Market Design for Unit Commitment

Anthony Papavasiliou, National Technical University of Athens (NTUA)

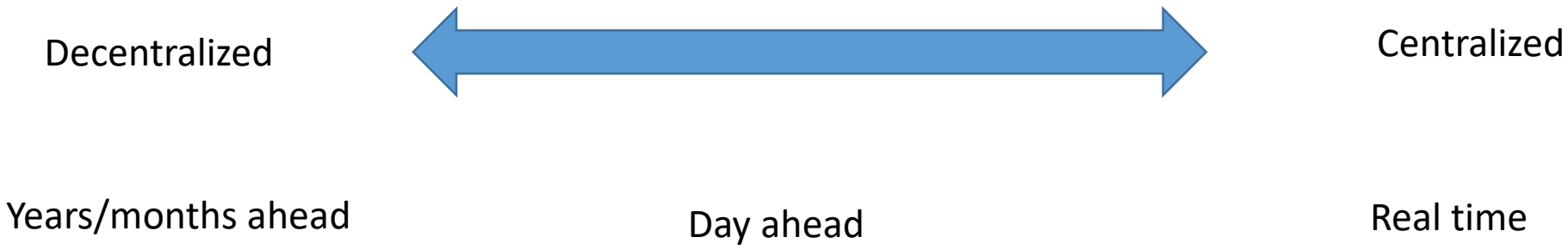
Source: chapter 7.2, Papavasiliou [1]

Outline

- The two-settlement system
- Design dilemmas

The two-settlement system

Varieties of day-ahead market designs



We will analyze two variations:

- Exchanges (more decentralized)
- Pools (more centralized)

Role of day-ahead markets

Day-ahead markets are *forward* markets for power

Two-settlement system: organization of (1) day-ahead markets as forward markets for trading power, followed by (2) a real-time market for settling imbalances

Two-settlement system for producers

Suppose generator *sells* quantity Q_1 at price P_1 in day-ahead market, and *produces* Q_0 in real time:

- *Paid* $P_1 \cdot Q_1$ from day-ahead market
- If $Q_0 > Q_1$, *paid* price P_0 for extra energy $Q_0 - Q_1$
- If $Q_0 < Q_1$, *pay* price P_0 for energy shortage $Q_0 - Q_1$

Generator is paid

$$R = P_1 \cdot Q_1 + P_0 \cdot (Q_0 - Q_1)$$

Two-settlement system for consumers

Suppose load *buys* quantity Q_1 at price P_1 in day-ahead market, and *consumes* Q_0 in real time:

- *Pays* $P_1 \cdot Q_1$ to day-ahead market
- If $Q_0 > Q_1$, *pays* price P_0 for extra energy consumed $Q_0 - Q_1$
- If $Q_0 < Q_1$, *paid* price P_0 for less energy consumed $Q_0 - Q_1$

Load pays

$$R = P_1 \cdot Q_1 + P_0 \cdot (Q_0 - Q_1)$$

Design dilemmas

Design dilemmas

As we move back from real time to earlier markets (e.g. to day-ahead market) two important differences emerge:

- Natural resources no longer need to be controlled separately (chapter 7.2)
- Costs and constraints are not always convex (chapter 7.3)

Design dilemmas:

- Portfolio-based versus unit-based designs
- Exchanges versus pools

Portfolio-based design

- Production and consumption resources are *aggregated* at the market clearing stage
- Aggregated offers are constructed by portfolio owners
- The market clears
- Portfolio owners disaggregate the market outcome to setpoints of *individual* physical assets
- These setpoints are announced to the system operator after the day-ahead markets, but before real time, at the **nomination** stage
- Operations can be separated:
  - Market clearing by a power exchange
  - Nominations received by system operator

Unit-based design

- Separate physical assets bid separately to the market
- Often associated with integrated operation of system and market, where auctioneer is also system operator
- Design of choice in the US
- It is also possible to separate auctions from system operation in unit-based design
  - Greece: day-ahead market operated by power exchange, which is a separate entity from the system operator

