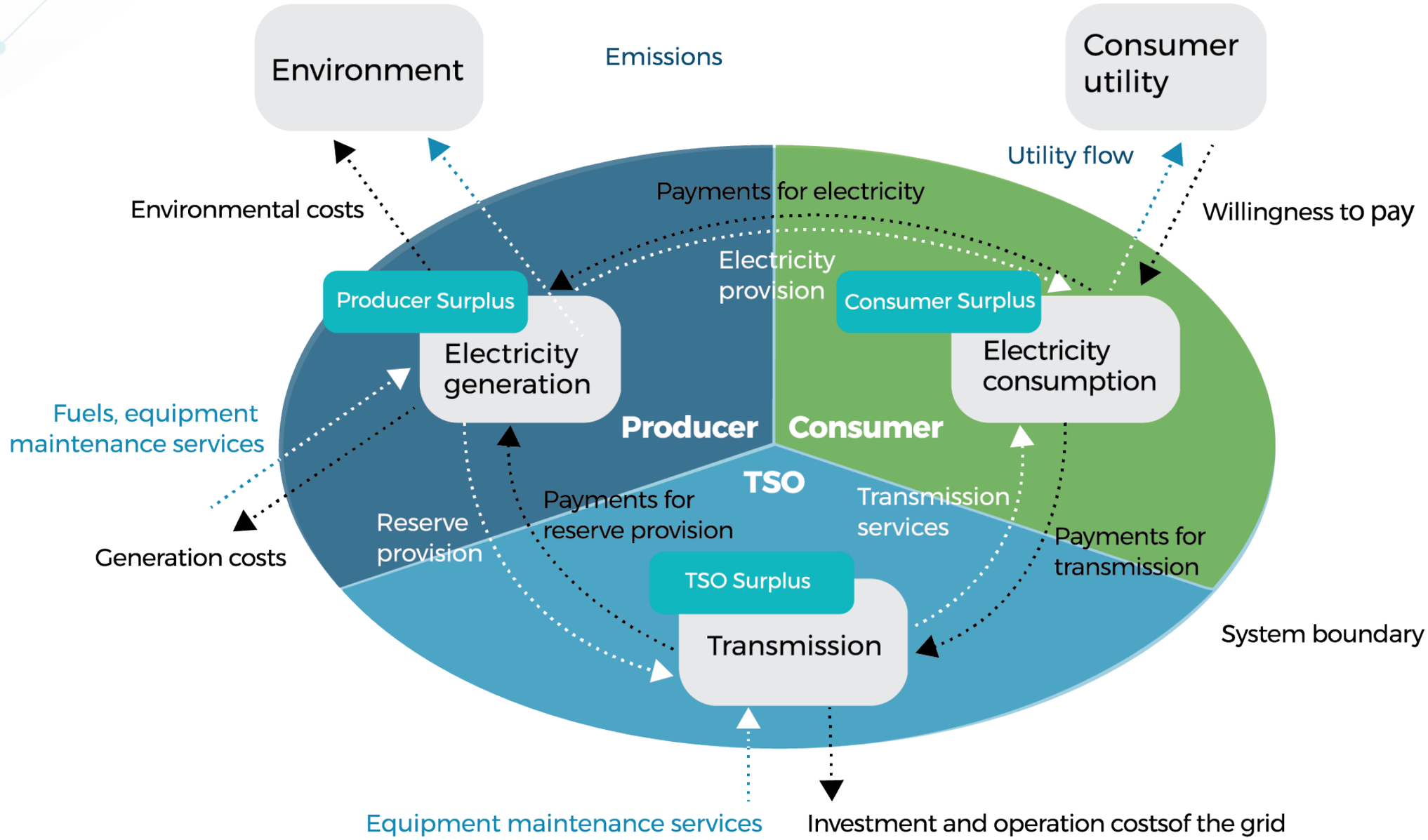
- **The SEIA quantifies surplus as the *difference between (monetised) benefits and costs* for stakeholders**

# System Attributes

| Assessed market | Stakeholder groups | Geographical scope | Activity/ Temporal scope |
|---|---|---|---|
| **Electricity market *)** | Electricity consumers | Affected areas | System operation |
| | Electricity producers | | Operational planning |
| | TSO | | Asset management |
| | Government | | System development |
| | Society/environment | | |

