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Value of Network-Driven DSM

Port Macquarie 22nd March 2006

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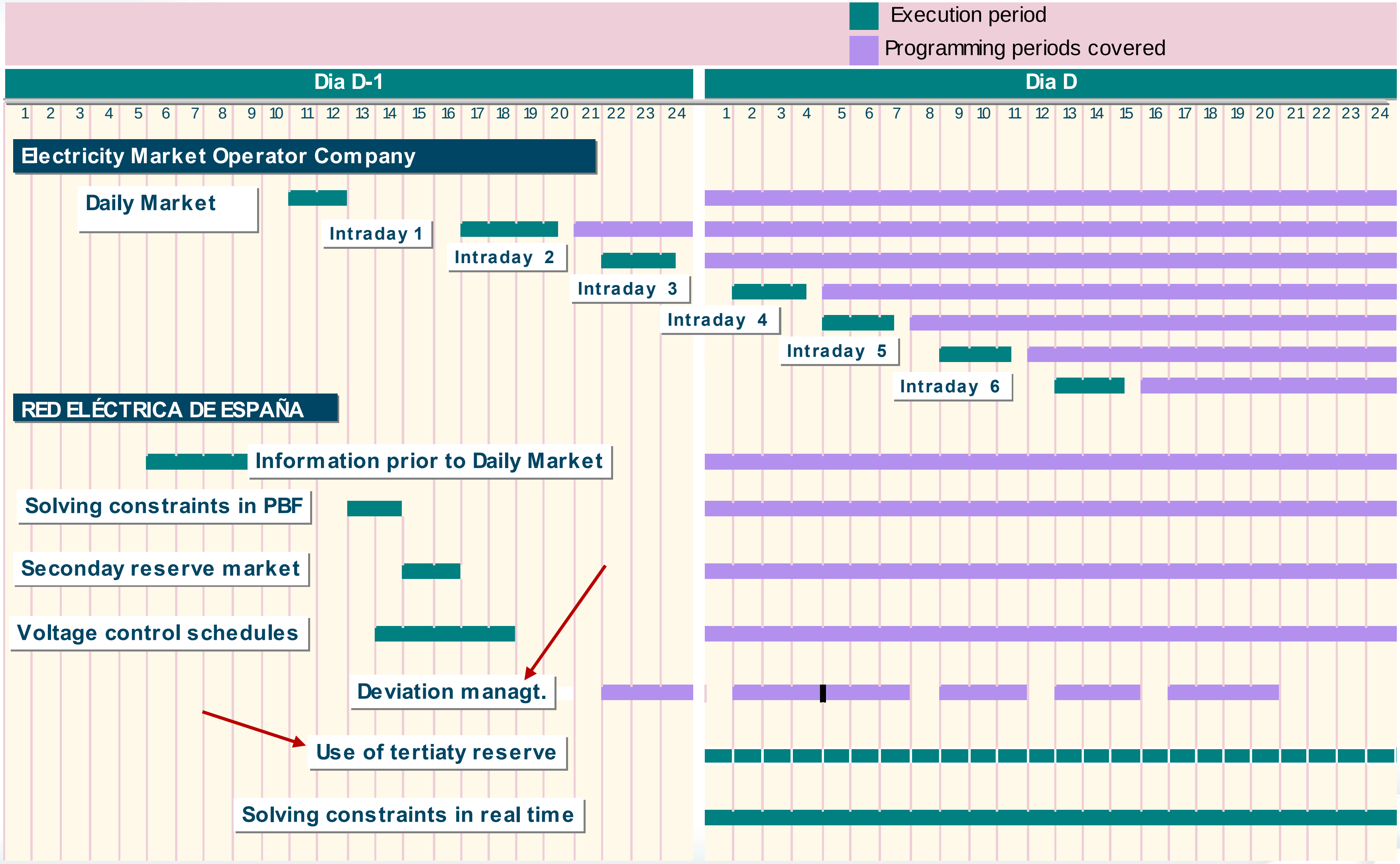
- **Spanish study case : Interruptibility Contracts**
  - **Benchmark assessment**
  - **Benefit-cost framework methodologies**
  - **Cost-effectiveness framework methodologies based on reliability benefits**

