Challenges of the future electricity market design

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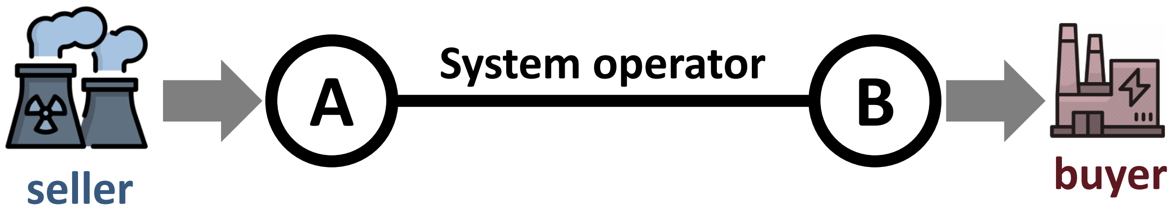
What makes electricity specific

- ***Specificities of electricity as a commodity*** → need for coordination
  - Exchanged through an **electrical grid** : physical network constraints
  - Demand must be met just-in-time by production
  - **Difficult/expensive to store**
  - **Low elasticity** of demand (few substitutes & lack of metering)
- ***Liberalization of power systems***:
  - Deregulation: “vertical” separation of the competitive segments (**generation** and **retail**) from the natural monopoly segments (**transmission and distribution**)
  - From a **coordination by a a firm to a coordination through *market transactions*** (Coase, 1937)
  - *“the move to liberalizing the electricity sector […] was effectively a bet that the costs of any residual imperfections in competitive wholesale markets are smaller than the costs of imperfections associated with the behaviour of vertically integrated regulated monopolies.”* (Joskow, 2019)

→ **Electricity market design challenge**: foster **efficiency** both in **short-term** operations & **long-term** investments

Electricity markets = 3 main commodities with 2 main links

- The ultimate goal, or the main service, delivered by the entire electricity sector is **the provision of electrical energy in real time to the end-consumer**.



- **3 main commodities** (further indexed by time and location) are traded to achieve this goal :
  - ***Electrical energy***: produced by power plants, consumed by consumers
  - ***Transmission capacity***—the roads of electricity: natural monopoly because of economies of scale
  - ***Ancillary services***: ensure power quality and contribute to the *reliability* of the system—*public good* (non-rival & non-exclusive). Some "spare capacity" left available by the supplier in order for the system operator to have the flexibility to cope with contingencies.

Electricity markets = 3 main commodities with 2 main links

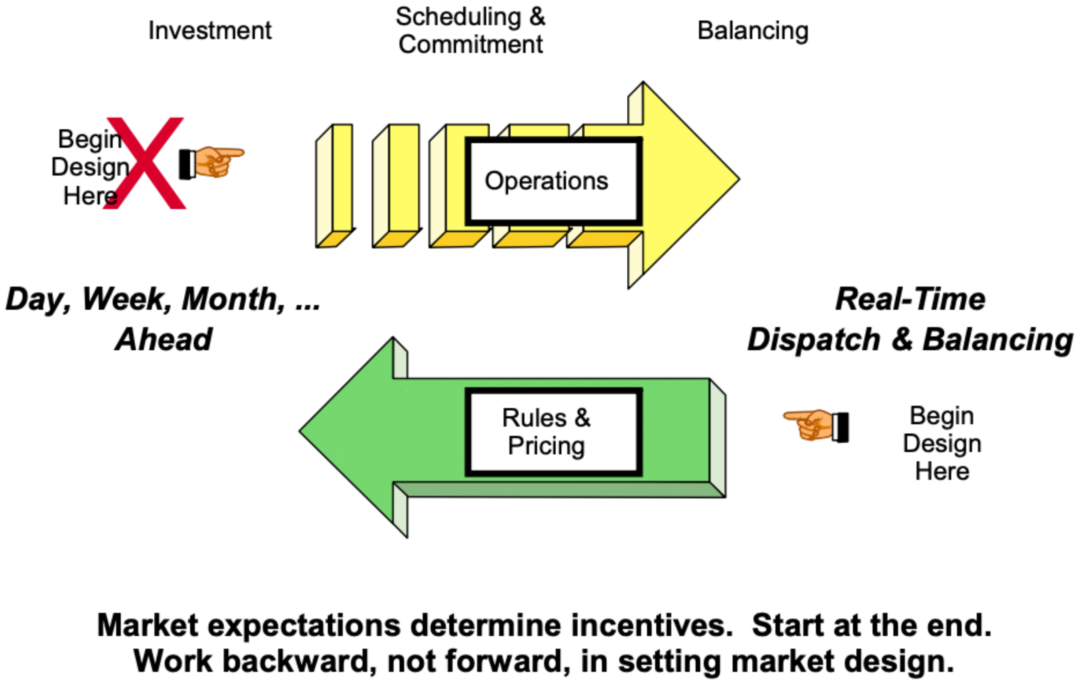
- The economic properties of these goods lead to **heterogeneous market arrangements**:

Commodity	***Type of good***	***Supply-side***	***Demand-side***
Electrical energy	Private good	Competition (multiplicity of sellers)	Competition (multiplicity of buyers)
Transmission capacity	Private good	SO is monopoly seller	Competition (multiplicity of buyers)
Ancillary services	Public good	Competition (multiplicity of sellers)	SO is monopsony buyer

- 2 tight **links** between these goods:
  - **Energy – Ancillary services**: for a seller selling energy for 20€/MWh, selling ancillary services (reserve) is a missed opportunity of selling energy → reserve price is 20€/MWh – MC.
  - **Energy – Transmission capacity**: if price in A is 20€/MWh and price in B is 10€/MWh, then the value of the line is 10€/MWh (value of supplanting production in A by production in B).

Good market designs work *backward*

*"A key step in developing an efficient wholesale electricity market design is to begin the process at the end. In a system of monopoly and central direction, real-time incentives may be of secondary importance […]. However, in a competitive market operating under principles of open access and non-discrimination, **good design begins with the real-time market and works backward**. A common failure mode starts with the forward market, without specifying the rules and prices that would apply in real time."* (Hogan, 2022)



- → **Importance of the spot market & the price signal in the spot market!**
- → **Prices are the hands that guide LT & ST behaviors**
- → **How to get prices right?**

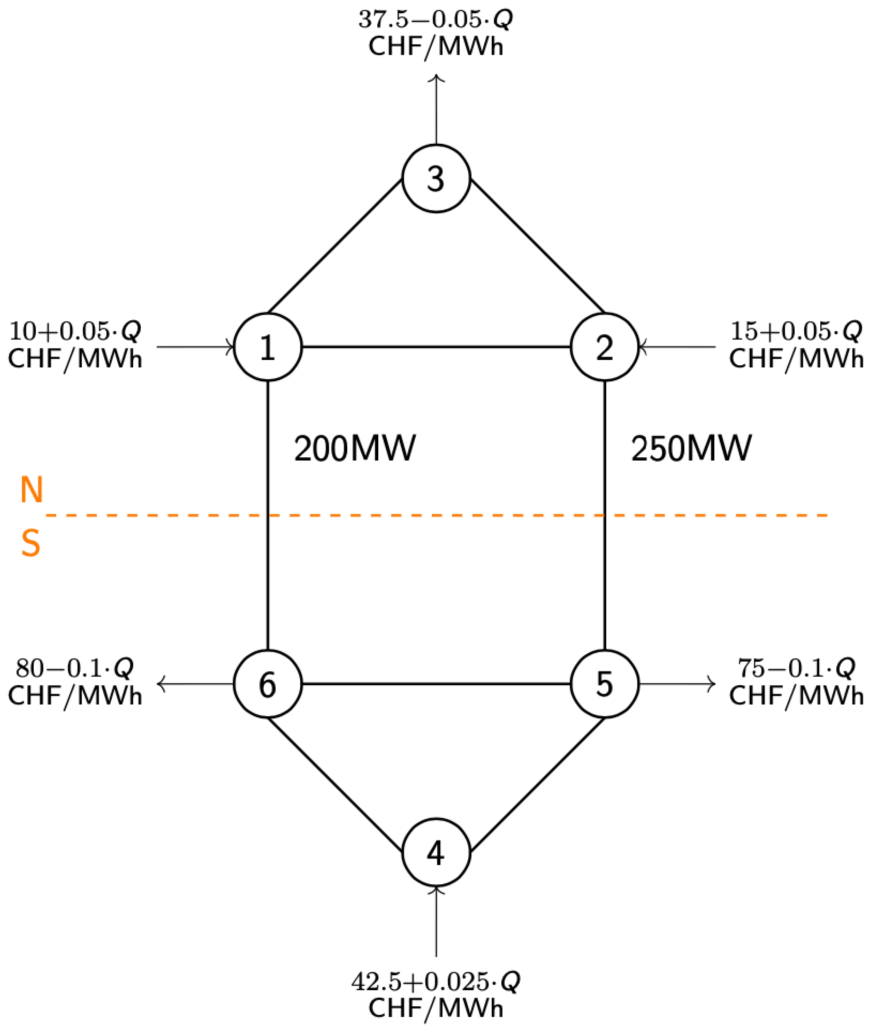
Figure from Hogan (2021)

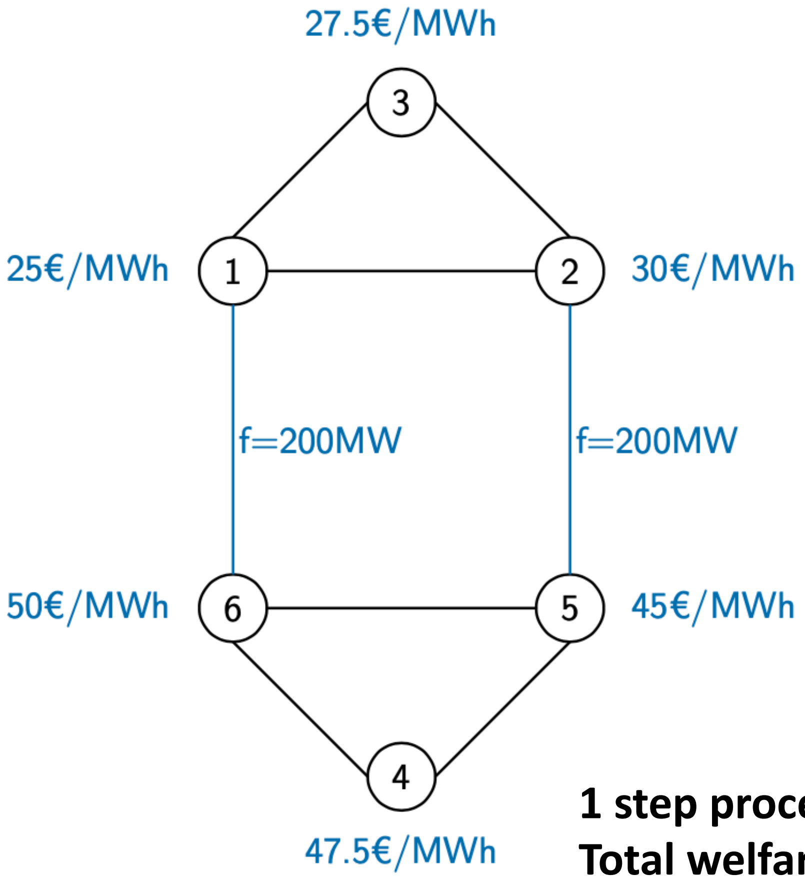
Content

Locational pricing of electricity

- Nodal & zonal markets
  - **Nodal** = recognize that **electrical energy is exchanged through an electrical grid** (cf. previous slides)
    - Transmission capacity = one of the 3 commodity of electricity
    - Tightly linked with energy
  - **Zonal** = ignore most transmission constraints (then managed with **out-of-market redispatch**)
- Locational **price signal to drive incentives** of market participants:
  - Efficient operations
  - Efficient investments (where to invest, e.g. investing in North/South Germany)
- **Theory** of locational marginal pricing known at least since Bohn et at. (**1984**), Schweppe et al. (**1988**)
- **Implemented successfully in PJM** market since **1998** (early zonal model of PJM was not successful, cf. Hogan (2002)); and since then, in all US markets.
- Not adopted everywhere yet: **European market is zonal**, thus ignoring most transmission constraints

