CHAIRE EUROPEAN ELECTRICITY MARKETS
Fondation Paris-Dauphine

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Integration des Europäischen Strommarktes: Herausforderungen und Lösungsperspektiven

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1) Challenges for European Electricity Market Integration due to Variable Renewable (VaREN) Production

a) The Growing Gap between Costs, Prices and Market Tariffs
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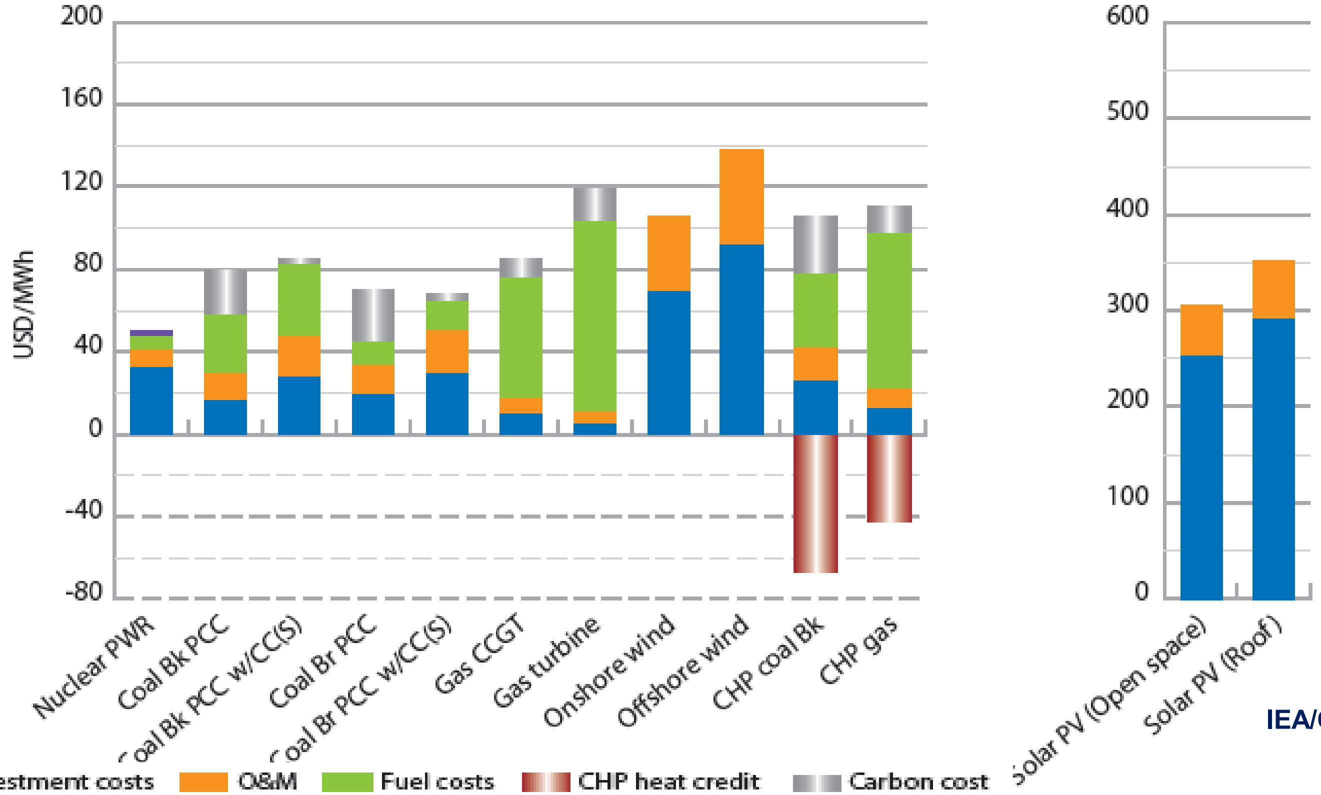
Plant Level Production Costs



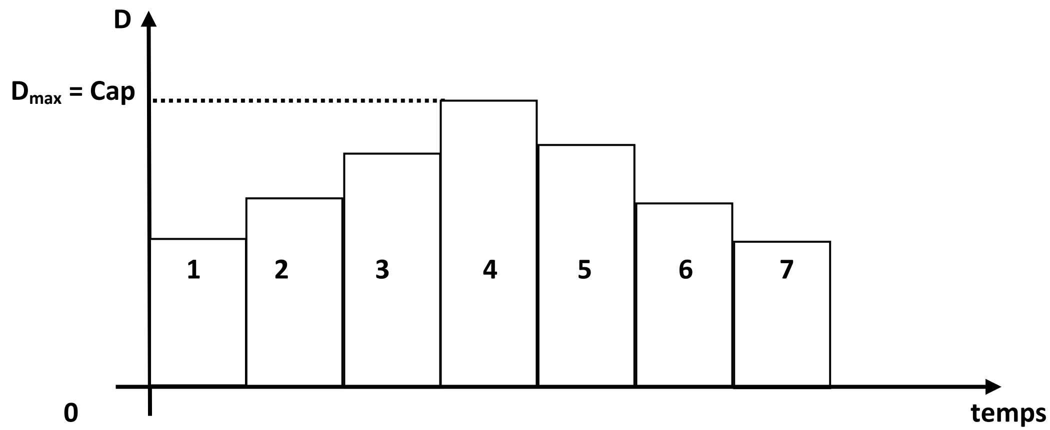
IEA/OECD (2010)

LCOE$_i$ = $\sum[(I_{tj} + M_{ti} + F_{ti} + CO2_{ti})*(1+r)^{-t}]/\sum[E_{ti}*(1+r)^{-t}]$

Note the differences in the ratio of **Investment Costs/Variable Costs. High** for low-carbon technologies such as wind, solar PV or nuclear. **Low** for fossil-fuel technologies such as gas or coal.

Cost recovery implies $\sum_t \boldsymbol{p_t} * \boldsymbol{qt} = \sum_i \boldsymbol{LCOE_i} * \boldsymbol{qi}$ where $\boldsymbol{p_t} = \boldsymbol{CVit}$

From Costs to Prices: The Basic Idea



Optimally regulated system for single non-storable good sets prices such that

$$\sum_i q_i * CV + CAP * r = \sum_{i \neq 4} q_i * CV + q_4 * (r + CV) = \sum_{i \neq 4} q_i * p_i + q_4 * p_4$$

With $p_1 = p_2 = p_3 = p_5 = p_6 = p_7 = CV,$

$p_4 = r + CV$ *(VOLL)* and $q_4 = CAP$.

