Value of Network-Driven DSM

Port Macquarie 22nd March 2006
Value of Network-Driven DSM

- Spanish study case: Interruptibility Contracts
  - Benchmark assessment
  - Benefit-cost framework methodologies
  - Cost-effectiveness framework methodologies based on reliability benefits
Benchmark assessment: Interruptibility Contracts

- Interruptibility specific characteristics

- Implemented by the TSO:
  - curtailment orders sent to customers when required to guarantee system security.

- Four types depending on the warning time and the interruption time.
  - Type A: 16 hrs, maximum interruption time and 12 hrs, minimum warning time
  - Type B: 6 hrs, maximum interruption time and 6 hrs, minimum warning time
  - Type C: 3hrs, maximum interruption time and 1 hr, minimum warning time
  - Type D: 45min, maximum interruption time and 5min, minimum warning time
    - In the past four years only type C and D orders (“fast” types) have been sent.

- In both cases, the reduction in demand would affect only to prices in Operational Markets that are called 1 hour in advance or in real time:
  - Tertiary Regulation Market (called in real time)
  - Deviation management (1 hour in advance)

- These two markets, are managed by the TSO.
### Benchmark assessment: Interruptibility Contracts

#### Daily Market

<table>
<thead>
<tr>
<th>Dia D-1</th>
<th>Dia D</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24</td>
<td>1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24</td>
</tr>
</tbody>
</table>

**Electricity Market Operator Company**
- Daily Market

**RED ELÉCTRICA DE ESPAÑA**
- Solving constraints in PBF
- Secondary reserve market
- Voltage control schedules
- Use of tertiary reserve
- Deviation management

**Information prior to Daily Market**

**Use of tertiary reserve**

**Solving constraints in real time**

Analysis of the prices in the Deviation Management Market: How much prices would have dropped following a reduction in demand?
- Marginal price of energy in Deviation management market: 13.1985 c$/kWh,
- Generation requirement for that specific market: 1000 MW.
- If 500 MW curtailed → 500 MW of generation assigned in this market and marginal price would have been 12.5866 c$/kWh

Interruptibility savings for that hour:
- \[(1,000 \text{MW} \times 13.1985 \text{ c$/kWh}} - 500 \text{ MW} \times 12.5866 \text{c$/kWh}) \times 1\text{h} \times 10 \text{kWh/c $} \times \$/\text{MWh} = 690,466 \text{ $}\]
- Difference between what had cost and what would had cost.
Particular case 2: 27/06/05. Interruption order between 12:20h and 13:05h to 343 MW. (Type D).

Analysis of the prices in the Tertiary Regulation Market: How much prices would have raised following an increase in demand?

- Tertiary Regulation Market marginal price for hour 12: 14.758c $/kWh,
- 756.4 MW required
- If no curtailment order had been sent → 1099.4 MW required in the Tertiary Regulation Market. Marginal price: 16.9697 c $/kWh.

Interruptibility savings for that hour:
- Actual cost: 756.4 MW * 14.758 c $/kWh * 10 $/MWh = 111,616.63 $
- Cost for no curtailment: (756.4+343) MW * 16.9697 c $/kWh * 10 $/MWh = 186,542.071 $
- Interruptibility savings for that hour = 74,931.210 $
Cost–effectiveness based on Reliability Benefits

Marginal value of the additional reliability provided by the curtailment capability

Reduction in the probability and severity of forced outages

The more the probability of forced outages is, the more the value of interruptibility is

Spanish case: Hypotheses

• Interruptibility reduces probability of occurrence of forced outages from 100 to 0
• One Interruptibility order would avoid one forced outage of the same magnitude
### Cost-effectiveness based on Reliability Benefits

