The Coordination Challenge: The Nature, Value and Limits of Different Flexibility Options

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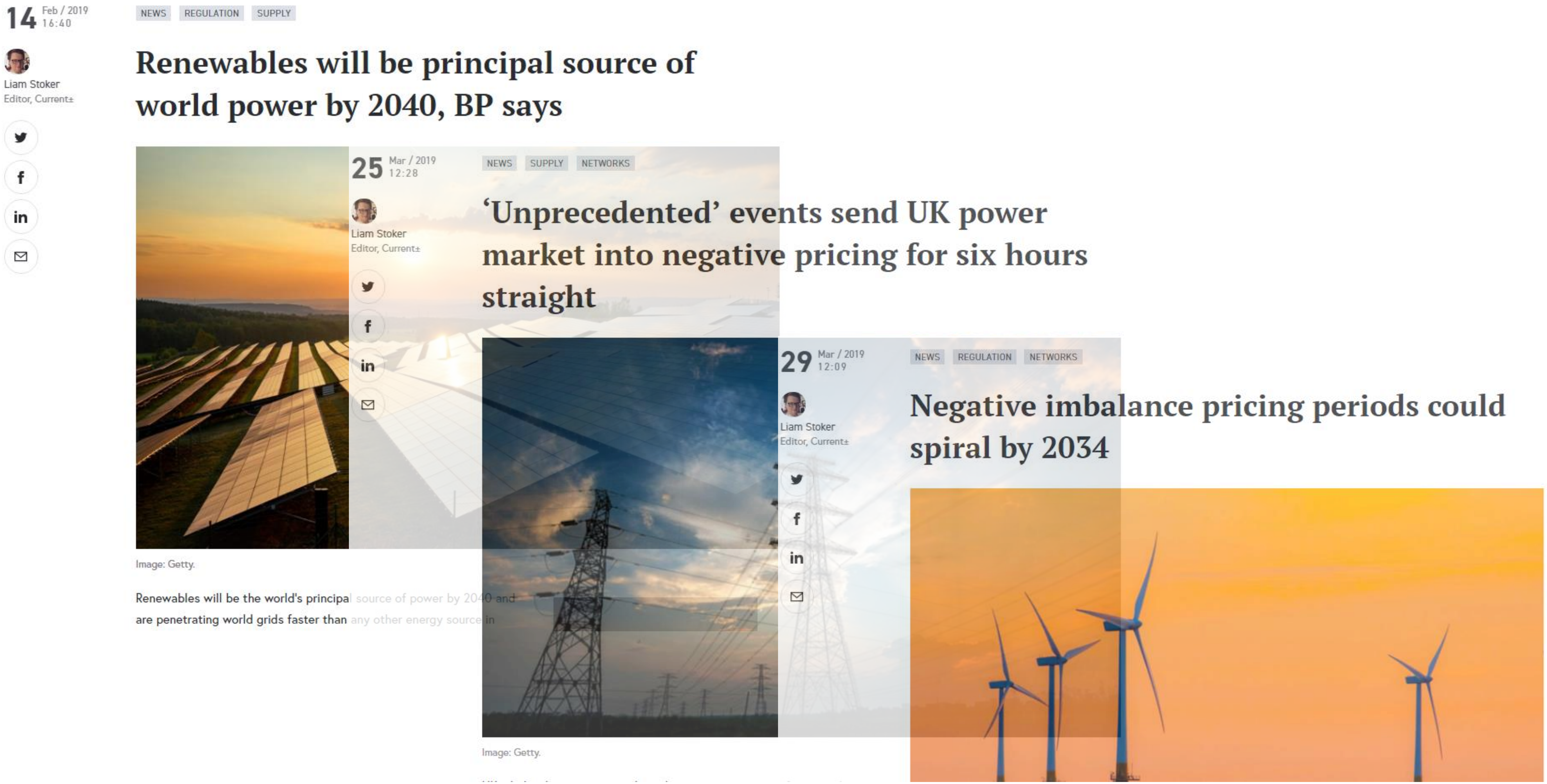
Background



14 Feb / 2019 16:40

NEWS REGULATION SUPPLY

Liam Stoker
Editor, Current±

Renewables will be principal source of world power by 2040, BP says

Image: Getty.

Renewables will be the world's principal source of power by 2040 and are penetrating world grids faster than any other energy source in

25 Mar / 2019 12:28

NEWS SUPPLY NETWORKS

Liam Stoker
Editor, Current±

'Unprecedented' events send UK power market into negative pricing for six hours straight

Image: Getty.

29 Mar / 2019 12:09

NEWS REGULATION NETWORKS

Liam Stoker
Editor, Current±

Negative imbalance pricing periods could spiral by 2034

Background

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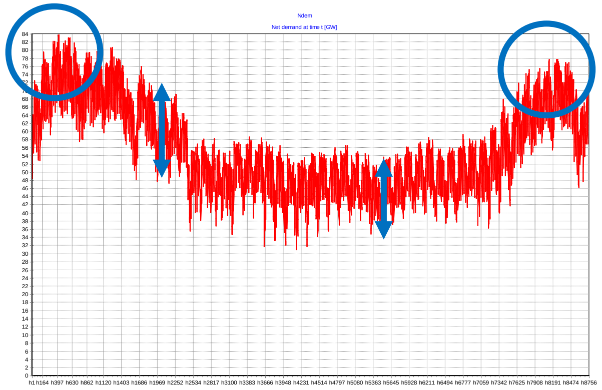
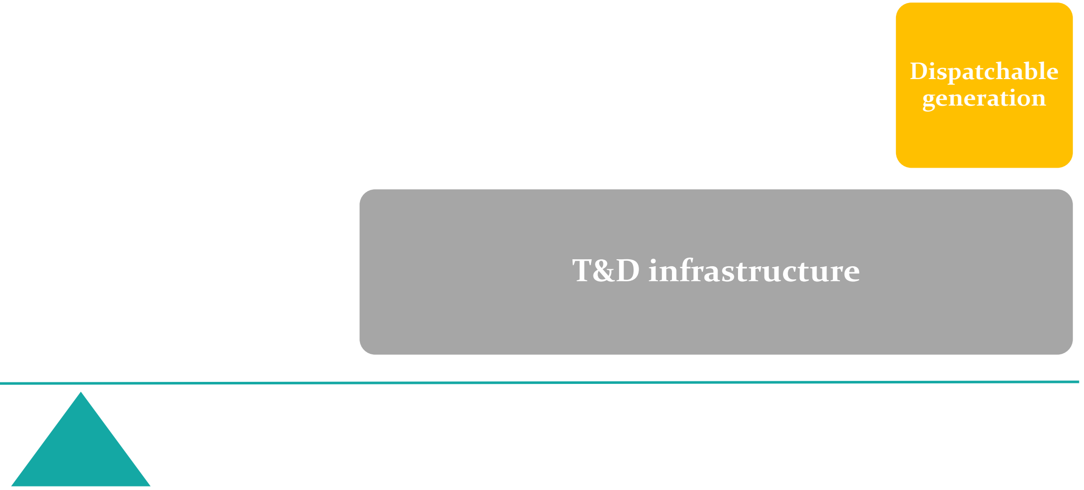
Balancing variable residual load: the role of flexibility options

Traditionally, power systems have always dealt with some degree of load variability and uncertainty. Flexibility was supplied as a by-product of energy. The main concern of market design was capacity adequacy rather than flexibility[1].

