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RECENT DEVELOPMENTS IN POWER MARKET DESIGN – FOCUSING ON HYDROPOWER

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June 7, 2023

Why should we look into power markets developments from hydropower perspective?

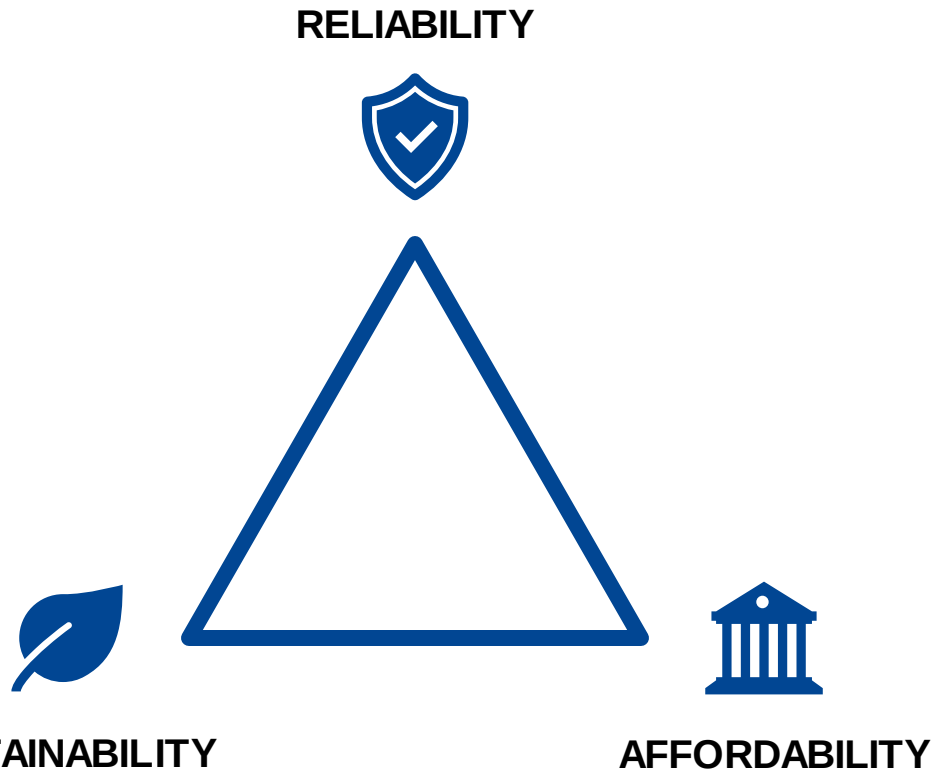
Highly valuable flexibility for integration of variable renewable energies (VRE)

Unique long-duration storage capabilities

Unique operational constraints and type of weather-dependency

Sometimes forgotten in the common opposition thermal VS VRE

The energy trilemma



Several market design options can be considered for tackling the energy trilemma.

SUSTAINABILITY	RELIABILITY	AFFORDABILITY
Global policies and mechanisms	Capacity	Wholesale market design
Intermittent renewables support and financing	Ancillary services	Grid optimization
	Flexibility	Retail market design

Several market design options can be considered for tackling the energy trilemma.

SUSTAINABILITY

Global policies and mechanisms
- Carbon pricing, emission trading systems
- Emissions performance standards
- Subsidy for reduction of carbon emissions, coupled with output

Intermittent renewables support and financing
- Contracts for Differences (CfDs)
- Power Purchase Agreements (PPAs)
- Suppliers obligations
- Renewable Portfolio Standards (RPS), Renewable Energy Standards (RES)
- Feed-in premiums (FiPs)
- Feed-in tariffs (FiTs)
- Renewable Energy Certificates (RECs)
- Net-metering

Hot topics
Focus on hydro

RELIABILITY

Capacity
- Equivalent firm power auctions (with CfDs)
- Capacity payments
- Centralized/decentralized reliability options
- Strategic reserve
- Targeted tender

Ancillary services
- Smaller minimum bid sizes
- Aggregation of resources
- Asymmetrical bids
- Passive balancing
- Flexible ramping products
- Frequency response

Flexibility
- Flexibility enhancements to the capacity market
- Cap & floor
- Suppliers obligations
- Flexibility contracts
- Coupling of intra-day and balancing markets
- (Long-term prices for hydropower and nuclear)

AFFORDABILITY

Wholesale market design
- National/zonal/nodal pricing
- Continuous trading/auctions
- Balancing regions
- Pay-as-clear/bid
- Self-/central dispatch
- Gate closure/settlement periods
- Addition of near-term forward markets
- Dual market/green power pool
- Single buyer model

Grid optimization
- Locational signals for investments
- Locational imbalance pricing
- Reform of network access
- Local markets
- Flow-based market coupling/splitting
- Dynamic line rating
- Coordinated reserves

Retail market design
- Real-time pricing, volumetric or capacity tariffs
- Prosumer interface and incentives
- Local markets and energy sharing schemes

Several market design options can be considered for tackling the energy trilemma.