In principle, liberalised market can replicate such non-linear prices even with multiple technologies by eliciting demand response at VOLL.

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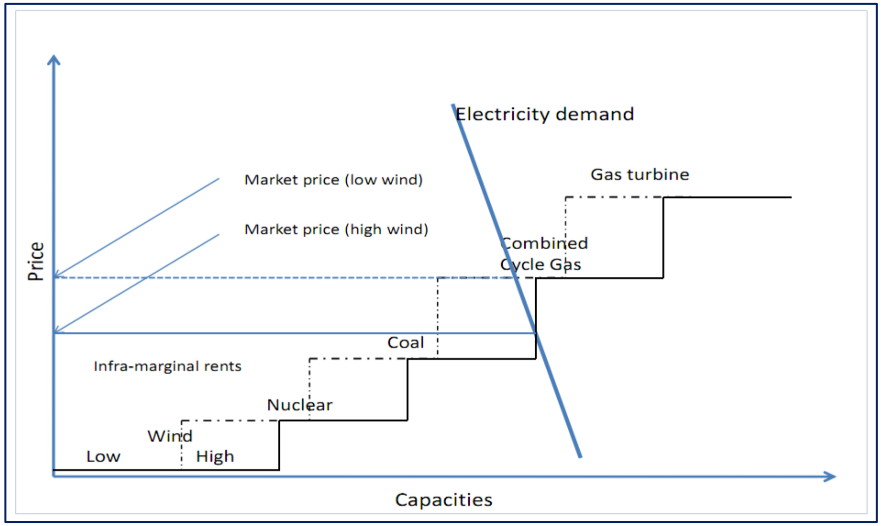
From Costs to Prices: Where's the Problem?



In the past system worked with few VOLL hours due to combination of:

- High variable costs for marginal (carbon-intensive) technology and hence high prices;
- Ample load factors for DT,
- Capacity financed at historic costs.

The influx of VaREN has lead to

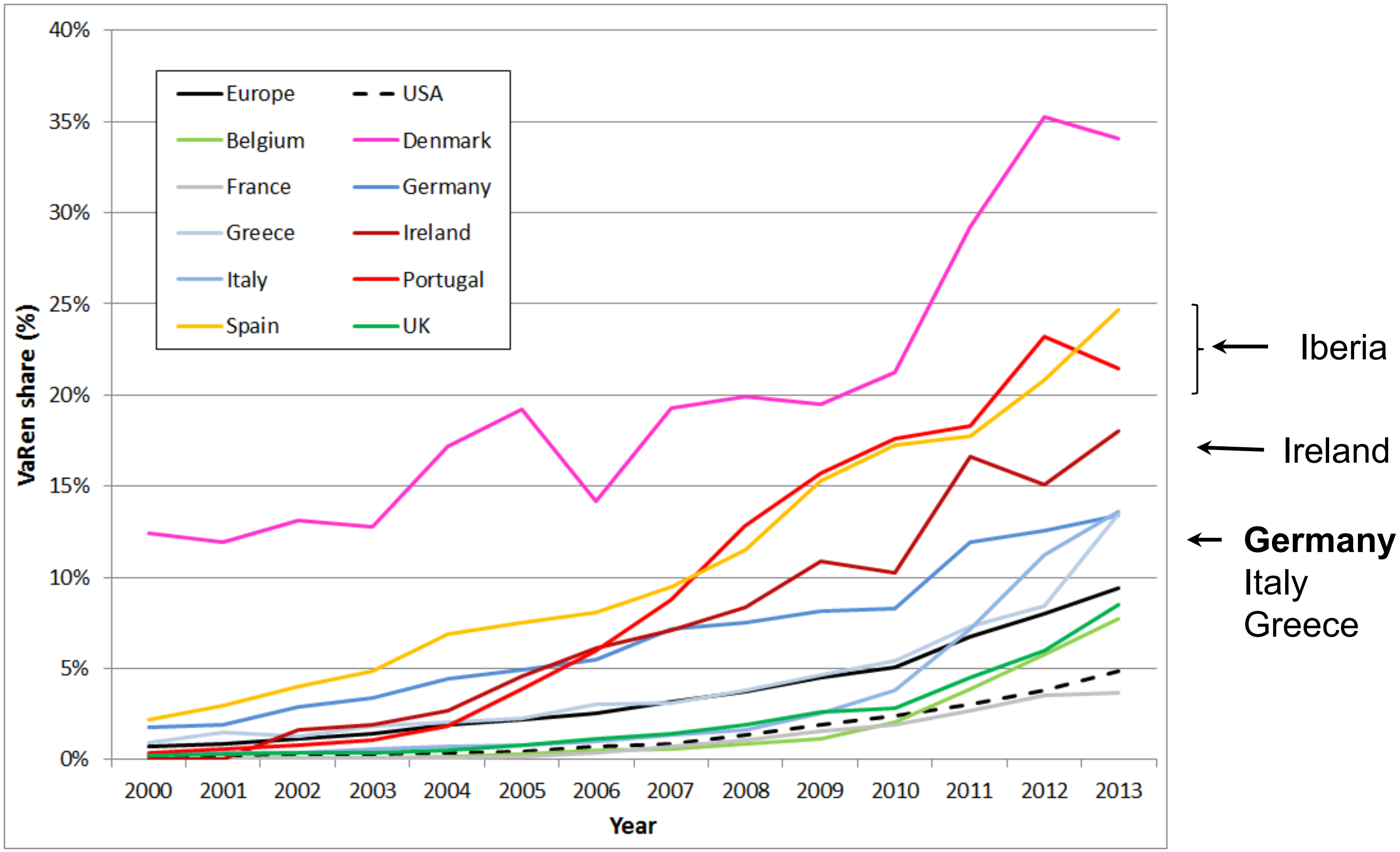
- Lower prices (exacerbated by collapse of EU ETS) and reduced load factors,
- Capacity retirements as free cash flow < fixed O&M costs.

