Refining Short-Term Electricity Markets to Enhance Flexibility

Stocktaking as well as Options for Reform in the Pentalateral Energy Forum Region

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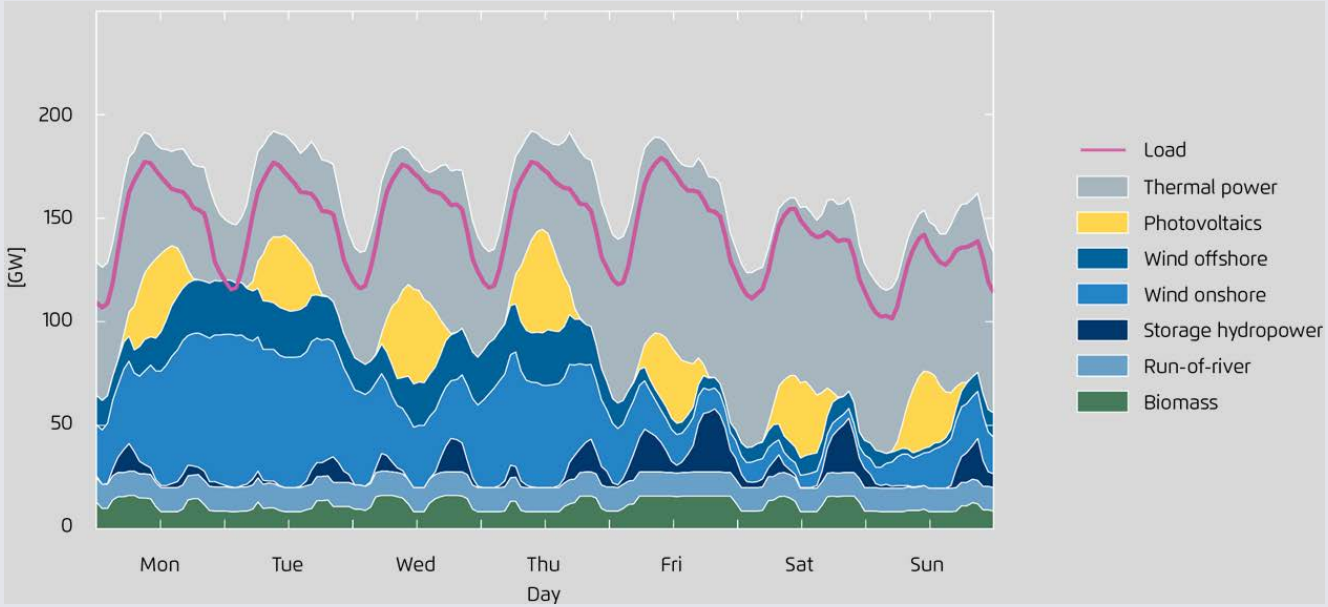
Starting point 1: Are the short-term electricity markets geared to deliver the impending demand for flexibility?

Electricity generation* and consumption* in the CWE region in a week in late summer 2030 (calendar week 32)



Fraunhofer IWES (2015) * Modelling based on 2011 weather and load data

PV / Wind penetration increases need for flexibility. Flexibility need emerges in day-ahead (DA), intraday (ID) and real-time (RT) markets

How are markets/prices behaving today in the CWE/PLEF region?
Empirical analysis of “efficiency” or “inefficiency” & pricing

How to change market design to improve efficiency? Mapping of key design features and identification of pathways for enhancement

Study performed by CE Delft and Microeconomix on behalf of Agora Energiewende

Starting point 2: Regional cooperation becomes key

Pentalateral Energy Forum region: AT, BE, CH, DE, FR, LU, NL

Regional approaches increasingly important to minimize total system costs and maximize system adequacy (and to achieve EU wide integration…)

Pentalateral Energy Forum (PLEF) important role model for the EU

“Bottom-up” coordination and cooperation in the field of market design & integration, system adequacy and flexibility

Growing common understanding of medium and long-term challenges and no-regret ways forward

