Grenzüberschreitende Effekte von Kapazitätsmechanismen – Verzerren nationale Alleingänge den Europäischen Binnenmarkt für Energie?

Roland Meyer, Gert Brunekreeft, Olga Gore, Satu Viljainen

Workshop „Energiemärkte im Wandel – Herausforderungen für Tarifstruktur und Kapazitätsmärkte“

4. November, WU Wien

Content of the presentation

Keywords

- Many European countries face market design challenges
- Unilateral introduction of capacity mechanisms may cause cross-border effects
  - Price and trade distortions
  - Investment distortions

- Joint research project of Jacobs University Bremen and Lappeenranta University of Technology, Finland.
  - Two-country model to simulate cross-border effects of CMs
  - Game-theoretic approach: each country decides whether or not to implement a CM
  - Two CMs modelled:
    1) Strategic reserve
    2) Reliability options

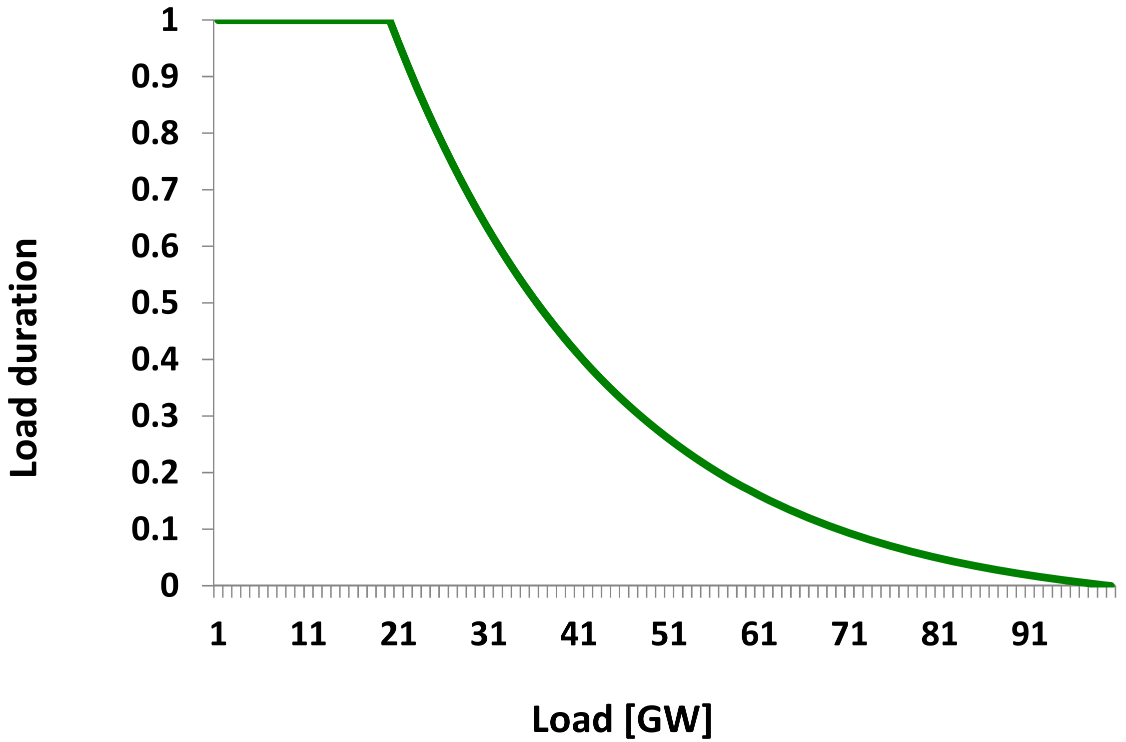
Two-market model – Basic assumptions

Two interconnected markets (market coupling)

- Market coupling between both markets
- Price-inelastic demand
- Interconnection constraint: 5 GW
- Slight cost advantage of market 1 (“export market”)
- Scarcity pricing following „residual supply index“

Load Duration Curve

- Price-inelastic demand
- Same load in both markets
- Variation of demand between 20 GW and 100 GW

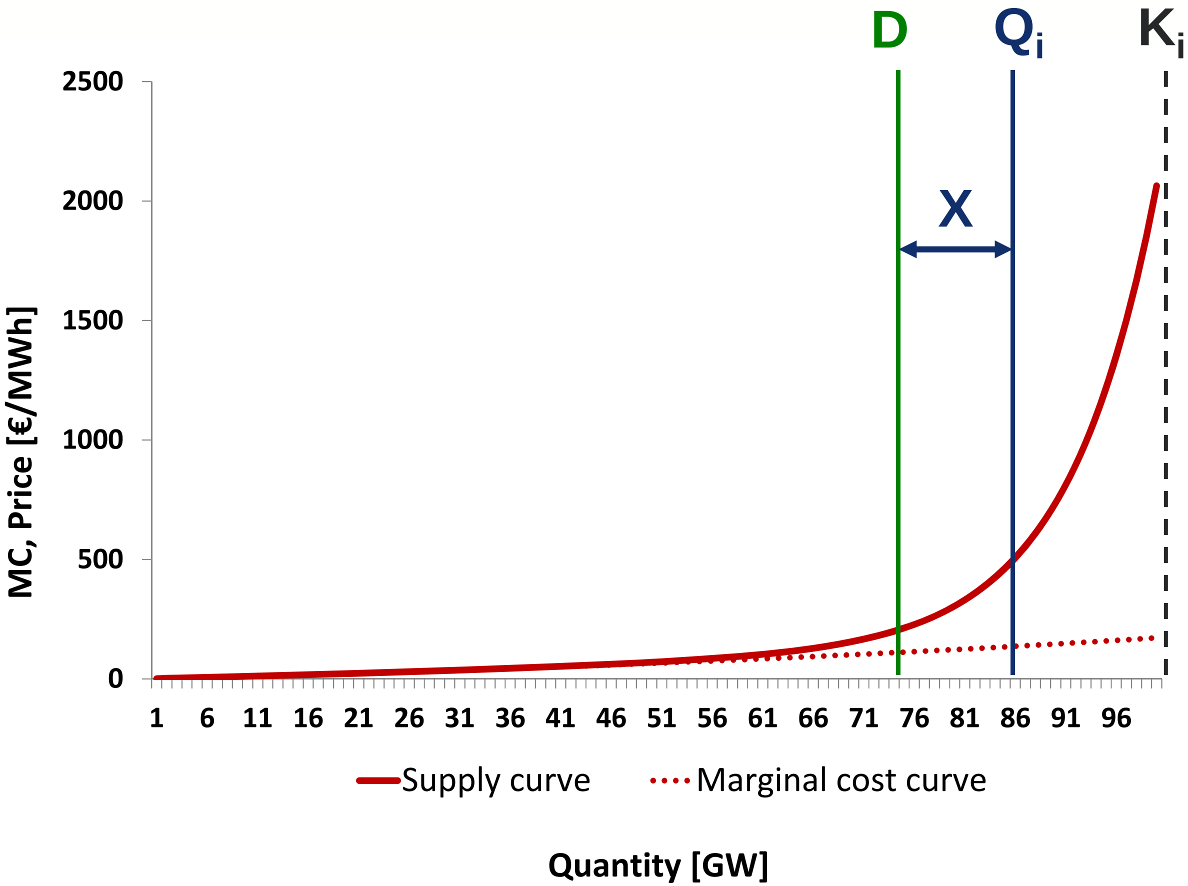


JACOBS UNIVERSITY

Supply curves (merit order)