Financing of fixed costs for un-subsidised dispatchable technologies requires:

- High number of VOLL hours (politically and socially unsustainable)
- Free provision of back-up services by utilities (economically unsustainable)
- Alternative capacity financing mechanisms (CRMs)

Just the Beginning

Share of Solar PV and Wind in Electricity Production



IEA Electricity monthly reports

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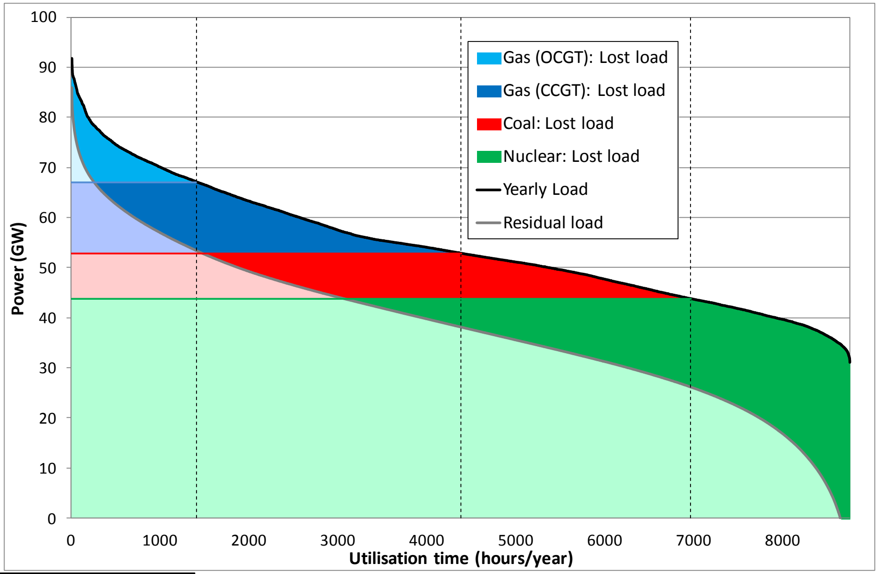
Impacts for Coal and Gas Are Real Now!

In the ***short-run***, renewables with zero marginal costs replace technologies with higher marginal costs. This means:

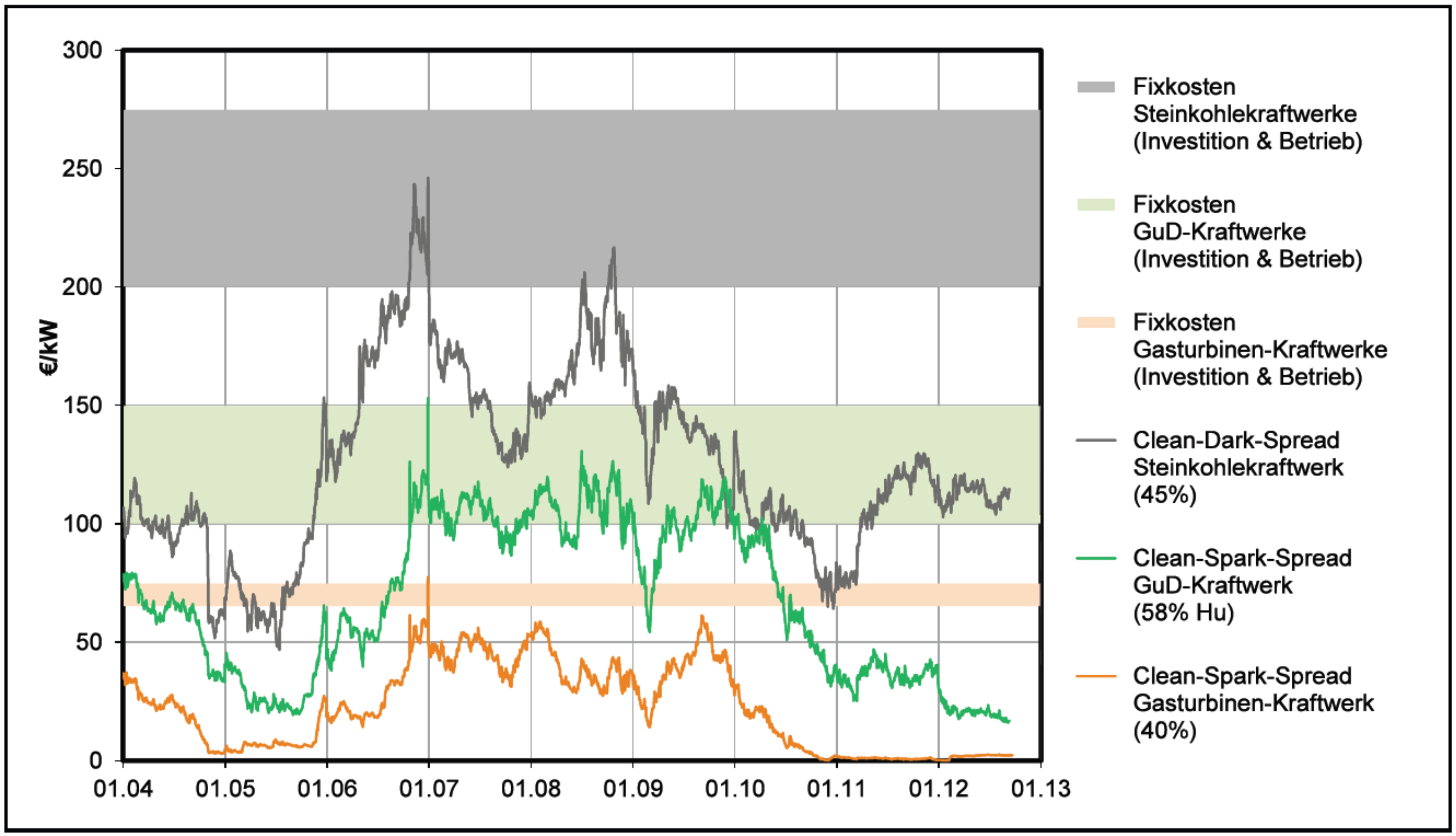
- Reductions in electricity produced by dispatchable power plants (lower load factors, *compression effect*).
- Reduction in average electricity prices on wholesale power markets, *merit order effect* (by 13-14% and 23-33%).



		10% Penetration level		30% Penetration level	
		Wind	Solar	Wind	Solar
Load losses	Gas Turbine (OCGT)	-54%	-40%	-87%	-51%
	Gas Turbine (CCGT)	-34%	-26%	-71%	-43%
	Coal	-27%	-28%	-62%	-44%
	Nuclear	-4%	-5%	-20%	-23%
Profitability losses	Gas Turbine (OCGT)	-54%	-40%	-87%	-51%
	Gas Turbine (CCGT)	-42%	-31%	-79%	-46%
	Coal	-35%	-30%	-69%	-46%
	Nuclear	-24%	-23%	-55%	-39%
Electricity price variation		-14%	-13%	-33%	-23%

- Declining profitability especially for gas (nuclear less affected).
- No incentives for new investment.
- Security of supply risks as 30 GW of gas plants close.