SUSTAINABILITY	RELIABILITY	AFFORDABILITY
Global policies and mechanisms	**Capacity**	**Wholesale market design**
	➢ Capacity payments ➢ Centralized/decentralized reliability options ➢ Strategic reserve ➢ Targeted tender	➢ Pay-as-clear/bid
Intermittent renewables support and financing ➢ Contracts for Differences (CfDs) ➢ Power Purchase Agreements (PPAs)	**Ancillary services**	➢ Addition of near-term forward markets ➢ Dual market/green power pool
	➢ Flexible ramping products ➢ Frequency response	**Grid optimization**
	Flexibility ➢ Flexibility enhancements to the capacity market ➢ Cap & floor ➢ Suppliers obligations ➢ Flexibility contracts	**Retail market design**

Hot topics
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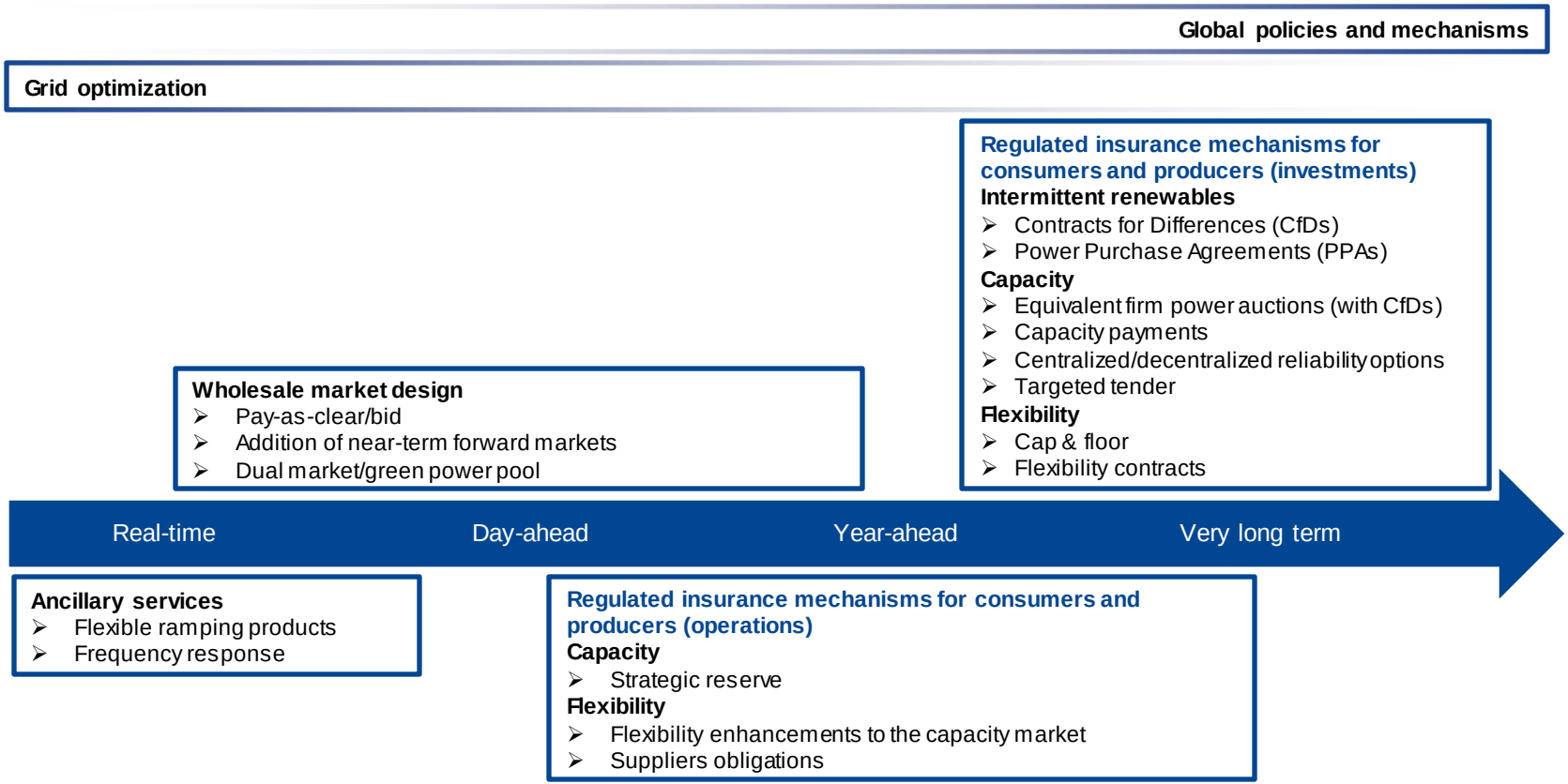
These market design options apply to various horizons.