Illustration of market (in-)efficiency and evaluation of market design aspects

Theoretical principles for markets to be efficient	Critical market design features
→ Marginal pricing principle → Opportunity cost pricing principle → No arbitrage principle → Under certain assumptions (limited market power, some homogeneity of products, rational expectation,…) the applicability of these principles implies markets to be efficient	→ Market access → Programme requirements and balancing responsibility → Trading arrangements → Product specifications → Market completeness → Alignment of trading periods → Alignment of delivery periods → Market pricing → Pricing mechanisms → Price restrictions

Market design parameters show broad range of implementation specifications…
Market access: Demand Side Participation

	Load				Aggregate load			
	R1	R2	R3	Special DR products	R1	R2	R3	Special DR products
Austria	yes	yes	yes	n.a.	yes	yes	yes	n.a.
Belgium	partial (R1 Load share max. 33%)	no	partial 10 per-cent (R3 DP) + 40% (R3 ICH)	n.a.	partial (R1 Load share max. 33%)	no	partial 10 percent (R3 DP) + 40% (R3 ICH)	n.a.
France	yes	yes	yes	yes	yes	yes	yes	yes
Germany	yes	yes	yes	yes	yes	yes	yes	yes
The Netherlands	yes	yes	yes	n.a.	yes	yes	yes	n.a.
Switzerland	yes	yes	yes	n.a.	yes	yes	yes	n.a.

Demand side market access in the reserve markets (primary (R1), secondary (R2), reserves (R3)) in 2015. Demand side access in day-ahead and intraday markets is allowed across the PLEF region. Source: CE Delft and Microeconomix based on TSO information and SEDC (2015). Abbreviations: R1 Load = R1 interruptible load (FCR), R3 DP (Dynamic Profile) = interruptible load – max 2h interruptions (mFRR), R3 ICH = Interruptible load – 4h, 8h or 12h interruptions (mFRR), DR = Demand Response

- → Authorization and facilitation of demand side participation induces enhanced flexibility provision
- → PLEF short-term markets typically allow demand side participation (industrial demand, aggregated demand side)
- → Independent aggregation (separating roles of BRP and BSP), which can further enable DSR, is marginally institutionalised in PLEF region (only in France and Switzerland, partially in Germany)

Market access: Product Specification

	Temporal product resolution energy bids			Contracting period for operational reserves capacity bids			
	R1	R2	R3	R1	R2	R3	Spec. DR prods.
Austria	15 mins	12 hrs (WD), 48 hrs (WND)	4 hrs	1 week	1 week, 1 day	1 week	n.a.
Belgium	15 mins	15 mins	15 mins, 4 hrs (IL)	1 month	1 month	1 year (1 month for 10% fraction)	n.a.
France	30 mins	30 mins	30 mins	n.a.[6]	n.a.[7]	1 week or 1 year[8]	1 year (IL)
Germany	15 mins	12 hrs (WD), 48 hrs (WND)	4 hrs	1 week	1 week	1 day	1 month
The Netherlands	15 mins	15 mins	15 mins	1 week	1 year	1 year	n.a.
Switzerland	15 mins	15 mins	4 hrs	1 week	1 week	1 day	n.a.

Product duration requirements in the reserve markets in 2015. Product duration requirements for DAM and IDM are typically 1 hour, with the exception of the Austrian DAM and the Austrian, German, and Swiss IDMs that facilitate trading of 15 minute products as well. Source: CE Delft and Microeconomix based on TSO information.
Abbreviations: WD = weekday, WND = weekend, IL = interruptible load

- → Longer products and contracting periods restrictive for RES, DSR, small-scale storage as they cannot be committed over longer time periods
- → Operational reserves contracting ranges from weekly products to yearly products in most PLEF countries
- → Product duration in DAM / IDM typically 15-60 min., duration for reserve power in BMs much longer
  - ☐ Limited arbitrage & coordination