If Profits (Revenue minus Variable Costs) no Longer Cover Investment Costs, New Investment Stops…



Source: Matthes, Schlemmermeier *et al.* (2012), p. 19.

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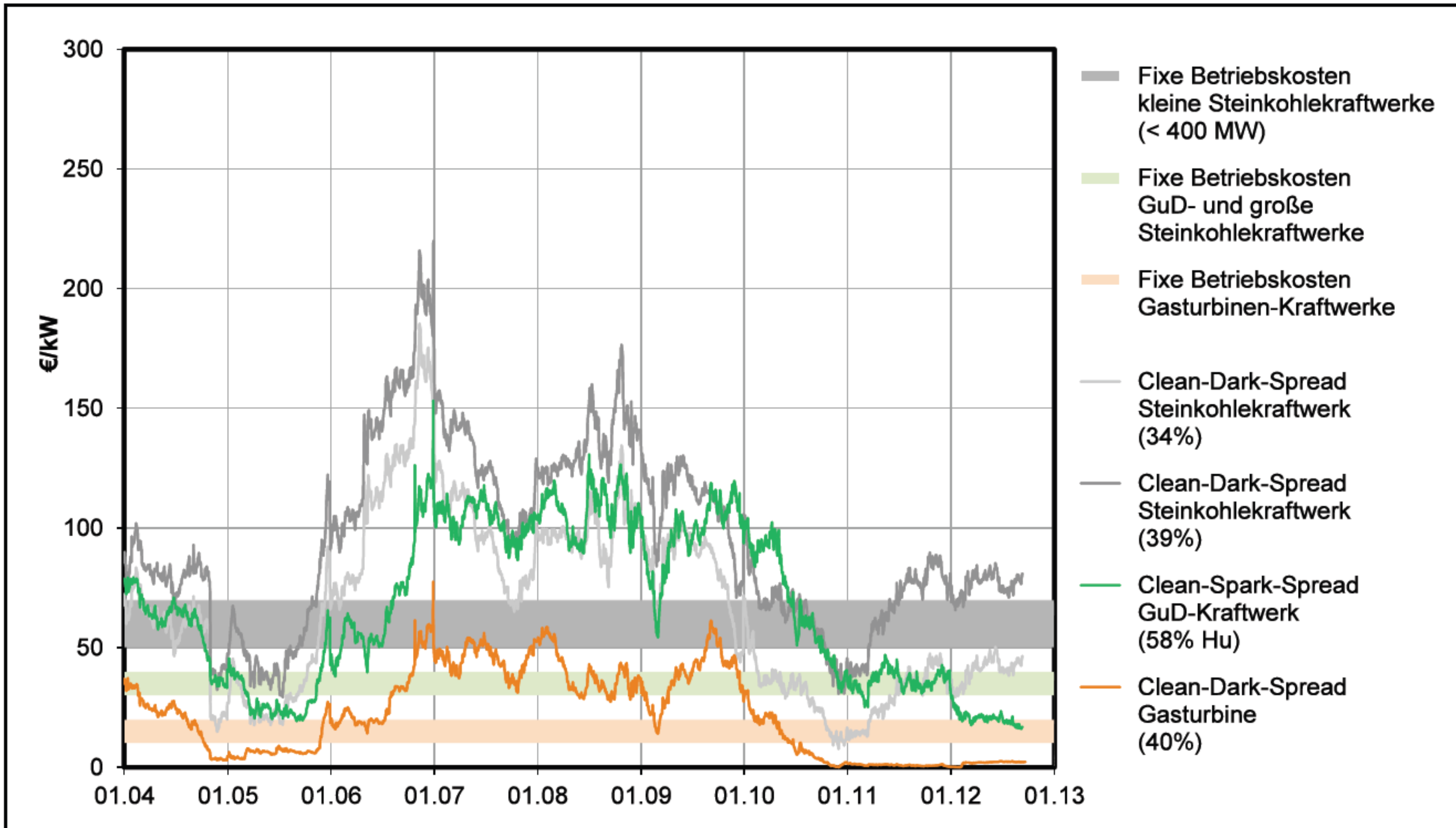
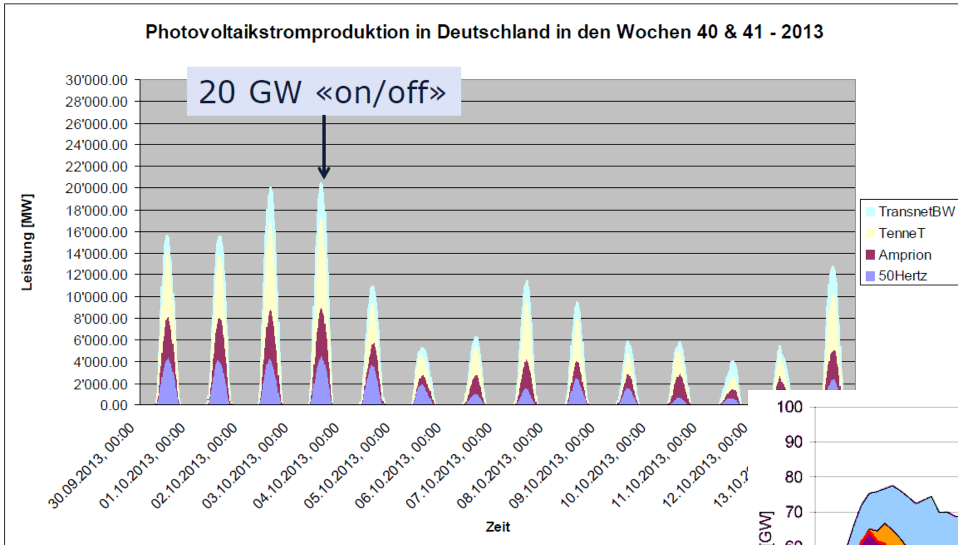
…but if Profits no Longer Cover Fixed Operating Costs, Existing Plants Close!