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



Benchmark assessment: Interruptibility Contracts

- **Particular case 1: 27/01/2006: last winter peak demand in Spain: 40,600 MW 11hrs.**
- **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:**
  - **(1,000MW*13.1985 c $ /kWh – 500 MW*12.5866c $ /kWh)*1h*10 kWh/c $ * $ /MWh = 690,466 $**
  - **Difference between what had cost and what would had cost.**

Benchmark assessment: Interruptibility Contracts

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- **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 $ *10 $ /MWh = 111,616.63 $**
    - **Cost for no curtailment. : (756.4+343) MW *16.9697 c $ * 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

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

Spanish case: Hypotheses

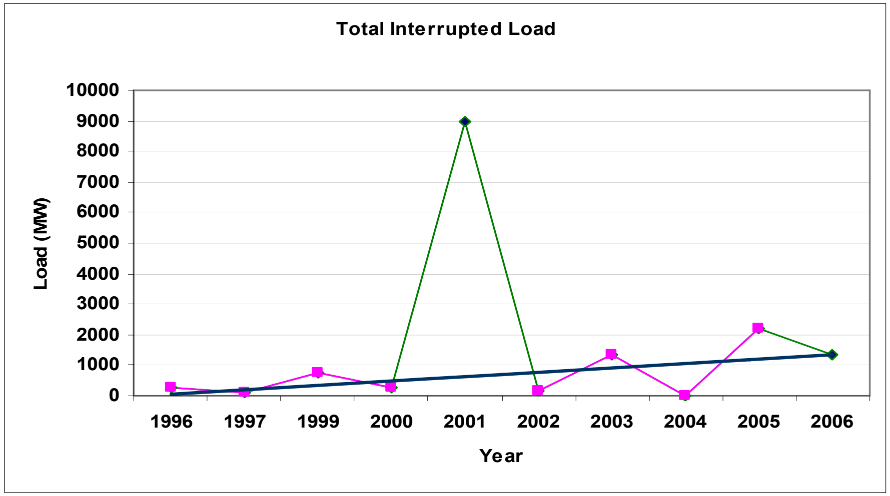
- **Interruptibility reduces probability of occurrence of forced outages from 100 to 0**
- **One Interruptibility order would avoid one forced outage of the same magnitude**

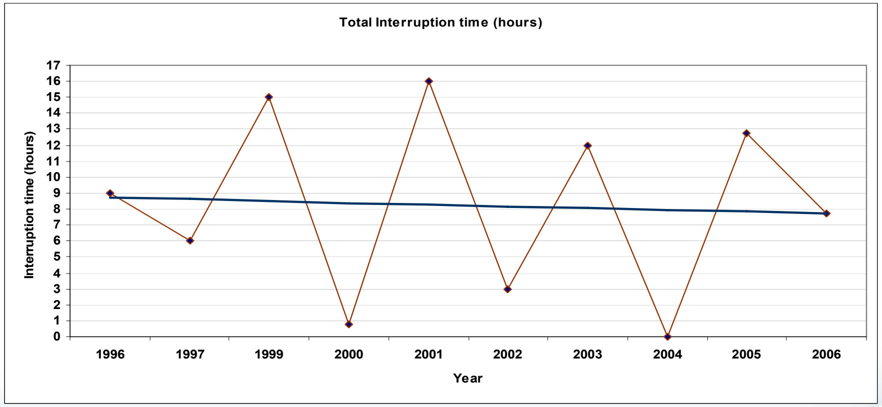
Cost–effectiveness based on Reliability Benefits

Interruption orders given in the past years

Year	Total Interrupted Load (MW)	Total Interruption time (hours)
1996	244	9
1997	125	6
1999	772	15
2000	283	0,75
2001	8980	16
2002	151	3
2003	1345	12
2004	0	0
2005	2202	12,75
2006	1350*	7,75*

