Guaranteeing that the lights always come on – how much is this really worth?

Presentation for

NEW ZEALAND INSTITUTE FOR THE STUDY OF COMPETITION AND REGULATION INC.

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seo economisch onderzoek
Background

- Attention for Supply interruptions
  - Californië 2000/1
  - Northeast USA & Canada, London, Sweden/Denmark, Italy 2003
- Electricity shortages?
  - (Dutch) reserve capacity decreased
  - Dutch network seemed to decrease

- New Zealand:
  - Large black-out in Auckland
  - Long black-out in Western part of South Island
  - Electricity shortages in cold and dry winters
  - HVDC link out of order
  - Taking supply security into account for transmission investment
Major versus minor disruptions

Major disruptions dominate debate, minor often reality

- Last major disruption in Netherlands: 1997
  - once about every 10 years
- Bailek (2003) analyzed several large disturbances
  - Common denominator: communication and bad luck.

- In 2004: 16,436 electricity disruptions caused 24 minutes of supply interruption (NL). 1997 interruption added 15 minutes on average
- Statistics work, so general rules are possible
Key Questions

- What is the cost of not having electricity?

- How to reduce the damage when there is a sudden shortage of electricity (and the market can not help to solve the problem)?

- How much to invest and where?
  - Grid
  - Reserve capacity of generation

- What rules give energy companies the right incentives?
  - N-1
  - Turnover of distribution companies
Outline of the presentation

- Characterizing supply interruptions
- Consequences of interruptions
  - Firms & Households
  - Interruptions with or without transfers
- Valuation methods
- Results
  - Damage per hour
  - Value of lost load
- Policy implications
  - Optimal distribution in case of scarcity of supply
  - Optimal investment
  - Network management
Characterizing interruptions

- Type of consumer
- Moment
- Length
- Cause of the interruption

- Announced?
- Expected reliability
- Structural or incidental
Consequences of outages

- Network problems: only social costs:
  - Firms: » Loss of production
    - Material damage
    - Restart cost
    - Overwork?
  - Households: » Loss of leisure time
    - Stress
  - Distress of public services
- Production shortages: social cost & price increases: transfer of wealth: can exceed the social cost
  - California: damage $0.5 billion, transfers $40 billion
  - Politically very relevant
  - Maximum prices can be used as an imperfect solution, they reduce supply and may cause outages.
Valuing the consequences

Market is missing: different economic tools:

- Interviews
  - estimation of damage, WTP, WTA, conjoint analysis
- Expenditures on back-up facilities
- Case studies
- Production function approach
Quantification method

- Direct effects calculated:
  - Production losses (value added) in firms
  - Loss of leisure (households; hourly wages)
- Simplifying assumptions:
  - All production and leisure is lost
    - Direct loss is most likely smaller
    - But: there are also other cost (e.g. stress)
      ➔ Reasonable first order approach
  - Damage proportional to time
    - Approximation of the relationship between length and damage
    - Seems reasonable within parts of the day
Quantification: more details

- Damage of firms
  = value added which would have been produced during the outage

- Damage of households
  = value of lost leisure
  = number of people that would enjoy leisure during the outage but can't because of the outage times the average hourly wage net of taxes (for non-working people half the average hourly wage was taken)

- We distinguished nine different periods and several industrial sectors
Valuing time

money

wage

Marginal utility of leisure

time 24 hour

working time

leisure
### Key figures per sector (2001)