Marginal cost curve $$MC_i = a_i \cdot [\exp(b_i \cdot Q_1) - 1]$$

MC mark-up $$\frac{(P_i - MC_i)}{MC_i} = c_i \cdot \exp\left(d \cdot {Q_i}/{K_i}\right)$$



JACOBS UNIVERSITY

Market coupling optimization

$$Max\{PS_1 + CS_1 + PS_2 + CS_2\}$$

$s.t.$	$Q_1 + Q_2 \leq 2 \cdot D_1$	(no oversupply)
	$Q_1 \geq 0;\ Q_2 \geq 0$	(non-negative outputs)
	$Q_1 \leq K_1;\ Q_2 \leq K_2$	(generation constraints)
	$Q_1 \leq IC + D;\ Q_2 \leq IC + D$	(interconnection constraint)

$$PS_i = a_i[\exp(b_i Q_i) - 1]\left[Q_i + c_i exp\left(d_i \frac{Q_i}{K_i}\right) Q_i - \frac{1}{b_i}\right] + a_i Q_i$$

$$CS_i = (Voll - P_i(Q_i) \cdot \min(D; Q_i + X)$$

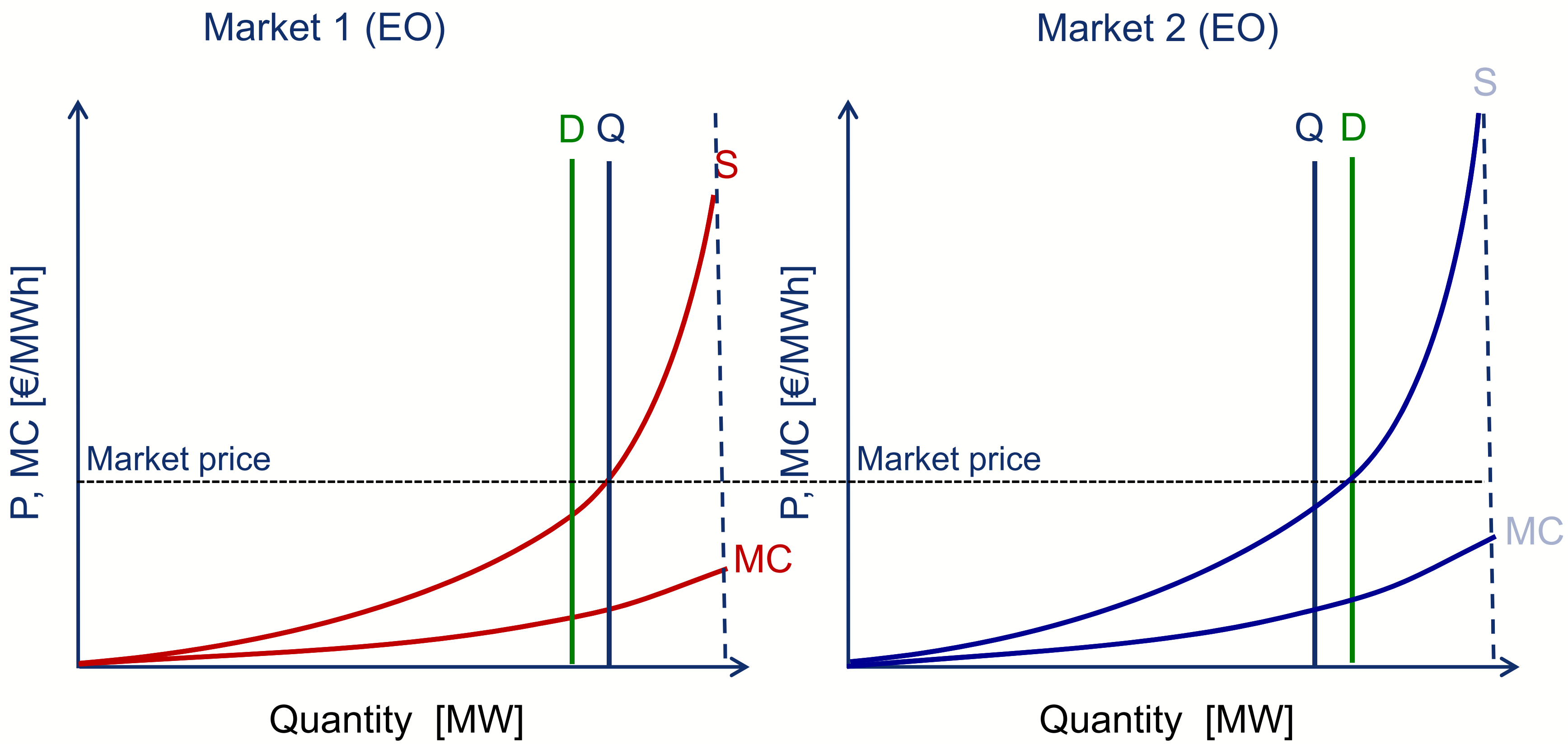
Voll (value of lost load): 10,000 €/MWh

JACOBS UNIVERSITY

Market coupling equilibrium

Reference case: both markets energy-only

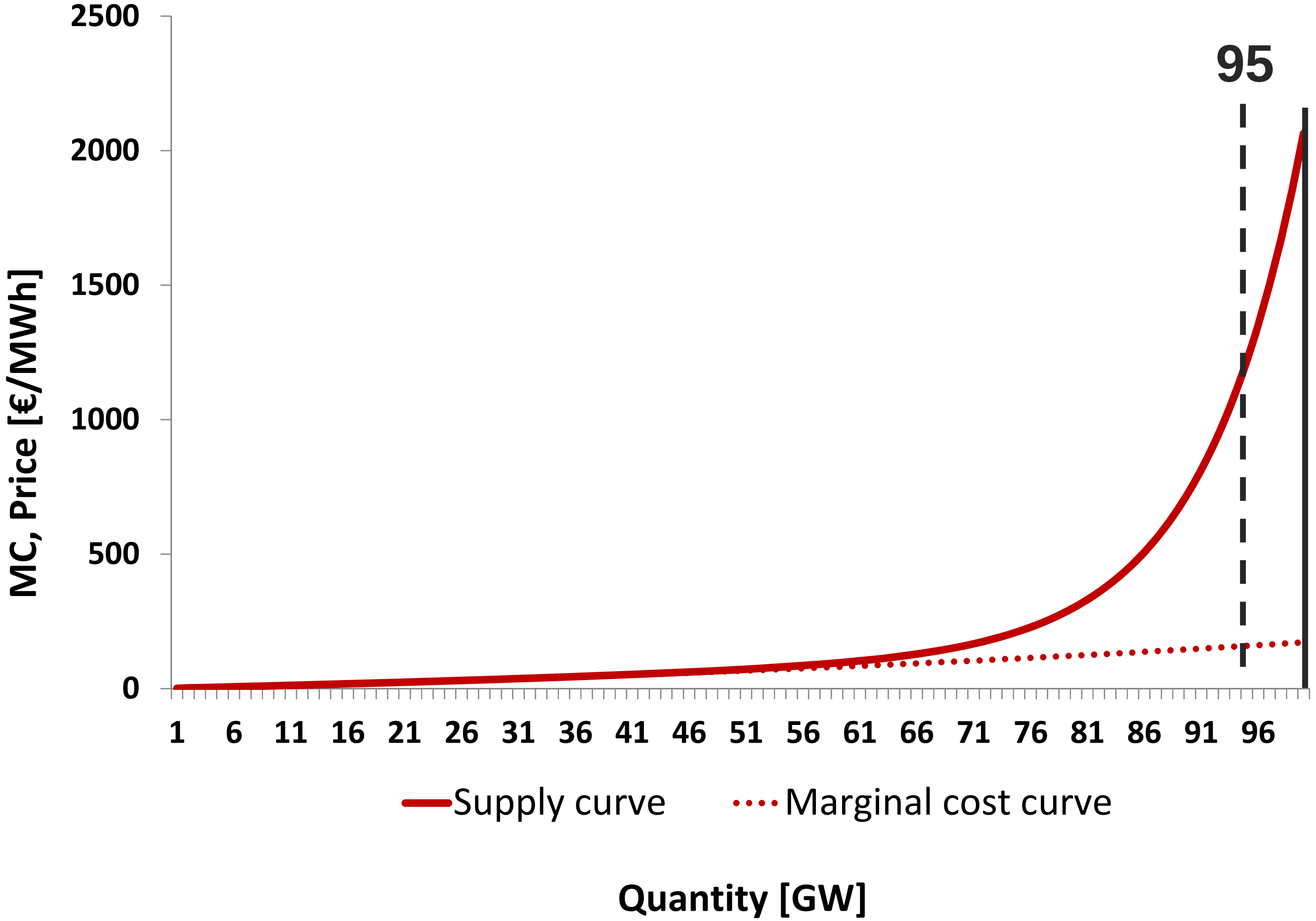
- Short-term (capacity = 100 GW)