Some widely discussed options lately

OPTIONS	SUSTAINABILITY	RELIABILITY	AFFORDABILITY
Intermittent renewables Contracts for Differences (CfDs)			
Power Purchase Agreements (PPAs)			
Wholesale market design Pay-as-bid			
Dual market/green power pool			
Addition of near-term forward markets			

Focusing on hydro: a capacity provider

OPTIONS	SUSTAINABILITY	RELIABILITY	AFFORDABILITY
Capacity Capacity payments			
Centralized/decentralized reliability options			
Targeted tender			
Strategic reserve			

Focusing on hydro: a flexibility provider

OPTIONS	SUSTAINABILITY	RELIABILITY	AFFORDABILITY
Flexibility Flex. enhanc. to the cap market			
Cap & floor			
Suppliers obligations			
Flexibility contracts			
Ancillary services Flexible ramping products			
Frequency response			

Key Takeaways

Conflicts between and within dimensions of the **energy trilemma**

- Income certainty for investors and price stability for consumers VS market efficiency
- Clear requirements for power grid needs VS market liquidity and competition
- Design simplicity VS cost-efficiency
- **Hydropower:** exploiting its full generation and flexibility potential VS preserving the local environment

Well-functioning short-term market, **improvements** to be made to **forward markets**

CfDs and PPAs could be **valuable tools for VRE** development, but remuneration mechanisms outside the market increase the **need for a more complex market**, and **impacts on flexible generation** must be investigated.

Various **constraints** and **failures** in wholesale markets create a **need for complementary markets**

Thank you for your attention!

