



Lessons Learned from the Power Outage in North America and Europe

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**RIETI Policy Symposium
Tokyo, 15 December 2004**



Outline

- **California**
- **2003 Blackouts**
- **Market Reform and Transmission Reliability**
- **Some Lessons**



California – It's A Different Story

- **California should not be included with the 2003 blackout cases**

- **Key Issues in the Californian Case:**
 - ◆ **Slow and difficult investment approvals**
 - ◆ **Market design flaws**
 - ◆ **Structure that facilitated market power**
 - ◆ **Unexpected growth in demand**
 - ◆ **NO_x and So_x permit restrictions**
 - ◆ **Inappropriate (and slow) regulatory responses**
 - ◆ **High gas prices**
 - ◆ **Water shortages limited hydro access**

- **Californian experience illustrates the need for good market structure, design and regulation**



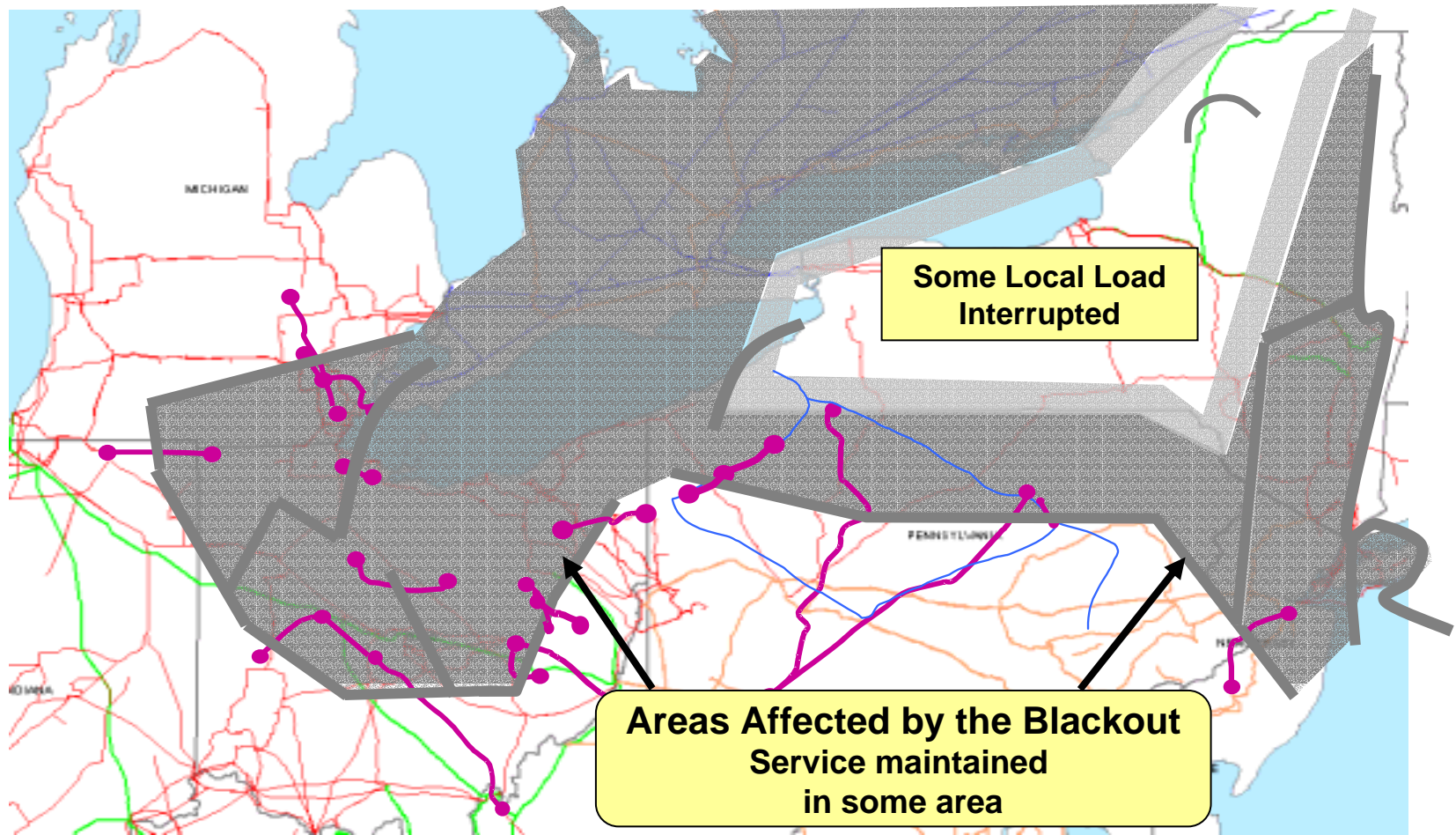
2003 Blackout Case Studies: North America