Scarce capacity episodes → Capacity adequacy issues → LT reliability concerns (LOLE>security margin) → Security of supply

VRE_{share} = 0%





[1] For a detailed discussion on revenue and capacity adequacy issues see:
Newbery, D. (2015). Missing money and missing markets: Reliability, capacity auctions and interconnectors. *Energy Policy*, *94*, 401–410. https://doi.org/10.1016/j.enpol.2015.10.028

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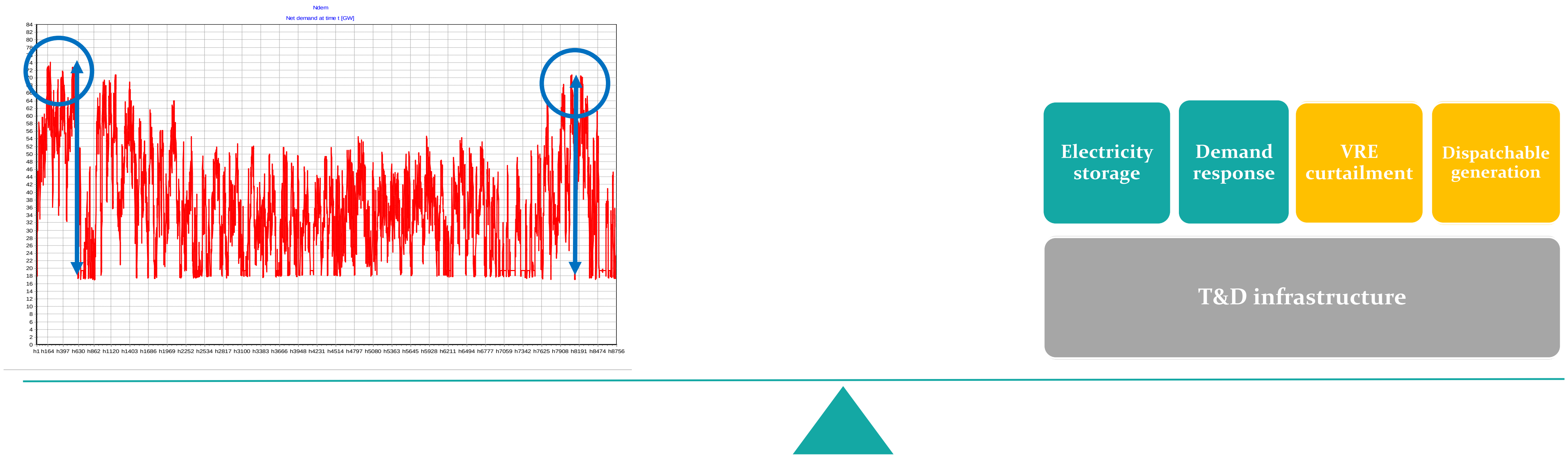
Balancing variable residual load: the role of flexibility options

New flexibility options start getting commercial maturity and prove competitive on current markets for dealing with variability, mainly on the provision of reserves. Analysts claim for a “**technology-agnostic**” market design and for the provision of a “**level-playing field**” for all technologies on every market segment, focusing on new flexibility options (e.g. FERC’s Order 841).

VRE_{share} = 40%



Background

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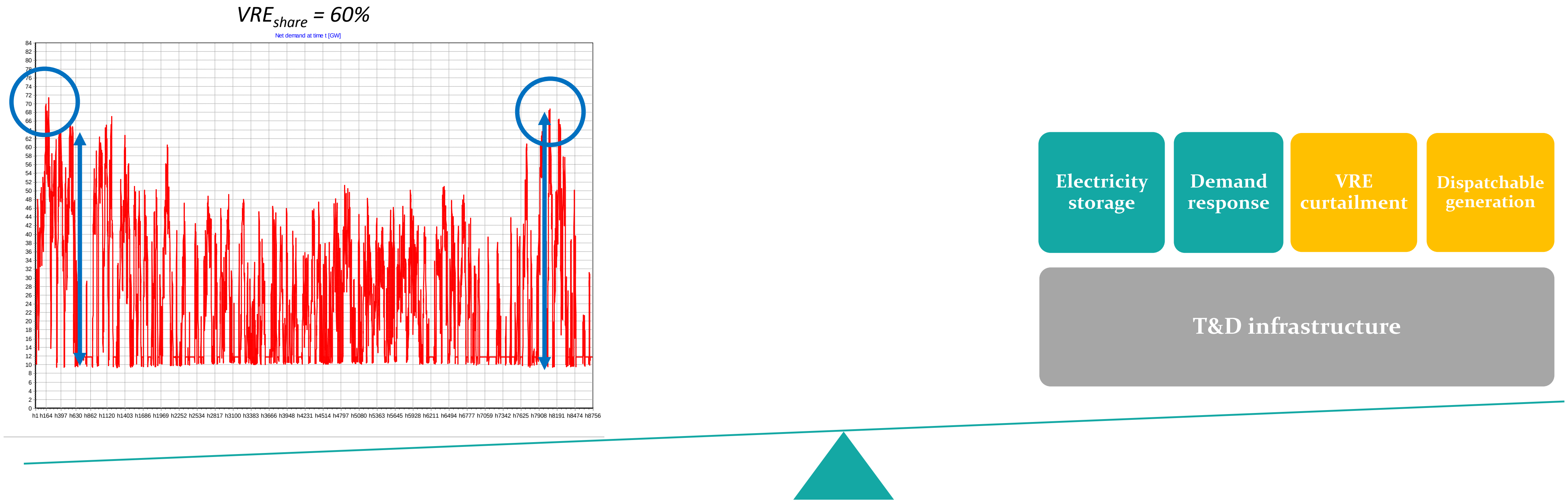
Capacity adequacy and system capability: would available capacity be responsive enough?



Background

More than semantics: is there a workable definition of flexibility?

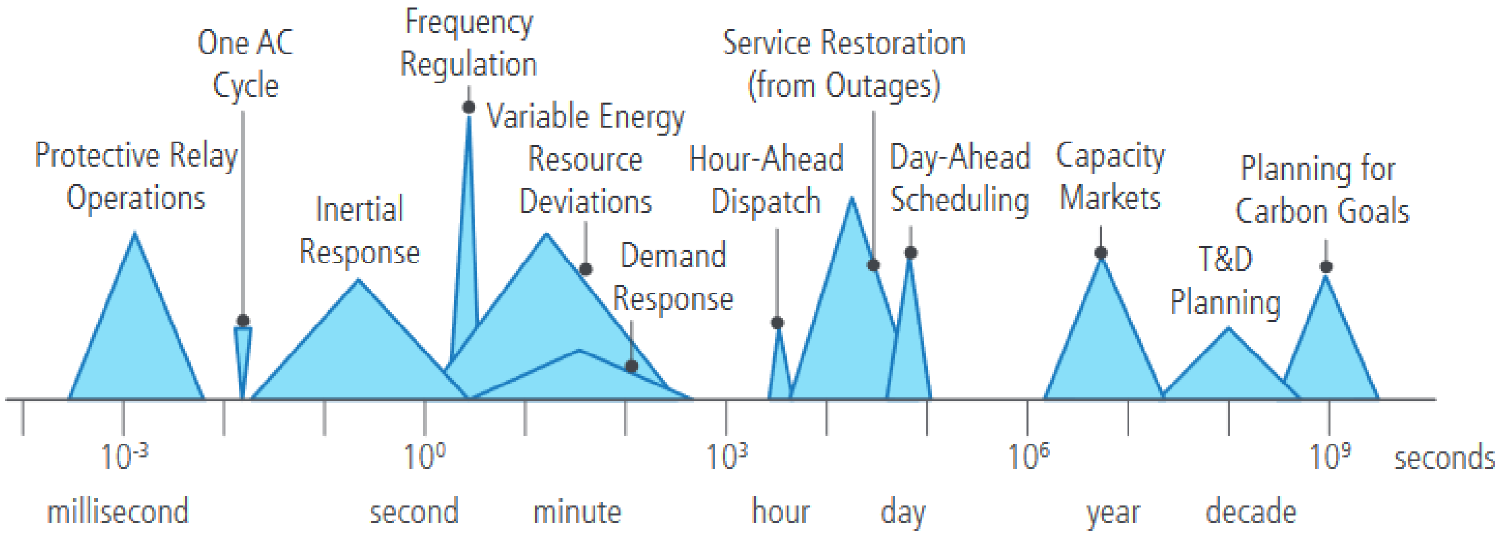
1. *EURELECTRIC (2014): "On an individual level flexibility* ***is the modification of generation injection and/or consumption patterns in reaction to an external signal (price signal or activation) in order to provide a service within the energy system****. The parameters used to characterize flexibility include the amount of power modulation, the duration, the rate of change, the response time, the location, etc."*

2. MIT Energy Initiative (2016, p235): *"****Flexibility is just a concept — it is not really a service, and its value cannot be decoupled from the electricity price by implementing a separate product****. To reflect the value of flexibility for the power system, the granularity of electricity prices should be aligned with dispatch instructions and reflected in reserve product design."*

3. *IEA (2017, p14): "****Flexibility is the ability of the power system to deal with a higher degree of uncertainty and variability in the supply-demand balance****".*

Background

More than semantics: is there a workable definition of flexibility?