* 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

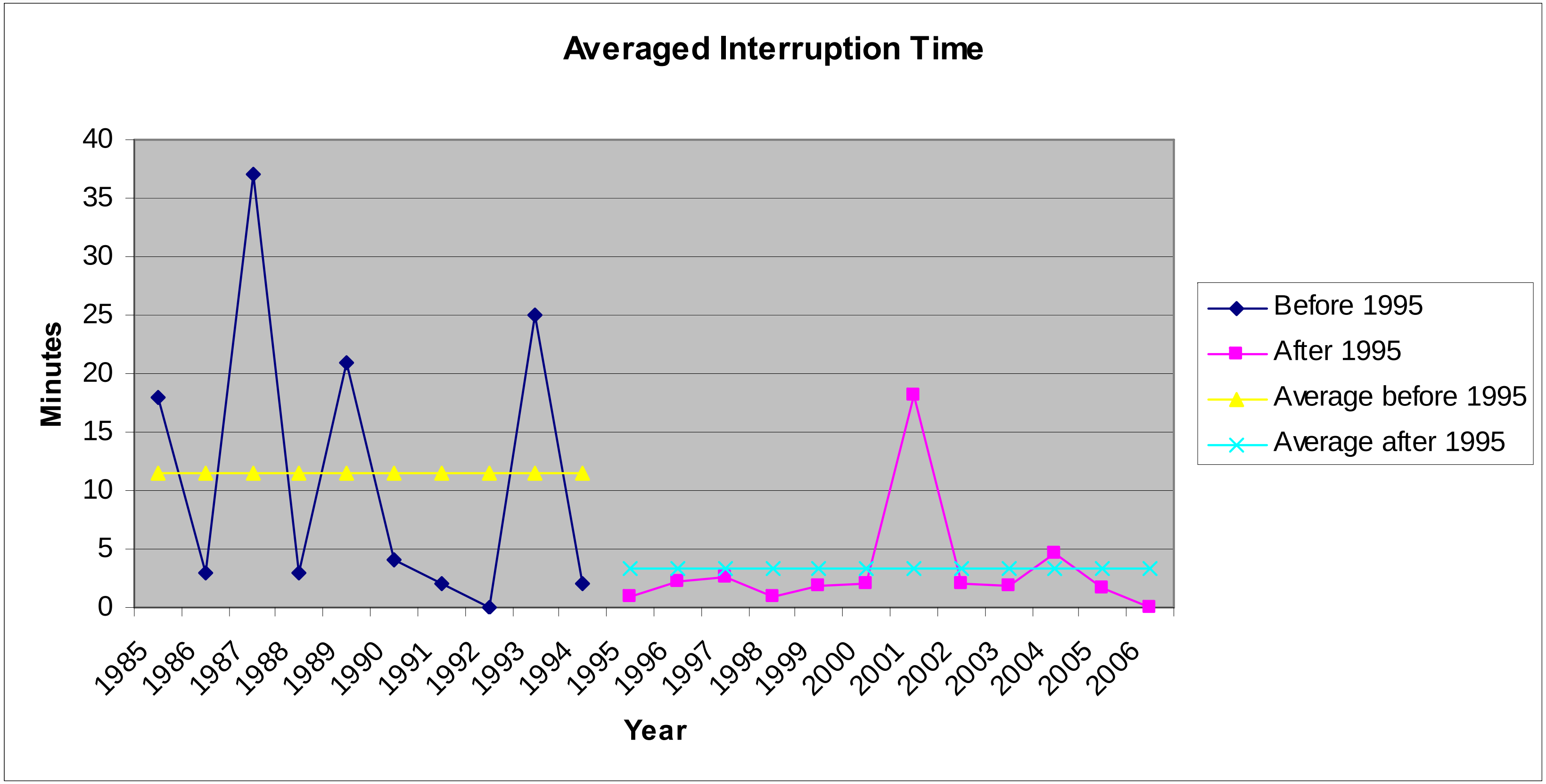
Cost–effectiveness based on Reliability Benefits

- **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 $ ≈ 47 M$**
  - **2.- 10,000 $/MWh x 10,462.5 MWh = 105,856,599 ≈ 106 M$**

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 + CO_2 Emission Cost =**

        Fuel Cost = 6.4 c$/te x 2.35 te/kWh = 150.6 $/MWh

        Maintenance Cost = 6 $/MWh

        CO_2 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$/km → 50 km cable → 90 M$**

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- **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.**