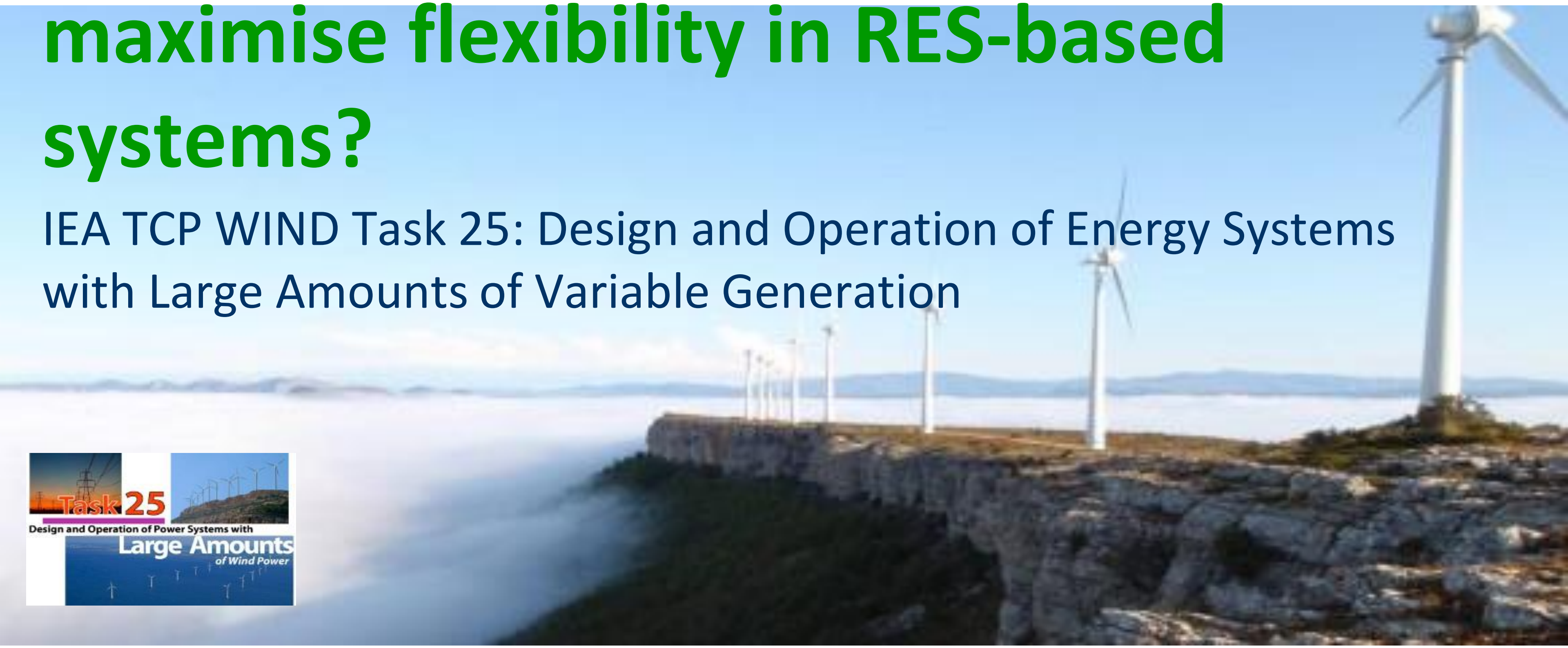
Over-capacity, diversity, storage - Where are the thresholds that maximise flexibility in RES-based systems?