Market completeness: Alignment of Trading Periods

	DAM	IDM	(pre-contracted) operational reserves capacity bids			operational reserves energy bids			
			R1	R2	R3	R1	R2	R3	free (R3) bids allowed
Austria	D-1; 12h00 (EPEX), D-1; 10h12 (EXAA)	M-30	W-1	W-1	W-1	W-1	W-1, D-1[55]	D-1; 15h00	yes
Belgium	D-1; 12h00	M-5	MO-1	MO-1	mainly Y-1 (1 month for 10% fraction)	MO-1	D-1; 15h00	H-1	yes
France	D-1; 12h00	M-30	n.a.[56]	n.a.[57]	Y-1	n.a.	n.a.	H-1	yes
Germany	D-1; 12h00	D-1; 15h00 (auction), M-30 (continuous)	W-1	W-1	D-1	W-1	W-1	D-1	no
The Netherlands	D-1; 12h00	M-5	W-1	Y-1, Q-1	Y-1	W-1	H-1	H-1	yes
Switzerland	D-1; 12h00	M-30	W-1	W-1	D-1	W-1	W-1	D-1; 8h00	yes

CE Delft and Microeconomix based on TSO information. Abbreviations: Y = year, MO = month, W = week, D = day, H = hour, M = minute

→ Lengthy gate closure times for pre-contracted reserve capacity and energy induce bids based on highly uncertain opportunity costs (involved with estimating forgone value in DAM / IDM)

Market completeness: Intraday Cross-Border Capacity Allocation

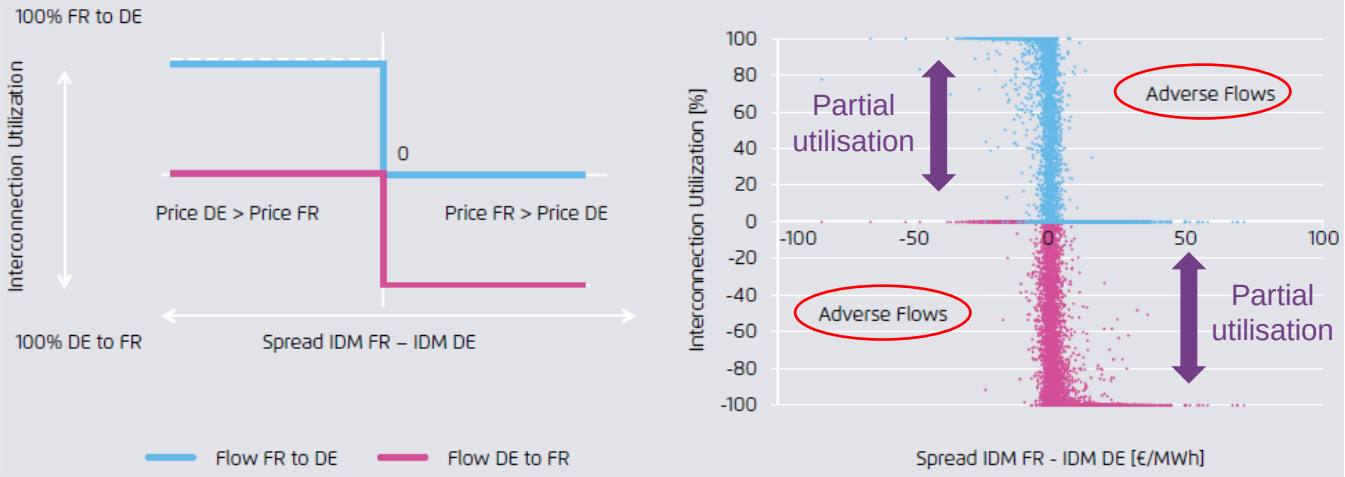
	Austria	Belgium	France	Germany	The Netherlands	Switzerland
Austria						
Belgium	n.a.					
France	n.a.	Explicit[58]				
Germany	Implicit & explicit	n.a.	Implicit & explicit			
The Netherlands	n.a.	Implicit	n.a.	Explicit		
Switzerland	Implicit & explicit	n.a.	Implicit & explicit	Implicit & explicit	n.a.	