Source: US DOE (2017)

4. *<u>ENTOS-E (2017)</u> to the CEER consultation:*

A technical dimension as the *“**Capability to adapt power generation or consumption (MW) at a certain moment, over a specific period of time (h), at a certain speed (MW per second), at a certain location or within a certain area,** and thus to inject or withdraw energy (MWh) in or from the transmission/distribution system, **and the capability to use assets to control network flows within secure limits**.”*

A commercial dimension as the *“**Ability to conduct commercial transactions between market participants, TSOs and DSOs that utilize the technical capabilities**. These can be used for portfolio management of energy schedules (i.e. energy balancing by BRPs), system balancing (i.e. power balance by TSO), or redispatch measures and voltage control (TSOs and DSOs). The transactions can be facilitated by explicit products that specify required capabilities, e.g. lead time to response, location, power profiles.”*

Background

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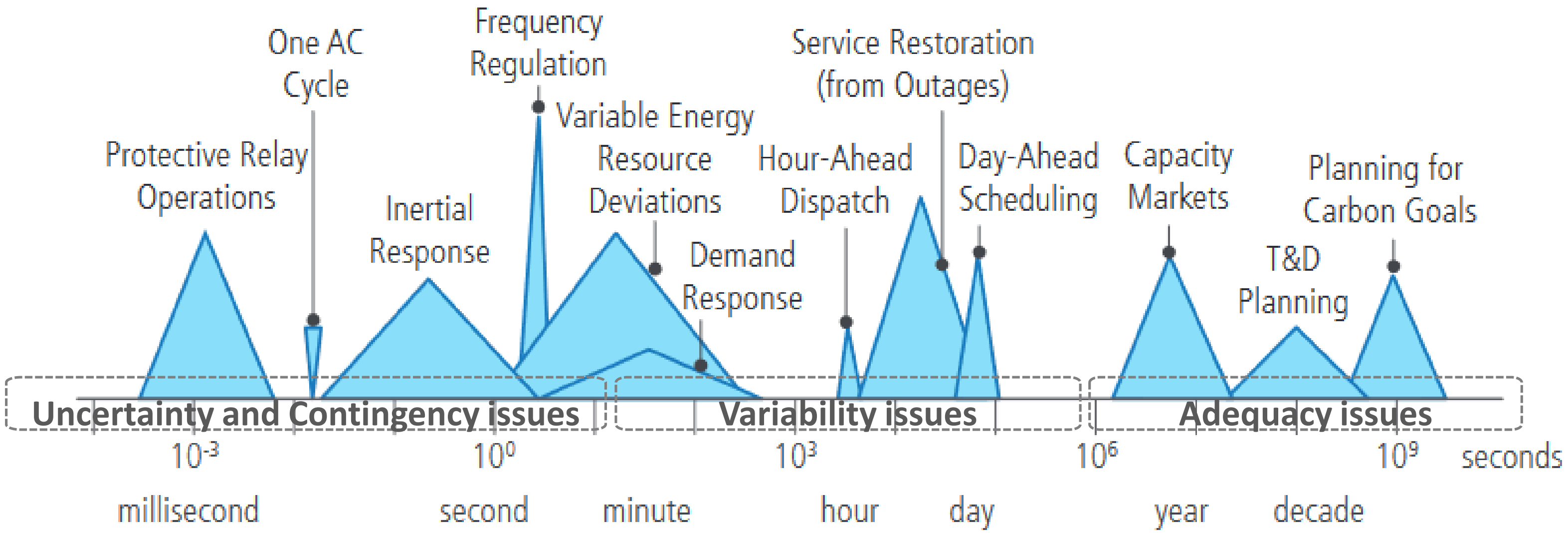
Capacity adequacy and flexibility: two sides of the same coin?



Source: US DOE (2017)

Scarce capacity episodes → Capacity adequacy issues → LT reliability concerns (LOLE > security margin) → Security of supply

Extreme ramping episodes → Insufficient ramp issues → ST reliability concerns (IRRE[2] > security margin) → Security of supply

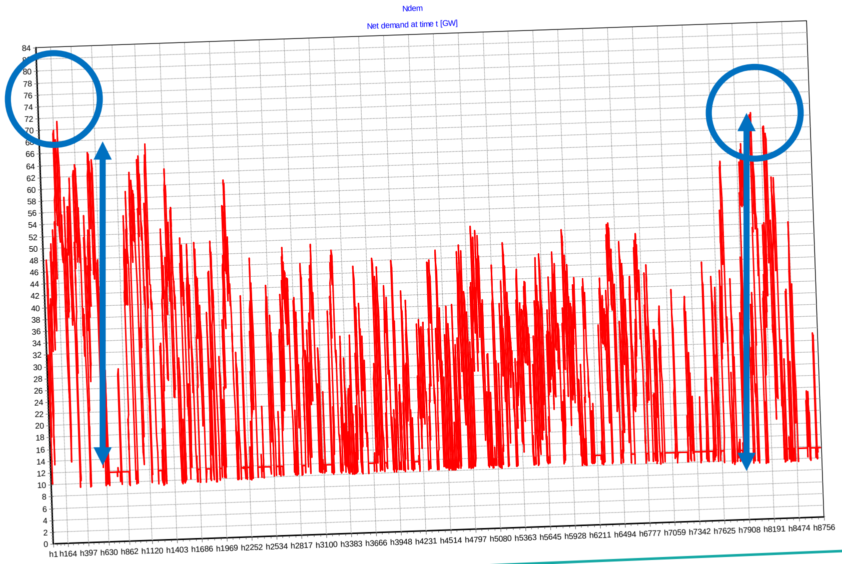
[2] IRRE: Insufficient Ramp Resource Expectation. See:
Lannoye, E., Flynn, D., & Malley, M. O. (2012). Evaluation of Power System Flexibility. *IEEE Transactions on Power Systems*, *27*. https://doi.org/10.1109/TPWRS.2011.2177280

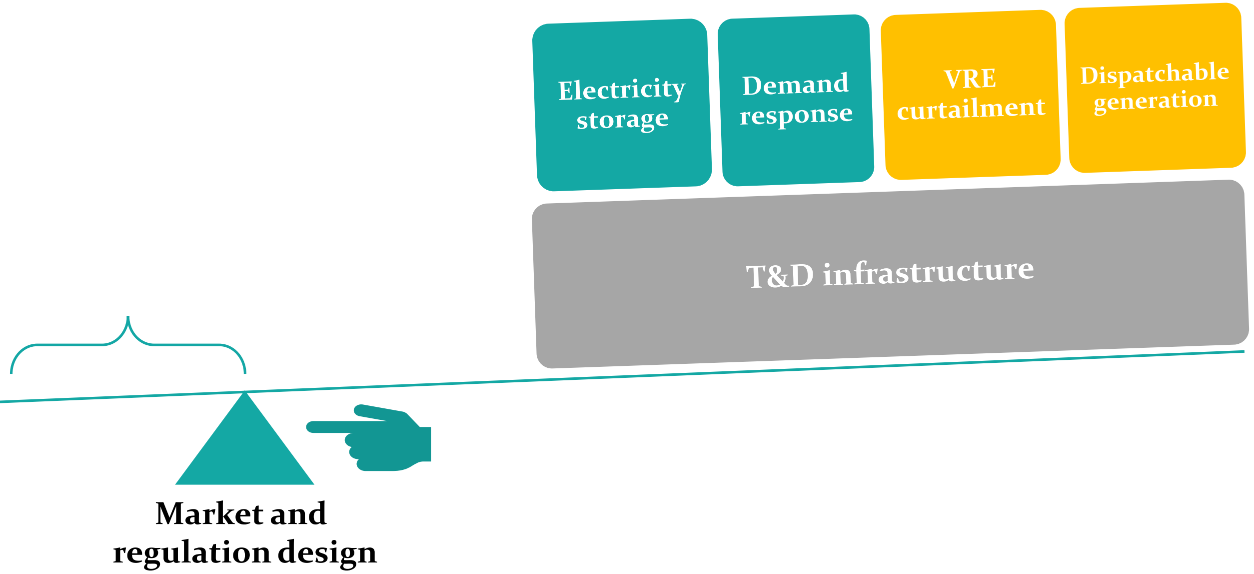
Balancing variable residual load: the role of market design

Due to increasing variability and uncertainty, flexibility concerns come to the floor and joins old-day's issues of capacity adequacy. The aim of designing markets for harnessing flexibility is becoming widespread.

