

CEER

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Nodal and Zonal Market Clearing

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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

DAY-AHEAD OPERATIONS

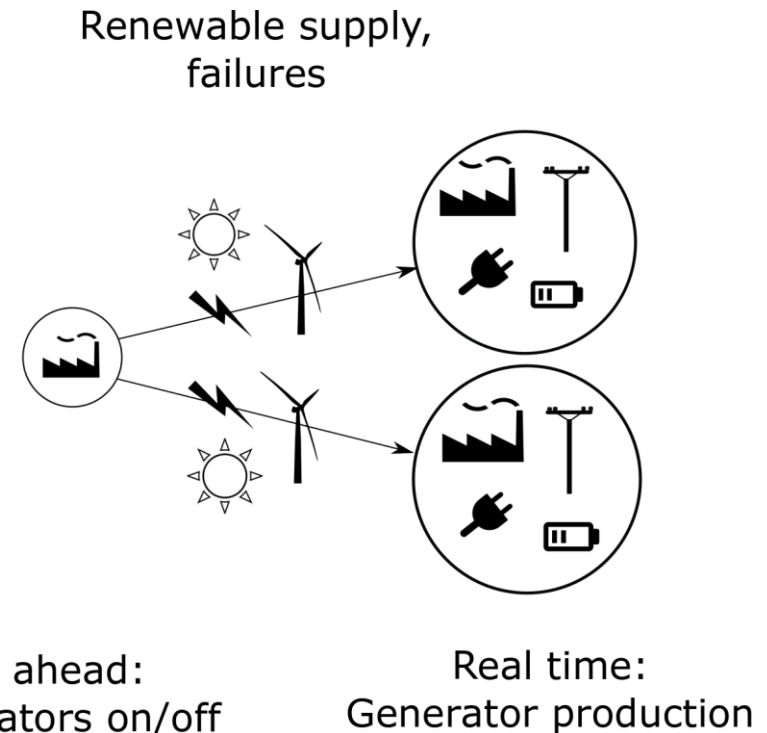


Efficient Decisions in Day-Ahead and Real-Time Operations

Short-term operational efficiency depends on

(i) Efficient **irrevocable** day-ahead decisions

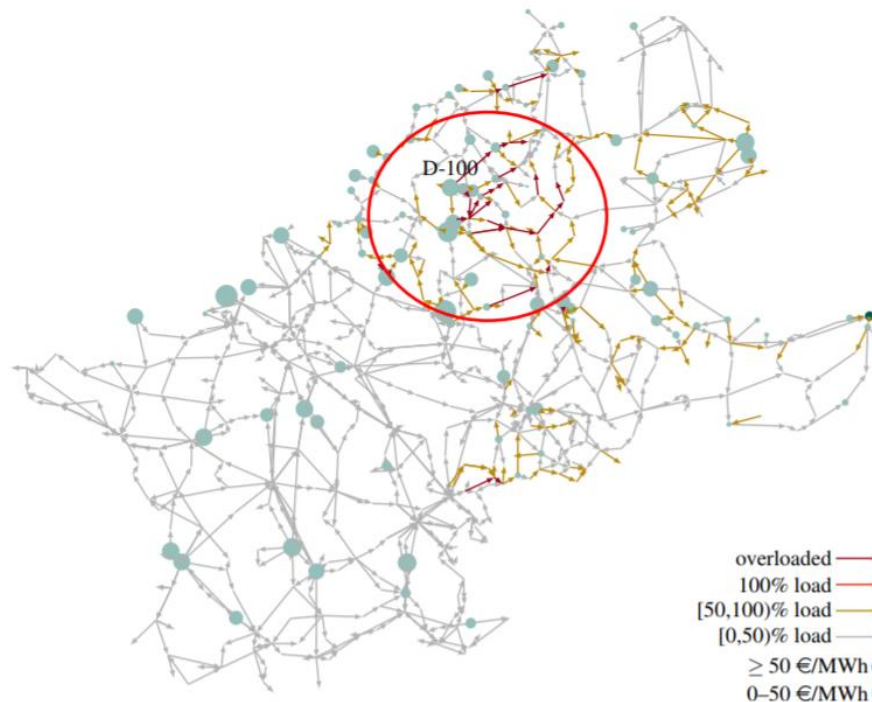
(ii) Real-time **coordination**



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)

=> operating costs that could be avoided



Source: [Aravena, 2017]