Intraday cross-border capacity allocation mechanism in the PLEF countries in 2015. Source: CE Delft and Microeconomix based on PX and TSO information

- Misalignment between IDM product trading and ID XB capacity allocation induces inefficiencies and hampers arbitrage across borders, compromising the large potential of cross-border flexibility provision
- Implicit and explicit allocation methods co-exist, and in some instances even only explicit allocation is applied
- Often gate closure and product duration for the intraday market and the ID XB capacity allocation are misaligned
- Lack of effective pricing mechanism for ID XB capacity (capacity value is set to zero for continuous trading & implicit auctions) is likely to induce additional inefficiencies

Illustration: Limited cross-border arbitrage for the intraday markets induces inefficiencies

German-French IDM spreads (defined as French minus German intraday price) vs. cross border flows in 2014



CE Delft and Microeconomix based on PX and TSO data

- Flows scheduled in wrong direction and partial capacity allocation in right direction
  - Current arrangements prohibit full consistency between cross-border power flows and cross-border intraday price differences
  - Flexibility often not provided at least cost
- Causes
- Parallel use of explicit and implicit allocation
- Difficulties to design efficient implicit market coupling for continuous trading (Available CB transmission capacity offered free of charge in ID timeframe)
- Lack of centralised ID XB capacity pricing (auctions)

Market completeness: Alignment of Delivery Periods

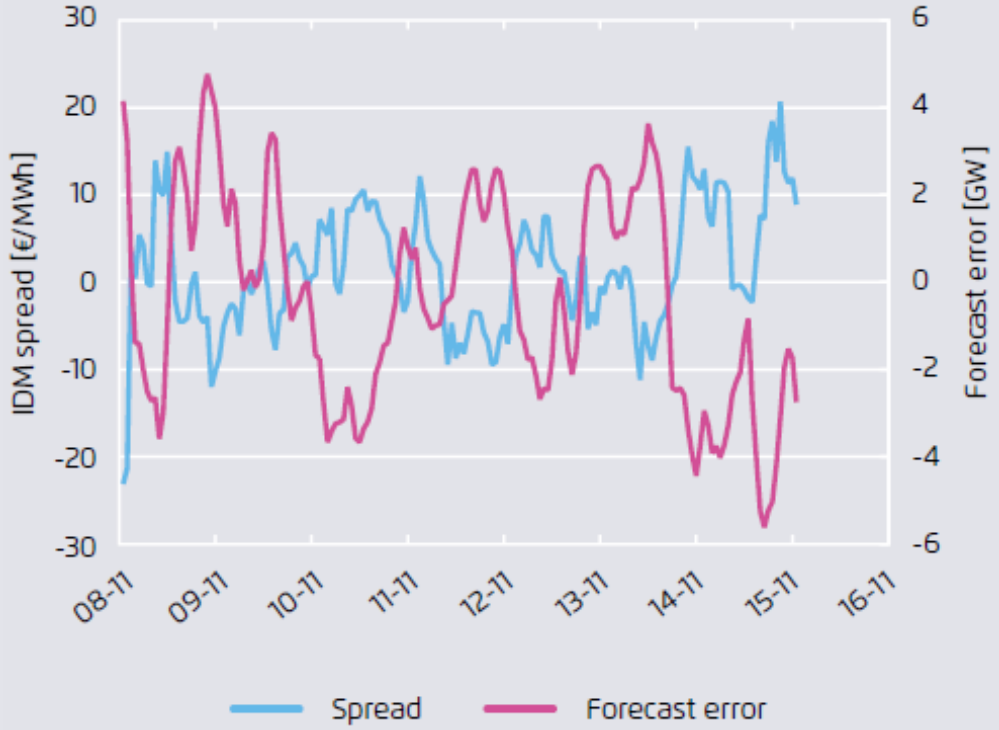
	Temporal product resolution energy bids				
	DAM	IDM	R1	R2	R3
Austria	60 mins, 15 mins	60 mins, 15 mins	15 mins	12 hrs (WD), 48 hrs (WND)	4 hrs
Belgium	60 mins	60 mins	15 mins	15 mins	15 mins, 4 hrs (IL)
France	60 mins	60 mins	30 mins	30 mins	30 mins
Germany	60 mins	60 mins, 15 mins	15 mins	12 hrs (WD), 48 hrs (WND)	4 hrs
The Netherlands	60 mins	60 mins	15 mins	15 mins	15 mins
Switzerland	60 mins	60 mins, 15 mins	15 mins	15 mins	4 hrs

Alignment of delivery periods in short-term electricity markets in the PLEF countries in 2015. Source: CE Delft and Microeconomix based on TSO information.
Abbreviations: WD = weekday, WND = weekend, IL = interruptible load