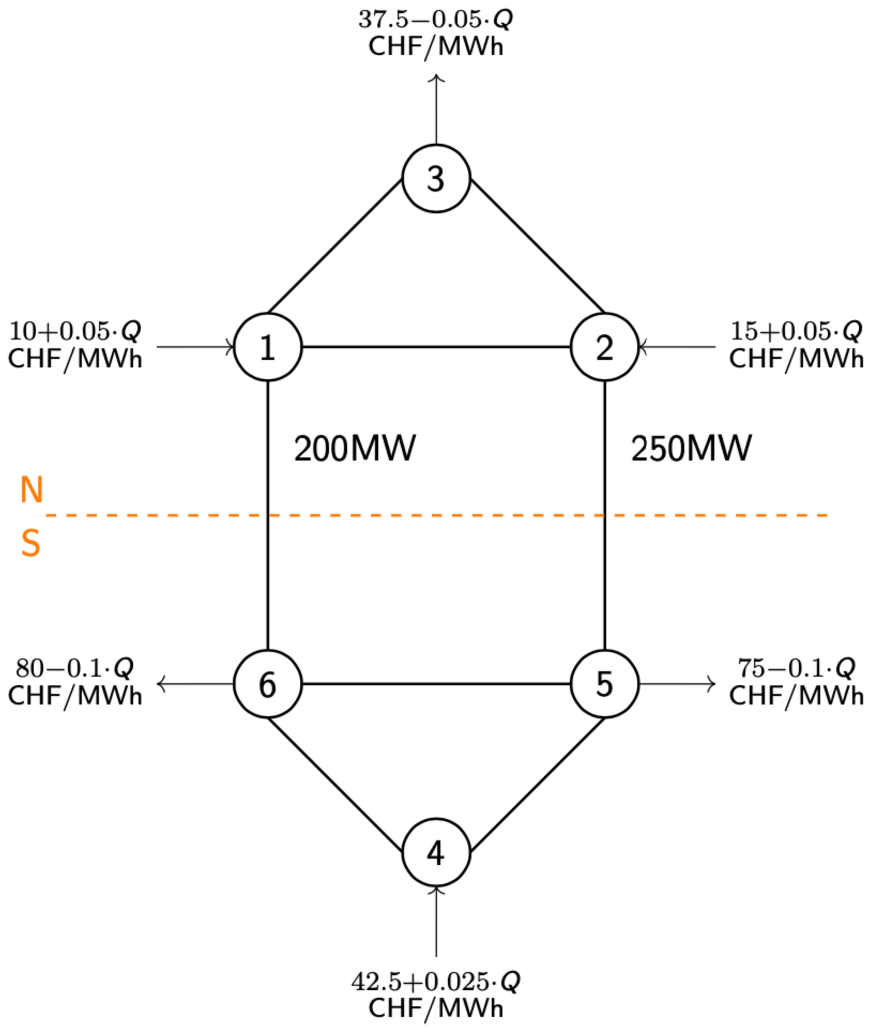
Example from Lété (2022)
Nodal pricing

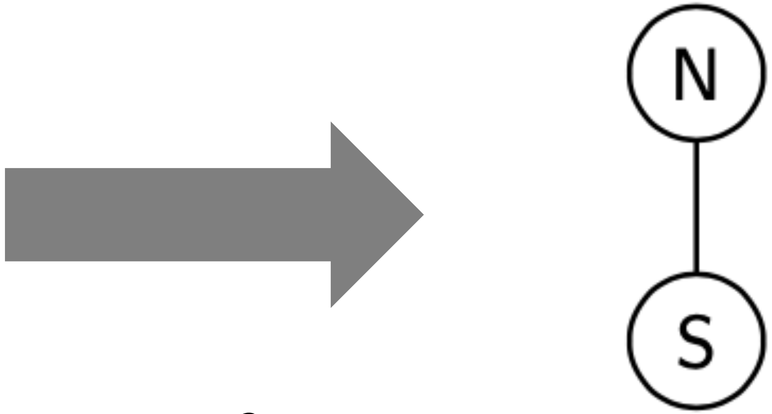




1 step process: the market
Total welfare = 23k€/h

Example from Lété (2022)
Zonal pricing





2 step process:
1. **Wholesale market** (grid constraints mostly ignored)
2. **Out-of-market redispatch** by TSO to ensure grid-feasibility.

Example from Lété (2022)
Poll

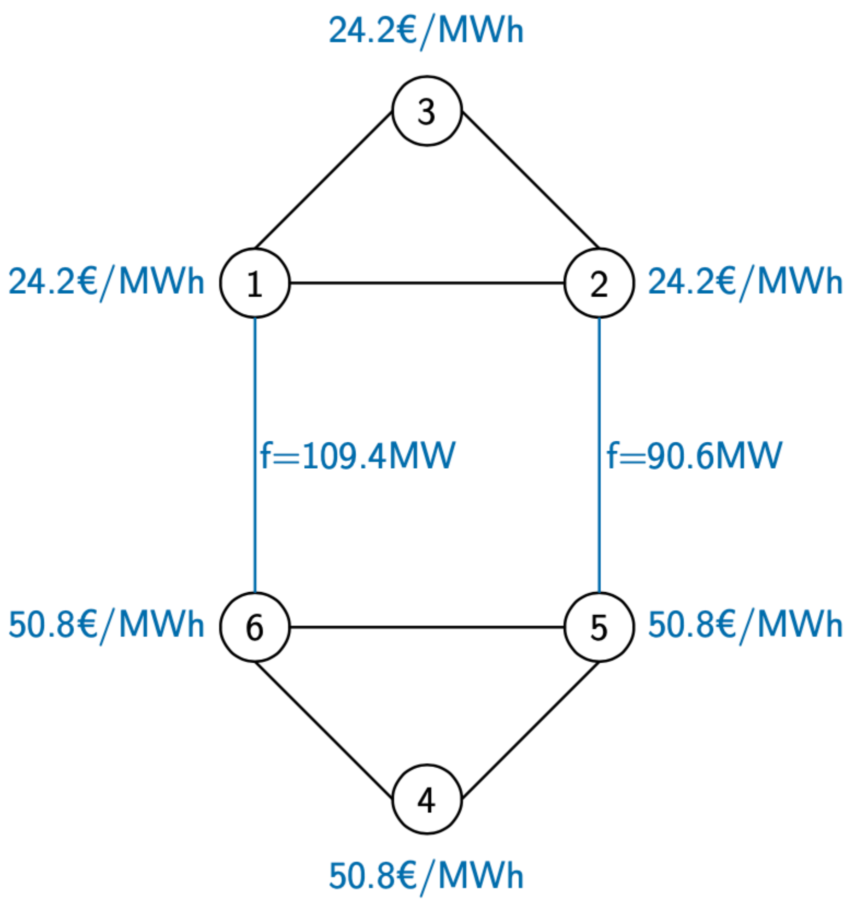
Consider two versions of a perfectly competitive market with transmission constraints:

- *Version 1*: **nodal** pricing.
- *Version 2*: **zonal** pricing with ATC. If the dispatch obtained in the market is not feasible, the TSO proceeds to a cost-based **redispatch**.

In this situation, the short-term welfare (including the congestion rent and re-dispatch cost of the TSO) of the zonal pricing version of the market is:

- ❑ Always greater or equal than that of nodal pricing.
- ❑ Always lower or equal than that of nodal pricing.
- ❑ It depends on the value of the ATCs.

Example from Lété (2022)
Zonal pricing

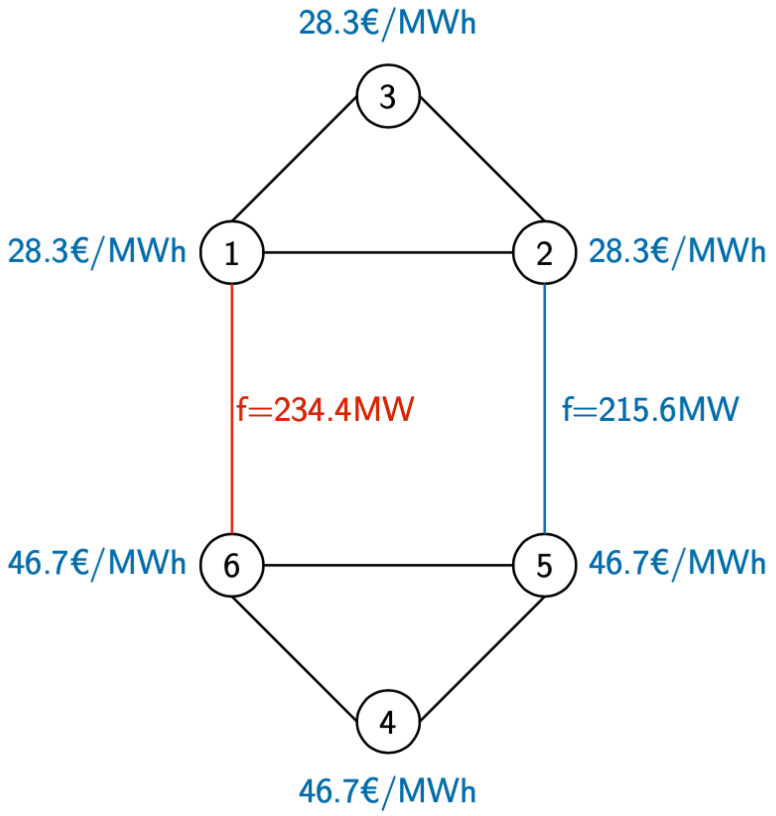


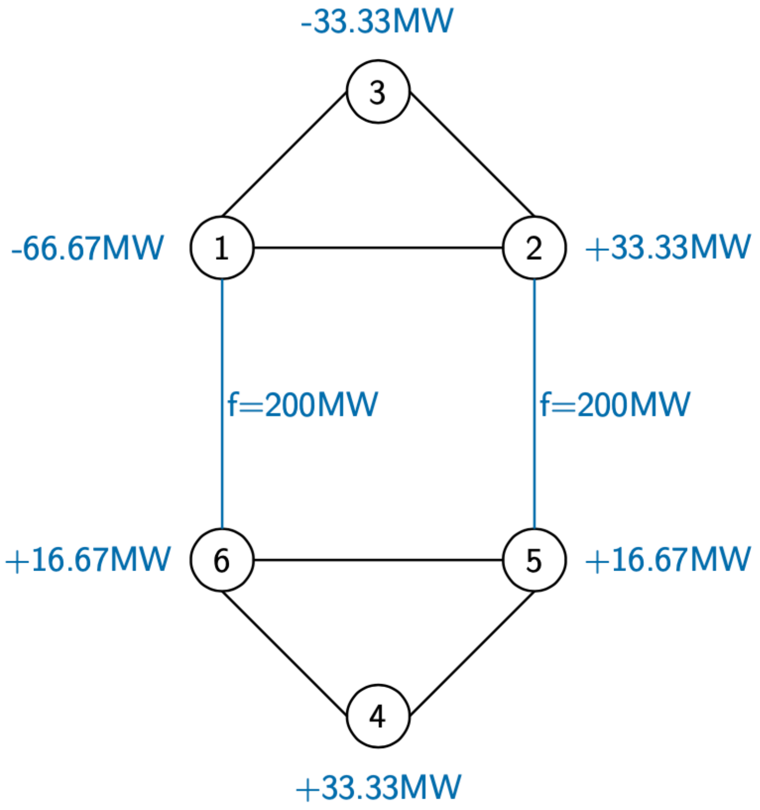
Conservative solution: ATC=200MW

Solution is feasible → no need of redispatch

Total welfare = 18.52k€/h

Example from Lété (2022)
Zonal pricing: perfect redispatch





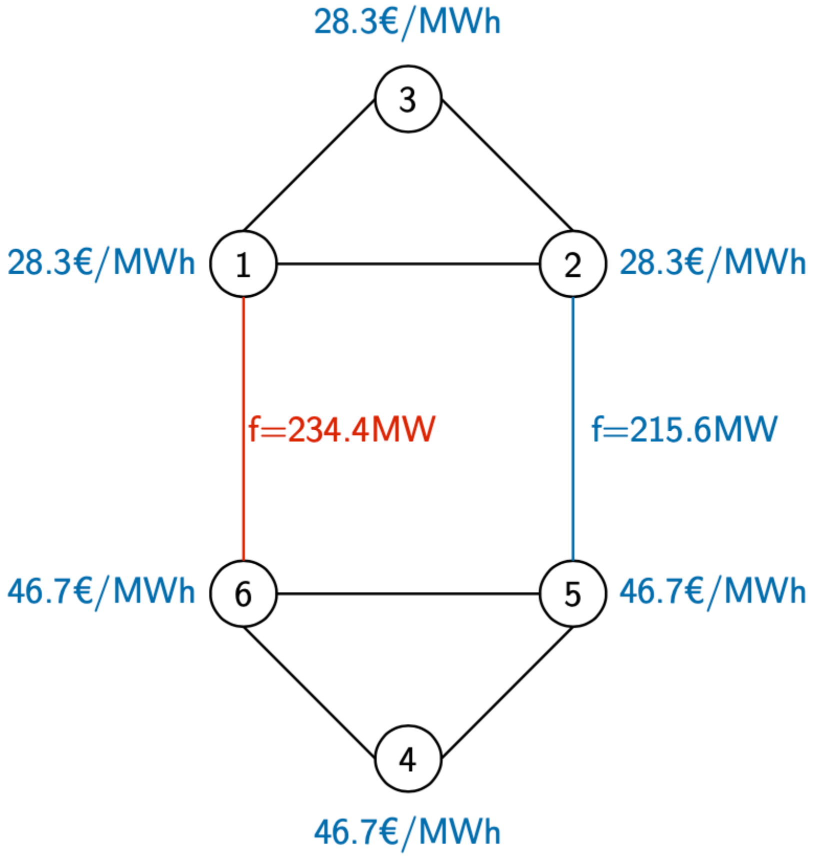
Step 1: the market
Loose solution: ATC=450MW
Welfare = 24.145k€/h but solution is infeasible !