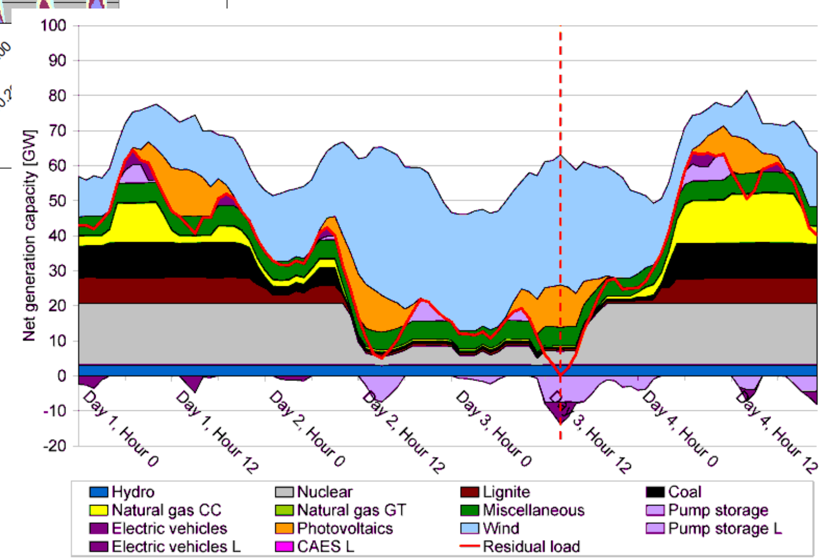
Source: Matthes, Schlemmermeier *et al.* (2012), p. 22.

Intermittency Means VaREN Cannot Go it Alone



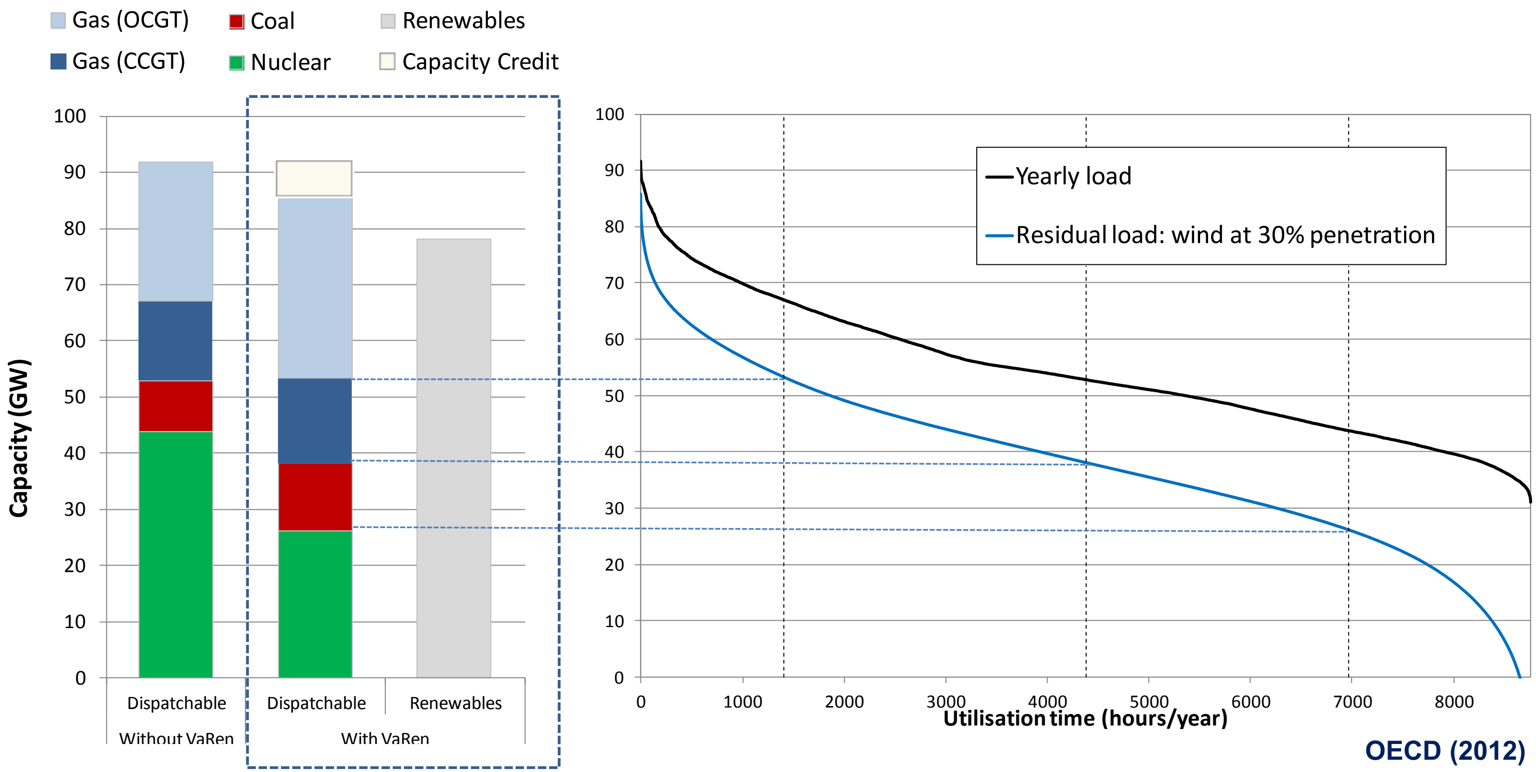
Datenquelle:transparency.eex.com

Increasing the capacity and the total production of wind and solar PV will not do away with the need for conventional back-up due to **auto-correlation** of VaREN.



Dispatchable renewables (biogas, hydro…), storage and DSM will be part of solution but will not be sufficient, see IER (2011) model run with a 30% share pf PV and wind. Capacity mechanisms are logical consequence.

Since the *Capacity Credit* of VaREN is Low, Conventional Capacity is Still Required

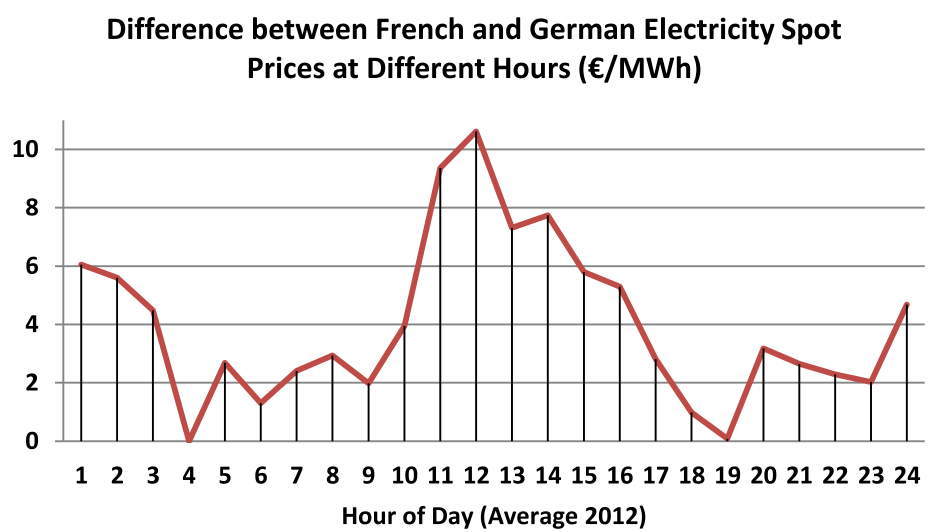


OECD (2012)

- Renewable production will change generation structure also for back-up.
- Without carbon taxes, mix will become **more carbon-intensive**.
- Cost for residual dispatchable load will rise with more expensive technologies.