<table>
<thead>
<tr>
<th>Sector</th>
<th>electricity use (1000 gWh)</th>
<th>‘value’ (bln euros)</th>
<th>Cost of a one hour outage weekdays during the daytime</th>
<th>value of lost load (€/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>3</td>
<td>11</td>
<td>1.3</td>
<td>3.9</td>
</tr>
<tr>
<td>energy sector</td>
<td>-72</td>
<td>23</td>
<td>2.6</td>
<td>-0.3</td>
</tr>
<tr>
<td>manufacturing</td>
<td>34</td>
<td>63</td>
<td>10.2</td>
<td>1.9</td>
</tr>
<tr>
<td>construction</td>
<td>1</td>
<td>25</td>
<td>9.5</td>
<td>33.1</td>
</tr>
<tr>
<td>transport</td>
<td>2</td>
<td>20</td>
<td>5.4</td>
<td>12.4</td>
</tr>
<tr>
<td>services</td>
<td>25</td>
<td>198</td>
<td>69.3</td>
<td>7.9</td>
</tr>
<tr>
<td>government</td>
<td>2</td>
<td>80</td>
<td>23.7</td>
<td>33.5</td>
</tr>
<tr>
<td>firms</td>
<td>67</td>
<td>397</td>
<td>122.0</td>
<td>6.0</td>
</tr>
<tr>
<td>households</td>
<td>22</td>
<td>362</td>
<td>37.4</td>
<td>16.4</td>
</tr>
<tr>
<td>total</td>
<td>89</td>
<td>759</td>
<td>159.4</td>
<td>8.6</td>
</tr>
</tbody>
</table>
Welfare per region (mln. € per hour, 2001)

- Weekdays during the daytime:
  - 0 to 5
  - 5 to 10
  - 10 to 20

- Weekdays during the evening:
  - 0 to 2
  - 2 to 4
  - 4 to 9

- Sundays during the daytime:
  - 0 to 2
  - 2 to 4
  - 4 to 7
VOLL (€/kWh, 2001)

Workdays during the daytime:
- 0 to 7.5
- 7.5 to 8.5
- 8.5 to 10

Workdays during the evening:
- 0 to 8
- 8 to 9.5
- 9.5 to 11.5

Sundays during the daytime:
- 0 to 9.5
- 9.5 to 11
- 11 to 13
### Value of lost load and damage, all moments (2002)

<table>
<thead>
<tr>
<th></th>
<th>Voll (€/kWh)</th>
<th>Damage of a one hour interruption (€ mln)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Workdays daytime</td>
<td>7.7</td>
<td>155.9</td>
</tr>
<tr>
<td>Workdays evening</td>
<td>8.4</td>
<td>99.1</td>
</tr>
<tr>
<td>Workdays night</td>
<td>2.5</td>
<td>17.3</td>
</tr>
<tr>
<td>Saturdays daytime</td>
<td>8.4</td>
<td>146.6</td>
</tr>
<tr>
<td>Saturdays evening</td>
<td>11.5</td>
<td>93.1</td>
</tr>
<tr>
<td>Saturdays night</td>
<td>3.4</td>
<td>12.8</td>
</tr>
<tr>
<td>Sundays daytime</td>
<td>9.4</td>
<td>81.9</td>
</tr>
<tr>
<td>Sundays evening</td>
<td>11.5</td>
<td>93.1</td>
</tr>
<tr>
<td>Sundays night</td>
<td>3.4</td>
<td>12.8</td>
</tr>
<tr>
<td><strong>average</strong></td>
<td><strong>7.3</strong></td>
<td><strong>89.7</strong></td>
</tr>
</tbody>
</table>
Use (in policy)

1. Shortage of supply
2. Optimal investment
3. Network regulation
Policy: Criteria and norms

- Possible criteria:
  - Economic optimality
  - Social cost and benefits
  - “justice”
    - Equal probability (for interruptions)
  - Or a combination
    - Minimum level of reliability
    - Additional reliability on economic grounds
- Focus: economic optimality
Reactions to a shortage of supply (i)

Shortage leads to high prices:
- Producers: generate more electricity
- Users: consume less (interruptible contracts, direct demand response to high prices, ...)
- Government:
  - Loosen regulation to increase production
  - Stimulate electricity saving
- If these reactions are not sufficient, TSO has to interrupt users
  - What role for the consequences of outages?
- For the Netherlands, we calculated that efficient rationing can reduce social costs by 21 to 93 percent compared to random rationing (using data for each municipality).
Reactions to a shortage of supply (ii)
Policy versus efficiency

- **Reality** (the Netherlands):
  1. Electricity system
  2. Public order and safety, health care
  3. Critical processes in manufacturing, public utilities
  4. Remaining industrial sectors, public buildings, companies and firms.
  - Households not mentioned
  - Differences in economic versus random rationing