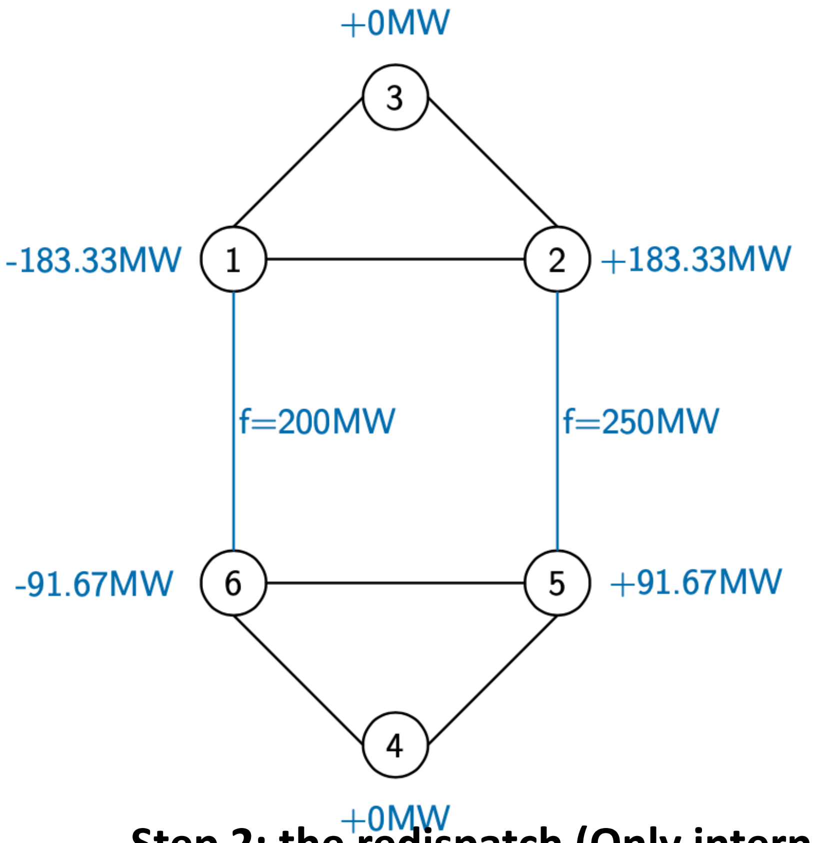
Step 2: the redispatch (assume perfect cost-based):

Total welfare	=
DA welfare	+ 24.145
Redispatch cost	− 1.145 = **23k€/h**

Example from Lété (2022)

Zonal pricing: internal re-dispatch



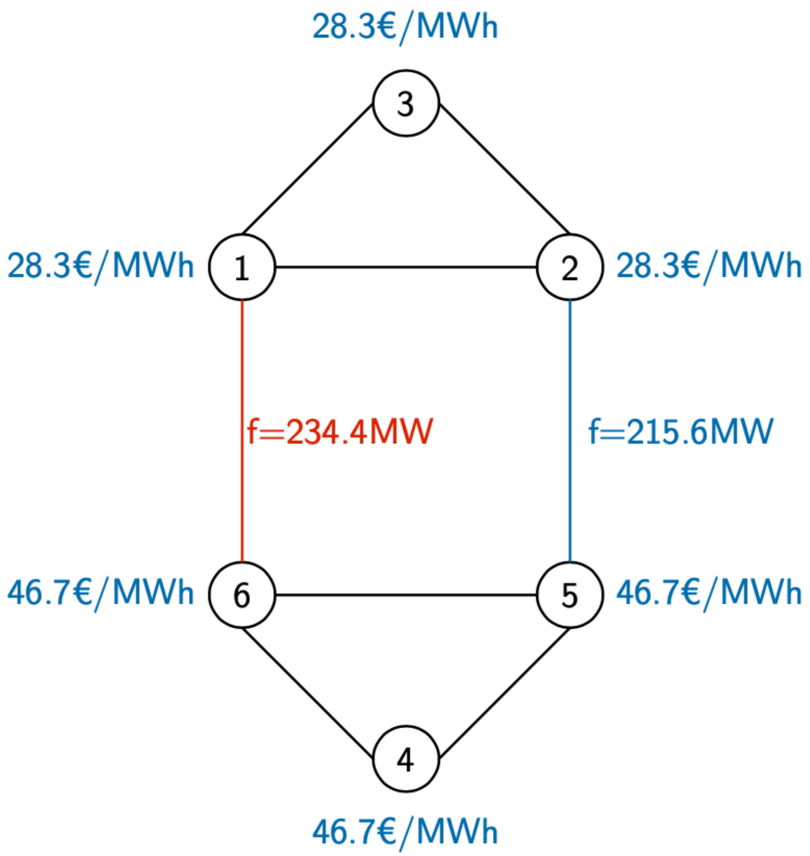


Step 1: the market
Loose solution: ATC=450MW
Welfare = 24.145k€/h but solution is infeasible !

Step 2: the redispatch (Only internal re-dispatch):

Total welfare	=
DA welfare	+ 24.145
Redispatch cost	− 2.52= **21.65k€/h**

Example from Lété (2022)
Zonal pricing: redispatch with limited flexibility



Step 1: the market
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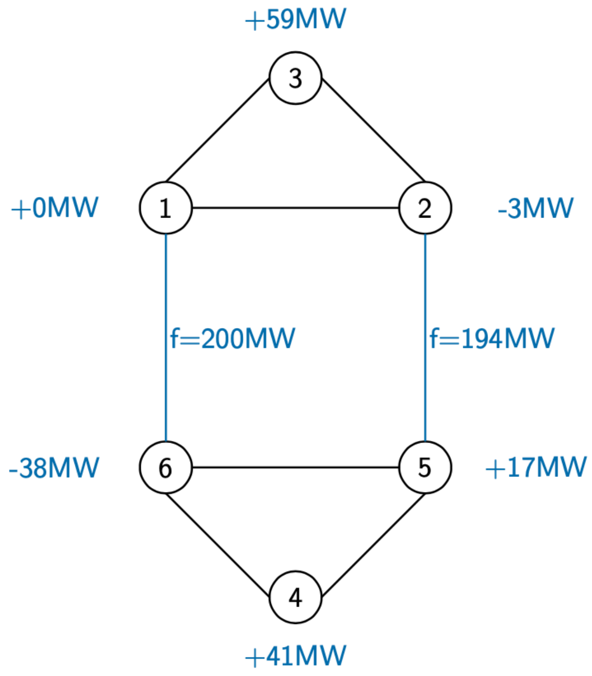


Step 2: the redispatch (with limited flexibility — unit commitment): Assume that Generator in node 1 is inflexible and cannot be redispatched down.

Total welfare	=
DA welfare	+ 24.145
Redispatch cost	− 1.337 = **22.81k€/h**

Example from Lété (2022)
Zonal pricing

Conclusions of the example:

- Nodal prices are the natural competitive prices in markets with transmission constraints

- Under very optimistic assumption, zonal can reproduce nodal

- Otherwise : **loss of welfare due to imperfect redispatch**
  - Operational inefficiencies
  - (Wrong investment signal)

A primer on costs & benefits analysis

Important to make a distinction between two types of discussion:

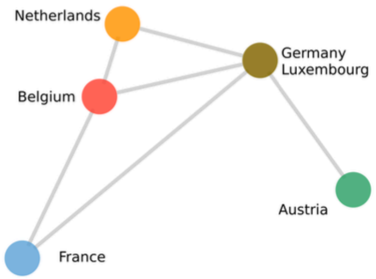
- **Arguments against nodal pricing** (flawed or have a possible policy response, cf. Eicke & Schittekatte (2022))
  - Arguments often rely on the idea that zonal market are bigger and simpler
  - This however neglects that ignoring the constraints in the wholesale market does not make them disappear, cf. the two-stage nature of zonal pricing (market + redispatch)
  - E.g. market power: zonal market create incentives to game between wholesale market and redispatch (inc-dec gaming)
- **Cost and benefits of nodal pricing**: should be the focus of policy-makers
  - What are the costs and what are the benefits of nodal pricing?
  - Can depend on the regional characteristics
  - If the transmission network is strong, maybe the benefits are lower
  - No doubt nodal pricing in EU market is policy-wise disruptive, thus costly
  - Future: greater reliance on renewable intermittent resources will put the network under stress

Evidences of nodal pricing benefits

- In **CAISO** : Wolak (2009) finds **2.1% improvement in operating costs** (approximately **$105 million** reduction in annual cost) due to nodal pricing in CAISO (2009)

Evidences of nodal pricing benefits

- In **CAISO** : Wolak (2009) finds **2.1% improvement in operating costs** (approximately **$105 million** reduction in annual cost) due to nodal pricing in CAISO (2009)
- In **CWE**:
  - Simulations by **Aravena et al. (2021)** on CWE market : **short-term** benefits



Total costs and efficiency of different policies

Policy	Day-ahead [M€/year]	Real-time [M€/year]	Total [M€/year]	Efficiency losses
PF	–	11 476	11 476	-2.90%
LMP	11 284	534	11 818	–
FBMC	10 458	1 963	12 420	5.09%
ATCMC	10 470	1 949	12 419	5.08%

- ▶ 632 buses, 945 branches, 346 slow thermal generators (154GW), 301 fast thermal generators (89GW) and 1 312 renewable generators (149GW)
- ▶ 768 typical snapshots $\times$ 1 000 random uncertainty realizations $\rightarrow \sim$88 years of operation

Efficiency losses of zonal markets amount to about 5% of total costs, ~600M€/year