JACOBS UNIVERSITY

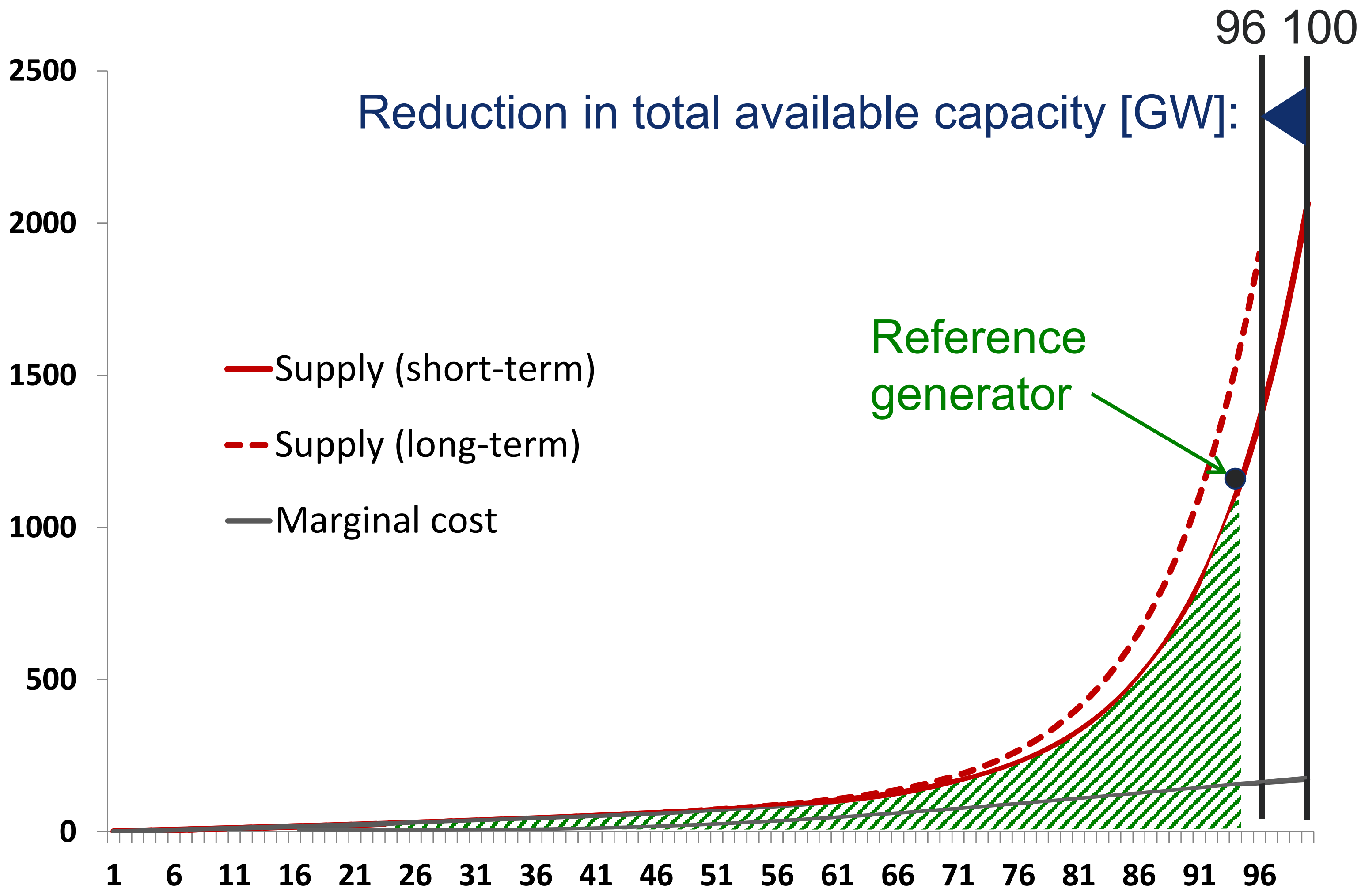
Missing-money-problem

Main assumption: Reference generator “95 GW” with zero profits



JACOBS UNIVERSITY

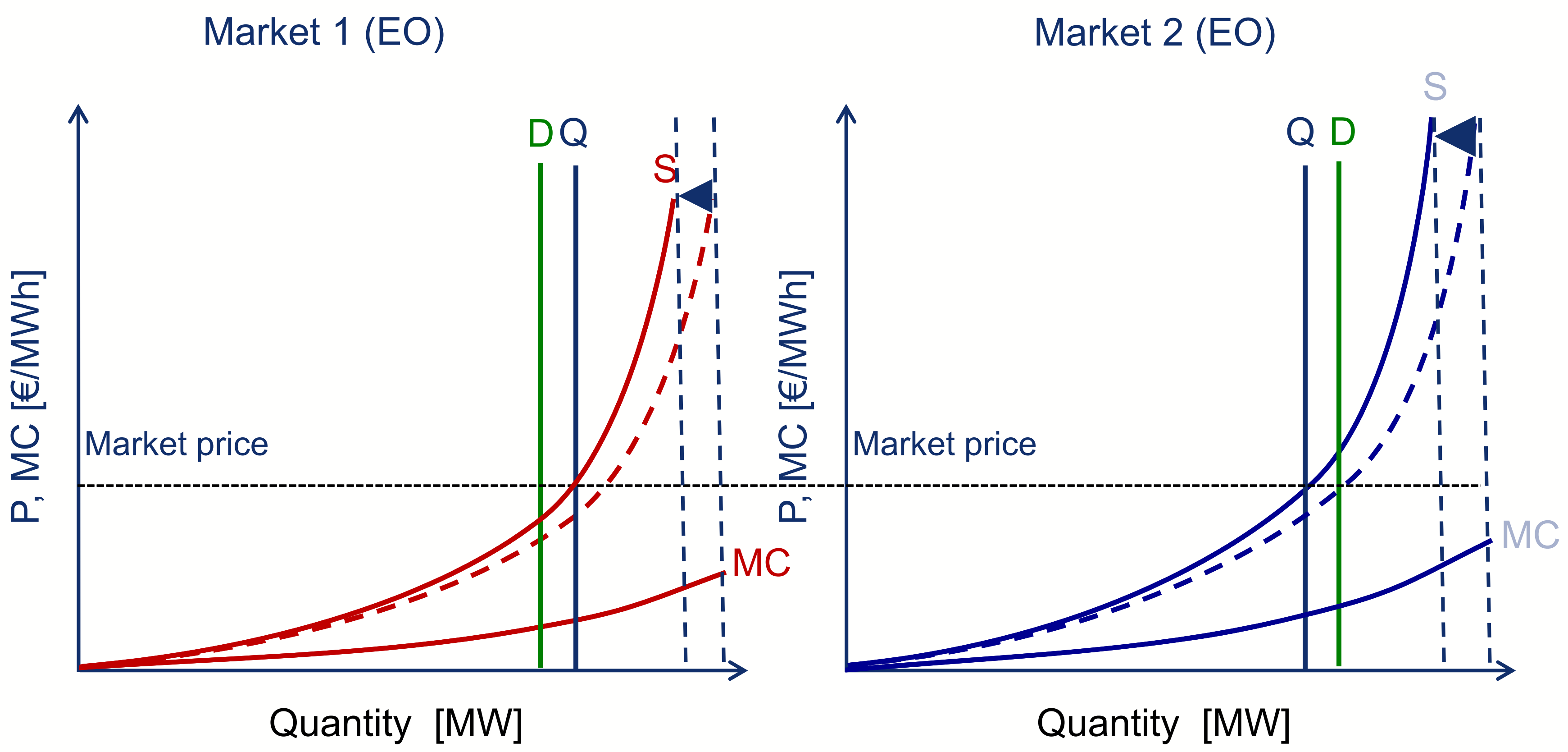
Missing-money-problem



Reference case “EO-EO”

Reference case: both markets energy-only

- Long-term („do-nothing“-scenario)



Capacity remunerative mechanisms