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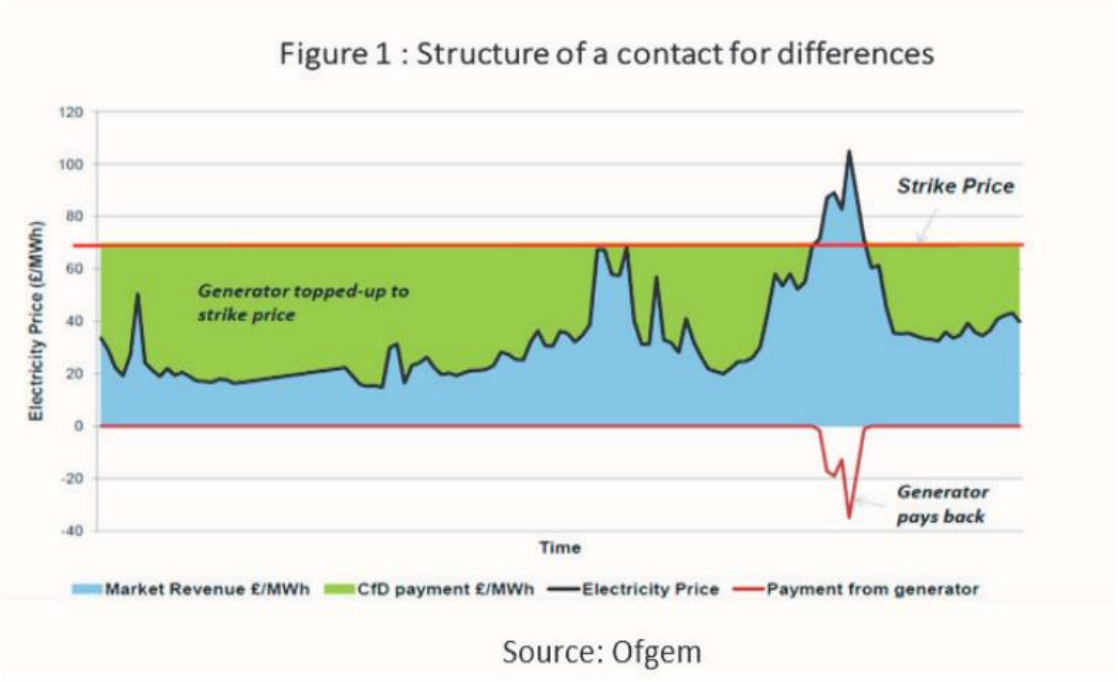
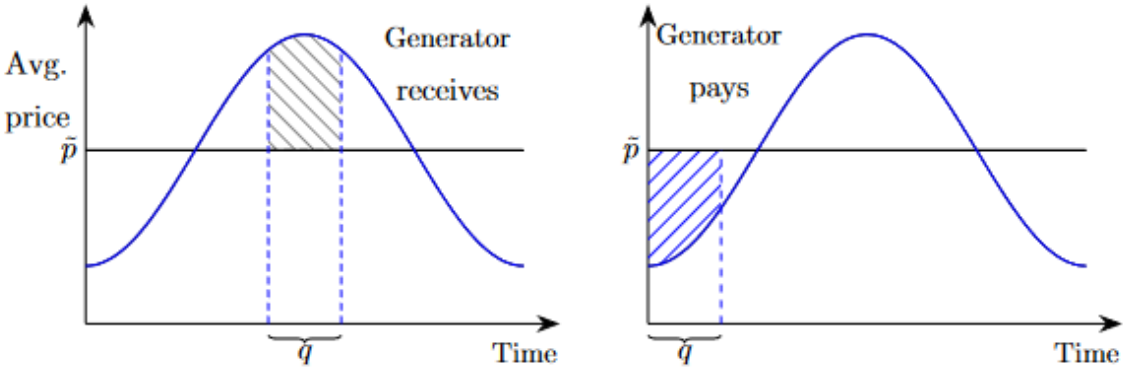
APPENDIX

Zooming on CfDs



Zooming on flexibility contracts



(a) Flexibility bonus (b) Flexibility penalty

Figure 6: Flexibility contract or CfD with a sliding premium

Source: Fabra, 2022

Some widely discussed options lately

OPTIONS	DESCRIPTION
Intermittent renewables Contracts for Differences (CfDs)	**Basic version:** Central contracts guarantee a pre-determined **strike price,** for every MWh generated. The strike price is set through a **competitive auction** and contracts are awarded for a long period (~15 years). **Variants:** To enable **market exposure**, a **strike range** can be used instead of a strike price, the **reference price** can be set on a weekly horizon, or the payment can be decoupled from output through a **cap & floor** mechanism, or by being based on the **potential to generate** rather than on the actual generation.
Power Purchase Agreements (PPAs)	PPAs consist of **bilateral contracts** between a renewable energy generator and a power purchaser (typically a utility or corporate buyer) for the **sale and purchase of electricity**. PPAs establish the **terms**, namely the price, volume, duration, and other contractual provisions, between the generator and purchaser.
Wholesale market design Pay-as-bid (vs -clear)	The **pay-as-clear** mechanism sets a **uniform price** for all actors at **the highest accepted bid** for clearing the market. The **pay-as-bid** mechanism pays **each producer** a price corresponding to **their bid**.
Dual market/green power pool	This structure would **split the market** into two settlements: prices in the **variable, 'as available'** market would be set by the **long-run marginal cost of renewables**; prices in the **firm, 'on demand' market** would continue to be set by **short-run marginal cost**. The green power pool would work on a voluntary basis.
Addition of near-term forward markets	New **trading platforms or mechanisms** allowing participants to buy and sell electricity contracts, for **delivery periods shorter than a few months**, would be introduced, focusing on **smaller time intervals** and **greater granularity**.