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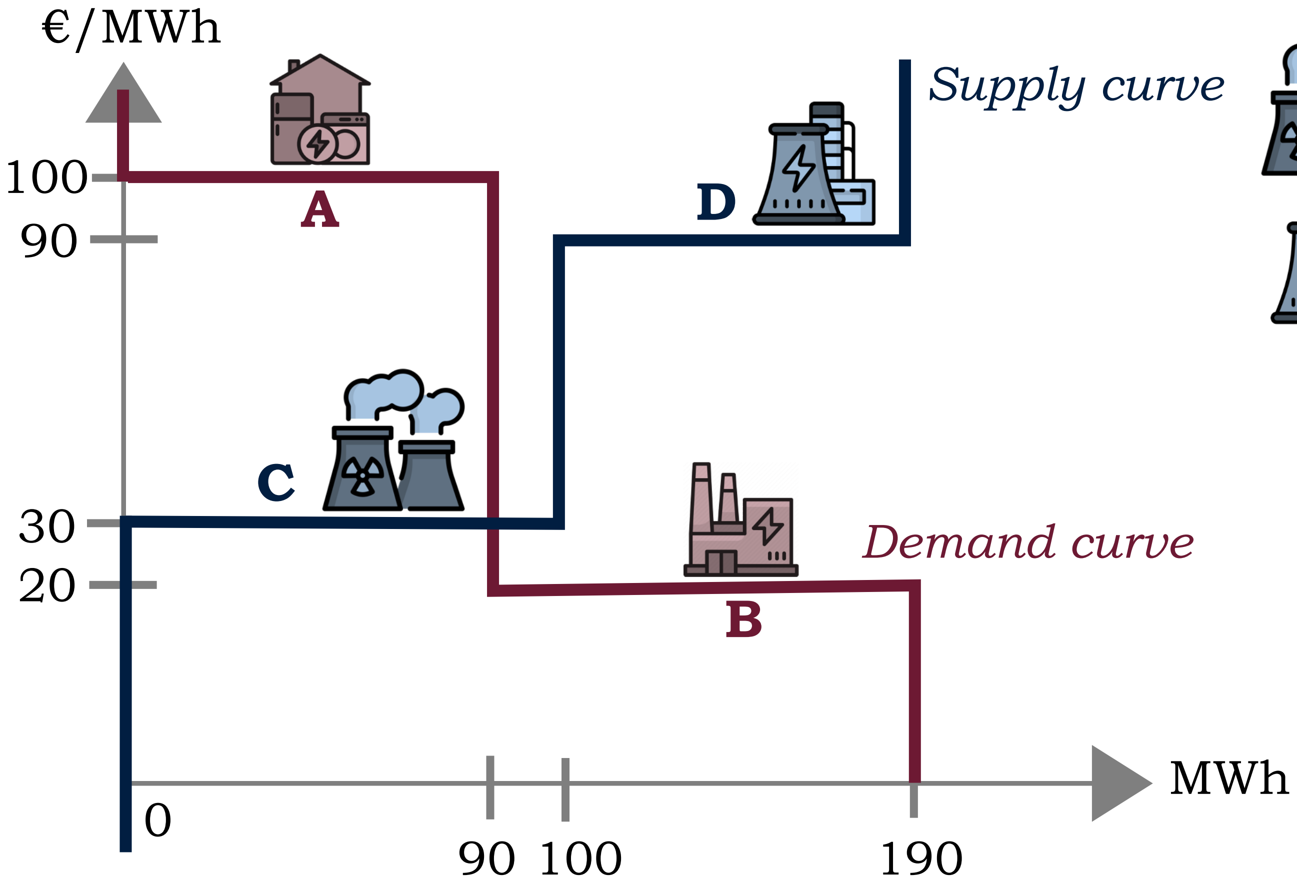
Pricing with indivisibilities



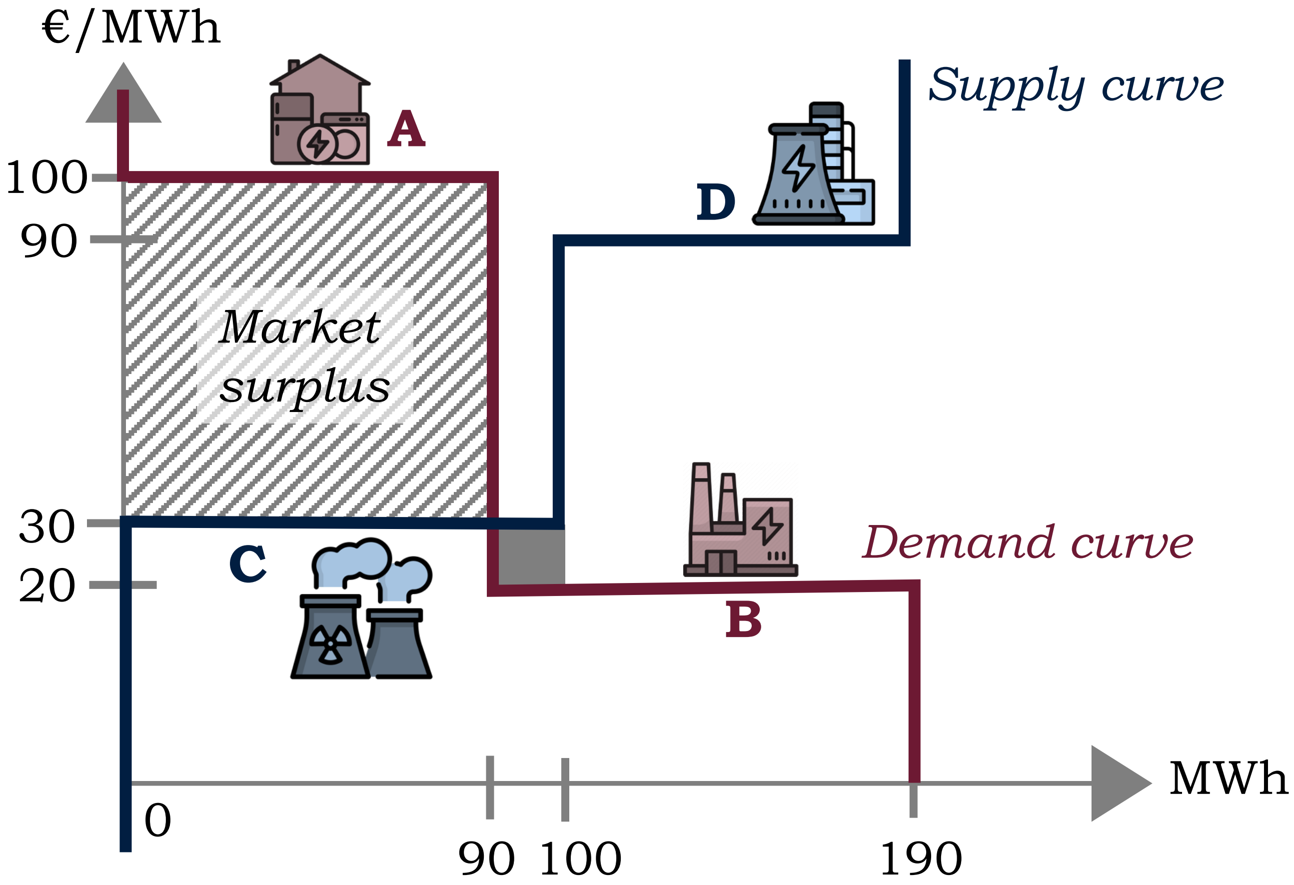
Supply

Producer	Capacity [MW]	Cost [€/MWh]
C	100	30
D	90	90

Demand

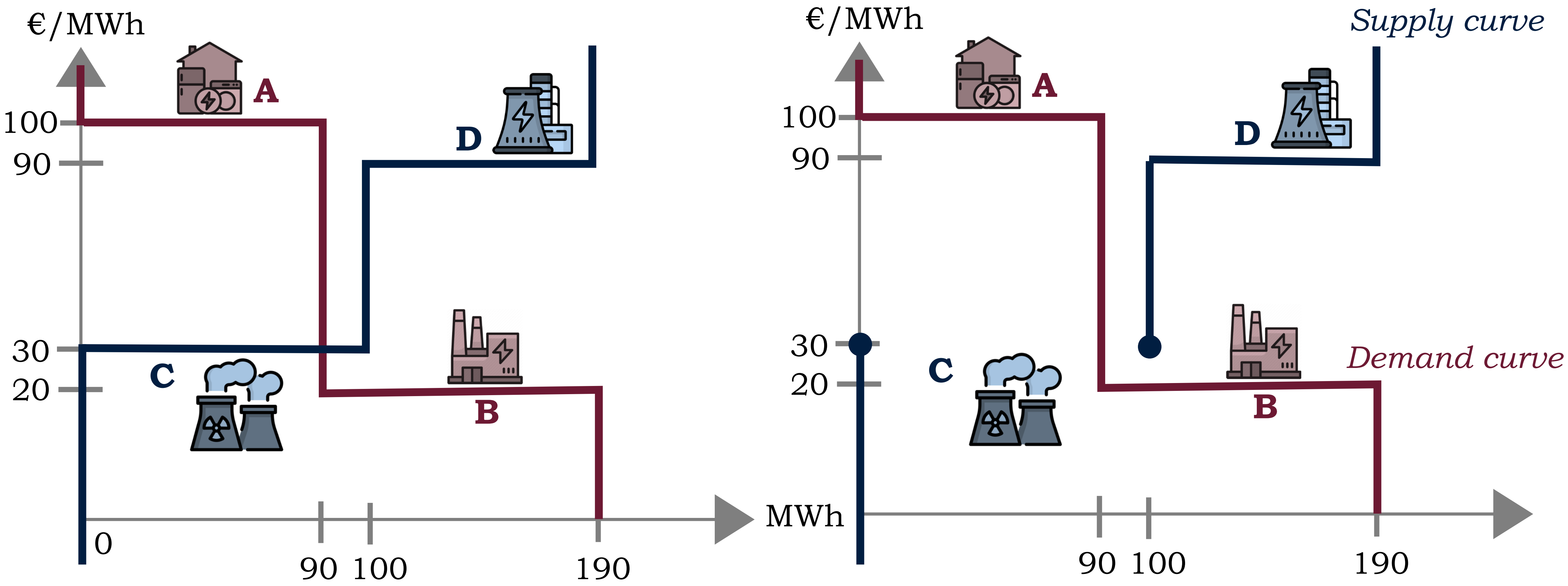
Consumer	Demand Capacity [MW]	Willingness-to-pay [€/MWh]
A	90	100
B	100	20

Pricing with indivisibilities



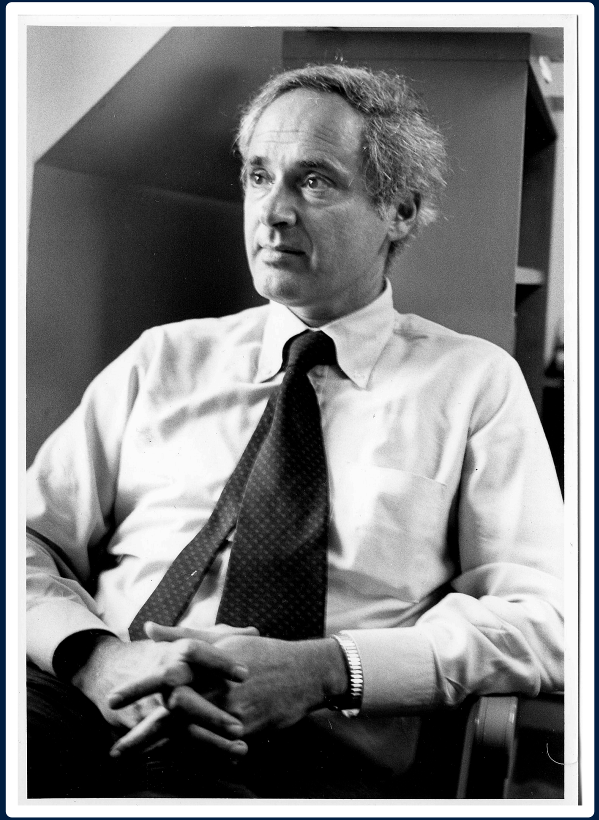
- What if **C** is ***indivisible*** (all-or-nothing)?
- Surplus maximizing solution: clear **A**, **C** and a fraction of **B**
- What is the price?
  - At 20€/MWh **C** is not willing to produce
  - At 30€/MWh, **B** is not willing to consume

