Nodal and Zonal Market Clearing

Anthony Papavasiliou
Université Catholique de Louvain

March 18, 2019

Presentation at the 14th EU-US regulator roundtable

Outline

Impact of market design on day-ahead operations

Impact of market design on real-time operations

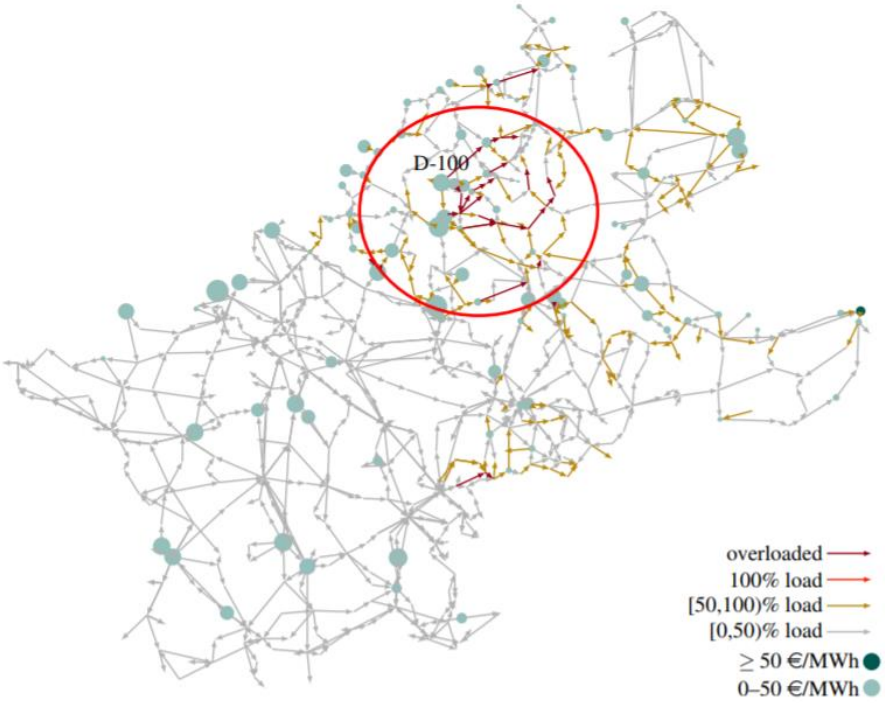
- Real time as a market versus real time as a service
- European balancing operations
- Active network management

CEER
Council of European Energy Regulators

DAY-AHEAD OPERATIONS

Market Design Matters in Turning on the Right Generators in Day-Ahead

- Zonal models can result in **infeasible** power flows (e.g. starting up cheap coal)
- Power flows can be made feasible in real time, but it is costly, e.g.
  - reduce production of coal
  - start up combined cycle gas turbines



Source: [Aravena, 2017]

=> operating costs that could be avoided

Estimate of Day-Ahead Inefficiencies in Central Western Europe

Policy	Day ahead (M€/year)	Real time (M€/year)	Total (M€/year)	Efficiency losses
Nodal	11,248	534	11,818	-
Flow-based zonal	10,458	1,963	12,420	**602 M€/year**
ATC-based zonal	10,470	1,949	12,419	**601 M€/year**

Source: [Aravena, 2019]

Conclusion: *Day-ahead* generator on/off decisions have significant *real-time* economic implications

REAL-TIME OPERATIONS

Real time as a market versus as a service
Real-time dispatch procedures
Active network management

Real Time as a Market Versus Real Time as a Service

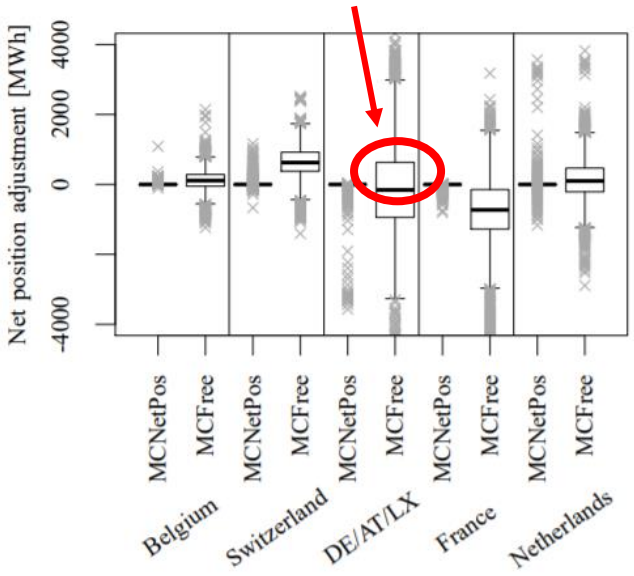
- US view
  - Real time: spot market
  - Day ahead: forward market
- European view
  - Day ahead: spot market
  - Real time: a service that supports balancing

- Implication of EU view: **balancing responsible parties (BRPs) should remain balanced from day ahead to real time**

RT renewable supply > DA renewable forecast

(i) Should the BRP stay in balance, or

(ii) Should the power be exported?