*) Restricting attention to the electricity market: implicit assumption that changes there do not have a significant effect on other markets

# SYSTEM COSTS AND BENEFITS
# and transfer payments between stakeholder groups



# System and stakeholder balances

| System balance | Stakeholders' (Sub-system) balances *) | | |
|---|---|---|---|
| | Consumer balance | Producer balance | Transmission balance |
| **+ Consumer utility from electricity consumption**<br>**- Disutility due to energy not supplied**<br>**- Generation costs**<br>**- Investment and operation costs of the grid** | + Consumer utility from electricity consumption<br>- Disutility due to energy not supplied<br>- Payments for Electricity<br>- Payments for Transmission<br>+ Payments for Flexibility services | + Payments for Electricity<br>+ Payment for reserve provision<br>- Generation costs | + Payments for Transmission<br>- Payments for Flexibility services<br>- Payment for reserve provision<br>- Investment and operation costs of the grid |
| **= Social surplus** | = Consumer surplus | = Producer surplus | = TSO surplus |

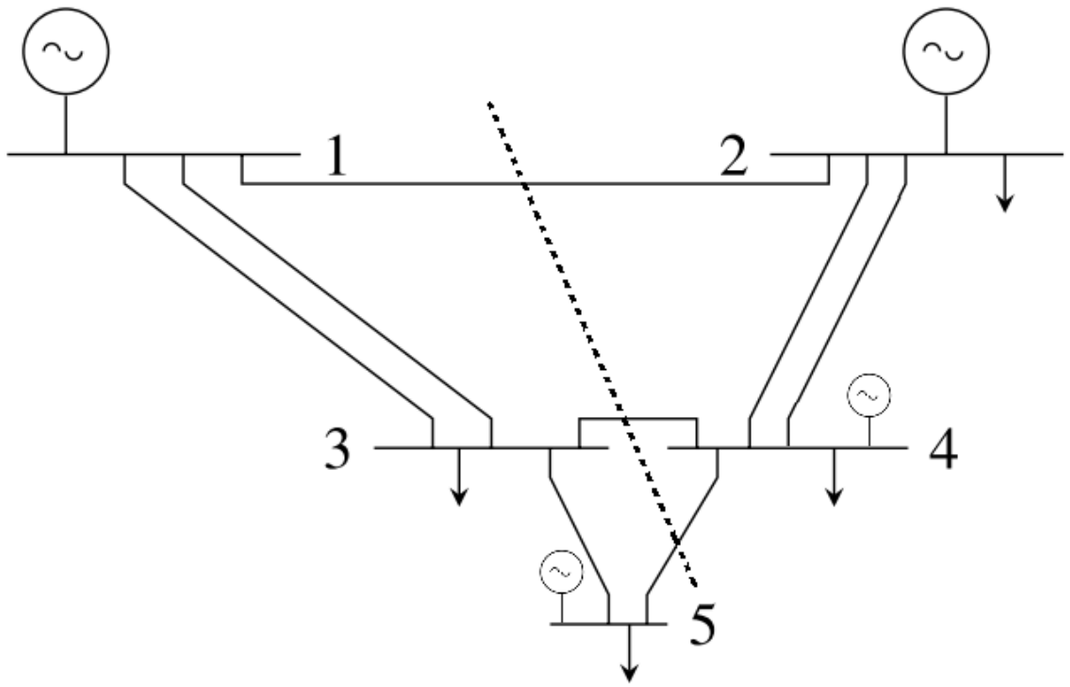
*) For purposes of simplification, the government (taxes on electricity) and environment (emission costs) are left out of the table; they are, however, included in the SEIA. There may be more categories of flows between stakeholders, e.g. payments for interruptions