● Event Summary (14 August 2003):

- ◆ Phase 1: 600 MW generator fails (13h31) and 345 Kv line fails (14h02) in Ohio. Communication and monitoring equipment failures prevent appropriate responses
- ◆ Phase 2: Tree flashover leads to parallel line failures around Cleveland. Voltage falls (15h05-15h57)
- ◆ Phase 3: 138 Kv net around Cleveland collapses and North Ohio is isolated as more lines trip (15h39-16h08)
- ◆ Phase 4: Isolation of North Ohio brings huge power swings, leading to cascading failures (16h08-16h13)

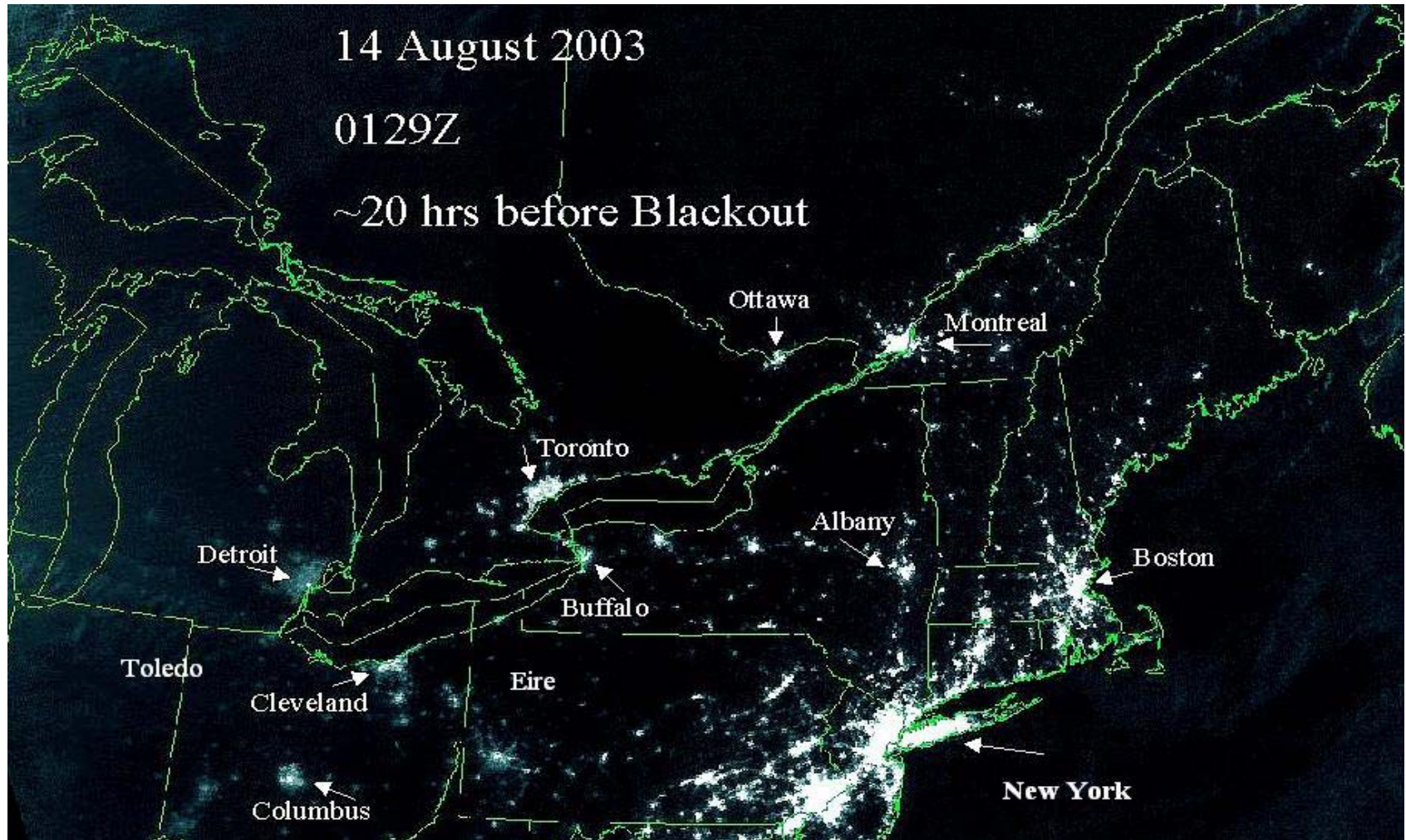