Comparison

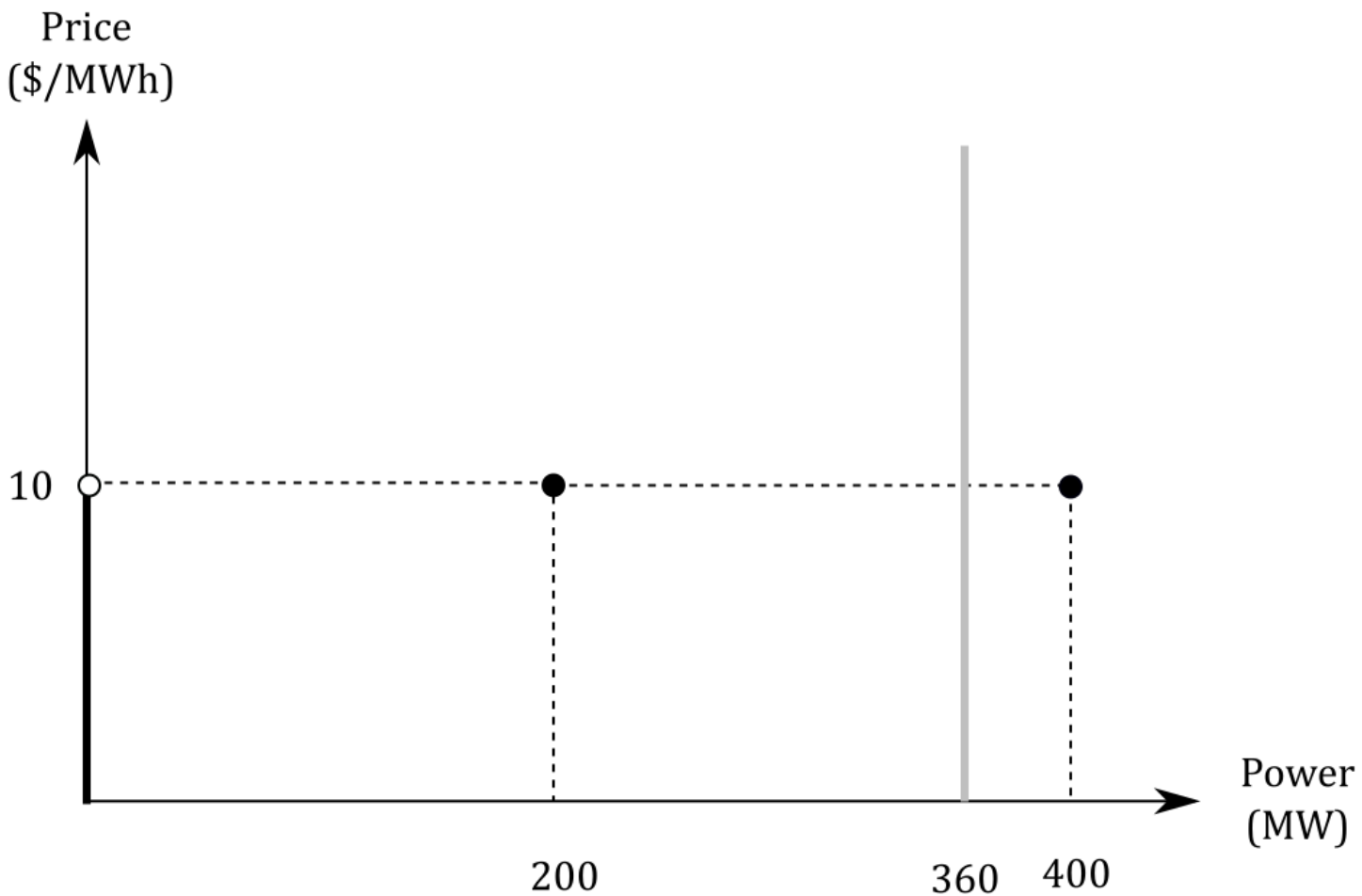
Portfolio-based designs	Unit-based designs
Impossible to represent network (-)	Possible to represent network (+)
More flexibility to traders (+)	Less flexibility for traders (-)
More challenging to mitigate market power (-)	Easier to mitigate market power (+)

Example 7.5: a system without a market clearing price

Consider the following market:

- Inelastic demand: 360 MW
- Three identical generators
  - Capacity: 200 MW
  - Startup cost: $1000
  - Marginal cost: 5 $/MWh

Note: there is no price that exactly equilibrates supply and demand


Price
($/MWh)
10
200
360
400
Power
(MW)

Exchanges

Exchange: uniform price auction with simple bidding rules

- Bidders internalize fixed costs in their bids
- Less complicated rules (hence less gaming)
- More complicated bidding strategy required by market participants

Pools

Pools are multi-part auctions where producers submit their costs and operating constraints, and different producers effectively receive different prices due to uplift payments

- Complex auction rules ⇒ susceptible to gaming
- Simpler for market participants, more complex for market operator
- Market participants effectively paid differently, because of side payments

References

[1] A. Papavasiliou, Optimization Models in Electricity Markets, Cambridge University Press

https://www.cambridge.org/highereducation/books/optimization-models-in-electricity-markets/0D2D36891FB5EB6AAC3A4EFC78A8F1D3#overview