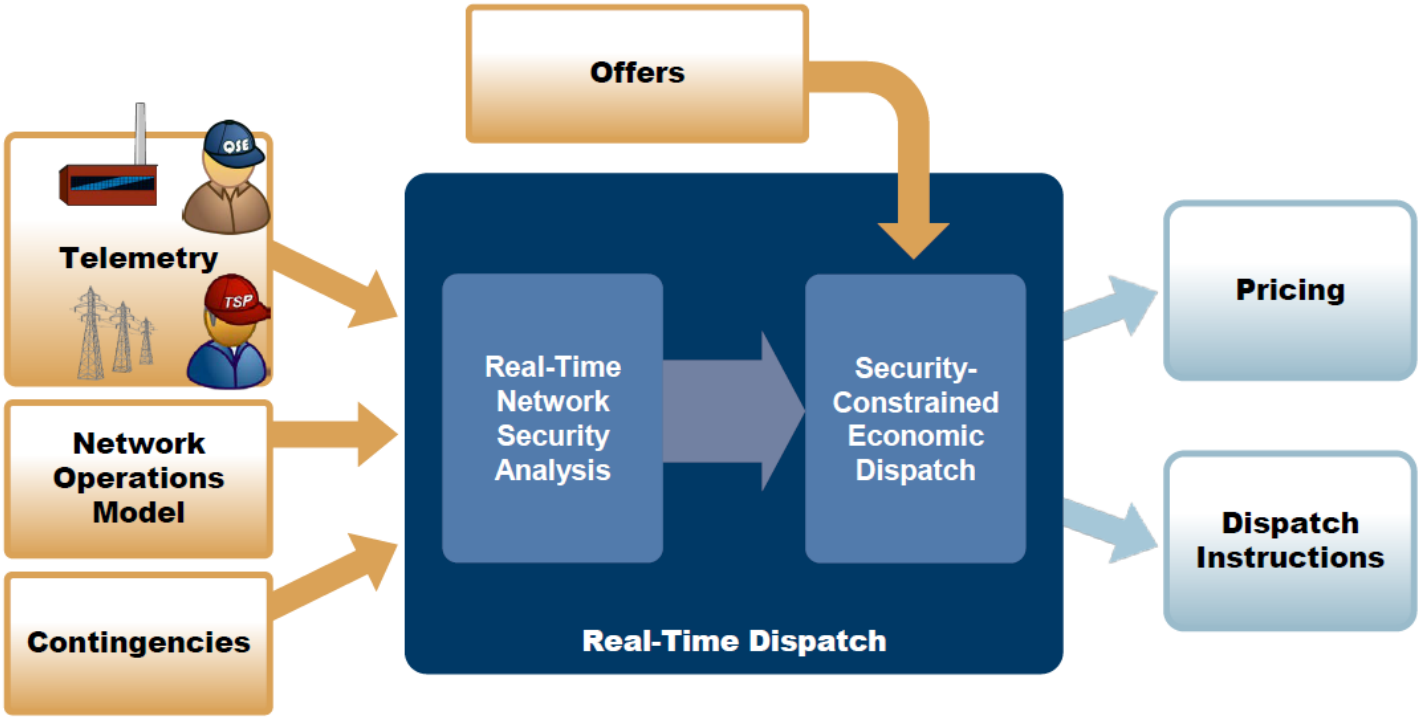
Source: [Aravena, 2017]

CEER
Council of European Energy Regulators

Real-Time Operations

	USA	Europe
Optimization-based	Yes	Not necessarily (e.g. Belgium: no, France: ?)
Coordination of balancing & congestion management	Yes	No
System operator coordination	Interface scheduling	Move towards coordinated balancing (MARI, PICASSO)
Active network management	Not much (e.g. PJM)	Extensive (e.g. France, Netherlands switches 3x/day (?))

Example: Texas Real-Time Operations



ERCOT real-time dispatch (source: [ERCOT-RTM])

CEER
Council of European Energy Regulators

Efficiency of Real-Time Operations

	Inter-SO coordination ?	Optimization in real time?	Real-time cost (€)
Option 1	yes	yes	163,721
Option 2	no	yes	888,578
Option 3	no	no	1,670,110

Conclusion: *Coordination* and *optimization* can have a major impact on real-time cost

Indicative results based on a single snapshot of Central Western Europe system

Active Network Management

- **Active network management (ANM)**: bus-bar/line switching …
- ANM practice in the US
  - Significant R&D efforts (ARPA-E)
  - Current view: ANM mostly *reactive* (contingency response)
  - Switching in practice: limited (?)
  - Interference with financial transmission rights market
- ANM practice in Europe
  - ANM is **extensive** in Europe, a chicken-and-egg question
  - ANM is Central Western Europe is coordinated by the CORESO organization [Han, 2015]

References

- **[Aravena, 2017]** I. Aravena, A. Papavasiliou. *Renewable Energy Integration in Zonal Markets*, IEEE Transactions on Power Systems, vol. 32, no. 2, pp. 1334-1349, March 2017.
- **[Aravena, 2019]** I. Aravena, A. Papavasiliou, Y. Smeers, *Transmission Capacity Allocation in Zonal Electricity Markets*, under review.
- **[ERCOT-RTM]** ERCOT, *ERCOT Market Education, Basic Training Program, Module 6: Real-Time Operations*.
- **[Han, 2015]** J. Han, A. Papavasiliou, *Congestion Management through Topological Corrections: A Case Study of Central and Western Europe (CWE)*, Energy Policy, vol. 86, pp. 470-482, November 2015.