# Calculation of surplus on stakeholder level

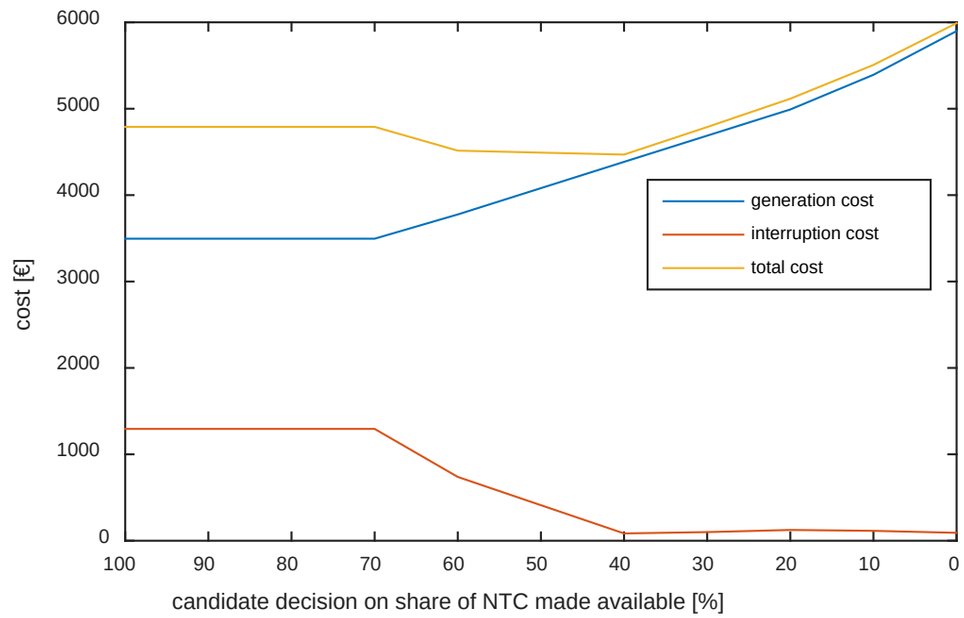
- Requires an assessment of all flows of goods and services and the corresponding flows of money
- Internal flows – also referred to as transfers – require a detailed account of market regulations and agreements between stakeholders
  - Example: taxes; payments for electricity supply interruptions
- But cancel out when adding up all stakeholders' surpluses and are thus irrelevant for the SEIA from the system perspective
  - Example: payments for electricity supplied
- Double counting – i.e. considering an item twice or multiple times – must be avoided!
  - Example: costs of emission allowances vs. social costs of emissions
- Detailed formulas developed for the surplus of stakeholder groups for different activities/time horizons considered
- Methodology numerically illustrated on a test case (a modified RBTS)

# EXAMPLE: NTC given to the market

## Modified RBTS with two regions West and East




## Costs for different TSO candidate decisions



# Implementation issues

- How to value consumption of electricity and supply interruptions?
  - The implementation takes the demand of electricity as given (inelastic)
  - A simplification for the purposes of GARPUR
  - But allows for modelling the cost of interruptions in some detail
    - Consumer type, location, time of interruption, duration

- Multiple time horizons / activities
  - Cost items taken into consideration as well as granularity will differ depending on the horizon
  - Costs and benefits should be either calculated as net present values or annualized

- Modifications needed when several countries, regions and TSOs are involved
  - Cross-border flows must be accounted for

# Multiple countries/regions/TSOs

- Flows crossing borders have to be included in the expression of surplus
- When several affected countries are considered in SEIA, flows between countries cancel out in the overall SEIA
- Cross-border reliability cooperation is beneficial – it increases overall surplus
  - The more integration the higher the expected socio-economic surplus
  - Shown in the context of cooperation on reserves
- However, distributional issues arise – there will typically be winners and losers
  - E.g. producers vs. consumers in a low-cost country where exports increase due to cooperation on reserves
- Direct or indirect side payments may be necessary to make cooperation between TSOs incentive compatible

# Multiple consumer groups

- Reliability criteria have distributional effects on different consumer groups and different locations
- Changing the reliability criterion will come at a cost for some consumers and as an advantage for others
- So its acceptability may differ
- A change leads to two fundamental trade-offs
  - First, economic efficiency versus equity
    - Imposing limits on inequality, e.g., a minimum or universal reliability level, not raising costs of high-cost consumers, decreases efficiency but is generally considered to be more fair
  - Second, individualism versus solidarity
    - That is, does every consumer pay for the cost he imposes on the system or are costs socialised?
- Striking the balance between these opposing objectives is the role of a regulator, based on society's preferences.