2 CRMs

- Strategic Reserve
- Reliability Options

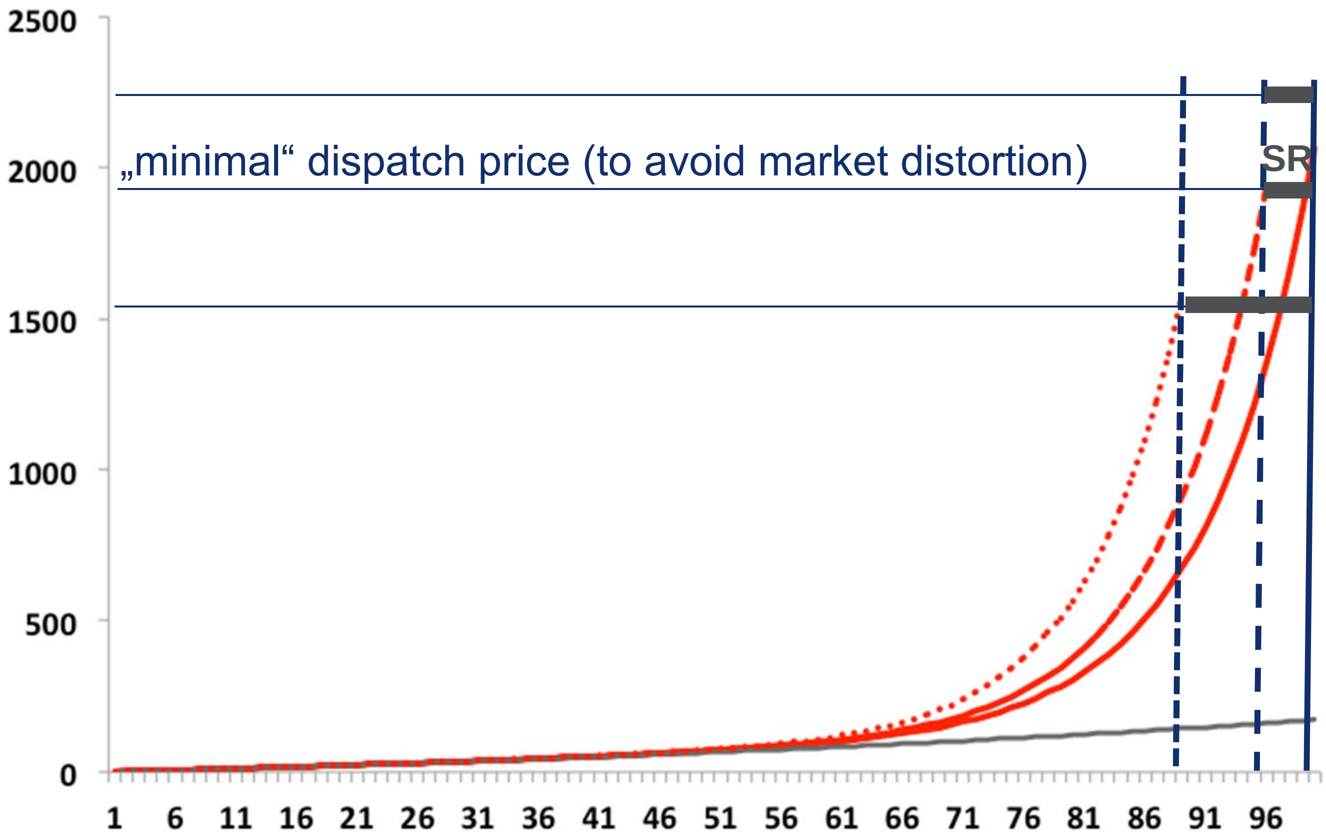
Basic assumptions

- Generation adequacy in the short-run (100 GW)
- This is current situation for most European countries
- Goal of CRM is to keep the existing generators in the market and ensure reinvestment when needed
- Hence: 100 GW is the target capacity for both markets