Some widely discussed options lately

OPTIONS	PROS	CONS
Intermittent renewables Contracts for Differences (CfDs)	Provides income certainty to investors Price stability for consumers Variants can enable market exposure	Limited market exposure in the basic version, market distortions Complexity and difficult access for smaller consumers
Power Purchase Agreements (PPAs)	Provides income certainty to investors Price stability for consumers Market access	Contractual obligations with limited flexibility Negotiation complexity
Wholesale market design Pay-as-bid	Could avoid downfall profits if bids were truly based on costs	Risk of market power abuse and inefficiency Lack of transparency
Dual market/green power pool	More clear and stable price signals Access to low costs of renewables	Complexity, need for coordination Decreased competition
Addition of near-term forward markets	Enhanced price discovery Improved risk management	Risk of low-liquidity

Focusing on hydro: a capacity provider

OPTIONS	DESCRIPTION
Capacity Capacity payments	This market-wide approach sets an **explicit price for capacity**. All capacity is eligible for every trading period in which they are available. The **level of payment is set by a central body** and varies through time.
Centralized/decentralized reliability options	The TSO/suppliers determine the amount of capacity to be auctioned and, in return for a **reliability premium**, secure the right to buy electricity from the assets on the wholesale market at a **strike price**. Contract holders are **penalized if they are unavailable** when the real-time price is above the strike price.
Targeted tender	A targeted tender is a centrally coordinated process to **secure the construction of a specified quantity of new capacity** which is identified by a central body. Tenders can be tailored to meet **specific requirements.**
Strategic reserve	A central authority auctions a certain amount (and type) of **reserve capacity on top of what the market** is expected to provide. Successful providers receive payment at their bid price, which usually includes **a payment for being available and a separate activation payment**. Capacity in strategic reserves generally **does not participate in the market** and is **dispatched only in case the market does not clear**.

Focusing on hydro: a capacity provider

OPTIONS	PROS	CONS
Capacity		
Capacity payments	Possibly a useful top-up revenue stream Simplicity	Low cost-effectiveness, risk of overpayment Limited incentive for new developments
Centralized/decentralized reliability options	Price stability through a price cap Support for investment through a rent	Risk for consumer fairness if decentralized Risk of strategic behavior
Targeted tender	Support for specific policy goals Can be adapted to specific needs	Limited competition Low cost-effectiveness, risk of overpayment
Strategic reserve	Possibly lower costs than capacity market Price stability Could ensure long duration storage capacity	Risk of underutilization of resources Risk of limited effectiveness for ensuring reliability (time and location constraints)

Focusing on hydro: a flexibility provider

OPTIONS	DESCRIPTION
Flexibility Flexibility enhancements to the capacity market	**Flexible auctions** would be open to all low-carbon technologies and **procure flexible characteristics**, e.g., response time and duration. **Multipliers valuing flexible characteristics** would be applied to the **clearing price** of low carbon capacity. **Separate auctions and multiple clearing prices** are also considered.
Cap & floor	Flexibility assets would compete for a **guaranteed minimum revenue (floor)** from the government for each period. A **maximum revenue (ideally soft cap)** could be introduced to prevent excessive profits.
Suppliers obligations (market-based)	A supplier obligation is a **decentralized, market-led** approach that places a **legal requirement on suppliers** to achieve a **target set by the government**.
Flexibility contracts	Flexibility contracts would consist of a **CfD with a sliding premium for price exposure**. The payments are **coupled with output** and correspond to the **strike price**, set through auctions, in addition to the **differential between the market price and the reference price. Penalties for withholding** can be included.
Ancillary services Flexible ramping products	The aim is to ensure enough **ramping capacity (up and down)** is available **in real time**. The price and procurement are determined based on **demand curves**, which are calculated from historical forecast errors.
Frequency response	Power is injected into (or absorbed from) the grid **in response to changes in observed frequency**, as a way to **mitigate the deviation** after an unexpected disturbance or imbalance occurs.

Focusing on hydro: a flexibility provider

OPTIONS	PROS	CONS
Flexibility Flexibility enhancements to the capacity market	Enables targeting specific characteristics - could incentivize long-duration storage Continuity with present structure	Reduced liquidity if specific auctions Risk of miscalibration of multipliers Complexity, reduced predictability
Cap & floor	Income certainty for investors Limit to excessive profits	Soft cap to be implemented to avoid inefficiencies
Suppliers obligations (market-based)	Stronger invest. and operat. signals for flex. Competition across technologies	Income uncertainty for large flex. assets Risks in financing and delivery
Flexibility contracts	Provides income certainty to investors Price stability and (limited) market exposure	High transactions costs Risk of use of market power
Ancillary services Flexible ramping products	Incentive for flexible operations	Complex definition and valuation
Frequency response	Incentive for responsive resources	Complex definition and valuation

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