Do VaREN Constitute a Challenge for European Market Integration?

- Flows by intermittent renewables, in particular solar, lead to more frequent saturation of internal grids in Germany and external interconnections;
- More frequent saturation leads to increasing price differences and declining market efficiency (mutually advantageous trades not being made).



- In 2012, with ca. 60 TWh traded on EPEX Spot France price differences between France and Germany (annual average of € 4,27/MWh, volume-weighted) amounted to losses for French electricity consumers of € 253 million per year.

The Power and Limits of European Market Integration with Fixed Interconnection Capacity

VARIABLES	Before coupling Spread	After coupling spread
Spread-1	0.244***	0.221***
	(0.01030)	(0.00651)
Spread_2	0.096***	0.0509***
	(0.01022)	(0.00653)
Load F-D	0.000381***	0.000492***
	(1.68e-05)	(1.99e-05)
Nuclear	-0.000126***	-8.10e-05***
	(2.71e-05)	(2.71e-05)
Solar	**0.0007186*** **	**0.000634*** **
	(6.99e-05)	**(3.59e-05)**
Wind	**0.000575**	**0.000496*** **
	(2.62e05)	**(3.10e-05)**
Constant	4.165	0.0625
	(1.21)	(1.267)
Observations	8899	23,141
Number of hour	27	24
R^2	0.6153	0.7159

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

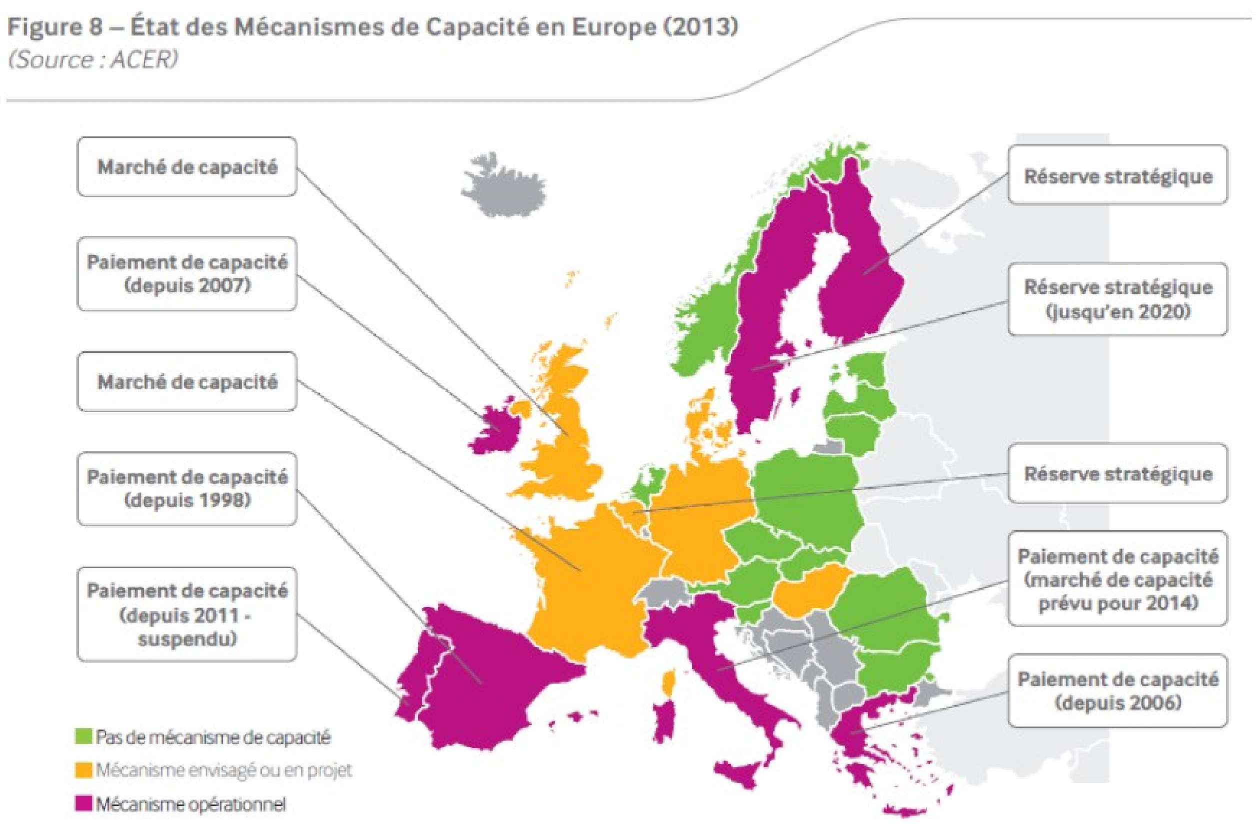
Table 1. Average percentage of price convergence

Month	2011	2012	2013
1	77%	63%	38%
2	76%	20%	26%
3	72%	52%	12%
4	73%	73%	48%
5	64%	72%	66%
6	44%	74%	57%
7	48%	85%	N.A
8	53%	82%	N.A
9	72%	75%	N.A
10	82%	51%	N.A
11	82%	69%	N.A
12	63%	50%	N.A
Average	67%	64%	41%

2) What is the Contribution of Capacity Remuneration Mechanisms (CRMs)?

a) No Theoretical Foundation but Strong Practical Pressures
b) Different Capacity Mechanisms Need to Address Specific Needs
c) Cross-border Participation Welcome in Principle but Needs Closer Cooperation between Transport system Operators (TSOs)

European CRMs Arise Due to National Prerogatives



Source: ACER (2013), RTE (2014).