Strategic Reserve (SR)

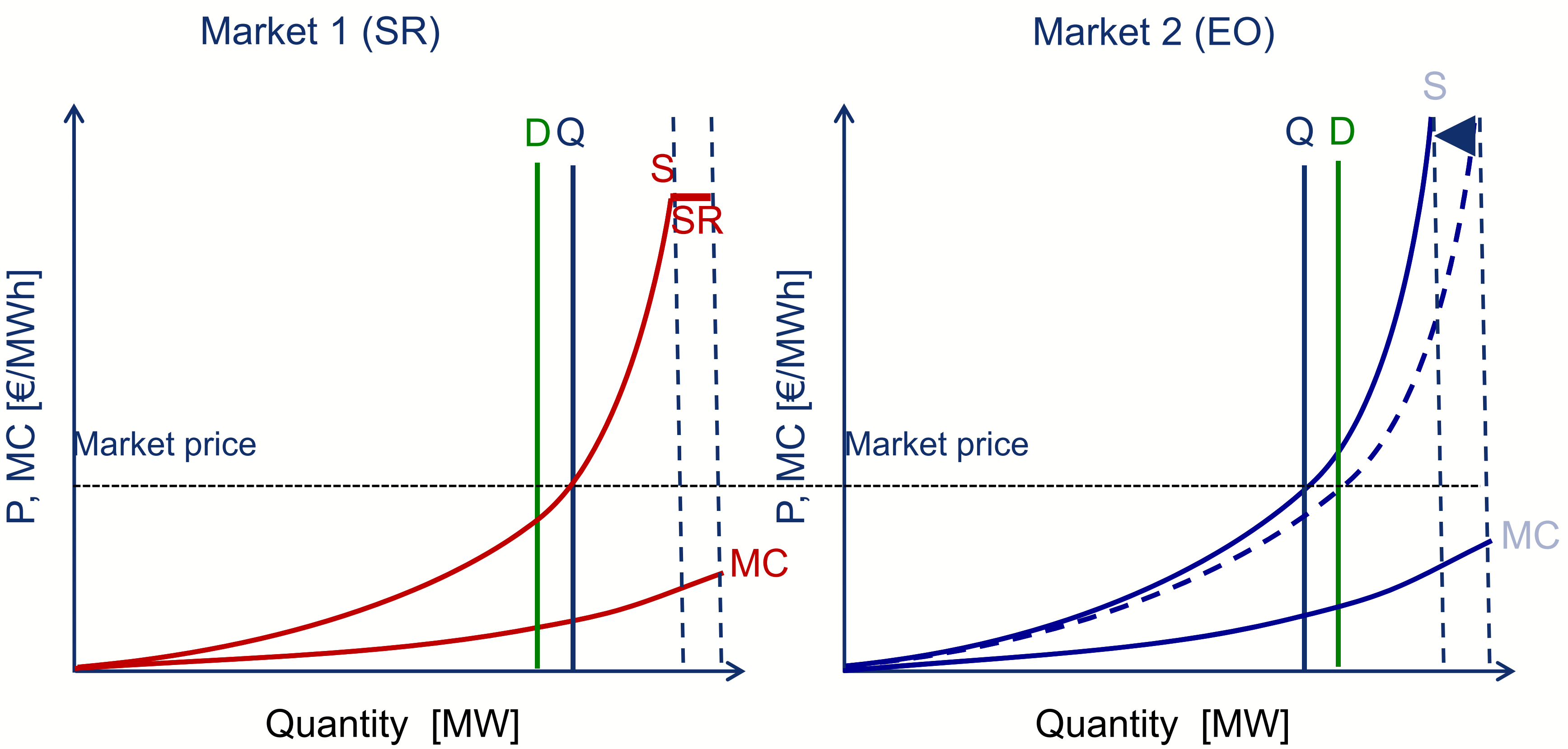
TSO auctions peak load capacity of “100 GW – market capacity”

→ Assumption: **price-based dispatch**



Strategic Reserve (SR)

Case “SR-EO”

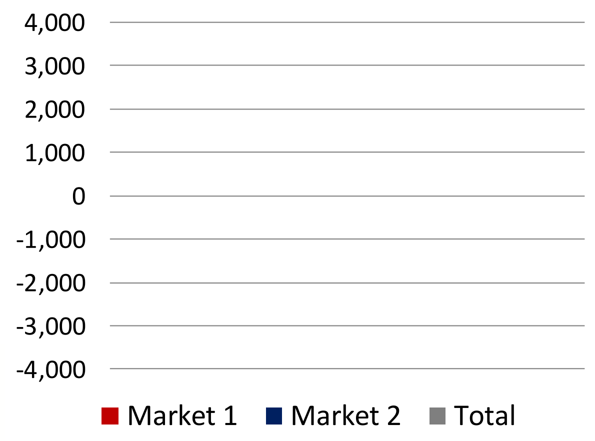
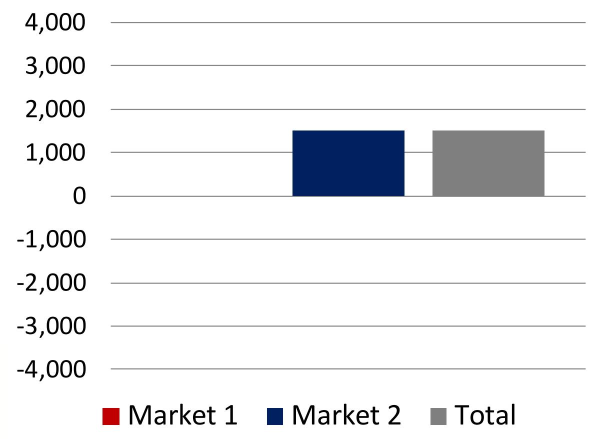
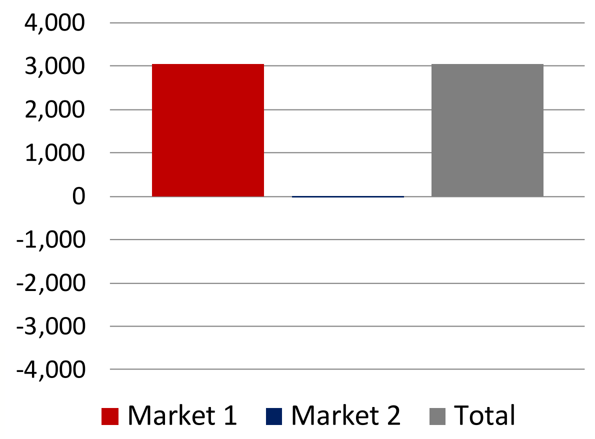
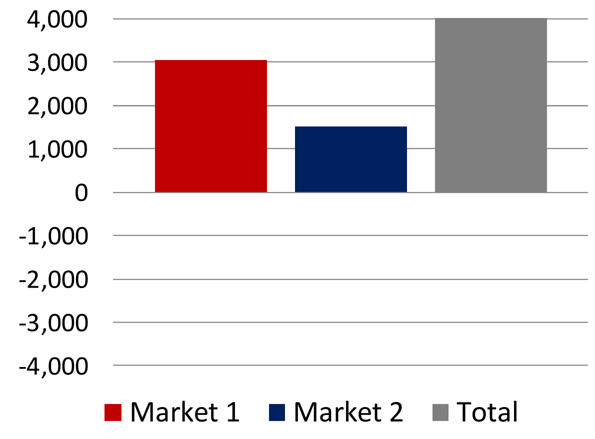


