Reliability and security of electricity supply: the Italian blackout

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2003: the year of security of supply concerns

- Italian and North American blackouts
- Security concerns in other countries
- Structural, managerial and legal framework weaknesses
Adequacy and security both play a role in reliability
- Adequacy is correlated with long-term investment
- Intrinsic security is correlated with the short-term management of available resources
Storm
- Tree tripping over Swiss EHV line
- Line shuts down
- Inappropriate counter-measures
- Second Swiss EHV line shuts down
- Cascade tripping and disconnection from UCTE system
- Blackout: 55 M citizens affected for up to 20 hours
AEEG’s Inquiry

- Phase 1: separation of the Italian grid from the European UCTE network
  - Swiss Office Fédéral unwilling to cooperate
  - Joint AEEG-CRE investigation (concluded on April 23, 2004)

- Phases 2 and 3: expansion of the interruption and restoration of service
  - preliminary investigations (concluded on June 9, 2004)
  - formal investigations concerning specific operators (ongoing)
...investigations...
Phase 1: Italian situation at 3:00 am vs GRTN forecast

- Everything going according to plan
  - consumption
  - interconnecting lines
  - voltages and currents
  - reserves

Table 1
Phase 1: Italian situation at 3:00 am vs GRTN forecast

<table>
<thead>
<tr>
<th>Type of reserve</th>
<th>Activation time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5 min</td>
</tr>
<tr>
<td>Pumping plant to be disconnected</td>
<td></td>
</tr>
<tr>
<td>Hydric</td>
<td></td>
</tr>
<tr>
<td>Thermal</td>
<td></td>
</tr>
<tr>
<td>Progressive activation</td>
<td>3.279</td>
</tr>
</tbody>
</table>

Table 2
Phase 1: how the problems began and unfolded

Figure 1 – Swiss interconnection transmission system
Phase 1: how the problems began and unfolded

Figure 2 – Power exchange request carried out by GRTN$^1$ on request of Swiss system operators
Phase 1: how the problems began and unfolded

<table>
<thead>
<tr>
<th>Event</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Trip of the 380 kV line Mettlen-Lavogyo (Lucarnier line - CH)</td>
<td>03:01</td>
</tr>
<tr>
<td>Attempts to re-close the line using automatic mechanism until 3.03:50. Also manual re-closure fails at 3:03:50.</td>
<td></td>
</tr>
<tr>
<td>2. Attempts to re-close the Mettlen-Lavogyo line. Information exchanges between ETRANS and ATEL and ECL dispatchers.</td>
<td>03:02-3:08</td>
</tr>
<tr>
<td>3. ETRANS requests a reduction of 300 MW in Italian imports to scheduled values.</td>
<td>03:10</td>
</tr>
<tr>
<td>4. Exchange of information between ETRANS, ATEL and ECL and changes in topology of the Swiss system.</td>
<td>03:18-3:22</td>
</tr>
<tr>
<td>5. Italian imports are reduced to 6400 MW.</td>
<td>03:21</td>
</tr>
<tr>
<td>6. Trip of the Sils-Soazza 380 kV line (San Bernardino line CH).</td>
<td>03:25</td>
</tr>
<tr>
<td>7. Trip of the Airolo Mettlen 220 kV line (CH)</td>
<td>03:25</td>
</tr>
<tr>
<td>8. Cascading effect: trip of all the interconnection lines from Italy to the remaining part of the UCTE system</td>
<td>03:25</td>
</tr>
</tbody>
</table>

Table 3 – List of “cascade events”
Phase 2: the main problems

- Sudden negative imbalance and very rapid decrease in frequency worsened by:
  - plant shutdowns
  - failed load rejection logics
  - load-shedding functions as expected but insufficient

![Figure 3 – Frequency decrease](image)
Phase 2: attempts made to solve the situation and results

- System Operator attempted
  - primary frequency regulation
    - pumping storage plant shutdowns
    - load shedding actions

- But
  - imbalance remained negative
  - frequency fell below the minimum 47,5 HZ threshold

- Thus leading to an almost total blackout
Phase 3: the main problems

- Analysis made more difficult by absence of recordings
- 3 main problems:
  - unavailability of black start functions
  - TLC communications inefficiencies
  - scarcity of load rejection actuations
Phase 3: North-South differences

![Image showing restoration process for main transmission stations](https://via.placeholder.com/150)

Figure 4 - Restoration process for the main transmission stations (Sicily isle not included)
Phase 3: North-South differences

Figure 5 – Restoration process for final customers (excluding Sicily)

Figure 5 - Restoration process for final customers (Sicily)
Lessons from the blackout

- **Phase 1**
  - failed application of UCTE rules and operational procedures
    - need for rules to be made more explicit
    - need for rules to be made mandatory and monitored

- **Phase 2**
  - non compliance
    - need for stricter enforcement
  - need for improvement of the rules
    - load shedding
    - load rejection logics

- **Phase 3**
  - non compliance
  - need for improvement of the rules
    - clarity
    - testing
Government initiatives