2003 Blackout Case Studies: North America



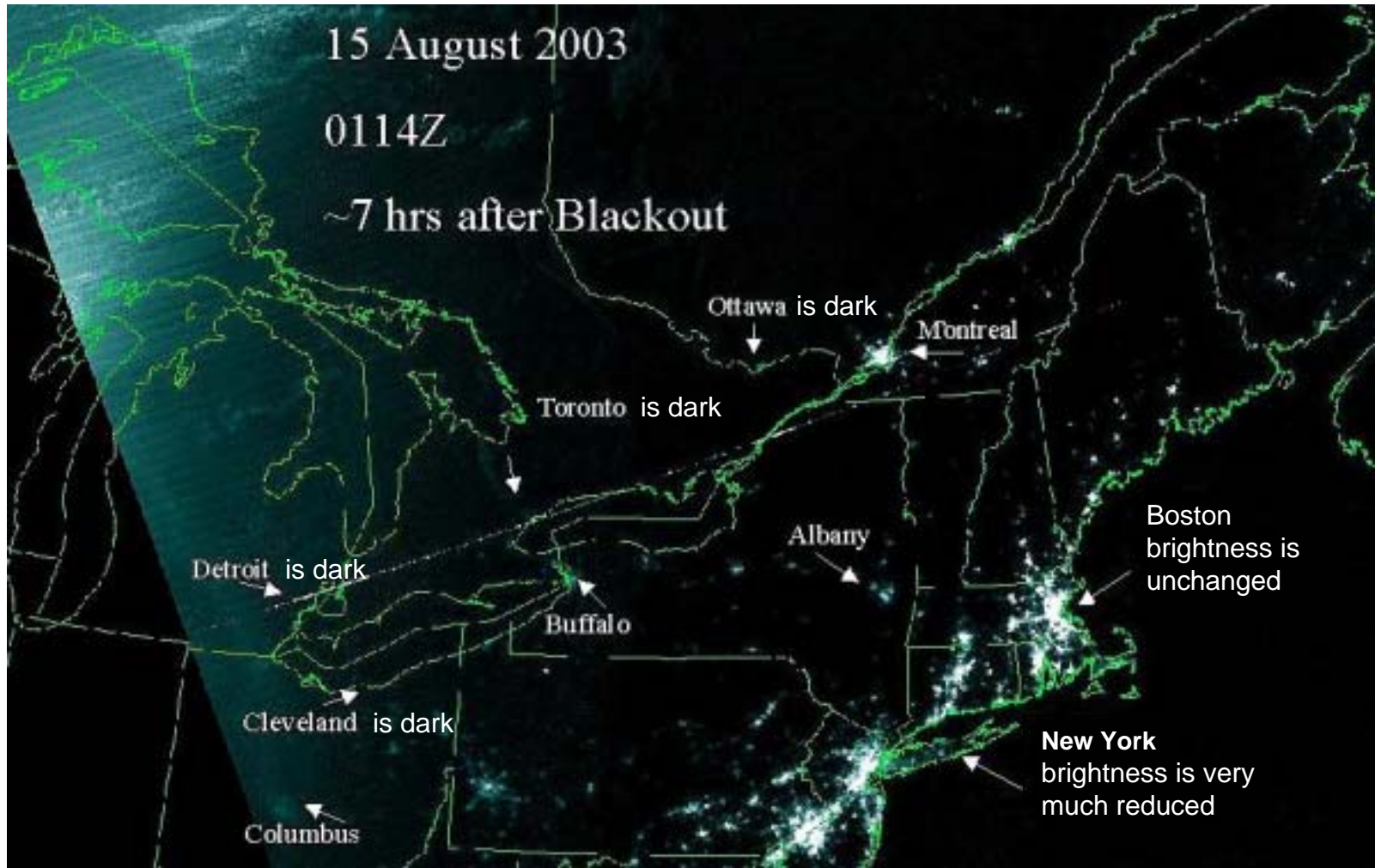


2003 Blackout Case Studies: North America





2003 Blackout Case Studies: North America





2003 Blackout Case Studies: North America

- **US-Canada Power Outage Task Force - key findings included:**
 - ◆ **Enforceable, appropriate reliability standards are needed (including tree management)**
 - ◆ **Training and expertise of system operators needs to be improved**
 - ◆ **Diagnostic and real-time operational equipment needs to be maintained and improved**
 - ◆ **Strengthen communication protocols**