Pricing with indivisibilities

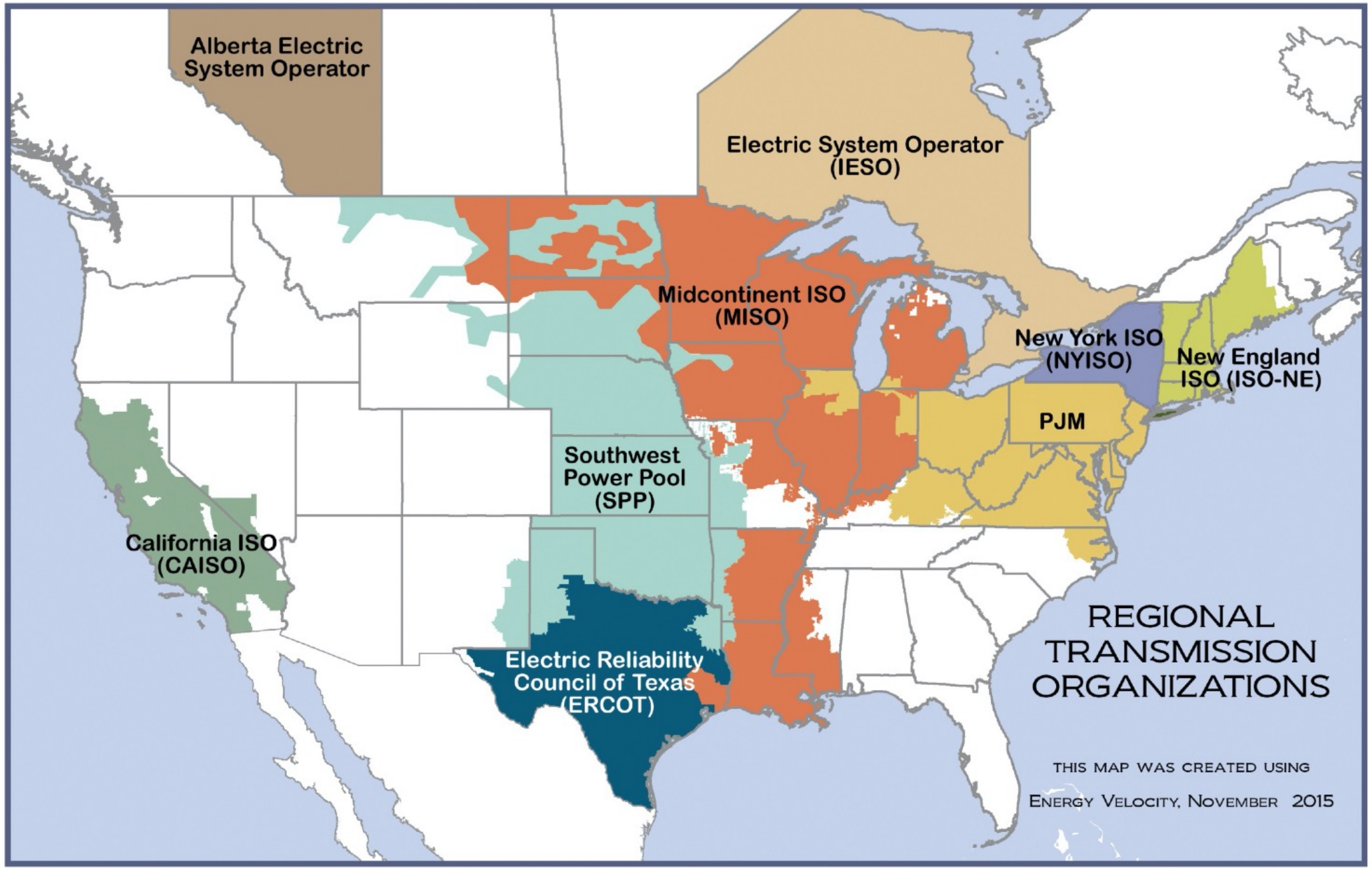


"in the presence of indivisibilities in production, prices simply don't do the jobs that they were meant to do"

(Scarf, 1994)



Pricing practices in the US



1992 : Energy Policy Act

creation of ISOs that operate the market

Early 2000': NYISO "hybrid pricing"

Marginal pricing traditionally adopted by many ISOs to clear the market + side payments

2014: FERC launches consultation about price formation

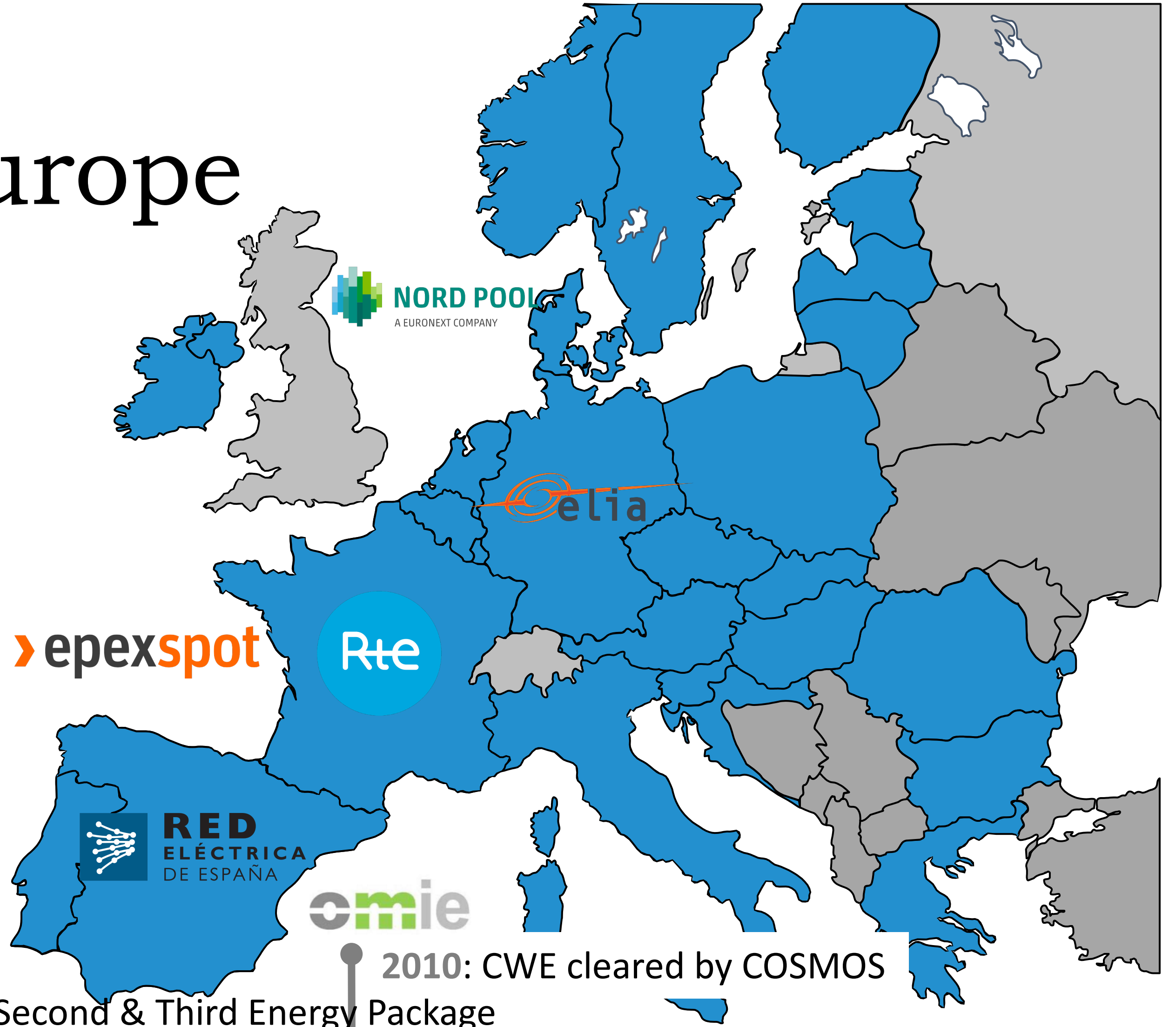
2015 : MISO implements ELMP

2017 : PJM made similar proposal

1990 2000 2010 2020

Pricing practices in Europe

- **Institutional framework**:
  - **TSOs** operate the grid
  - “**Nominated Electricity Market Operators**” (NEMOs) operate the market
- **EU Electricity market — “Price Coupling of Regions”**:
  - 27 countries
  - 30 TSOs
  - 16 NEMOs
  - 4.66 TWh daily trade



1990

1993 : European Single Market

1996 : First Energy Package (kickoff the liberalization of the power sector)

2000

2003 – 2009 : Second & Third Energy Package (unbundling of competitive and regulated segments)