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

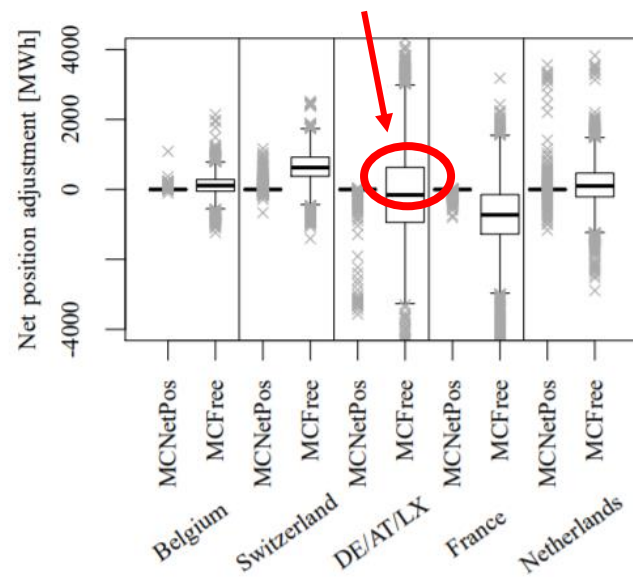


Real Time as a Market Versus Real Time as a Service

- 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]

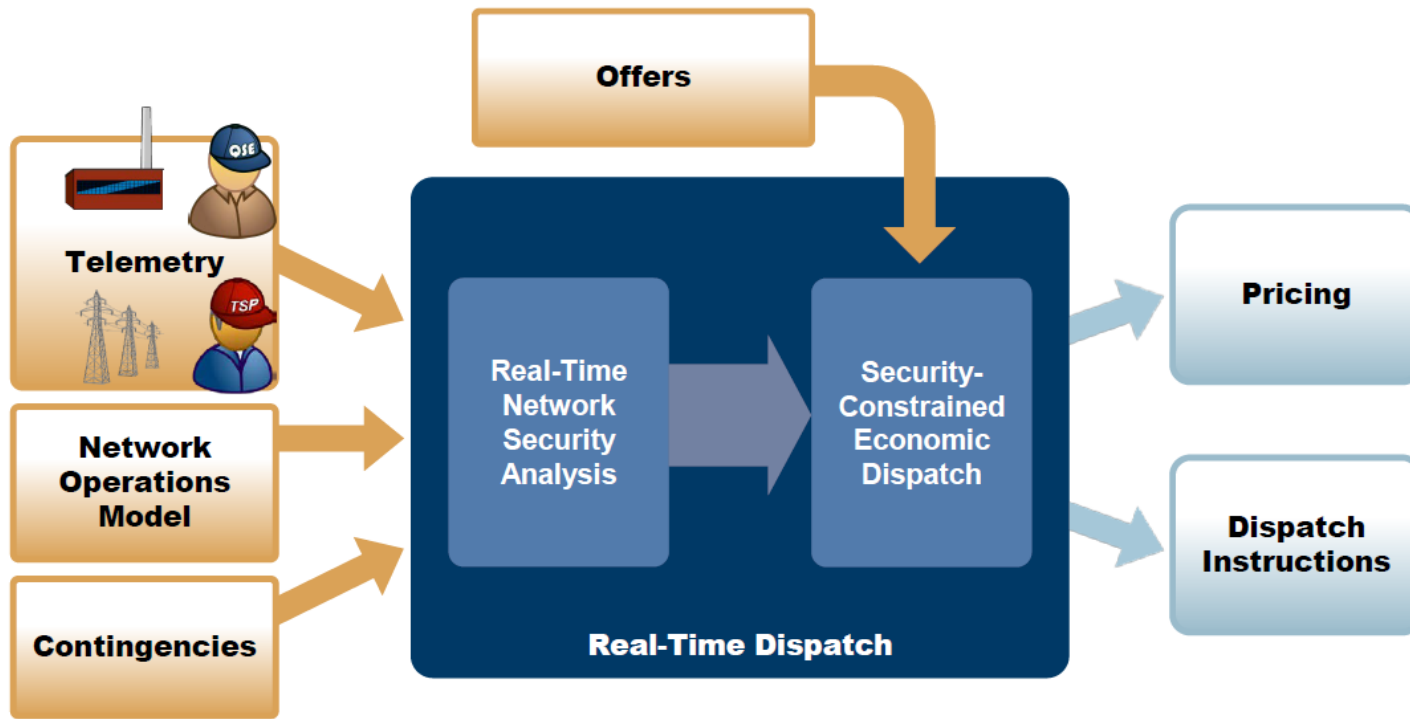


Real-Time Operations

	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])



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 in 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.