A "technology-agnostic" design and a "level-playing field" for new flexibility technologies, what do they mean? Are them possible? Sufficient?

VRE_{share} = 60%

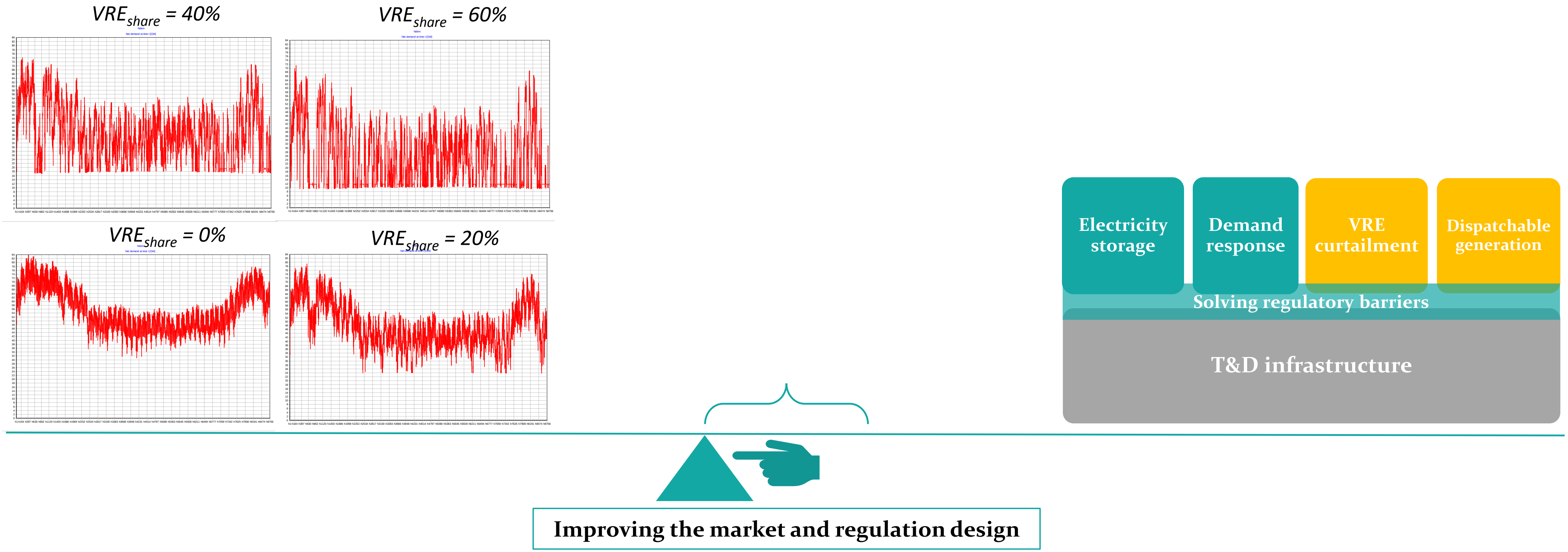




The coordination challenge

1. « What » is it?

Making the infrastructure **available** and **operating it at least-cost for balancing load at every location**. It implies **meeting energy demand while ensuring capacity, stability and secure operation of the system.** It shares the same frame than that of the early day’s of market design restructuring but **it includes a new dimension coming from the exacerbated variability and uncertainty of residual load**.



The coordination challenge

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2. **« Why » is it relevant?** As always, for “providing consumers more affordable electricity, and ensuring sufficient investment” (stoft 2002), so **fostering productive and allocative efficiencies** (i.e. social welfare).

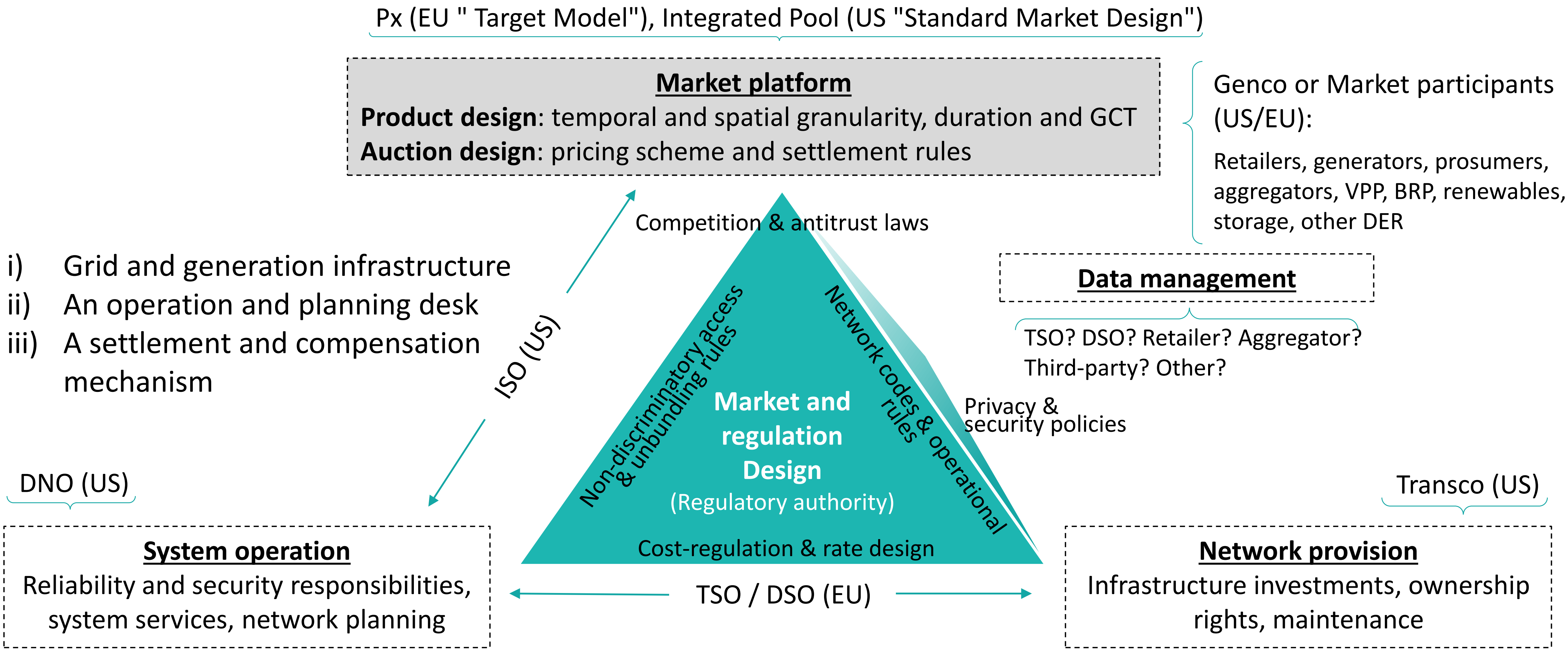
3. **« How » to proceed?** By re-thinking the design of electricity markets.