#### Interruption orders given in the past years

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Interrupted Load (MW)</th>
<th>Total Interruption time (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>244</td>
<td>9</td>
</tr>
<tr>
<td>1997</td>
<td>125</td>
<td>6</td>
</tr>
<tr>
<td>1999</td>
<td>772</td>
<td>15</td>
</tr>
<tr>
<td>2000</td>
<td>283</td>
<td>0.75</td>
</tr>
<tr>
<td>2001</td>
<td>8980</td>
<td>16</td>
</tr>
<tr>
<td>2002</td>
<td>151</td>
<td>3</td>
</tr>
<tr>
<td>2003</td>
<td>1345</td>
<td>12</td>
</tr>
<tr>
<td>2004</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2005</td>
<td>2202</td>
<td>12.75</td>
</tr>
<tr>
<td>2006</td>
<td><strong>1350</strong>*</td>
<td><strong>7.75</strong>*</td>
</tr>
</tbody>
</table>

* Estimated Values
Cost–effectiveness based on Reliability Benefits

- Impact of disconnections on customers, in terms of the value of losses sustained as a result of the disconnection: Two Methodologies:
  - 1.-
    \[
    \frac{GIP_{2005} (€)}{Consumption_{2005} (GWh)} = \frac{1,093,538.94 M \$}{243,766 GWh} = 4,484.95 \$ / MWh
    \]
  - 2.- 20 times the price of the energy supplied to end users.
    - Considering that the price of the energy supplied to end users is 500$/MWh, Value of Lost Load (VOLL) would be: 10,000$/MWh
Cost–effectiveness based on Reliability Benefits

- Expected reduction, resulting from the demand response program, in the occurrence and duration of outages: 100%

- Expected magnitude of load that would be disconnected during outages if they were triggered by system conditions: 1350 MW during 7.75 hours = 10,462.5 MWh of unserved energy

- The impact of disconnections on customers, in terms of the value of losses sustained as a result of the disconnection:
  - VOLL 1 = 4,484.95 $/MWh
  - VOLL 2 = 10,000 $/MWh
Cost–effectiveness based on Reliability Benefits

- Value of curtailable Load ($ per year) = Expected Unserved Energy (MWh per year) x VOLL ($ per MWh)

  1. $4,484/MWh x 10,462.5 MWh = 46,933,741.36 $ \approx 47$ M$

  2. $10,000/MWh x 10,462.5 MWh = 105,856,599 \approx 106$ M$

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How to measure Reliability Benefits?

- Before 1995: Interruptibility contracts between REE and some specific industrial customers.
- After 1995: Interruptibility contracts open to every eligible customer by Ministerial Decree.
- How does this affect to system reliability?
  - Averaged Interruption time (minutes) = Unserved Energy per month / Demand for that month.
How to measure Reliability Benefits?

- **Before 1995**: Averaged interruption time: 11.5 min.
- **After 1995**: Averaged interruption time: 3.3 min.
Cost–benefit analysis

- **From the system perspective:**
  - **Costs:**
    - Discounts that interruptibility customers receive on their electricity bills
    - Total amount in 2004: 246 M$
  - **Benefits:**
    - 1.- Avoided generation costs
    - Gasoil turbine for marginal generation in peak hour:
      - **Variable Costs** = Fuel cost + Maintenance Cost + CO2 Emission Cost
        - Fuel Cost = 6.4 c$/te x 2.35 te/kWh = 150.6 $/MWh
        - Maintenance Cost = 6 $/MWh
        - CO2 Emission Cost = 17.9 $/MWh
        - Total variable cost = 150.6 $/MWh + 17.9 $/MWh + 6 $/MWh = 174.524 $/MWh
  - 174.524 $/MWh x 1350 MW x 7.75 h ≈ 1.8 M$
 Cost–benefit analysis

2.- Avoided costs of line construction

- 400 kV line, double circuit, three conductors per phase, triplex → 480 000 $/km.
  - 100 km line → 48 M$
- 220kV line → 300 000 $/km. 100 km line → 30 M$
- Cable 1.8 M$/km → 50 km cable → 90 M$
Conclusions:

- Difficult to estimate expected unserved energy: Heterogeneous data.
- Interruptibility Contracts, difficult to evaluate their economical value for the system in the long term.
- In the short term, line construction and generation are not seen as actual alternatives for the operation in real time.
- Difficult to analyze societal costs.
- Difficult to analyze the cost of a blackout in Spain, that would be the value of the Interruptibility.