- → Delivery period misalignment compromises frictionless trading and hedging resulting in inefficiencies
- → Imbalance settlement periods (ISPs) typically 15 minutes while DAM and IDM often only facilitate hourly products
- → ISPs set to 15 minutes in most PLEF countries, while French ISP is set to 30 minutes

Illustration: Tight alignment of day-ahead / intraday and imbalance settlement periods facilitates wind & PV integration

IDM spread (defined as intraday minus day-ahead price) vs. day-ahead wind forecast error (actual wind generation minus forecast) in DE in November 2015



CE Delft and Microeconomix based on PX and TSO data

- German intraday market shows strong correlation with flexibility demand (here: adjustments in day-ahead vRES forecasts)

  ☐strong IDM / vRES forecast error correlation

- Intraday market remunerates flexibility and facilitates vRES integration

Market pricing: Balancing Energy Pricing

Pricing mechanisms in the balancing markets in the PLEF countries in 2015

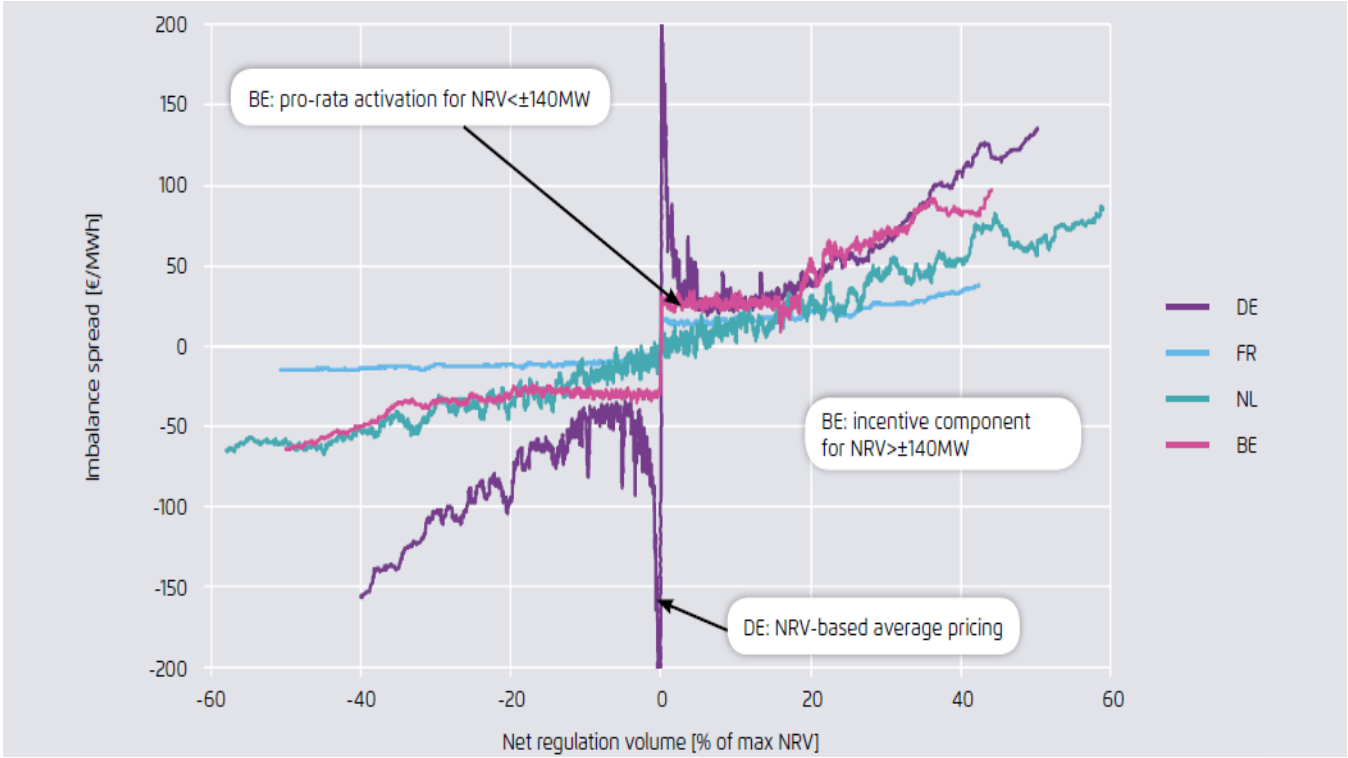
	Settlement price for balancing energy	
	R2	R3
Austria	Pay-as-bid	Pay-as-bid
Belgium	Pay-as-bid	Pay-as-bid
France	Pay-as-bid	Pay-as-bid
Germany	Pay-as-bid	Pay-as-bid
The Netherlands	Pay-as-cleared	Pay-as-cleared
Switzerland	Pay-as-bid	Pay-as-bid