The focus of this talk

The “how”? Part I

Core functions and archetype of electricity markets: the condition of “coordination for competition”[3]

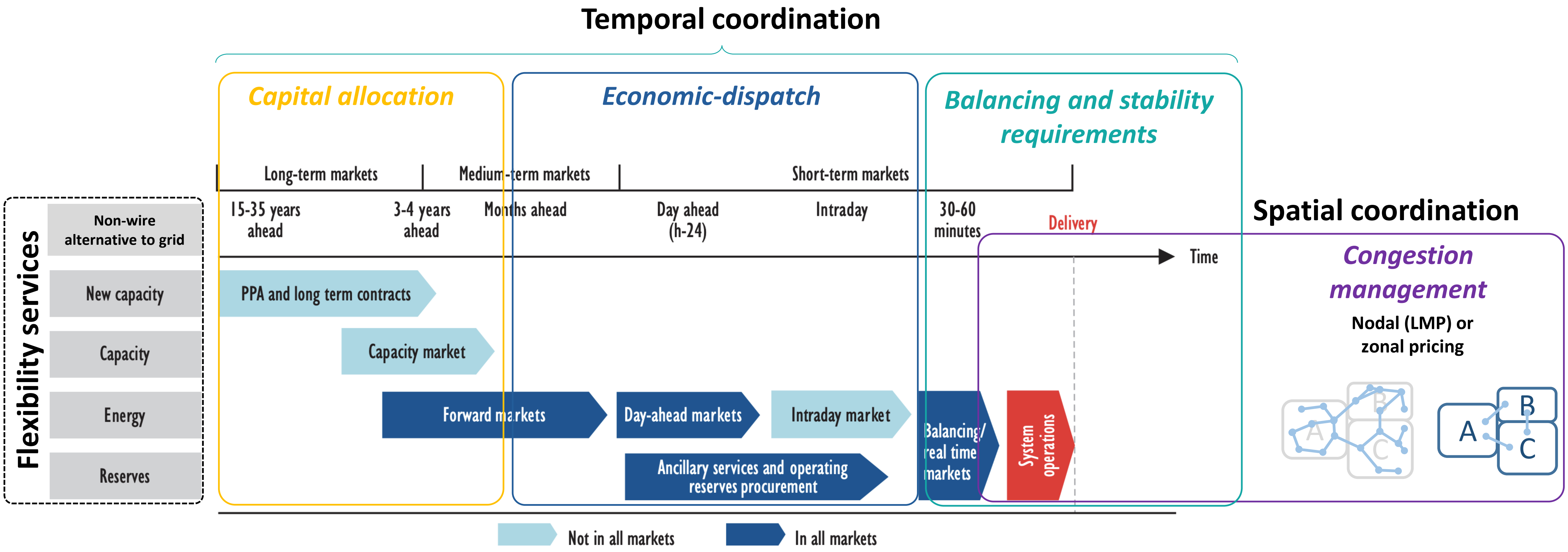
i) Grid and generation infrastructure
ii) An operation and planning desk
iii) A settlement and compensation mechanism



[3] Joskow, Paul L., and Richard Schmalensee. 1983. *Markets for Power: An Analysis of Electrical Utility Deregulation*. *MIT Press Books*. Vol. 1. The MIT Press. https://ideas.repec.org/b/mtp/titles/0262600188.html.

The “how”? Part I

Existing market architectures:



The "how"? Part I

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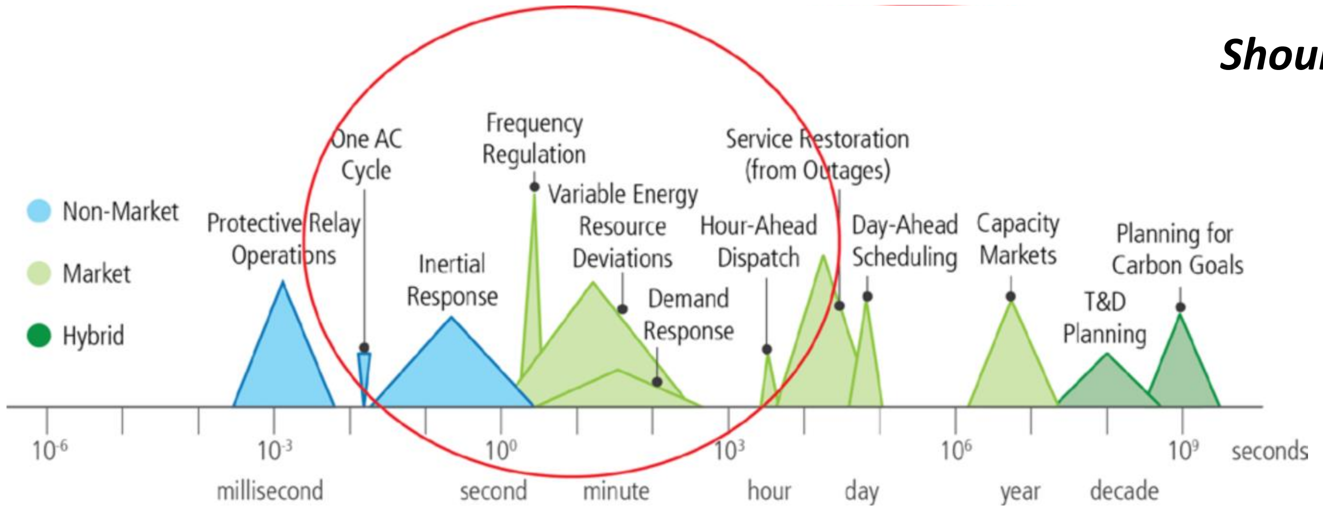
The notion of product granularity and the evolving system needs

1. The temporal dimension:

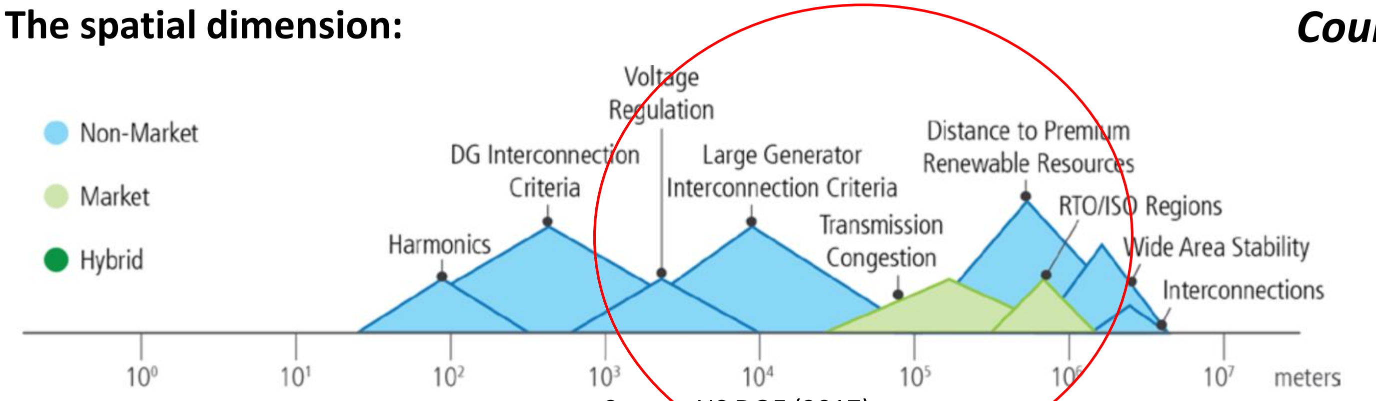
Should and could flexibility options compete for value on current market architecture?



Source: US DOE (2017)

2. The spatial dimension:

Could their full system services be priced with existing product granularities?



Source: US DOE (2017)

The “how”? Part II

Two school of thought can be depicted… with multiple shades of grey

The "Market Purist" view:

It advocates for enhancing flexibility valuation by refining current markets segments. Thus, it encourages larger balancing areas (e.g. market coupling), proposes shorter product duration with GCT closer to RT, and asks for improving scarcity pricing.

Market and regulation Design
(Regulatory authority)

The "Pragmatic designer" view:

It advocates for introducing explicit flexibility products on the top of existing market segments (e.g. « flexible ramping product » on CAISO and MISO and RegD reserves on PJM) or introducing dynamic capabilities on existing CRM.