Results SR

PD1 (€)	1,943	Absolute changes compared to reference case			
PD2 (€)	2,366				
		Cases			
	Market 1	EO	SR	EO	SR
	Market 2	EO	EO	SR	SR
Market 1					
Producer Surplus 1	'000 €	0	1,395	0	1,395
Consumer Surplus 1	'000 €	0	1,660	0	1,660
Capacity Payments 1	'000 €	0	1,395	0	1,395
Total Welfare 1	**'000 €**	**0**	**3,055**	**0**	**3,055**
Market capacity 1	GW	0.0	0.0	0.0	0.0
Strategic Reserve 1	GW	0.0	3.8	0.0	3.8
Total capacity 1	**GW**	**0.0**	**3.8**	**0.0**	**3.8**
Energy not supplied 1	GWh	0	-379	0	-379
Market 2					
Producer Surplus 2	'000 €	0	-239	874	635
Consumer Surplus 2	'000 €	0	218	645	863
Capacity Payments 2	'000 €	0	0	874	874
Total Welfare 2	**'000 €**	**0**	**-21**	**1,519**	**1,499**
Market capacity 2	GW	0.0	0.0	0.0	0.0
Strategic Reserve 2	GW	0.0	0.0	2.9	2.9
Total capacity 2	**GW**	**0.0**	**0.0**	**2.9**	**2.9**
Energy not supplied 2	GWh	0	0	-199	-199
Both Markets					
Total trade	GWh	0	-9	0	-9
Total Welfare	**'000 €**	**0**	**3,032**	**1,519**	**4,551**

Results SR (Strategy matrix)

Dispatch prices:	PD1 (€)	1,943	Absolute changes in welfare compared to reference case ('000 €)
	PD2 (€)	2,366	

Market 2 / Market 1	Energy-only	Strategic Reserve
Energy-only		
Strategic Reserve		

Results SR

Pros of a SR

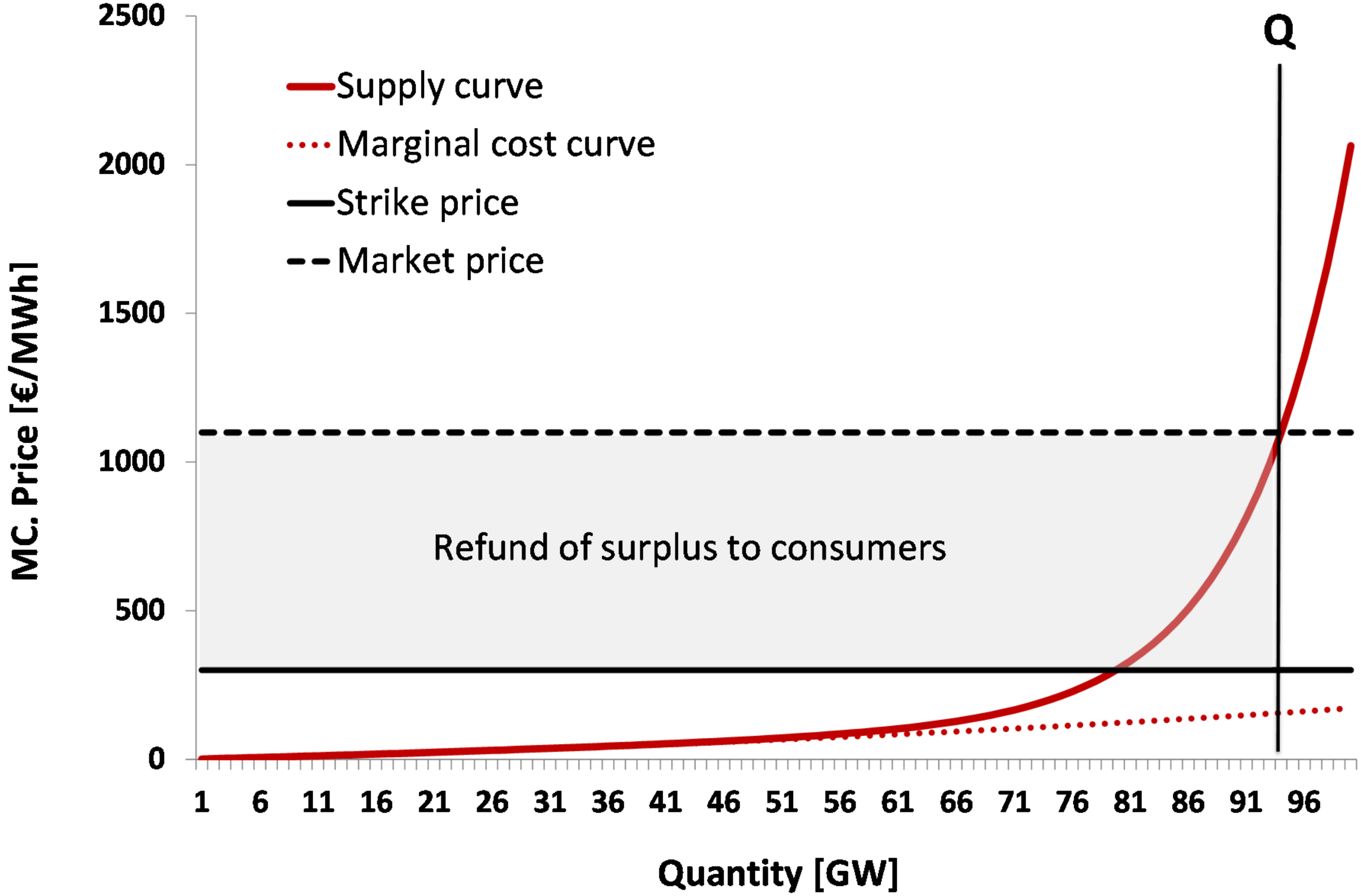
- Relatively low capacity payments
- Cross-border effects (welfare and trade) in equilibrium probably small
- Nash equilibrium is efficient outcome in terms of a second-best solution (no prisoner's dilemma)
- Negative cross-border effects only occur if SR replaces trade
  - SR in market 1 replaces imports from market 2 which would take place in the EO-EO case
  - These effects can be avoided by a quantity-based dispatch of SR