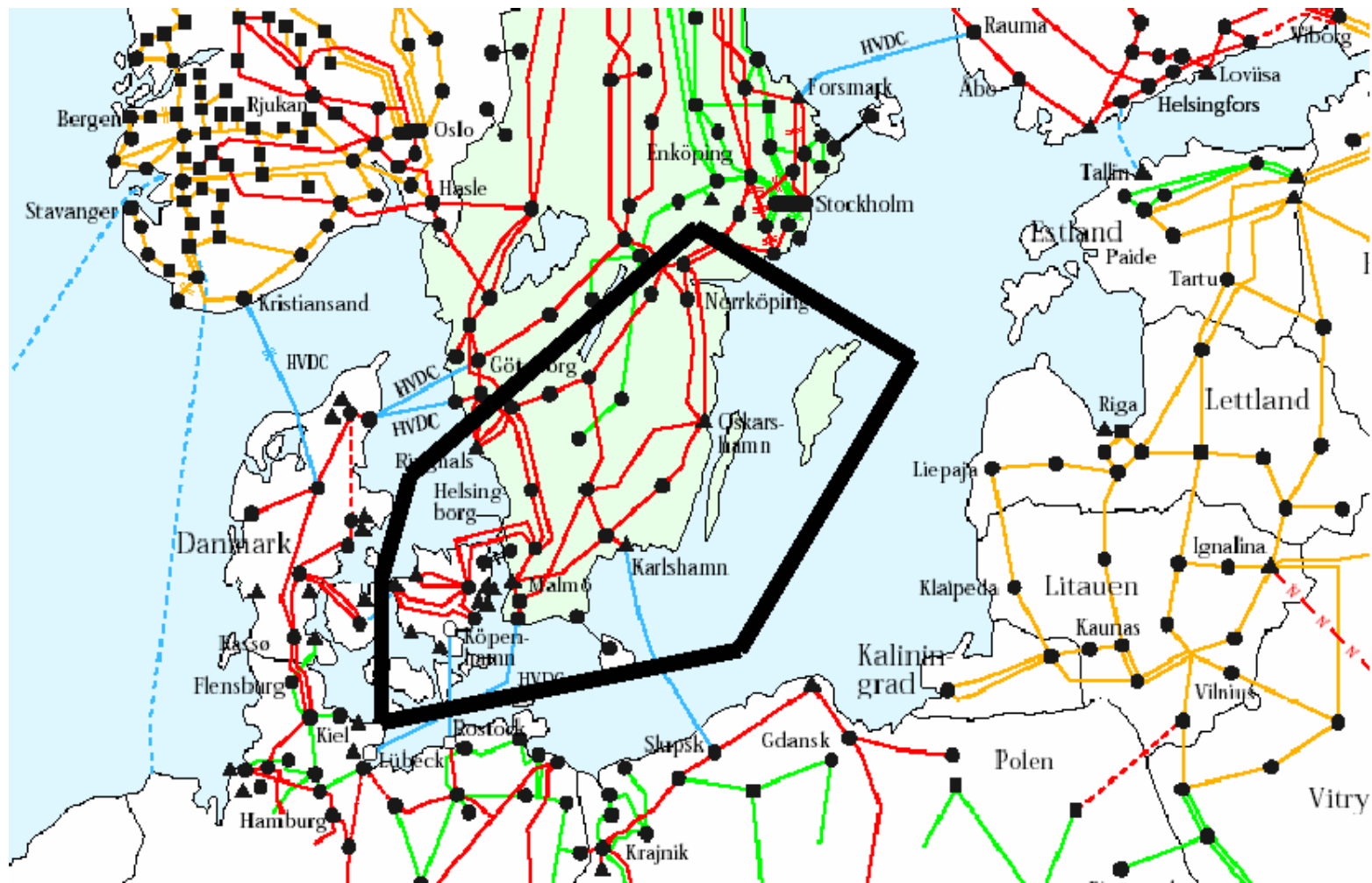


2003 Blackout Case Studies: Scandinavia

- **Event Summary (23 September 2003):**
 - **12h30: 1200 MW nuclear unit lost**
 - **12h35: double busbar fault, disrupts – 900 MW lost**
 - **12h37: Voltage collapse south of Stockholm**