An emerging alternative: Market "Re-regulation"

The “how”? Part II

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Market improvements related to increasing product granularity (Source: IRENA 2019):

Temporal granularity

- CAISO is proposing to move from a 1-hour to a 15-minute scheduling interval on the DAM.
- Australia transitioned from a 30-minute to a 5-minute financial settlement, and from a 2-hour to a 30-minute GCT.
- In 2016 Nord Pool, Fingrid and Elering launched a pilot with a 30-minute GCT in the intraday market on the Estonian-Finnish border, to replace the previous 60-minute one.
- In Austria, Belgium, Germany and Luxembourg (in certain transmission system operator areas only) the local intraday GCT was moved to 5-minutes before lead time (ACER, 2018).
- New ENTSO-E’s EB-GL considers smaller quantities (MW) and shorter time frames for standard balancing products (i.e. projects PICASSO, TERRE, MARI).

Spatial granularity

- Most RTO’s in the US have implemented nodal pricing at the transimission level. Recent efforts aim to extend LMP to the substation level (i.e. to distribution networks) (Caramanis et al. 2018)
- The pan-European market uses a zonal pricing mechanism, and some countries have divided the national transmission system into more bidding zones, including Denmark (two bidding zones), Italy (six geographical bidding zones), Norway (five bidding zones), Germany (five bidding zones) and Sweden (four bidding zones) (IRENA, 2017b). « Local flexibility markets » are being considered by different research projects in the EU (e.g. ENERA, NODES).

IRENA. 2019. *INNOVATION LANDSCAPE FOR A RENEWABLE-POWERED FUTURE: Solutions To Integrate Variable Renewables*. Available at: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Feb/IRENA_Innovation_Landscape_2019_report.pdf

The “how”? Part II

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Market improvements related to product design for the explicit valuation of flexibility (Source: IRENA 2019):

- In CAISO and MISO flexibility products have been designed, and batteries are allowed to participate.
- PJM has developed different frequency regulation products for the slower conventional resources and for the faster battery storage ones (RegD reserve).
- In the UK, a new product was introduced targeting battery storage: “enhanced frequency response”.
- EirGrid has defined several additional system service products to cope with wind energy fluctuations. Similarly, National Grid has launched the System Needs And Product Strategy (SNAPS) consultation to redefine existing AS products.
- CAISO is implementing a requirement for flexibility in its capacity market.
- PJM and France allow DR, storage and cross-border interconnections to participate in capacity markets.

IRENA. 2019. *INNOVATION LANDSCAPE FOR A RENEWABLE-POWERED FUTURE: Solutions To Integrate Variable Renewables*. Available at: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Feb/IRENA_Innovation_Landscape_2019_report.pdf

Critics and limits

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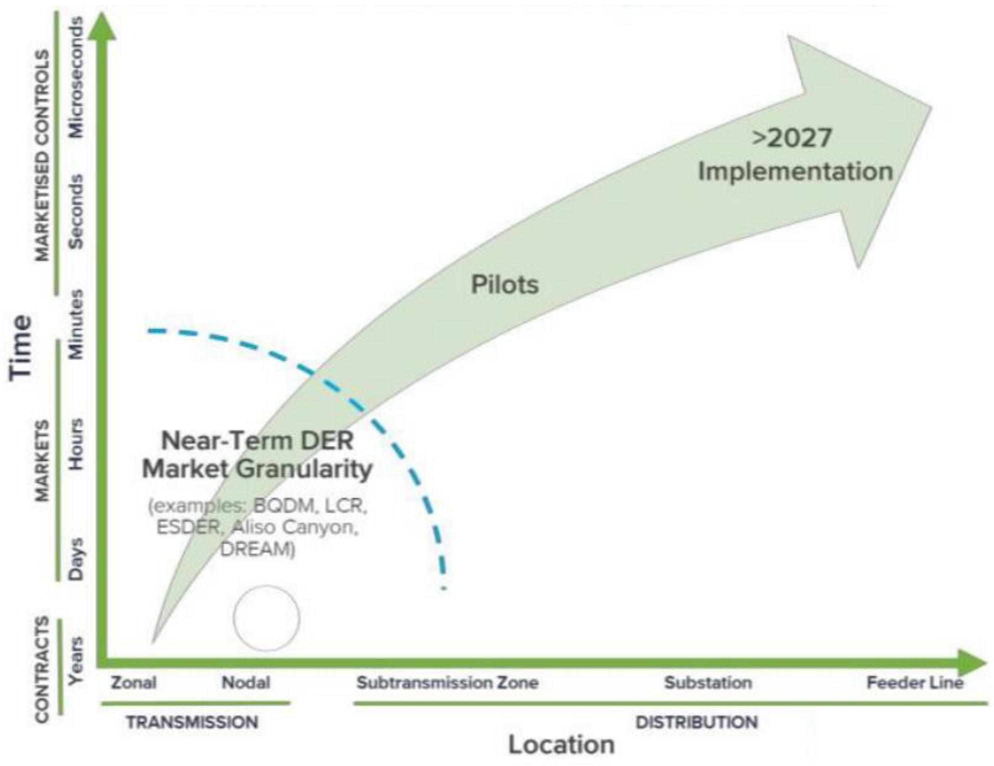
Is there a boundary to increasing product granularity?



Source: Strategen (2017)

Trading closer to real-time requires higher temporal granularity. Similarly, pricing congestions with DER connected at mid and low voltage levels requires higher spatial granularity.

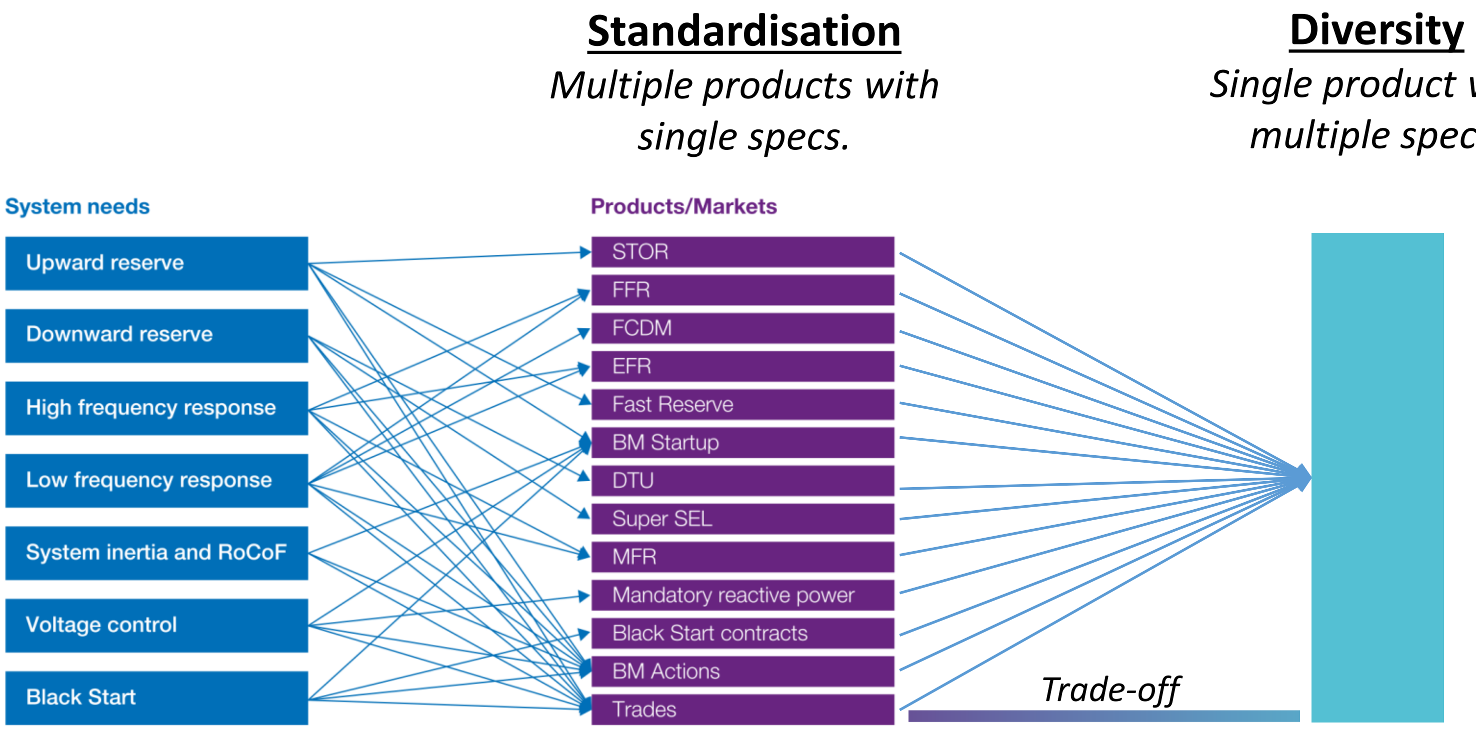
There is an intrinsic trade-off between increasing granularity and market liquidity. Market power issues might emerge.