IEA TCP WIND Task 25: Design and Operation of Energy Systems with Large Amounts of Variable Generation



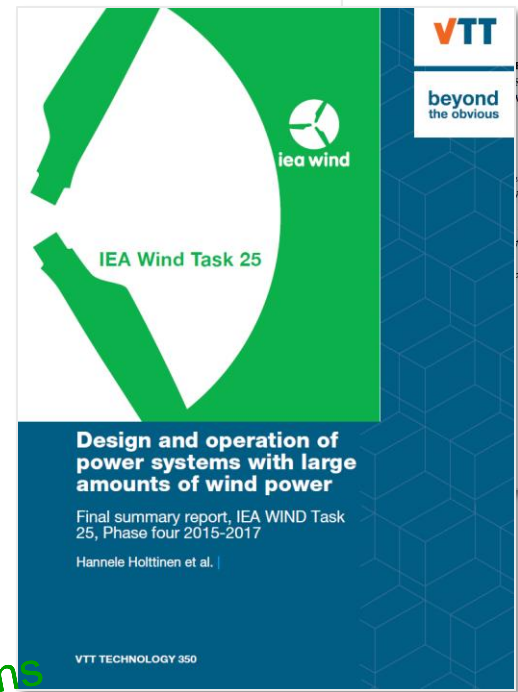
Hannele Holttinen, Operating Agent Task 25

IEA Paris webinar 11 March 2021

iea wind

IEA Wind Task 25: Design and operation of energy systems with large amounts of variable generation

- Started in 2006
- Comparisons of wind integration studies and experience
- Methodology best practices



Facilitate the highest economically feasible wind energy share within electricity power systems

https://community.ieawind.org/task25/

Contents

- What we know – good experience, challenges
- Flexibility at all time scales is the answer
- VRE dominated systems: Main challenges stability and resource adequacy
- Conclusions

Task 25
Design and Operation of Power Systems with Large Amounts of Wind Power

Experience from up to 50% VRE

- Increased variability and uncertainty is managed with many sources of flexibility inherent in systems

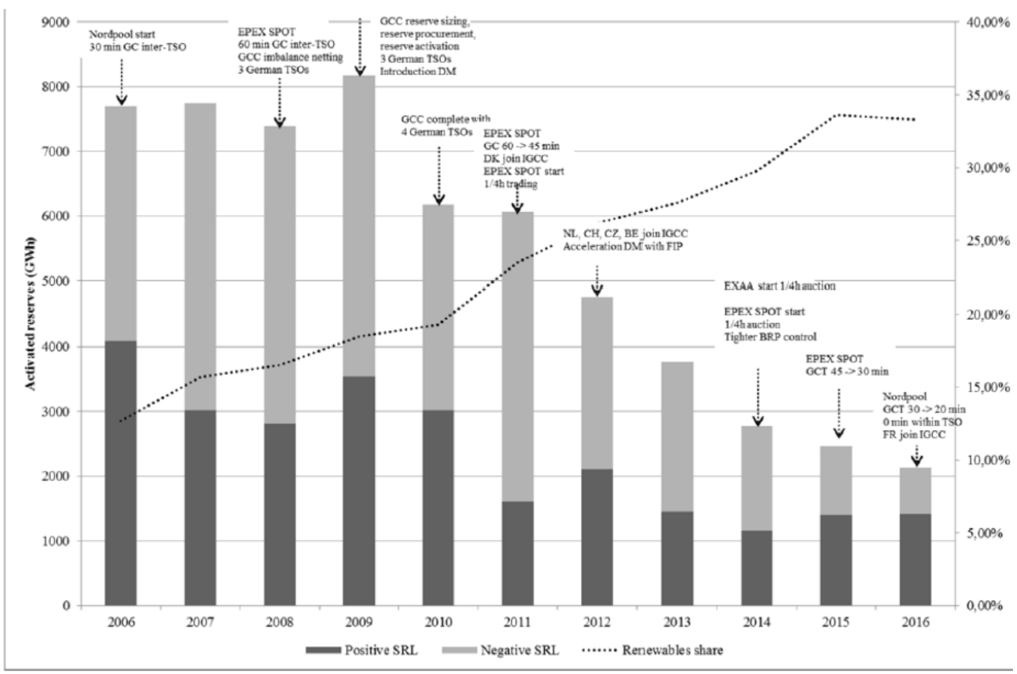


Figure 13: Total activated German Secondary Reserves (or aFRR) per year marked with events considered in this paper.