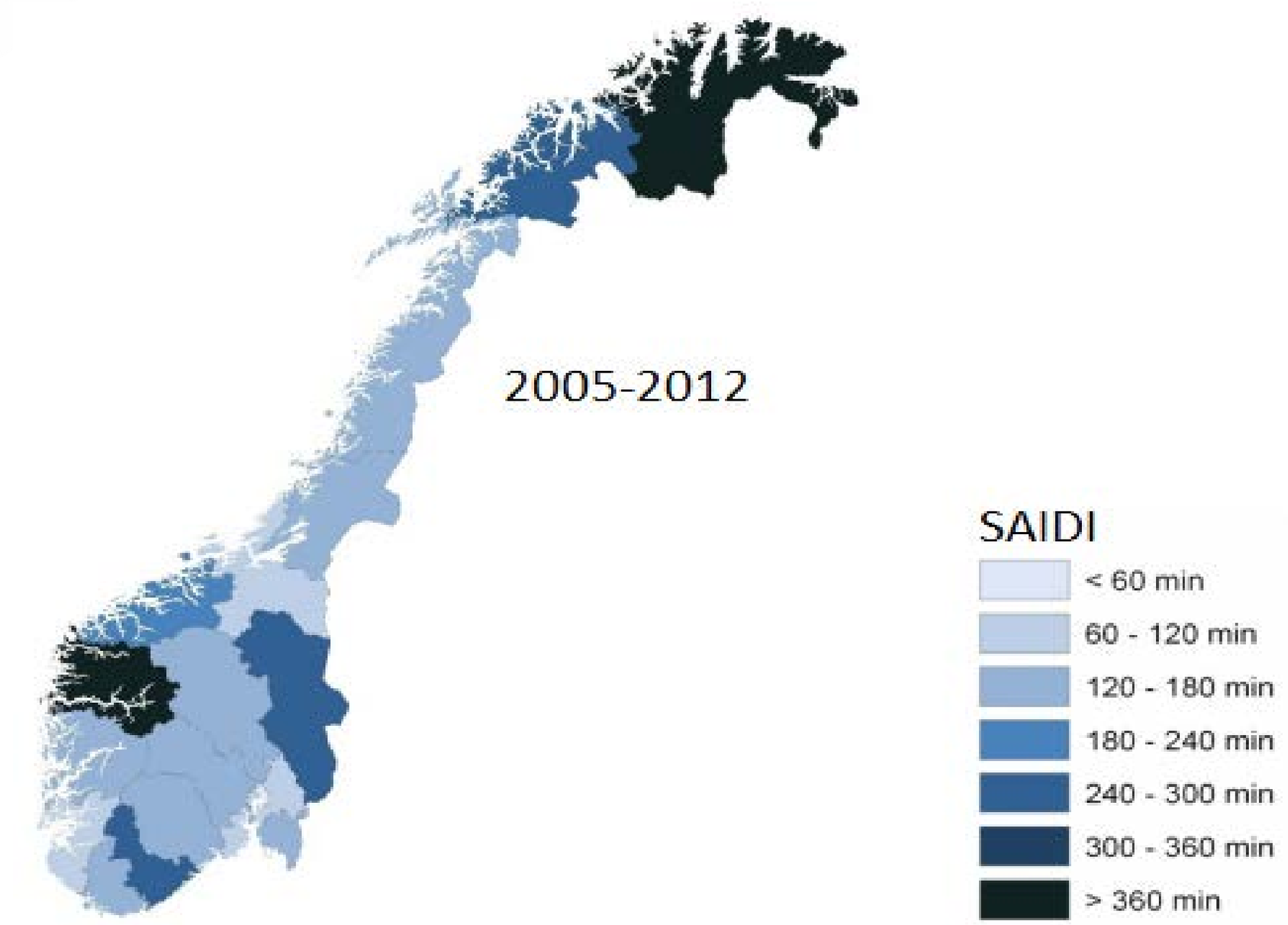
# Example from Norway

## Interruption cost for different duration and for various consumer types, cost level 2014, exchange rate 0.115 €/NOK

| Marginal interruption costs $V_{icd}$ [€/kWh] | | Residen-tial | Industry | Commercial | Public | Large industry | Agriculture |
|---|---|---|---|---|---|---|---|
| Duration interval | 0 – 1 minute | 7.80 | 235.2 | 193.8 | 401.40 | 339 | 34.80 |
| | 1 minute - 1 hour | 1.16 | 9.86 | 19.72 | 13.49 | 0.36 | 1.64 |
| | 0 hour - 1 hour | 1.27 | 13.62 | 22.62 | 19.96 | 6.00 | 2.19 |
| | 1 hour - 4 hours | 1.12 | 9.50 | 10.50 | 3.23 | 1.92 | 1.81 |
| | 4 hours - 8 hours | 1.15 | 6.44 | 16.30 | 5.97 | 0.32 | 1.64 |
| | 8 hours - 24 hours | 1.12 | 4.21 | 11.81 | 2.04 | 0.32 | 1.65 |

**L. Bjørk, E. Bowitz, C. Seem, U. Møller, G. Kjølle, M. Hofmann and H. Seljeseth, "Socio-economic costs of interruptions and voltage disturbances. Implications for regulation," Energy Norway, 2012.**

# SAIDI for different regions in Norway




**Source: NVE Rapport nr. 74, 2014**

# Devil is in the detail: SEIA data needs

| Quantity inputs | Value inputs |
|---|---|
| • Electricity demanded | • Value of served load |
| • Energy not supplied | • Value of lost load |
| • Demand and supply elasticities *) | |
| • Type and quantity of TSO investments, asset depreciation | • Corresponding per unit costs |
| • Maintenance actions | • Corresponding per unit costs |
| • Type and quantity of ancillary services | • Direct associated costs |
| • Generation fuel input | • Fuel prices |
| • Other generator variable input | • Corresponding per unit costs |
| • Operation input | • Corresponding per unit costs |
| • Type and quantity of generation investment, asset depreciation | • Corresponding per unit costs |
| • Emissions of pollutants not yet internalized | • Corresponding monetized value of social and environmental damage |
| • Electricity flows to/from other regions | • Electricity prices |
| | • Interest rate for discounting |

*) Despite their placement in the “Quantity inputs” column, demand and supply elasticities are dimensionless parameters that can neither be classified as quantity nor value inputs.

# Where do the data come from?

- In the GARPUR context, power system quantity data come from simulations in other modules

- Value inputs will typically need to be procured from various sources