CE Delft and Microeconomix based on TSO information

- → Balancing energy pricing mechanisms typically remunerate on pay-as-bid basis
- → Induces inefficiencies as market results likely diverge from a marginal pricing setting:
- → Pay-as-bid remuneration incentivises inframarginal bidders to bid up to expected marginal price in order to capture inframarginal rents
- → Resulting bidding induces inefficiencies in dispatch of supply and demand-side technologies

Illustration: Imbalance Settlement Pricing

Balancing market spread (settlement; defined as imbalance price minus day-ahead price) vs. net regulation volume (NRV) in DE, FR, NL and BE in 2015



CE Delft and Microeconomix based on TSO data and Hirth & Ziegenhagen (2015)

- → Expectation: Real-time shortage/surplus should positive/negative BM spreads, BM spreads should be near-zero for small volumes
- → Only true for NL; FR, BE and DE spreads for low volumes show non-zero and high values
- → BMs remunerate flexibility in assessed countries, to a differing extent
- → Average pricing (for imbalance settlement) may dampen cost impact of increasing NRV
- → DE average pricing is based on NRV instead of gross volume, inflating prices for low volumes
- → Imbalance settlement in BE uses marginal pricing, however R2 activation on pro-rata basis. Thus, most expensive offer for R2 set imbalance price
- → Marginal pricing and merit order activation best practices while typically PLEF BM diverge considerably in this area

Key insights

1. PLEF/CWE short-term markets characterised by rather inefficient patchwork of flexibility enabling and disabling elements

   This yields distortions of wholesale prices increasing cost of providing flexibility ☐Political momentum required to coordinate efforts to adjust key market design elements in enabling and regionally harmonised manner

2. Current market designs biased against demand side response, renewables and small-scale storage

   Small bid sizes and short contracting periods would be required in BMs

   Framework for independent aggregation would be required to fully tap demand-side flexibility potential

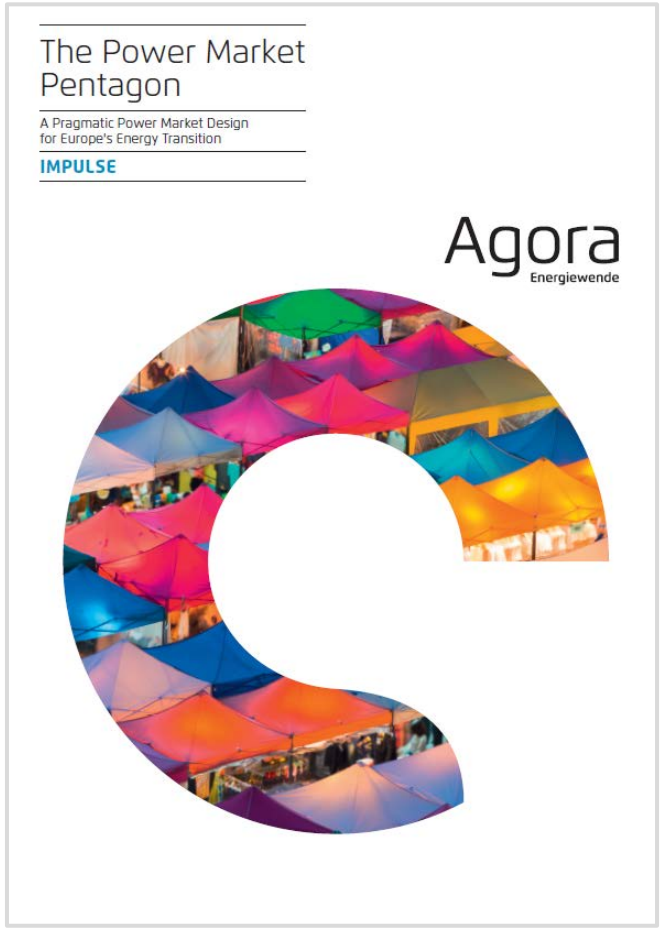
3. Balancing markets show large differences leading to inefficient pricing in preceding day-ahead and intraday markets