Cons of a SR

- Practical problems: efficient size of SR to meet target capacity difficult to determine
  - Problem of forecasting "EO market capacity"

JACOBS UNIVERSITY

Reliability Options (RO)



Bidding behaviour under RO

RO may change bidding behaviour

- Capacity payments cover (significant part of) fixed cost
- Any price above marginal cost increases profits
- For domestic market lower bidding only slightly lowers revenues since price is capped by the strike price

We consider two extreme cases

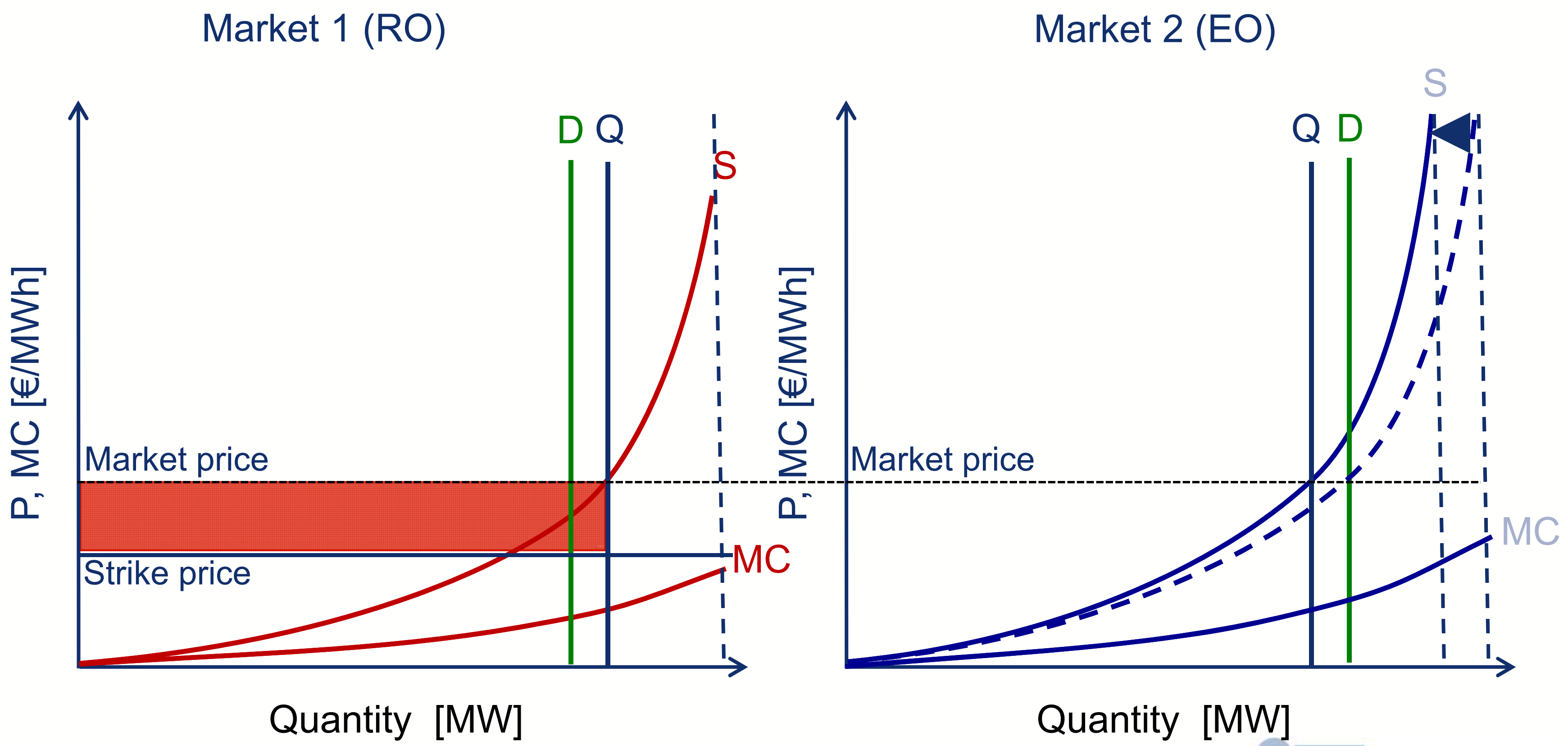
- Mark-up-bidding (as before)
- Marginal-cost-bidding

→ The “truth” lies probably in between

RO – Mark-up-bidding

RO in market 1

- No direct price effect
- Capacity effect (Capacity stays 100 GW)