- “Anti-blackout” decree
  - speeds up and simplifies authorisations procedures for the construction of new power plants
    - single authorization process
    - clear timetable for the concession or denial of permits
- Higher remuneration for new transmission lines
- Capacity payment for electricity generation
- Greater power to central government over authorisations
- Incentive mechanism to improve energy efficiency in final energy use
AEEG Initiatives

- Participation in the legislative process
- *Ad hoc* secondary legislation
  - temporary capacity payment mechanism
  - boost to investment in networks
  - demand side
    - remuneration of interruptible service
    - white certificate mechanism for efficiency in final energy use
  - potential advantages (and costs) of distributed generation need to be examined
CEER's response

- Endorsement of AEEG-CRE inquiry
  - bilateral EU-CH agreement
    - obligation to legally unbundle and create independent TSO
    - liberalized framework in line with European internal market
    - adoption of the principles of the EU Regulation on Cross Border Exchanges

- October 2003 position paper
  - new investment in generation
    - market methods
    - distributed generation
  - investment in transmission capacity and maintenance
  - cooperation and coordination among TSOs
  - interruptibility
  - energy savings; demand-side initiatives
European Commission’s response

- December 2003: draft Directive on Electricity Infrastructure and Security of Supply
  - clear policy to ensure supply and demand balance
  - definition of network security standards (non compliance can lead to financial penalties)
  - TSOs to submit regular investment plans to national regulator
  - regulators to submit a summary of these investment programs to the EC for consultation with ERGEG
  - right for regulators to intervene to speed up the completion of projects
CEER’s reaction to the EC’s proposal

- September 2004: position paper on draft Directive
  - need for network and generation adequacy
  - market design and market structure reforms
  - need for properly designed and regulated network activities and competitive markets
  - contributions from demand side measures and renewable generation in a non-discriminatory and market-based manner
  - clear and transparent definition of roles and responsibilities of all stakeholders and market participants
  - increased renewables and CHP pose new challenges
  - definition and publication through a transparent and co-operative regulatory process of security of supply indexes, and reliability standards and operational rules for interconnected systems
  - permanent monitoring and reporting under regulatory supervision
Conclusion

- Liberalisation of electricity markets creates a decentralised decision-making process → need for greater coordination and communication and supervision
- Emergence of regional markets → additional challenges for system operators
- Need for generation investment; promotion through market methods
- Need for transmission investment and efficient network performance
- Need for appropriate harmonised incentives and legal frameworks
- Need for transparent and sound regulation
- New challenges for enhanced international collaboration among regulators
DG applications
...also a regulatory challenge...

- Cogeneration (CHP)
- Standby operation
- Peak shaving
- Grid support
- Power quality applications
...difficult regulatory decisions...

- Connection tariffs
- Reconciliation procedure
- Balancing and reserve costs
Examples of DG technologies

- Internal combustion engines (30 – 6,000 kW, $\eta = 30\text{-}38\%$)
- Industrial gas turbines (500 – 20,000 kW, $\eta = 25\text{-}40\%$)
- Microturbines (25 – 300 kW, $\eta = 20\text{-}30\%$)
- Fuel cells (3 – 3,000 kW, $\eta = 36\text{-}60\%$)
- Renewables (hydro > 50 kW, photovoltaic cells 1 – 1,000 kW, wind 50 – 1,000 kW, transformation into electric energy from organic and industrial residue (biogas, etc...) 100 – 10,000 kW)
- Energy recoupments (turbo-expansors, recoupments from fuels other than commercial fossil fuels, heat process, etc...)
- Combined or simple configurations (combined cycle, hybrid, etc...)
DG plant technologies

• Technologies aimed at utilizing renewable sources (mini-hydro, photovoltaic, wind turbines, biomass driven plants)

• Innovative technologies aimed at utilizing fossil fuels (gas microturbines, internal combustion engines, fuel cells)

• Technologies aimed at utilizing renewable sources or fossil fuels for the combined production of electric and thermal energy (cogeneration plants and micro-cogeneration)
AEEG’s first initiatives with regard to distributed generation
Resale prices for mini-hydro plants (<3MW)

- prices are differentiated according to a progressive scale of production brackets

- this method has already been applied for 5 years and has proved efficient
Net metering for photovoltaic plants of up to 20 kW

Net metering is currently provided for captive customers who install **photovoltaic plants with nominal capacity of up to 20 kW**

For such plants:

- delivered electric energy (injected onto the grid) and electric energy uptake compensate each other on an annual basis, independently of time brackets;
- if positive, net balance is transformed into a credit usable during subsequent years;
- if negative, net balance is billed using normal supply contract charges.
Recognition of the lower losses connected to distributed generation

For plants connected to distribution networks, the producer receives from the distributor a credit of:

- F1 bracket: 0.77 €/kWh
- F2 bracket: 0.49 €/kWh
- F3 bracket: 0.32 €/kWh
- F4 bracket: 0.14 €/kWh
Uptake modalities and prices for energy produced from plants with capacity < 10 MVA and >= 10 MVA fueled by non-programmable renewable sources