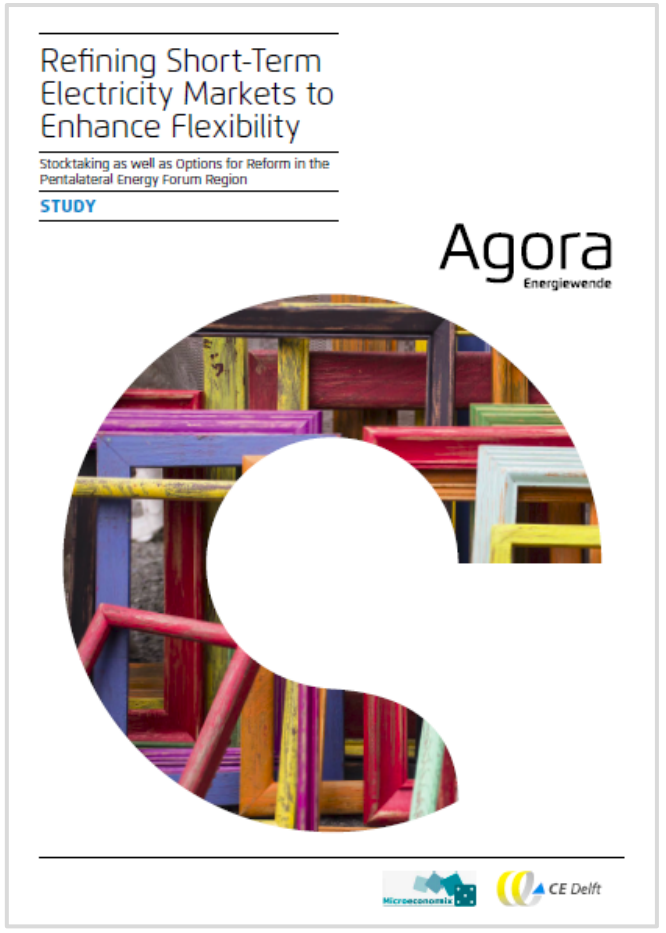
   Joint PLEF balancing market design (short products, late gate closure, marginal pricing) would enable efficient cross-border competition. Getting pricing right in balancing is key as it supports pricing in DA / ID markets (where most flexibility is traded)

4. Cross-border intraday trading needs reform to improve efficiency and enhance liquidity

   ID markets are key for integrating vRES. Harmonised rules (gate closure, product lengths) & improved continuous trading or intraday auctions are needed

More information and studies available at our website www.agora-energiewende.org – or subscribe to our newsletter!





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Thank you for your attention!

Questions or Comments? Feel free to contact me:

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Basic principles for efficient market prices

- **Marginal pricing principle**: Prices at marginal cost / value for the society ensure that market players produce if their internal marginal cost is lower or equal to price and consume if internal marginal benefit is higher or equal to price. *If prices follow marginal pricing, prices increase when market is tighter and vice versa*
- **Opportunity cost pricing principle**: Resources can be used to produce several goods (e.g. either sell energy on DAM or provide balancing services to BM). Efficient pricing needs to *include opportunity cost, i.e. foregone benefit of not producing alternative goods* (simplified: resource used for the BM cannot sell energy on DAM)
- **No-arbitrage principle**: Substitute products should be equal thus systematic arbitrage opportunities should not arise in efficient markets □ *law of one price*. Temporal dimension: electricity with same delivery date but traded at DA, ID or balancing stages are substitutes to some extent; Spatial dimension: Electricity produced at different locations is another example of substitute products. Arbitrage enables that least-cost alternatives available in differing markets are utilised

Source: CE Delft and Microeconomix