  - TSOs supply tariffs and their direct unit costs
  - Generation costs need to be estimated based on fuel prices, other input costs, generation technology etc.
  - Wholesale electricity prices, simulated by a separate market module
  - Compensation for ENS depends on regulation
  - Social cost of emissions (not internalized in generation costs) – external studies, e.g. IPCC reports
  - Prices of flexibility services and reserves, modelled separately
  - Interest rate: especially relevant for system development context
    - Social discount rate
    - Reasonable to use the rate recommended by ENTSO-E for evaluation of system development projects

- VoLL is a central value input – availability of estimates varies

# Estimating VoLL

- A variety of methods exists, but customer surveys are the most common approach
  - An approximation, but can be seen as a lower bound for the total socio-economic interruption cost
  - Cost of HILP events may need to be estimated separately

- Large variation in cost data between countries
  - Perhaps due to differences in factors such as sectoral composition of electricity consumption, dependency of electricity in the economy, etc
  - But also due to different cost estimation methods and different normalization factorsPrices of flexibility services and reserves, modelled separately
  - So care is needed when comparing cost estimates between studies
  - CEER has set out guidelines for best practice

- When no data are available it is possible to use data from a different country or region, but then scaled by purchasing power coefficients

# Further development of models and data

- SEIA framework can be extended in order to analyse possible responses of electricity market stakeholders to changing market variables.
  - Ideally, electricity market prices and power system volumes (quantities) would be determined simultaneously in a single module with interaction between the two types of variables.

- Future research also needs to be directed towards the building blocks of electricity market models
  - Especially consumer response to differing reliability
  - Assumption of price-inelastic demand in the SEIA – except for long-term – based on empirical research
    - This may change in the future – especially on the shortest horizons – with “smart” technologies

# THANK YOU FOR YOUR ATTENTION!