2006: Trilateral Market Coupling

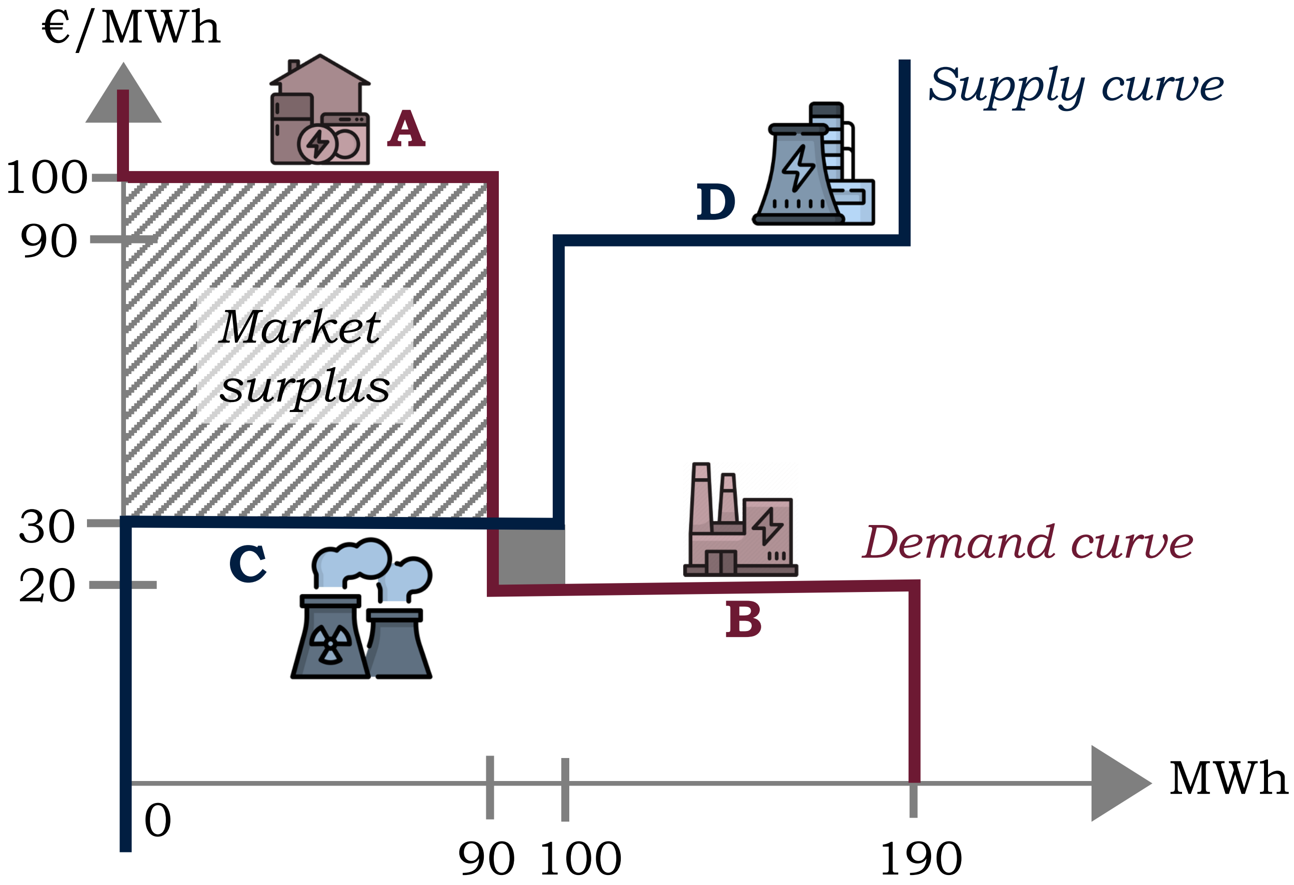
2010

2010: CWE cleared by COSMOS

2014: Single Day-Ahead Coupling (SDAC), Price Coupling of Regions

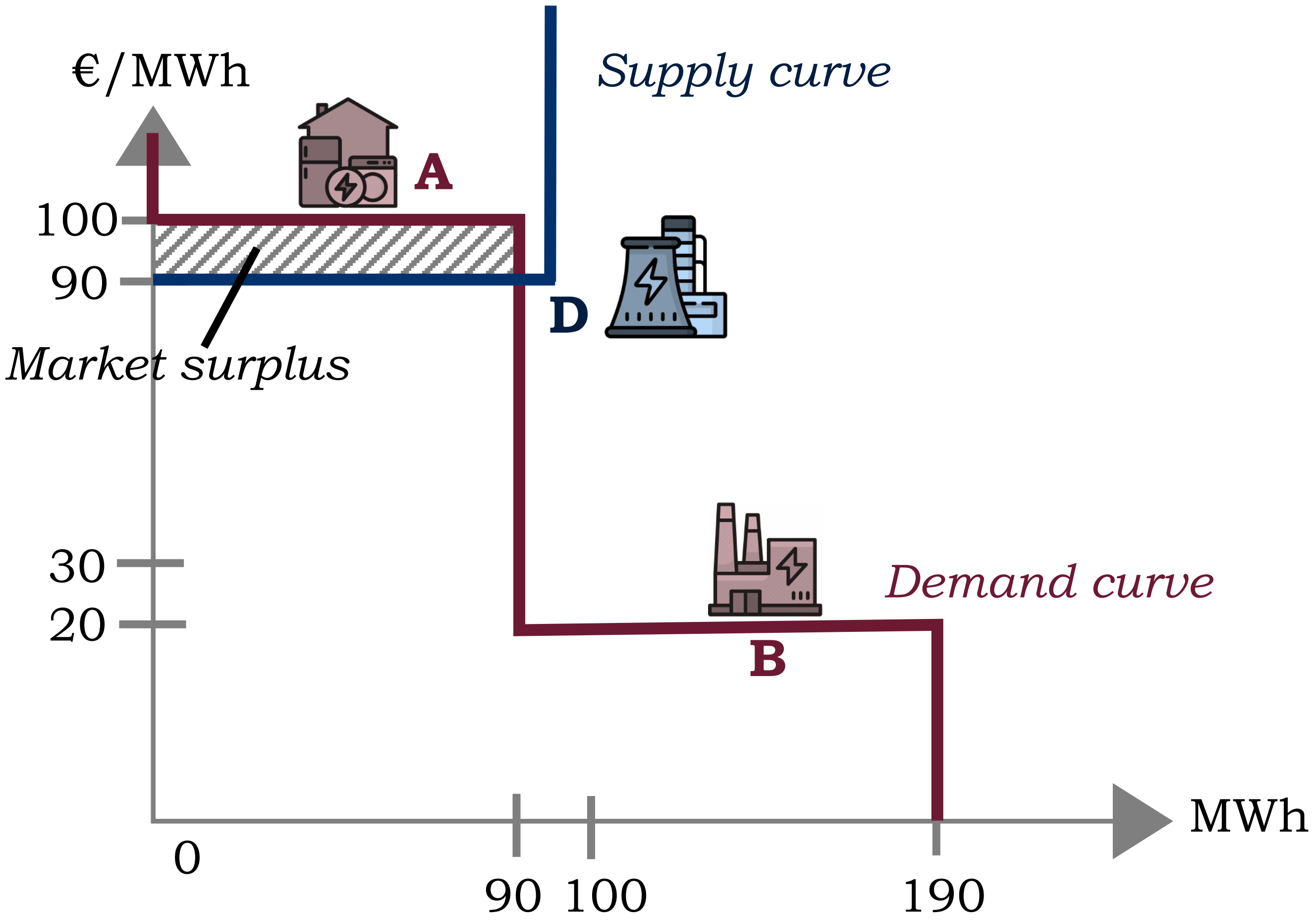
2020

Current European pricing rule



- Surplus maximizing solution: clear **A**, **C** and a fraction of **B**

Current European pricing rule



- Surplus maximizing solution: clear **A**, **C** and a fraction of **B**
- **Current European SDAC rule:**
  - Reject block **C**, clear **A** & **D**
  - Price: 90€/MWh
- 3 main **issues** (Art. 38, 1.a-b-e of CACM GL)
  - ***Inefficiencies by design***

Rejection of welfare-enhancing orders

  - ***Not an equilibrium*** (discriminations)

Some participants not cleared while they are profitable: the "paradoxically rejected blocks" (PRB)

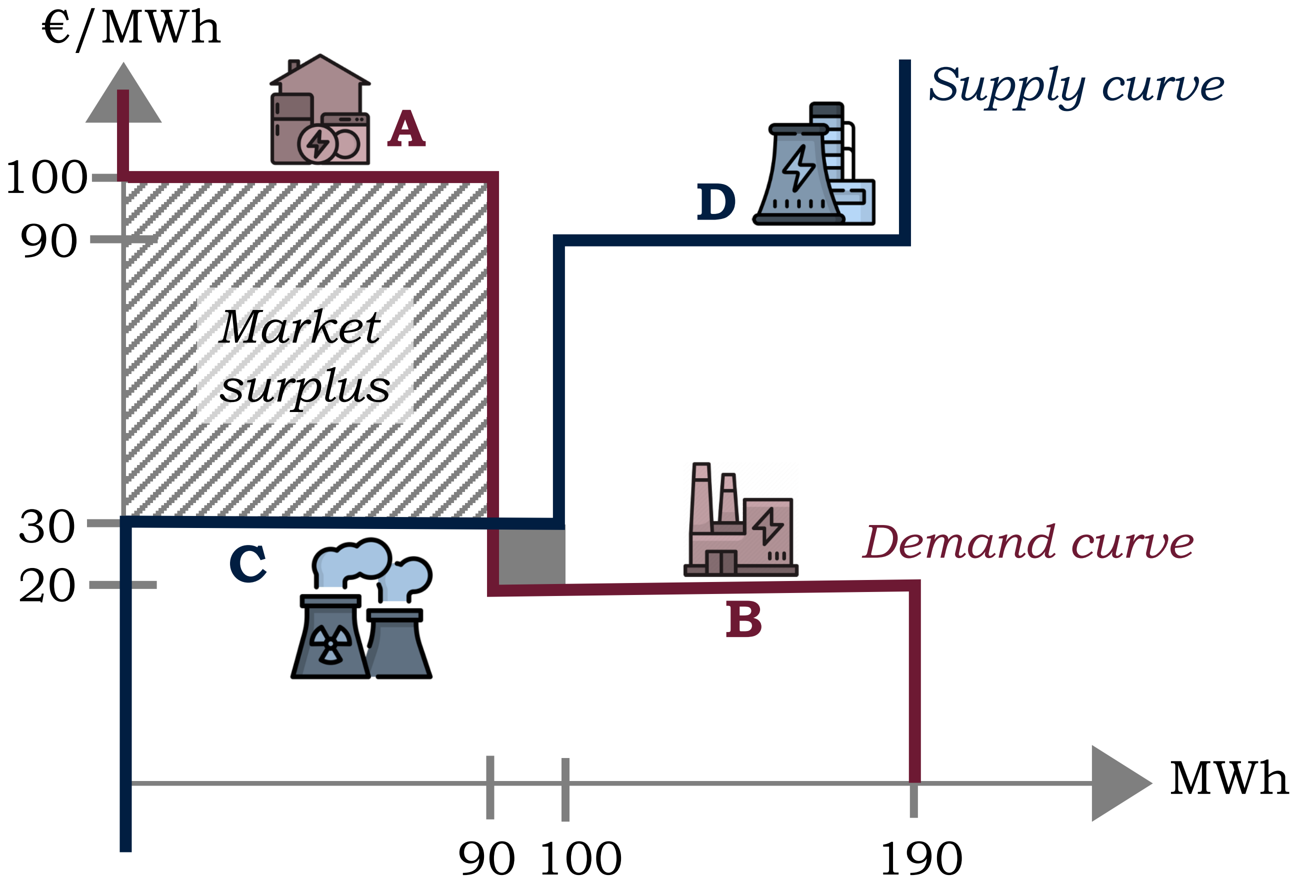
  - ***Computational scalability issues***

Runtime limit went from 12 to 17 minutes between 2019 and 2022—discussions to further extend it to 30 minutes or more.

Alternative pricing candidates

Pricing scheme	Objective	Math. Formulation	Computation	References
Marginal Pricing		Fix binary variables (primal-dependent)	Easy	O'Neill et al. (2005)
Convex Hull Pricing	Minimize "Lost Opportunity Costs" (LOC)	Take convex hull of production & consumption sets (primal-dual separated)	*Difficult*, but can be solved with the Level Algorithm (Stevens and Papavasiliou, 2022)	Hogan and Ring (2003) and Gribik et al. (2007)
Extended LMP	*Approximately* minimize LOC	Linear relaxation of binaries (primal-dual separated)	Easy	Chao (2019), Hua and Baldick (2017), PJM (2017)
Minimal Make-Whole Payment pricing	Minimize "Revenue Shortfall"	Solve ad-hoc problem (primal-dependent)	Easy	Madani and Papavasiliou (2022), Bichler et al. (2022). See also AIC pricing of O'Neill et al. (2023)

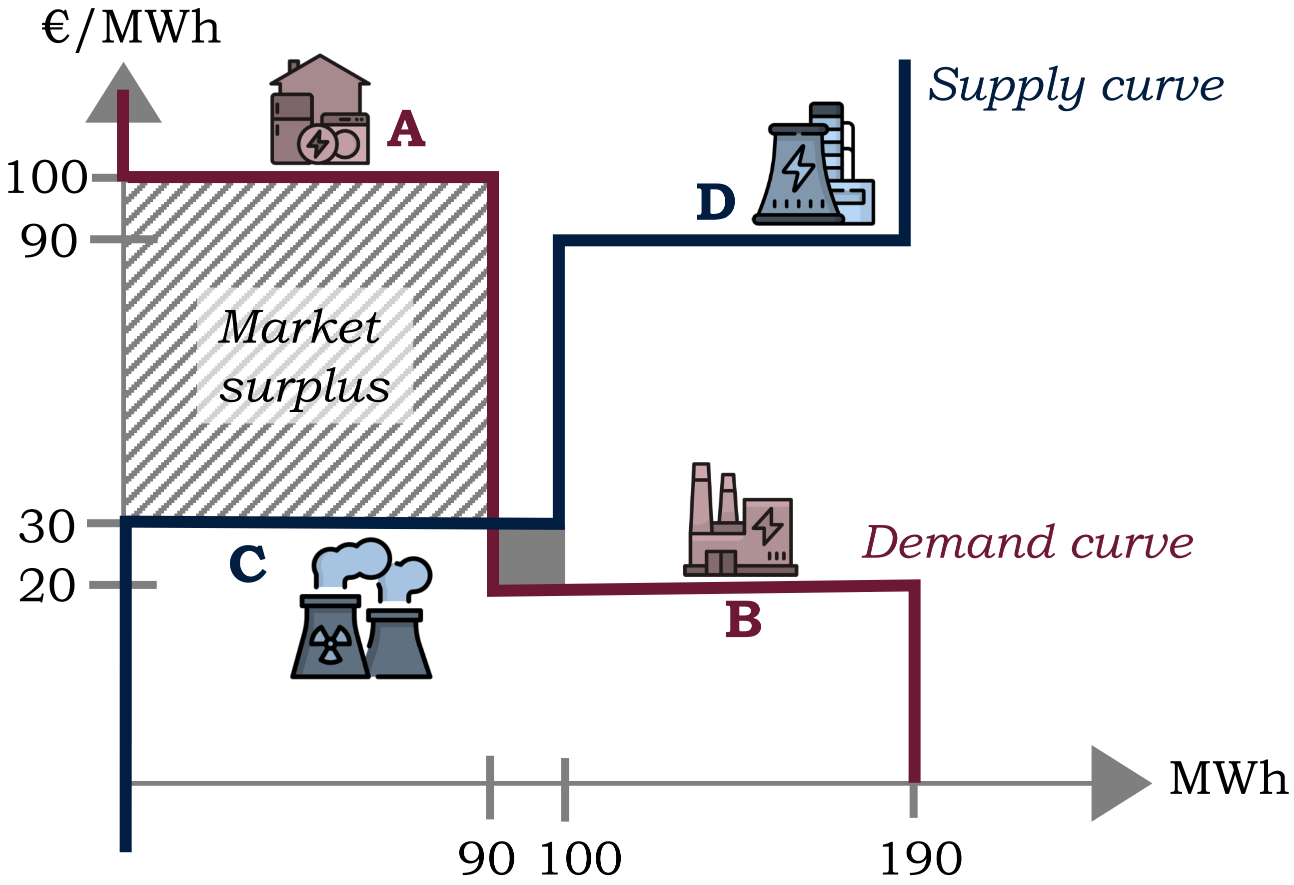
Pricing with indivisibilities
Option 1: Marginal pricing



- Marginal price: 20€/MWh
- Supplier C: loosing 10€/MWh
- Discriminatory payment of 1000€ to C

Pricing with indivisibilities

Option 2: “Convex Hull Pricing” (CHP)



- Convex hull price: 30€/MWh
- Demand B: loosing 10€/MWh
- Discriminatory payment of 100€ to B

→ Convex hull price **minimize the incentives to deviates from the cleared allocation**

→ This idea has attracted a lot of interest during the last decade

Some advantages of convex hull pricing

→ See **Stevens et al. (2024)** for full analysis of the topic. In a nutshell:

- Penetration of **RES** renders the operations of thermal plants more cyclic → **increase start-up costs** (Schill et al., 2017) → reflecting these cost in the price signal remains evermore critical
- **Experience** reveal that many US markets have exhibited the tendency to move away from marginal pricing, and towards CHP-like approaches, during the last ten years.
- CHP **improves significantly the incentives** of market participants to schedule their production efficiently
- CHP also **keeps discriminatory "make-whole" payments very low** (typically much lower than marginal pricing)
- CHP comes with some theoretical guarantees that when the market size increases, the **relative importance and impacts of non-convexities shrink**.
- CHP comes with **good theoretical properties**: consistency between surplus-maximization & incentives (LOC) minimization
- CHP **can be computed** on realistic auction datasets (Stevens & Papavasiliou, 2022)

Content

Investment, adequacy and markets

- Liberalization had two main objectives: **short-term efficiency** and **long-term efficiency** (Cramton, 2017)
- Inducing efficient investments has often been argued to be **the main benefit from deregulation**: "*Most efficiency gains from restructuring will be long-term resulting from better investment decisions*" (Oren, 2000).
- **Adequacy**: adequate generation resources to meet demand
  - **Over-investment** was a concern in the "old regime" of the electricity sector, dominated by vertically integrated monopolies, in which the investments were driven by regulatory decisions .
  - In the "new" liberalized regime, with market-driven investments, ***under*-investment**, or ***inadequacy***, has become the new challenge (Borenstein and Bushnell, 2000).