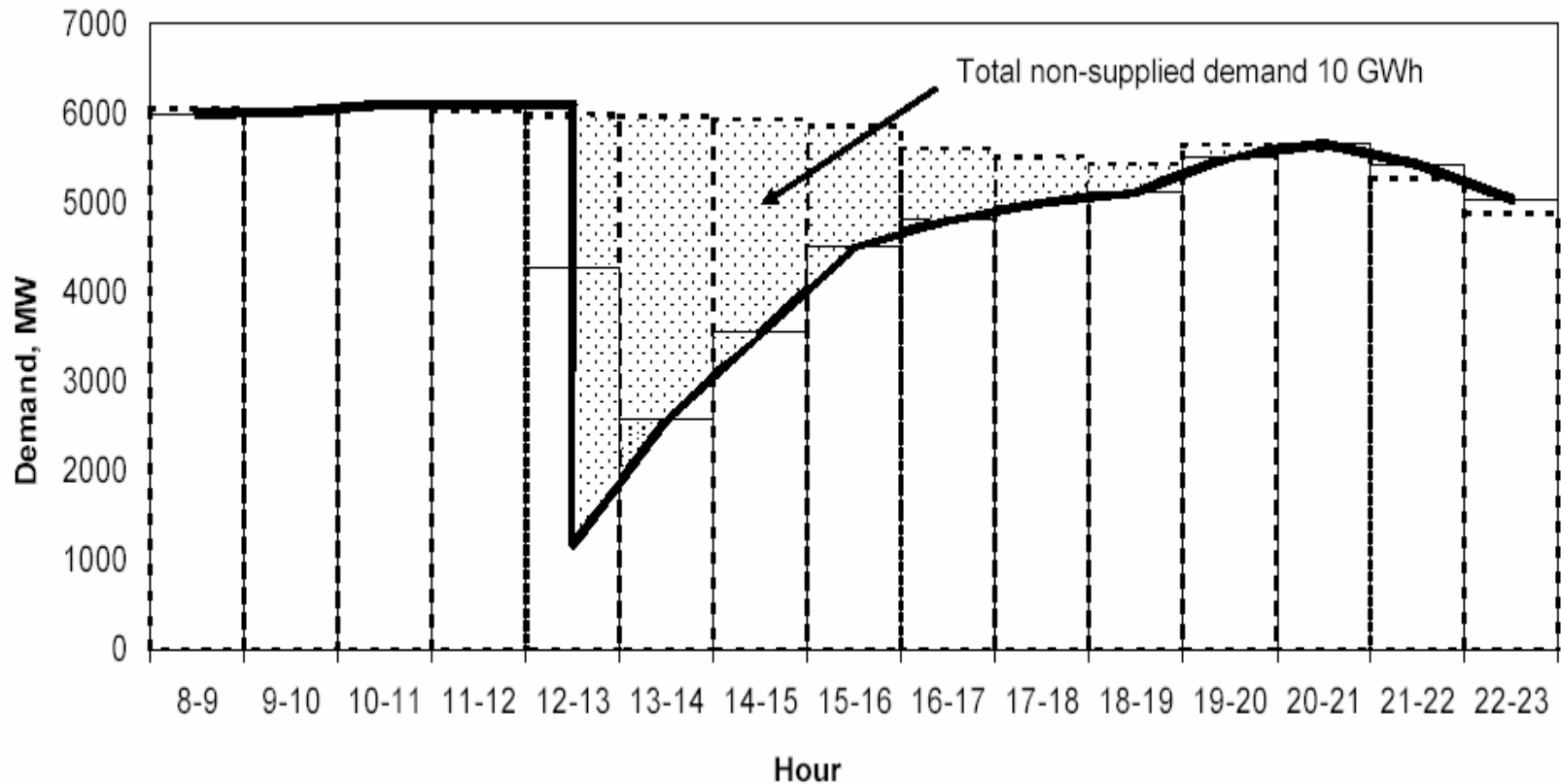
2003 Blackout Case Studies: Scandinavia





2003 Blackout Case Studies: Scandinavia

Swedish System Restoration





2003 Blackout Case Studies: Scandinavia

- **Joint Swedish-Danish TSO findings:**
 - ◆ **Review reliability standards and network structure**
 - ◆ **Review maintenance procedures**
 - ◆ **Ensure reliable system management tools and well trained staff**
 - ◆ **Provide timely information on emergency events**