Different Countries Have Different Challenges and Require Different Capacity Solutions

	FRANCE	GERMANY	UK	SPAIN	ITALY
Local specificities	- Thermo sensitivity of power demand (electric heating) - Growth of peak demand	- Grid constraints in the South - Nuclear phase-out - Strong RES growth	- Large retirements of thermal plants - Limited interconnection - Strong RES growth	- Weak demand - Strong RES growth - Limited interconnection - Quasi-obligatory pool	- Internal zones and grid constraints - Strong RES growth - Central dispatch
Key issues	- Peak demand growth (+25% in 10 yrs.) - Missing money for peaking plants - Low profitability of CCGTs	- Capacity needs in the south - Need for flexibility - Low profitability of CCGTs	- Major investment needs ('capacity gap') - Retirements driven by LCPD and IED - Need for flexibility	- Overcapacity and low profitability of CCGTs - Need generation back-up due to RES penetration	- Overcapacity and low profitability of CCGTs - Coordination of generation and network investment - Need for flexibility
Main objectives of CM	- Maintain generation adequacy - Development of demand-response - Robust to exercise of market power	- Retain existing capacity in the south & drive new investment - Ensure availability of flexible back-up generation	- Maintain generation adequacy - Drive new investment in CCGTs - Ensure availability of flexible back-up generation	- Incentivize availability and flexibility of existing plants - Manage smooth rebalancing / avoid massive retirements - Limit price spikes & volatility	- Incentivize availability and flexibility of existing plants - Manage smooth rebalancing / avoid massive retirements - Robust to exercise of market power

Source: Roques, Compass Lexecon (2014)

CRMs Are no Topic for Ideological Oppositions But Require Patient Case-by-Case Analysis

- So far, no general theoretical case for CRMs, pure theorists maintain VOLL pricing can finance investment. Wrong due to
  - Security of supply externalities (involuntary curtailing **is not equivalent** to voluntary DSM!) ,
  - Asymmetric incentives when choosing between over- and under-investment.
- A location-specific and context-dependent empirical case; good CRMs address issues in country-specific manner; one size does not fit all; EU target model must promote linking not convergence;
- **Key criteria are (a) the number of hours with potential S/D imbalances which determine appropriate technology and contingent investment risk, (b) the size of potential short-fall as well as (c) availability of demand response and storage;**
- Well-designed CRMs advance their own obsolescence by incentivising demand response and storage; regular review ("trial and error") needed.

Different CRMs for Different Problems

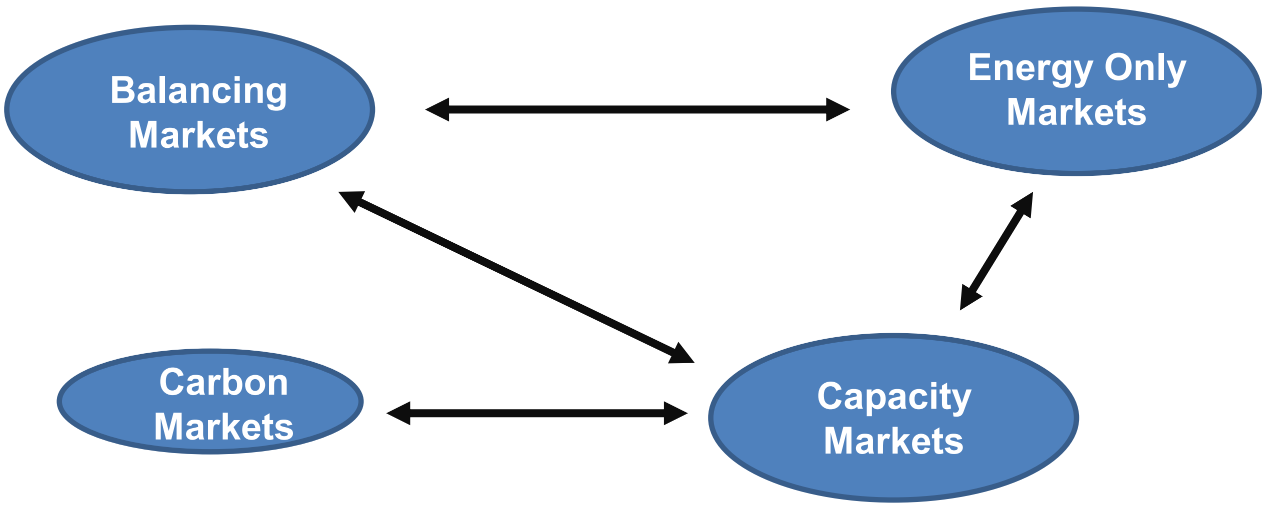
No-ideal-type! CRMs must address different issues in different contexts. Consider the following examples:

1. Flexibility provision at extreme peak hours (< 500 h/a, example France w/ thermosensitivity): **Capacity obligations enabling DSM**
2. Back-up for intermittent renewables (500 h/a < 3000 h/a, example Germany with large-scale intermittency): **Centralised auctions for gas capacity**
3. Generalised support for capital-intensive investments (> 3000 h/a, example UK with looming lack of baseload capacity): **Capacity payments for baseload capacity and low carbon investments, FITs and CFDs are capacity instruments as they remunerate average instead of marginal costs!**

Two further remarks:

1. Strategic reserves are easy to implement, politically sellable, attractive to investors and have low transaction costs. They also have a big drawback: no increase in total capacity due to added private investment retention.
2. In capacity markets, physical trading should be favoured over financial claims. "Quality" and diversity of capacity is an issue. Paper claims for DSM not always a substitute for production capacity (see US experience during "polar vortex").