Investment and the energy transition

- **Ambitious investment** requirements to fulfill the 2050 goals (Fabra, 2025)
- Some facts about RES investments (Fabra, 2025 & 2023):
  1. RES are **long-lived assets**
  2. RES investments are highly **capital intensive**
  3. Wholesale electricity **prices are highly volatile**
     - Prices (often) reflect the marginal costs of gas-fired plants
     - Gas price not correlated with wind/solar
  4. **Cannibalization effect**: investment in RES deflate spot prices
- Renewable investments must be **coupled with flex resources**

→ Investing in RES can be **risky**: how to design markets for this?

→ **Need to design long-term contracts to foster investments**

Source: IRENA (2019b)

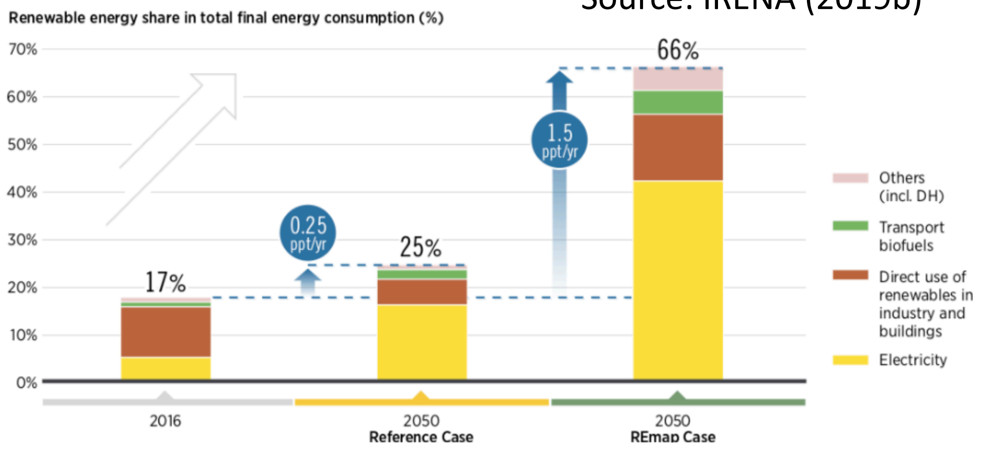


Illustration: different cost structures

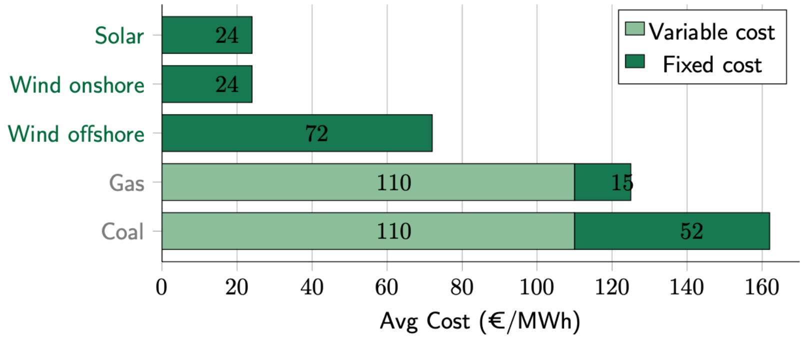


Figure: Cost break-up of power generation technologies

Source: Lazard (2023); own computations (ass. 90€/Ton CO2; 40€/MWh gas)

Market solutions for investment
An overview (Fabra, 2023)

- Promoting long-term contracting while **preserving well-functioning short-term market**
  - Efficient operations & consumption: flexible assets / consumers should be incentivized to shift supply/demand across time from when it is less valuable to when it is most valuable for the system
- Using **auction** to allocate these contacts efficiently
- Diversity of technologies call — according to Fabra (2023) — to a **diversity of contracts**:
  - **Contracts for Difference (CfD)**: generators sell their electricity and then pay/receive the difference between a ‘strike price’ and the ‘reference price’ times a ‘reference quantity’.
    - In its simplest form → **no price exposure** & no quantity risk → this can create distortions
    - CfD can however be modified to include some price exposure
    - Suitable for RES technologies to derisk investment
    - Allocated with **RES procurement auction**: technology -specific or -neutral auctions? Pay-as-bid, pay-as-cleared?
  - **Capacity markets**: cleared participants received a capacity price for the capacity sold in the auction
    - Demand for capacity
    - Technology-specificities (capacity credits, performance penalties etc. to account for asset performance)
    - Centralized auctions & call options contract with high strike price

Market solutions for investment
An overview (Fabra, 2023)

Market/Regulation & Horizon	Contract type	Technologies	Key challenge
Short-term market	Spot pay-as-clear	All plants	Productive efficiency
Auctions for long-term contracts	Capacity Payments	CCGTs Energy Storage Demand response	Price exposure for optimal operation Missing money problem Mitigate market power
	Contracts for Differences	Renewables	Derisk investments
Regulated long-term contracts		Hydro power Nuclear power	Cost-reflective prices

Market solution for investment
Forward energy market

A **FORWARD ENERGY MARKET** PROPOSED BY CRAMTON, P., ET AL. (2024) AND BRANDKAMP ET AL. (2025):

- **Derivative of day-ahead energy**
    - Energy forward (commodity becomes physical in the spot market; forward products are financial derivates of the spot product ; deviations in spot performance are settled at the spot price)
    - Energy options with high strike price ($1000/MWh) : hedge for price spikes
- **Monthly forward energy** (up to 48 months forward) **with fine granularity** in time and location: Hourly, weekday or weekend, load zones
- **Hourly forward energy** (up to 30 days forward): Hourly, load zones
- **Flow trading** (Budish et al., 2023)
    - **Frequent batch auction** (unique prices and quantities, trivial computation)
    - **>< big-event auction** like capacity market or RES proc. auctions
- Single key mandatory element: **load-serving entity obligation to buy real-time demand** increases from 0% 48 months ahead to 100% day-ahead
- **Centralized market**: conducted and settled by the system operator

Market solution for investment
Forward energy market

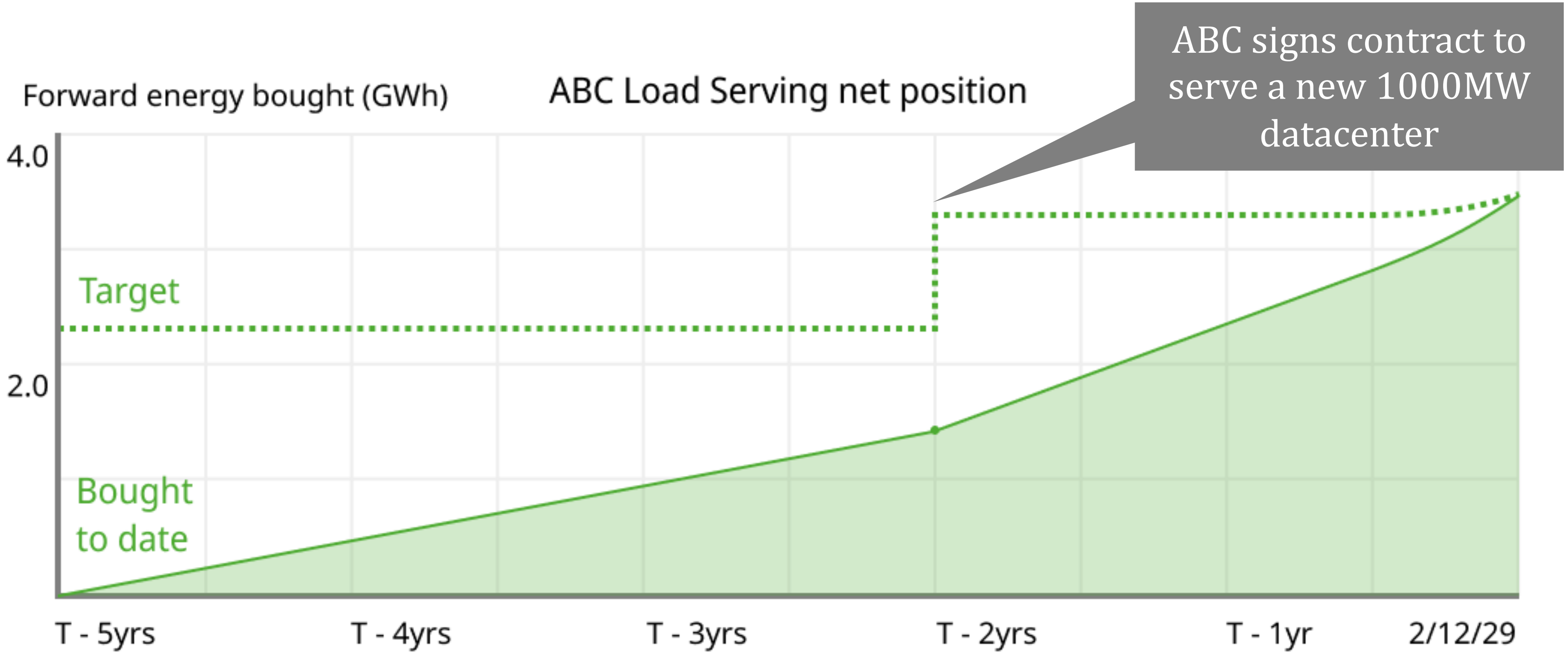
Transparent forward pricing and positions

- Promote **efficient investment decisions**
    - Complete markets
    - Reduce uncertainty (reduce risk)
    - Improve predictions
    - Foster innovation
- Improve **efficiency of operation**
    - Unlike quasi-physical capacity market, a forward energy market does not fundamentally change the functioning of the spot market
    - Enhance competition (Allaz & Vila, 1993)

Trade to target

- **Trade over time** to reach target on delivery date

- Buyers and sellers **adjust rate of trade** in response to information and market shocks



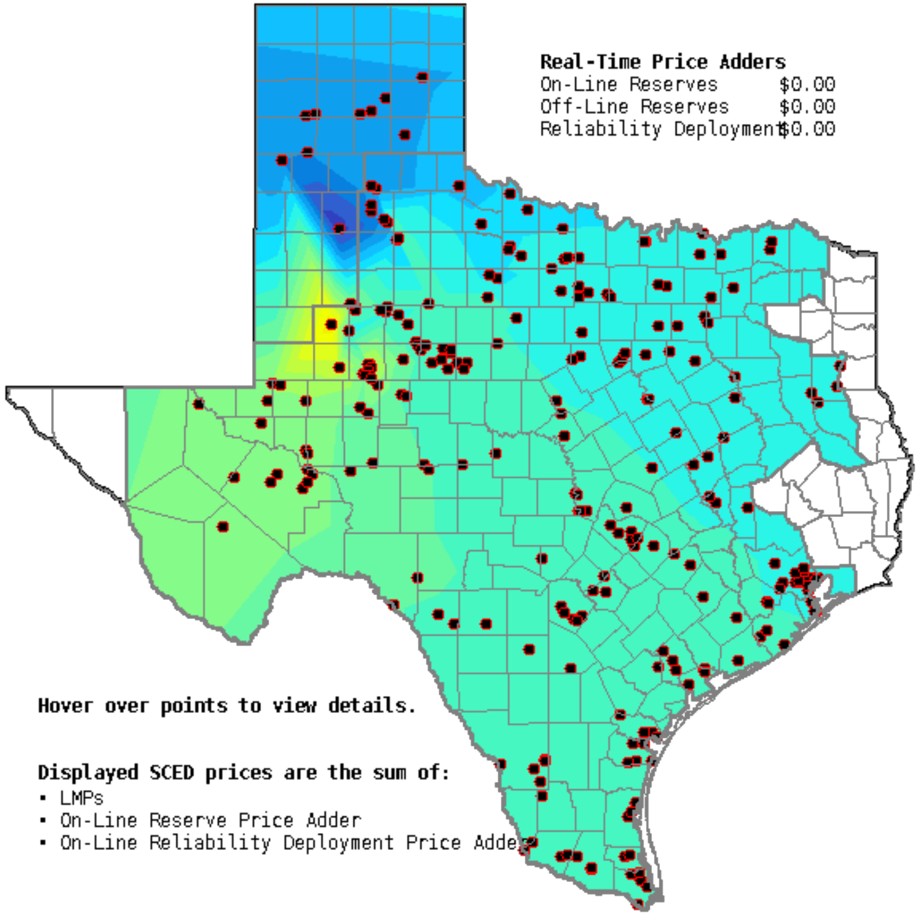
Market solution for investment
Forward energy market: ERCOT case

What?