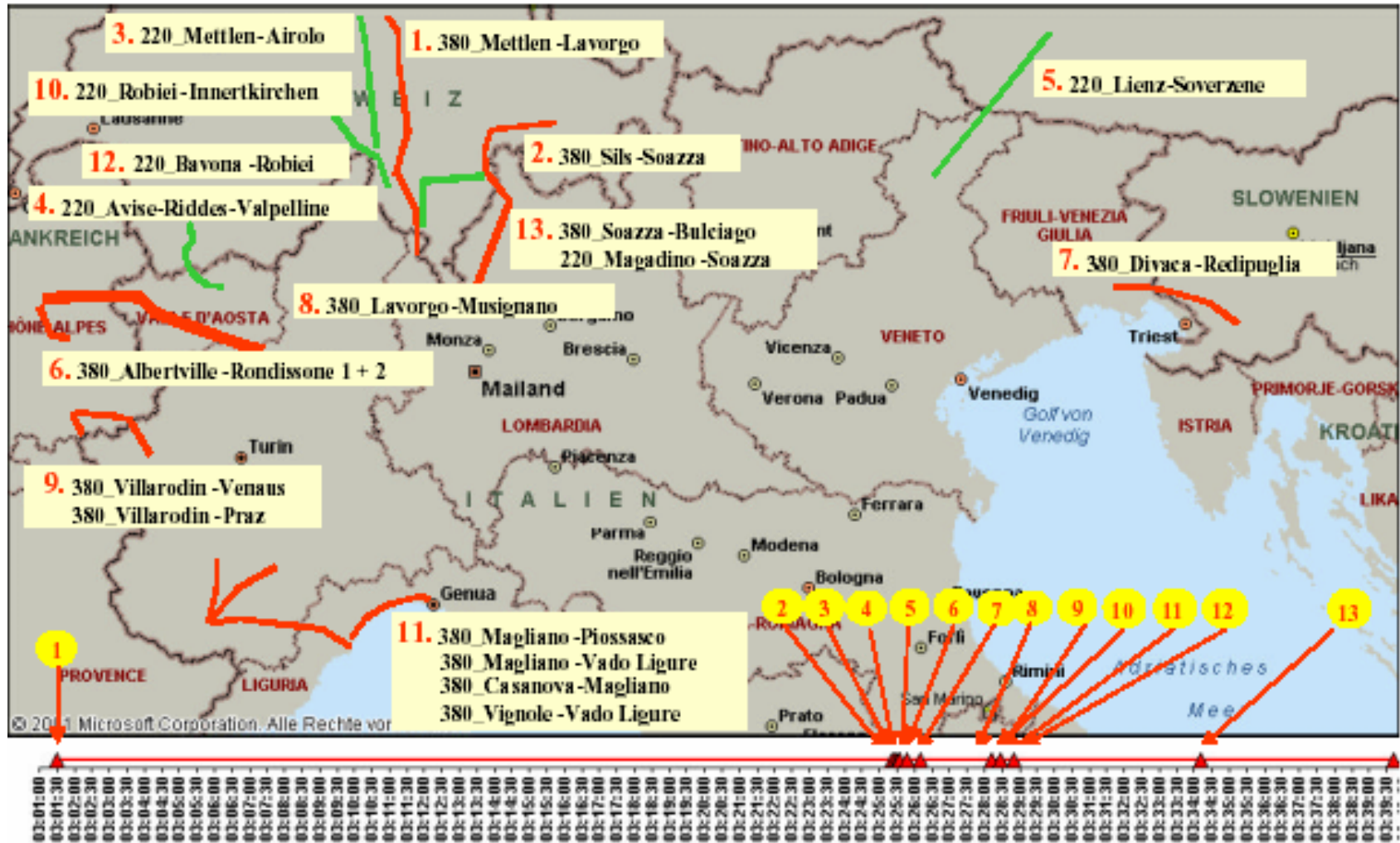


2003 Blackout Case Studies: Italy

- **Event Summary (28 September 2003):**
 - ◆ Tree flashover 380Kv link to Switzerland (03h01)
 - ◆ Attempt to reduce overloads on other lines (03h11-03h21)
 - ◆ Tree flashover second 380Kv line to Switzerland (03h25) and cascading line trips – Italy isolated
 - ◆ Voltage drop and frequency decline leading to blackout (03h28)