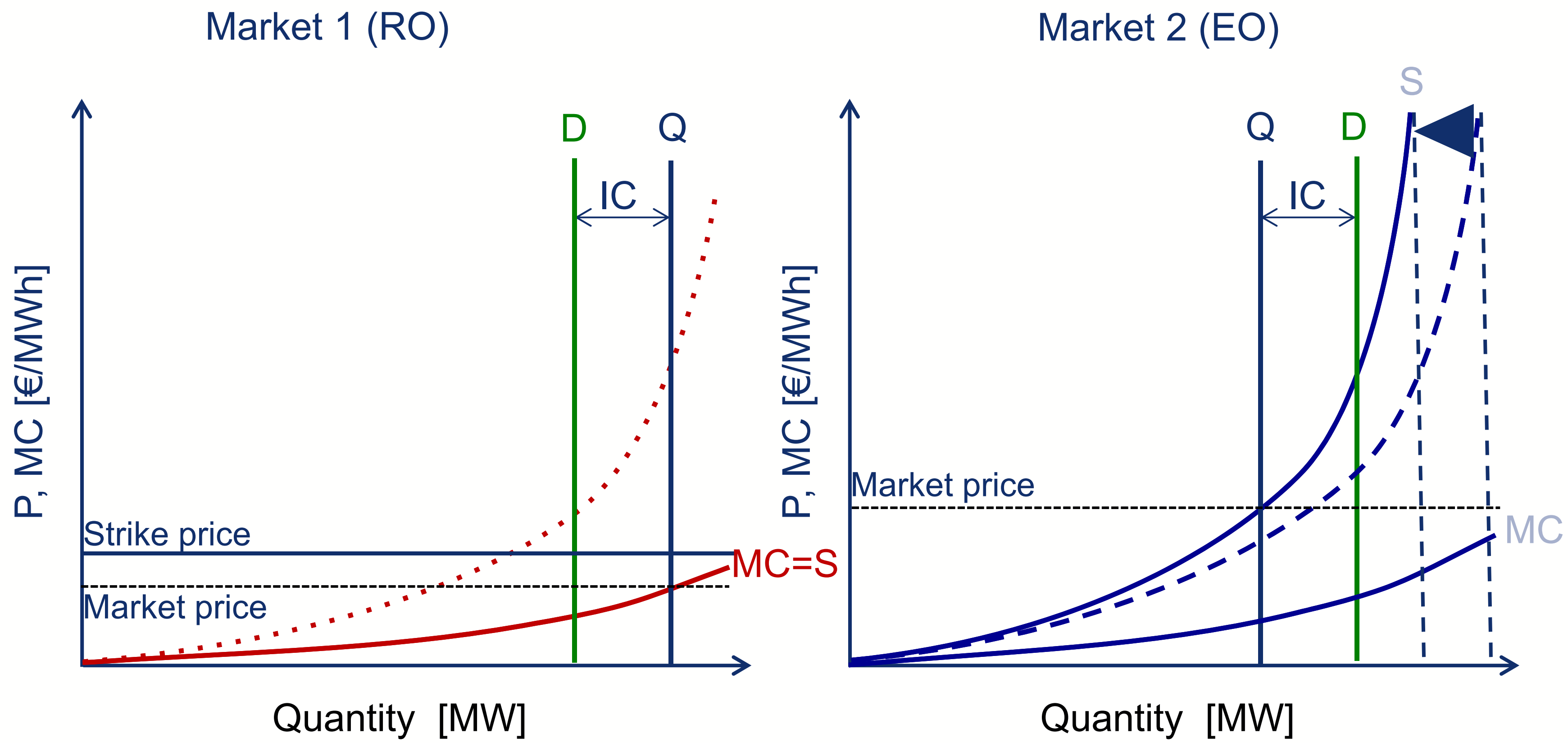


Results RO (mark-up-bidding)

Strike price 1 (€)	300	Absolute changes compared to reference case			
Strike price 2 (€)	300				
		Cases			
	Market 1	**EO**	**RO**	**EO**	**RO**
	Market 2	**EO**	**EO**	**RO**	**RO**
Market 1					
Producer Surplus 1	'000 €	0	-27.527	-7.297	-27.527
Consumer Surplus 1	'000 €	0	35.907	3.357	30.974
Capacity Payments 1	'000 €	0	84.143	0	91.233
Total Welfare 1	**'000 €**	**0**	**8.381**	**-3.941**	**3.447**
Total capacity 1	GW	0	4	-2	4
Energy not supplied 1	GWh	0	-379	86	-379
Market 2					
Producer Surplus 2	'000 €	0	-8.606	-39.092	-39.092
Consumer Surplus 2	'000 €	0	54	44.573	41.349
Capacity Payments 2	'000 €	0	0	83.733	89.076
Total Welfare 2	**'000 €**	**0**	**-8.552**	**5.482**	**2.257**
Total capacity 2	GW	0	-4	3	3
Energy not supplied 2	GWh	0	410	-199	-199
Both Markets					
Total trade	GWh	0	9.286	-859	2.012
Total Welfare	**'000 €**	**0**	**-171**	**1.541**	**5.705**

RO – Marginal-cost--bidding

- Price effect: lower bids in RO market increase exports
  → Producers in neighbouring market lose / consumers gain (free-riding)



JACOBS UNIVERSITY

Results RO (marginal-cost-bidding)

Strike price 1 (€)	300	Absolute changes compared to reference case			
Strike price 2 (€)	300				
		Cases			
	Market 1	**EO**	**RO**	**EO**	**RO**
	Market 2	**EO**	**EO**	**RO**	**RO**
Market 1					
Producer Surplus 1	'000 €	0	-27.527	-27.985	-27.527
Consumer Surplus 1	'000 €	0	33.948	14.205	30.560
Capacity Payments 1	'000 €	0	122.176	0	122.546
Total Welfare 1	**'000 €**	**0**	**6.421**	**-13.780**	**3.033**
Total capacity 1	GW	0	4	-6	4
Energy not supplied 1	GWh	0	-379	970	-379
Market 2					
Producer Surplus 2	'000 €	0	-17.528	-39.092	-39.092
Consumer Surplus 2	'000 €	0	8.015	44.609	41.876
Capacity Payments 2	'000 €	0	0	111.444	118.704
Total Welfare 2	**'000 €**	**0**	**-9.513**	**5.517**	**2.784**
Total capacity 2	GW	0	-5	3	3
Energy not supplied 2	GWh	0	710	-199	-199
Both Markets					
Total trade	GWh	0	18.630	8.558	15.075
Total Welfare	**'000 €**	**0**	**-3.092**	**-8.263**	**5.817**

Results RO

- RO-RO provides efficient solution (no market distortions)
- But strong negative cross-border effects
  - Foreign consumers gain (free-riding)
  - Foreign producers lose (more than consumers gain)
  - Strongest negative spillover in case of one-sided reduction of mark-ups
- Coordination (“cheap talk”) to prevent (temporary) negative welfare effects
- If mark-ups are reduced in both markets under RO-RO, efficiency gains compared to short-term situation are possible.
- Distribution effects between consumers and producers are small

JACOBS UNIVERSITY

Conclusions

- ✔ SR dispatch price should be higher than import prices or quantity-based to avoid negative spillovers effects

- ✔ RO provide
  - higher efficiency and
  - lower distribution effects (CS/PS) compared to SR
  - But asymmetric mark-ups may lead to negative spillovers

- ✔ If capacity payments lead to lower mark-ups on marginal cost, RO raises additional efficiency gains

- ✔ Coordination of market design policies (“cheap talk”) advisable to avoid temporary negative effects

Thank you for your attention!

Roland Meyer

Jacobs University, November 04, 2014

Bremen Energy Research (BER)

http://b-e-r.user.jacobs-university.de/

Annex: Reliability Options in a nutshell

- Auctioneer (e.g. TSO) specifies the desired generation adequacy level = amount of option contracts
  - Usually peak demand + reserve margin
  - Assuming reserve margin = 0; i.e. capacity target=100 GW
- Regulator sets a strike price at a price that is slightly higher than the marginal cost of the most expensive unit on the system
  - We set the strike price at SP = 300 €/MWh
- Generators submit the bids to the auction, expressing quantity (the capacity they want to sell) and price
  - We assume pay-as-bid auction
- If market price < SP, generators have to refund (P-SP)*D to consumers
- Accepted generators receive
  - capacity payments = option price
  - Energy payments are limited to SP*D (in case options are called)

JACOBS UNIVERSITY