A **forward market simulation** based on ERCOT's last 12 years

Why?

- **Shows benefit of a forward market** with realistic data
- **Shows market is practical** to implement
- Tests market rules and participant behavior
- Develops market software and tools



https://www.ercot.com/content/cdr/contours/rtmLmp.html

Monthly forward prices, Houston, weekday ($/MWh)
48 to 1 month ahead (48 × 24 = 1152 monthly products per load zone)

Price $/MWh: 10 – 333

Year / Months Forward / Month

	2022						2021						2020						2019					
	47	45	43	41	39	37	35	33	31	29	27	25	23	21	19	17	15	13	11	9	7	5	3	1
Hour	Nov	Sep	Jul	May	Mar	Jan	Nov	Sep	Jul	May	Mar	Jan	Nov	Sep	Jul	May	Mar	Jan	Nov	Sep	Jul	May	Mar	Jan
0	17	19	20	18	16	19	19	17	22	15	28	30	16	17	32	16	32	32	19	13	24	10	20	23
1	16	18	19	16	14	18	17	15	18	12	20	22	15	15	21	13	23	23	18	14	17	10	17	19
2	15	17	18	15	13	18	17	15	14	13	18	16	14	15	15	13	22	20	16	15	13	13	16	18
3	15	16	17	14	14	19	18	14	15	14	22	16	13	13	11	14	22	27	17	18	11	16	18	19
4	16	17	17	15	15	21	20	17	17	20	28	19	16	16	13	20	21	38	20	22	14	17	21	29
5	20	18	18	18	18	28	19	18	19	22	29	25	17	16	16	20	19	49	21	26	20	16	19	46
6	29	20	19	20	29	61	31	22	26	26	42	75	28	18	29	24	27	130	34	31	27	19	35	145
7	26	20	20	20	26	58	26	22	26	23	31	78	19	15	35	22	21	102	23	25	24	23	29	137
8	26	21	21	21	23	36	26	24	27	26	28	54	16	16	41	21	24	61	22	26	23	28	29	62
9	26	22	24	22	23	30	22	26	26	28	25	38	15	20	40	31	26	40	21	25	27	37	23	44
10	27	24	28	25	24	28	20	32	28	33	22	28	17	23	43	36	30	31	27	23	44	33	21	33
11	27	28	33	27	24	26	19	34	31	38	18	29	21	28	43	45	23	33	33	22	50	36	17	34
12	28	32	39	31	25	25	25	35	36	40	19	28	27	33	52	44	24	33	38	24	53	35	19	27
13	30	40	52	38	28	24	34	50	53	45	21	27	35	47	70	42	22	30	44	32	69	41	23	25
14	31	47	82	49	31	24	49	62	88	59	22	25	51	49	120	61	28	26	46	38	124	56	34	27
15	32	55	151	64	33	23	48	76	217	102	27	24	55	63	244	129	35	22	45	47	240	92	41	26
16	31	54	184	70	35	24	38	65	247	119	32	29	42	53	319	167	43	28	40	43	333	113	46	33
17	41	37	108	49	31	35	46	40	128	74	39	33	53	34	171	96	44	36	55	30	237	73	34	40
18	33	31	42	32	34	38	35	31	44	39	47	36	43	27	45	52	48	36	41	28	56	41	31	51
19	28	29	34	28	34	30	29	28	36	23	51	26	32	26	33	34	47	27	32	29	41	35	34	42
20	26	27	31	29	29	28	23	24	42	25	29	23	20	21	38	35	27	25	26	25	41	33	31	33
21	24	24	28	25	23	26	20	20	34	18	24	20	14	15	37	22	18	23	22	20	41	23	25	29
22	22	22	25	23	21	23	16	15	31	17	21	19	12	13	30	23	17	28	23	15	37	19	22	31
23	20	21	22	20	19	21	20	13	23	14	20	19	15	14	24	14	19	25	25	15	35	16	25	26

Prices are highest at 4pm in July (seasonal and hourly effects)

UCLouvain

LiDAM
CORE | Louvain Institute of Data Analysis and Modeling in economics and statistics

Thank you!

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MAX-PLANCK-GESELLSCHAFT

forward market design

References (must-read)

Here are **four must-read references**, one per section of the talk:

- ***Market design principles***

Hogan, W. W. (2019). Market design practices: Which ones are best?[in my view]. *IEEE Power and Energy Magazine*, 17(1), 100-104.

- ***Locational pricing of electricity***:

Eicke, A., & Schittekatte, T. (2022). Fighting the wrong battle? A critical assessment of arguments against nodal electricity prices in the European debate. Energy Policy, 170, 113220.

- ***Pricing with non-convexities***

Stevens, N., Papavasiliou, A., & Smeers, Y. (2024). On some advantages of convex hull pricing for the European electricity auction. *Energy Economics*, 134, 107542.

- ***Long-term contracts***:

Fabra, N. (2023). Reforming European electricity markets: Lessons from the energy crisis. *Energy economics*, 126, 106963.

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Homework & readings

Challenges of the future electricity market design

Nicolas Stevens

CEER Training

References ("must-read")

Here are **four "must-read" references**, one per section of the talk—I would advice reading at least one:

- ***Market design principles***

  Hogan, W. W. (2019). Market design practices: Which ones are best?[in my view]. *IEEE Power and Energy Magazine*, 17(1), 100-104.

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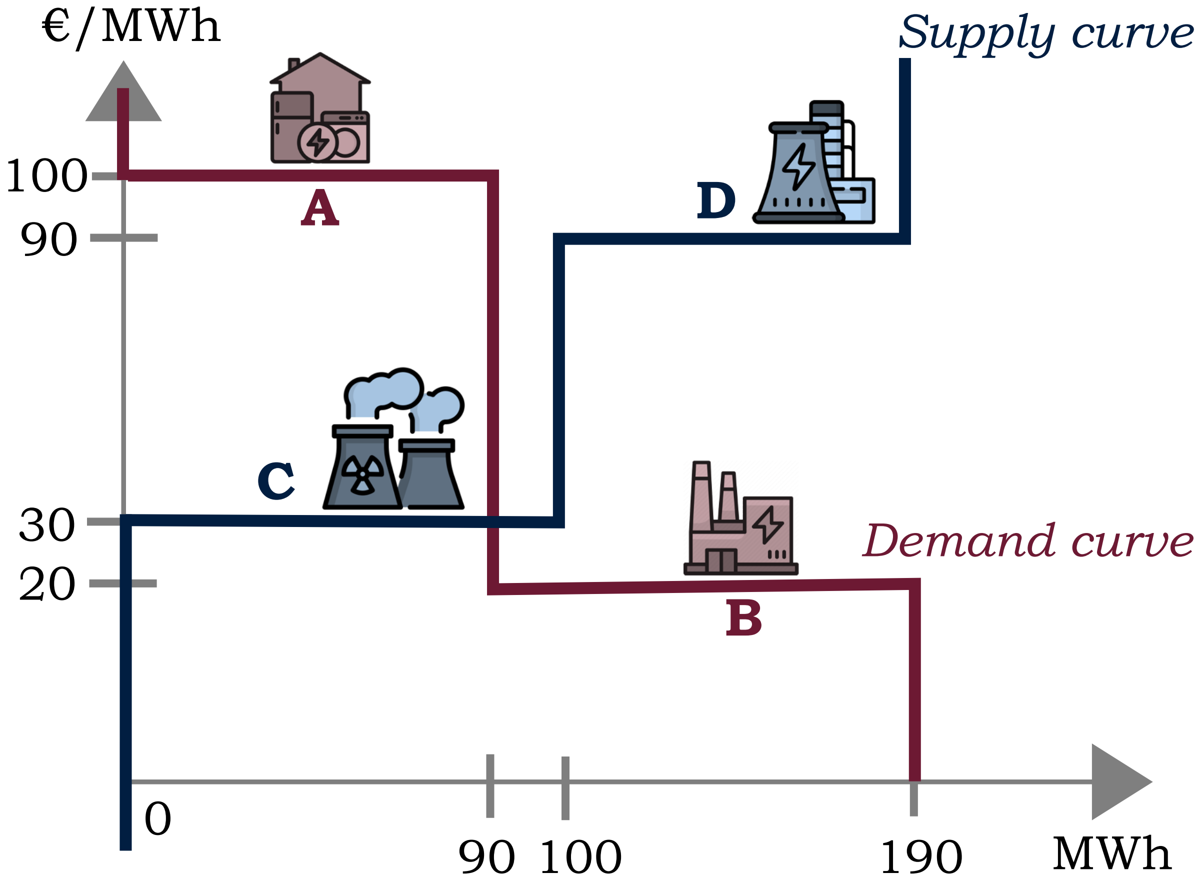
- ***Long-term contracts***:

  Fabra, N. (2023). Reforming European electricity markets: Lessons from the energy crisis. *Energy Economics*, 126, 106963.

Homework: a pricing exercise



Supply

Producer	Capacity [MW]	Cost [€/MWh]
C	100	30
D	90	90

Demand

Consumer	Demand Capacity [MW]	Willingness-to-pay [€/MWh]
A	90	100
B	100	20

- Here is a market with two sellers and two buyers
- **Questions**:
  1. If everything is **convex**, what is the surplus-maximizing allocation, the surplus & the market-clearing price? Is it an equilibrium?
  2. Producer *C* is now **non-convex**: *C* can produce either 0 or 100MWh, but nothing in between. What is the surplus-maximizing allocation, the surplus & the market-clearing price? Is it an equilibrium?

Appendices

Some advantages of convex hull pricing

Table 2
Incentives of market agents on the CWE dataset depending on the price (average over 12 scenarios).

		IP	CHP	ELMP	MMWP	MMWP*	MMWP**
Dispatch Cost		5,489,000					
Av. Price [€/MWh]		42.8	43.4	47.3	27.7	23.8	52.6
Num. Suppl. with LOC		33.2%	35.9%	45.3%	83.6%	63.4%	64.3%
Av. LOC per Suppl.		3,528	278	1,285	141,834	29,326	27,066
LOC	Tot.	83,543	8,093	42,948	98,681,795	41,808,171	20,789,079
	Suppl.	83,543	6,810	39,006	8,746,513	1,350,259	1,250,017
	Net.	0	1,282	3,942	89,935,282	40,457,912	19,539,062
RS (in LOC)	Tot.	10,550	1,987	8,508	0	0	0
	Suppl.	10,550	1,987	8,508	0	0	0
	Net.	0	0	0	0	0	0
FO	Tot.	72,993	6,106	34,440	98,681,795	41,808,171	20,789,079
	Suppl.	72,993	4,823	30,499	8,746,513	1,350,259	1,250,017
	Net.	0	1,282	3,942	89,935,282	40,457,912	19,539,062
RS (not in LOC)	Tot.	897,653	877,040	730,234	0	0	0
	Suppl.	897,653	877,040	730,234	0	0	0
	Net.	0	0	0	0	0	0