2003 Blackout Case Studies: Italy





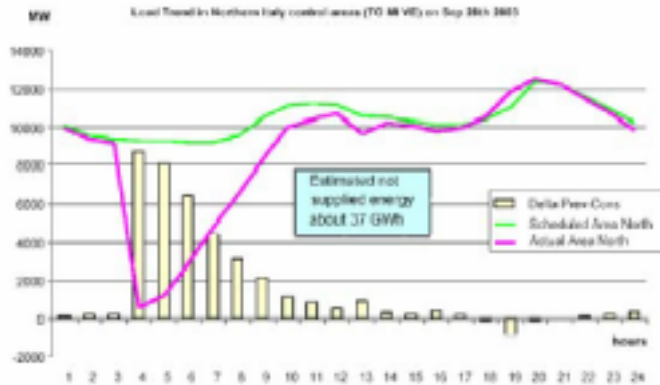
2003 Blackout Case Studies: Italy



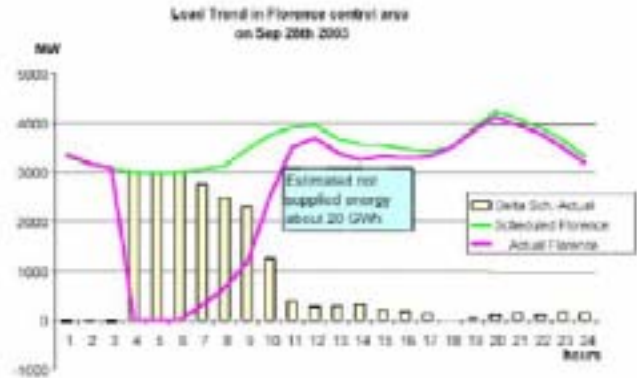


2003 Blackout Case Studies: Italy

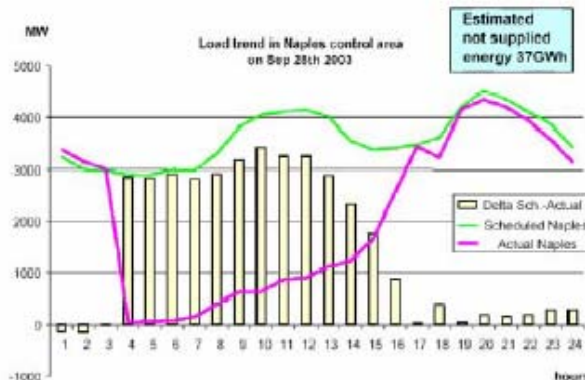
Restoration strategy - Northern Italy



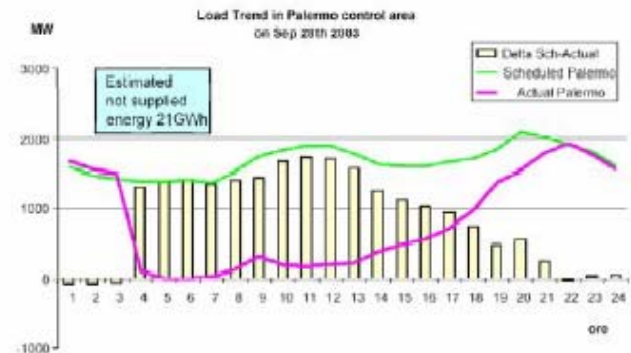
Restoration strategy - Center Italy



Restoration strategy - South



Restoration strategy - Southern Italy





2003 Blackout Case Studies: Italy

- **Swiss Federal Office of Energy findings:**
 - ◆ **Unresolved conflicts of interest between trading and system operation**
 - ◆ **Inappropriate standards and legal instruments**
 - ◆ **Italy needs more reserve capacity given its dependence on trade**



2003 Blackout Case Studies: Italy

- **Joint Report of the French and Italian Regulators Findings:**
 - ◆ **Swiss TSO procedures and practices did not comply with UCTE standards**
 - ◆ **Swiss operational errors led to tripping of key interconnectors**
 - ◆ **UCTE standards must be binding**
 - ◆ **TSO coordination needs to improve**
 - ◆ **Swiss must introduce reforms consistent with the EU Electricity Directives**



2003 Blackout Case Studies: Italy

- **UCTE Report Findings:**
 - ◆ **Line failures in Switzerland initiated the problem**
 - ◆ **Countermeasures were not activated in time, reflecting technical and operational failures**
 - ◆ **System restart could have been achieved more quickly**



Electricity Reform and Grid Reliability: New IEA Study

- **Electricity reform is not to blame for the blackouts**
- **Electricity reform has led to:**
 - ◆ **trade and regional markets**
 - ◆ **longer distance use of transmission**
 - ◆ **Greater, less predictable & more volatile usage**
- **Creating new real-time challenges for system operators**



Some Lessons from the Blackouts: A Story of “3 Ts” ...

- **T**ools – To monitor and assess a wide area and evaluate actions
- **T**rainning – Simulators, structured programs and drills to assure actions are taken
- **T**rees – Vegetation management



Some Lessons from the Blackouts: ... and “3 Cs”

- **Communication**
- **Coordination**
- **Cooperation**