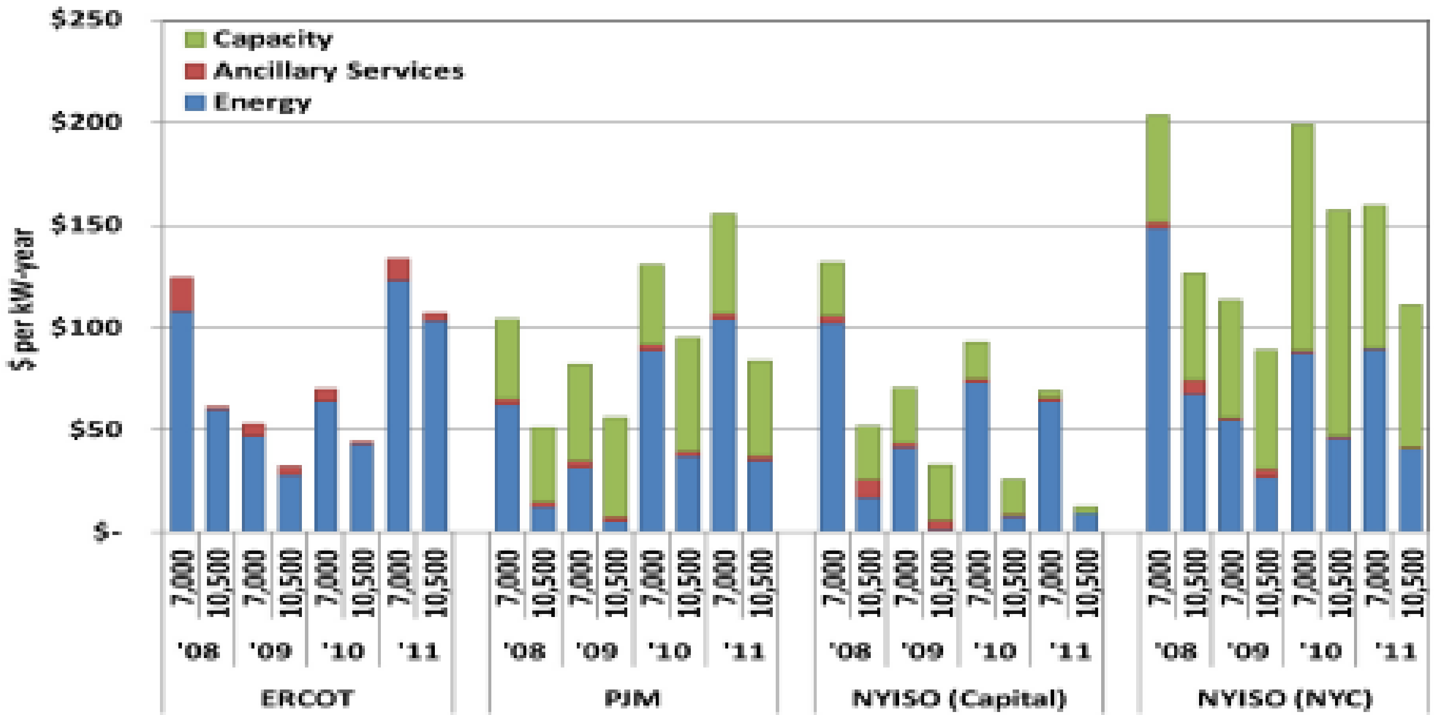
CRMs Are Indispensable but Will Create Issues of their Own



- Prices in day-ahead energy-only, balancing market and other short-term (Intraday) markets will fall with increased capacity;
- **CRMs are no substitute for short-term flexibility markets, as ramping and balancing continue to require specific products.**
- *Vice versa*, flexibility markets do not give required visibility to investors.

CRMs May or May not Increase and Stabilise Revenues for Generators

Figure 37 • Comparison of net revenues of gas-fired generation between markets



Source: Potomac Economics (2012) cited in IEA (2012), technologies are differentiated by efficiency, 7 000 MMBtu/MWh CCGT and 10 500 MMBtu/MWh OGT.

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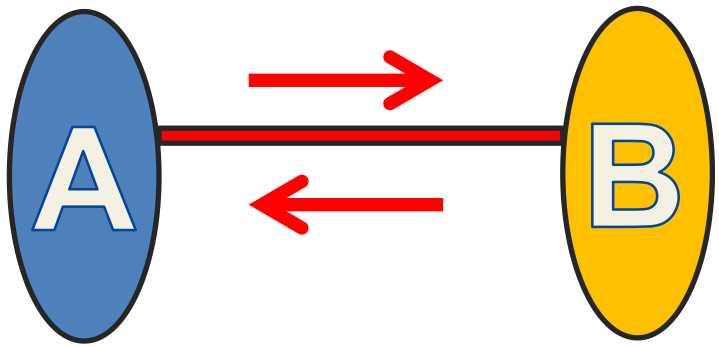
Think before You Act: Different CRMs Have Very Different Consequences

	Loss per MW Baseload	Loss per MW Extreme Peak	Hours of Scarcity	Hours of DSM	€/MWh Baseload	€/MWh Peakload	Highest Price
Hypothetical case "missing money"	-50 000	-50 000	0	0	23	60	150
Scarcity pricing	0	0	18	0	23	72	3 000
Capacity market w/ DSM	0	0	0	143	23	72	500
Cap. Payment (6 €/MWh)	0	0	0	0	29	66	156
Strategic reserve	-50 000	-29 730	0	0	23	60	150

Modelling results for a hypothetical system with 80 000 MW capacity and price cap of 3 000 €/MWh loosely built on Joskow (2006).

Cross-Border Cooperation in Capacity Mechanisms?



- Why not? However, with a scarcity situation in country A (B) and no scarcity situation in country B (A), then interconnections from B to A (A to B) will already be saturated in the right direction due to "normal" exports with a working market. Cross-border capacities in country B (A) will add nothing to security of supply in country A (B).

- Thus cross-border participation only can make a useful contribution if there is a scarcity situation in both countries. This however raises difficult legal and operational issues to be resolved between TSOs with national security of supply obligations.

- Two absolutely indispensable pre-requisites for cross-border participation:
  - Common understanding of security of supply criteria among national TSOs;
  - Coordination of operational procedures in bi-national scarcity situations.

3) Which Framework for Closer European Market Integration?

What Needs to Be Done

A. Markets and Products for Short-term Flexibility Provision in the Face of VaREN

Four options that should compete on cost (1) Dispatchable back-up capacity and load-following, (2) Electricity storage (3) Interconnections and market integration and (4) Demand side management (DSM). So far dispatchable back-up remains cheapest but DSM has promising perspectives. Appropriate products need to be developed.

B. Fairer Allocation of System Costs

Costs for balancing, grid extension and intermittency must be allocated to those who cause them. This regards also cross-border flows. Otherwise **Cost Entropy** will provide misguided incentives and lead to inefficiencies.

C. Mechanisms for the Long-term Provision of Capacity

There are always moments when the wind does not blow or the sun does not shine. Capacity mechanisms as pragmatic and possibly temporary solutions must assure profitability for dispatchable capacity where needed.

D. A Review of Infrastructure Needs

Cross-border markets require adequate interconnections to realise their full potential. Market coupling is optimising existing infrastructures but further progress will require increased interconnection capacity.