Auction design could help but still technical issues would constraint full "scarcity" pricing.

Critics and limits

Is there a merit for simplicity and parsimony on market design?

The specifications of market products should be in line with system needs as possible. Auction design could help but still technical issues would prevent full product diversity. Thus, there is a trade-off between product standardization and market diversity.



System Needs And Product Strategy (SNAPS). Source: adapted from National Grid 2017

Key takeaways

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- A fully workable definition of flexibility have not yet emerged.
- With respect to reliability, capacity adequacy and flexibility appear as « two sides of the same coin ».
- After almost three decades of experience with restructured markets, there is a growing consensus on considering current architectures as ill-designed for integrating high shares of VRE due to flexibility issues, among others.
- For redesigning electricity markets we should go back to fundamentals of industrial economics and game theory (i.e. follow the “structure-architecture-rule” string, explore principles of auction design). Particularly with current changes on economies of scale and scope introduced by DER, ICTs and DLTs.
- We can identify at least two schools of thought and multiple shades of greys for designing electricity markets capable of valuating flexibility.
- Improvements on market design are being implemented, and experience show that regulatory barriers could be improved so enabling a « level-playing field », but by definition, any market architecture (i.e. the design of products and auctions) can not be “technology-agnostic” on a rigorous sense.

Conclusion

There is no “one-size-fit-all” nor a “future-proof” market design. As any other construct, it can only be “fit-for-purpose” and should be progressively updated given the changing microstructure of the coordination it is supposed to deal with (an ever-evolving coordination challenge?).

When redesigning electricity markets, there is no trivial way of balancing the theoretical benefits of new market architectures with their implementation costs in practice. Thus, the Joskow’s (2010) conclusions holds:

“***We must always come back to the question “what is the best that we can do in an imperfect world?***””

Recommended readings

Thank you for your attention.

Any questions?

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APPENDIX

The coordination challenge

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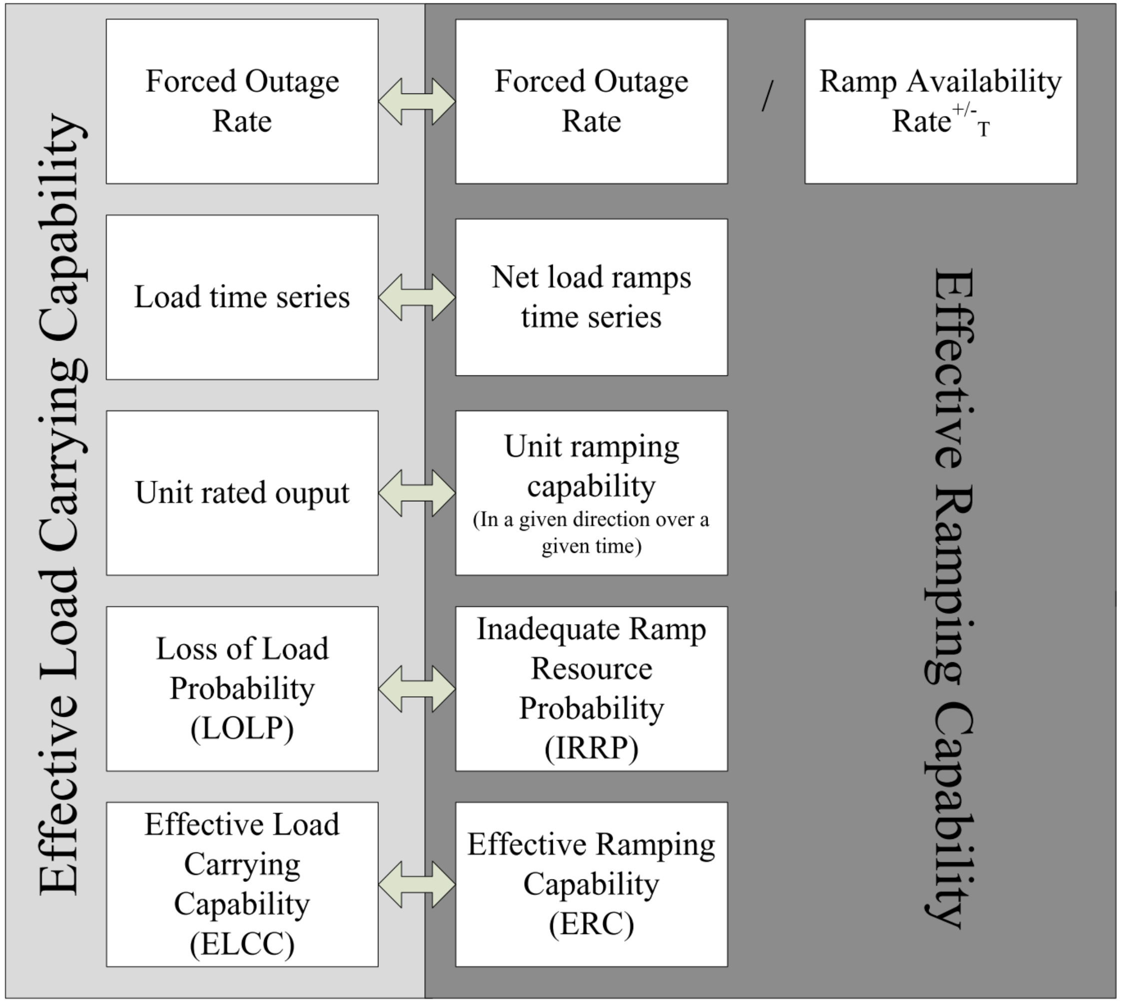
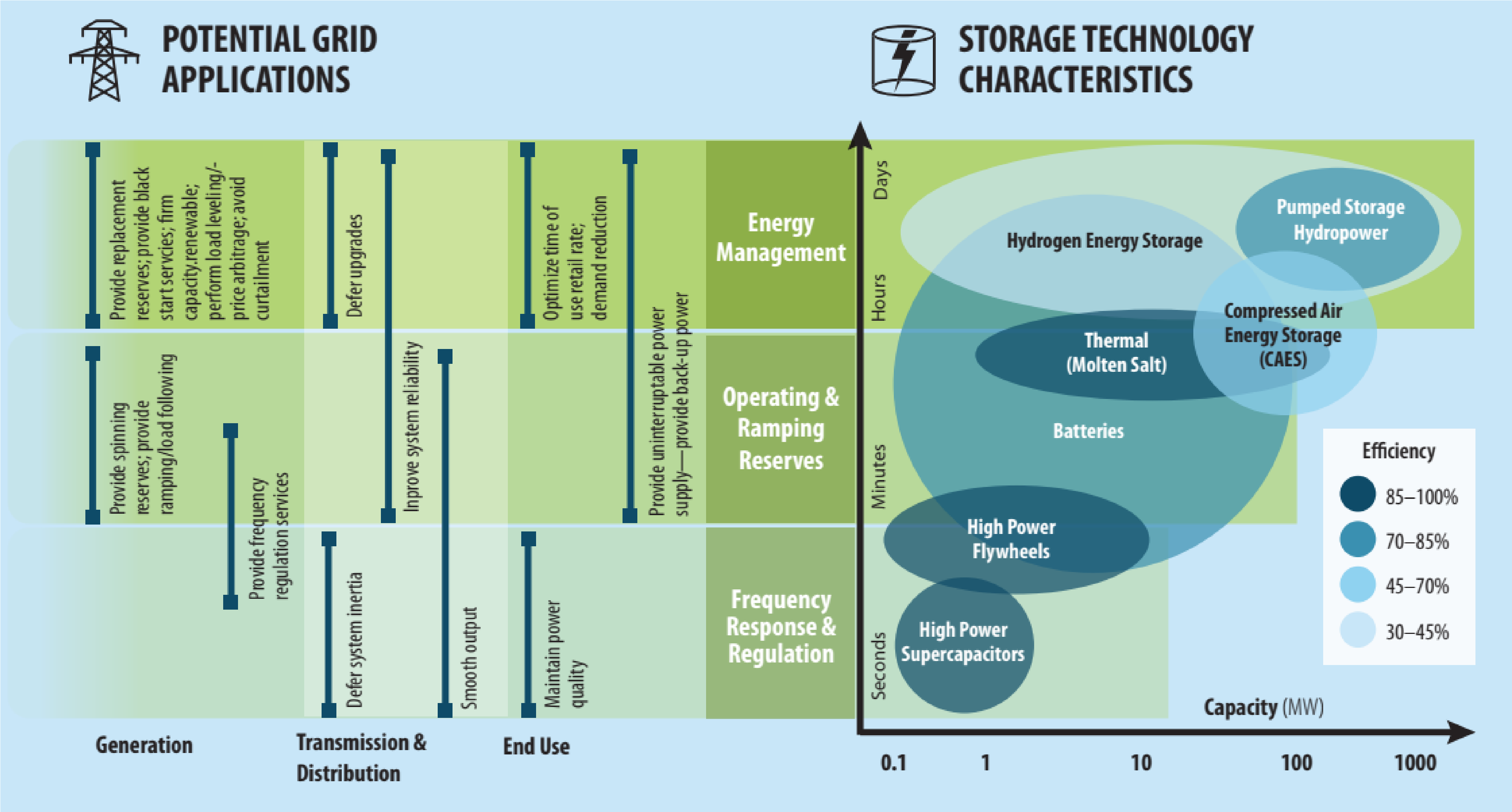
Capacity adequacy and flexibility: two sides of the same coin?