German use of operating reserve declining despite simultaneous increase in VRE
Source: Rena Kuwahata, Peter Merk, WIW17

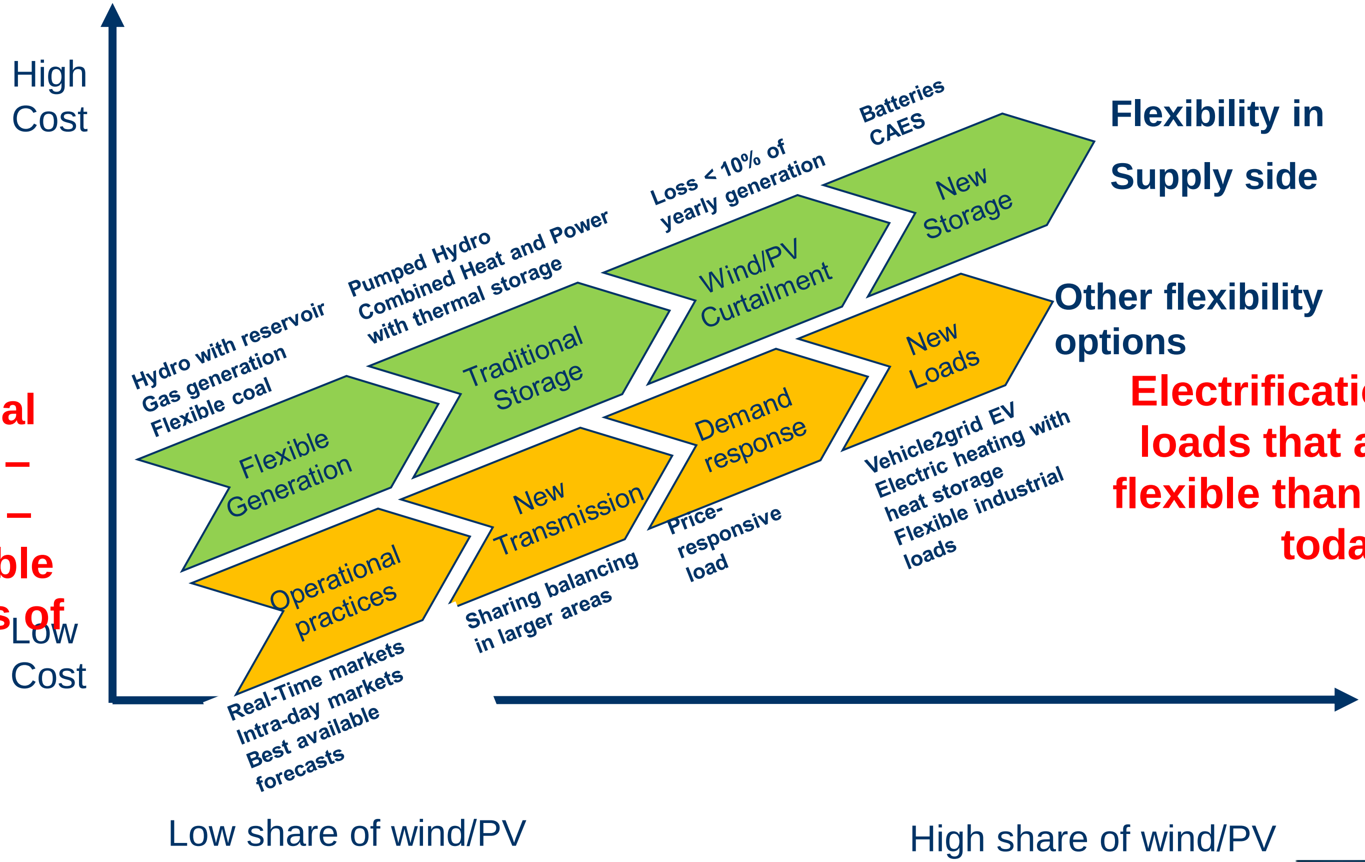
- Larger markets, faster markets help (EU – DE example, AUS, TX)
- New flexibility from wind and solar power plants (DK, ES), storage (AUS, PJM), loads (>20% share of VRE)
- Increased flexibility of thermal power plants – running a balancing area without large power plants online (DK)