- **Economic efficiency:** sectors/regions with a low voll first:
  1. Electricity system
  2. Government/ construction
  3. Households
  4. Services
  5. Manufacturing

Top of the list: most priority, sector least likely to be interrupted
Socially optimal investments

- Cost per minute interruption
- Cost of supply security
- Minutes supply interruption
- Marginal cost of one minute additional supply interruption
- Marginal damage of one minute additional supply interruption

Levels:
- Level 1
- Level 2
- Optimal interruption level

Minutes supply interruption
Socially optimal investments (ii)

- Reserve capacity of generation.
  - Optimal quantity?
Network regulation (i)

(Distribution) network operators can best take investment and operational decisions, but their incentives must be right.

NL:

\[ \text{Turnover}(t) = \text{turnover}(t-1) + \text{CPI} - \text{X} - \text{Quality} \]

- Quality: minutes of power interruptions times ‘price’
- In the Netherlands this ‘Price’ based on conjoint analysis
Conjoint analysis (i)

Baarsma et al: ‘competing colleagues’
Problem of contingent valuation studies: Questions are difficult, for example:

- Imagine an outage of 5 minutes on Thursday evening during the winter, without an advance warning. How much would you be willing to pay to prevent such an outage? 82% of the households and 83% of SME said they did not want to pay anything.

- Therefore they used vignettes
  - Each vignette different from the others in terms of duration, frequency, time of the year, …
  - Households and firms were asked to value a number of different vignettes
  - Followed by some econometrics, gives….
Conjoint analysis (ii)

<table>
<thead>
<tr>
<th>Duration of the outage:</th>
<th>Households</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>Average /hour</td>
</tr>
<tr>
<td>One outage (per year) of half an hour</td>
<td>1.70</td>
<td>3.40</td>
<td></td>
</tr>
<tr>
<td>One outage (per year) of an hour</td>
<td>5.00</td>
<td>5.00</td>
<td></td>
</tr>
<tr>
<td>One outage (per year) of four hours</td>
<td>11.60</td>
<td>3.90</td>
<td></td>
</tr>
<tr>
<td>One outage (per year) of eight hours</td>
<td>14.90</td>
<td>1.90</td>
<td></td>
</tr>
<tr>
<td>One outage (per year) of a day</td>
<td>20.10</td>
<td>0.80</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of outages:</th>
<th>Households</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>Average / outage</td>
</tr>
<tr>
<td>No outage ($F_0$)</td>
<td>-10.30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>One outage per year (of two hours)</td>
<td>8.50</td>
<td>8.50</td>
<td></td>
</tr>
<tr>
<td>Two outages per year (of two hours)</td>
<td>11.20</td>
<td>5.60</td>
<td></td>
</tr>
<tr>
<td>Four outages per year (of two hours)</td>
<td>13.90</td>
<td>3.50</td>
<td></td>
</tr>
<tr>
<td>Six outages per year (of two hours)</td>
<td>15.50</td>
<td>2.60</td>
<td></td>
</tr>
<tr>
<td>Twelve outages per year (of two hours)</td>
<td>18.30</td>
<td>1.50</td>
<td></td>
</tr>
</tbody>
</table>
Network regulation (ii)

- N-1
- 20 percent of Dutch households at the end of a line instead of using a ring structure (two lines).
- Solving that would cost €900 million in investment and 90 million annually.
- Benefits €3-4 million a year
Summary I

- Costs vary strongly between regions and times
- Households are important
  - Welfare is more than financial damage
  - Voll households exceeds voll manufacturing

→ Distribution of power and investments should take both into account
- Damage is larger than the price of electricity
Summary II

- Transfers are not a cost, but matter anyway
  - Maximum prices reduce redistribution, but cause social cost
  - Redistribution is a political issue
  - Policy w.r.t. scarce electricity could be more efficient
- Cost of power outages can be used for investments appraisal
- Cost of electricity outages should get a place in the regulation to give distribution companies the right incentives
  - Not too much interruptions, but also not too much reliability
- Users could accommodate to interruptions:
  - Possibly cheaper than investments in networks and production
Thank you for your attention

Questions?

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