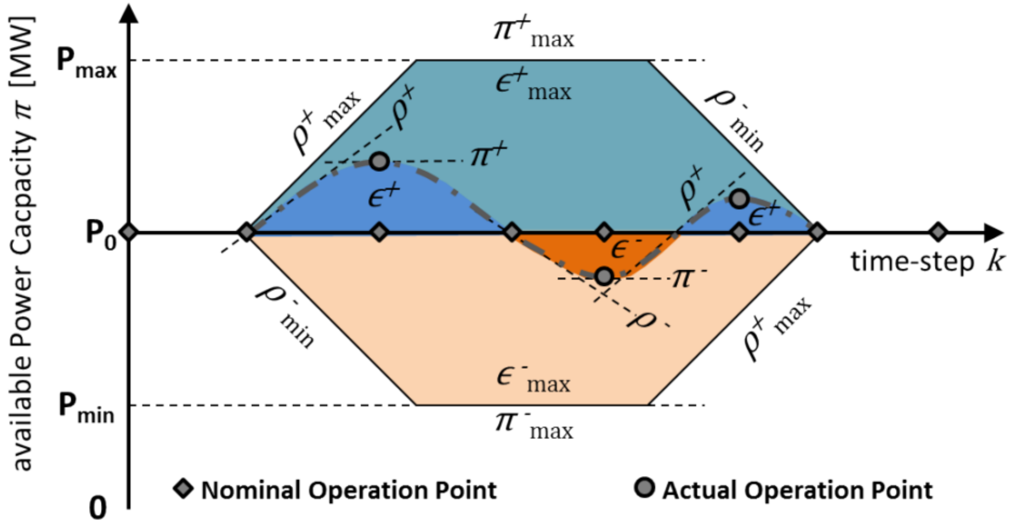
Source: Lannoye 2010

Background



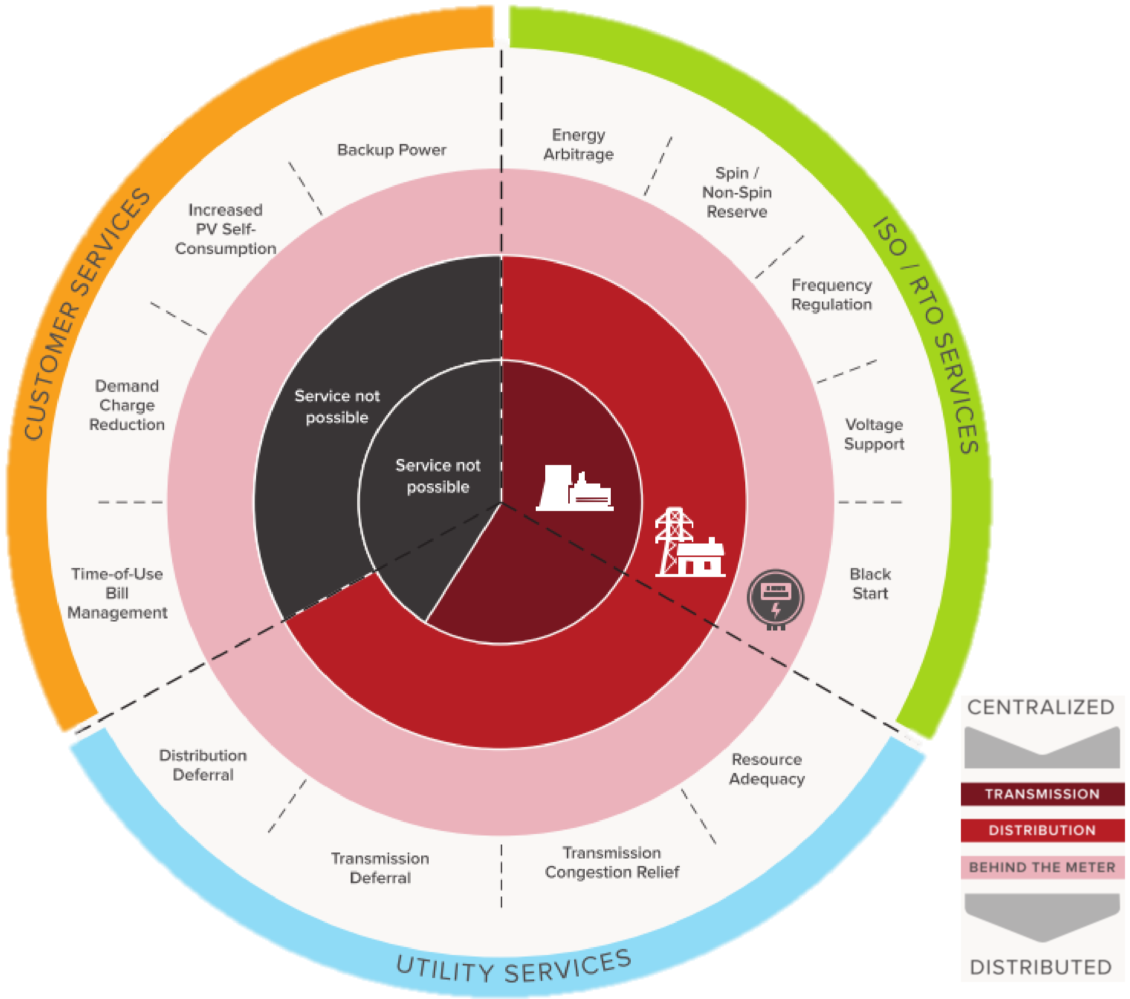
Electricity storage technologies and applications overview. Source: NREL (2016)

Flexibility as ramping capabilities (speed and extent) available at different voltage levels



Power Ramp-rate ρ, Power π and Energy ε

Flexibility metrics in power system operations. Source: Ulbig and Andersson 2013



Services that can be provided by EES technologies. Source: (Fitzgerald et al., 2015)