Integration challenges

- Scarcity of flexibility:
  - not fulfilling reliability requirements (operating reserves)
  - increased/unnecessary curtailment of VRE

- System optimization – both for capacity and operation – can determine how the system copes with added variability and uncertainty with flexibility
  - Results seen as system costs, also the use of flexibility options and their value

Flexibility options



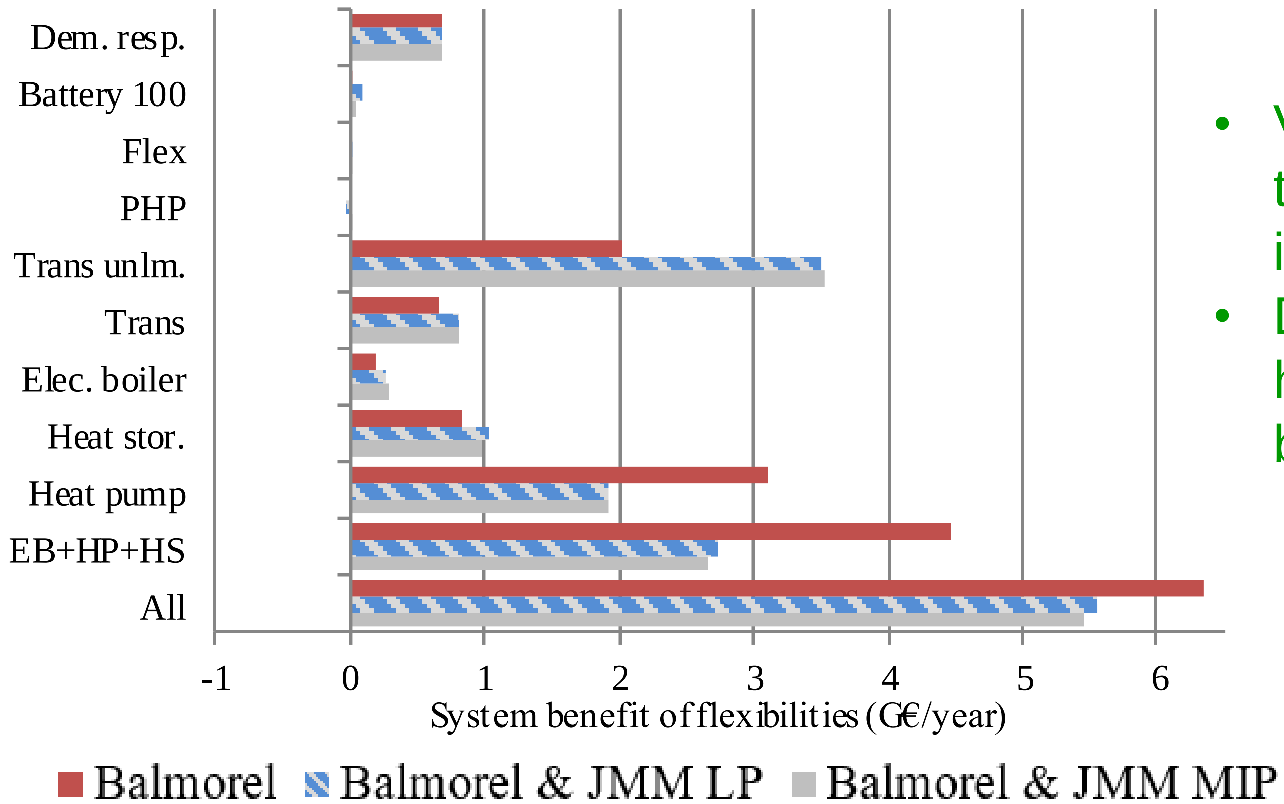
Operational practices – and tools – key to enable high shares of VIBRES

Electrification – new loads that are more flexible than the loads today

VIBREs – and loads and electrical storage can provide the system support services provided by generators today

Flexibility options are competing

Cost Benefit of Flexibility options: Case >40% wind/PV around Baltic sea

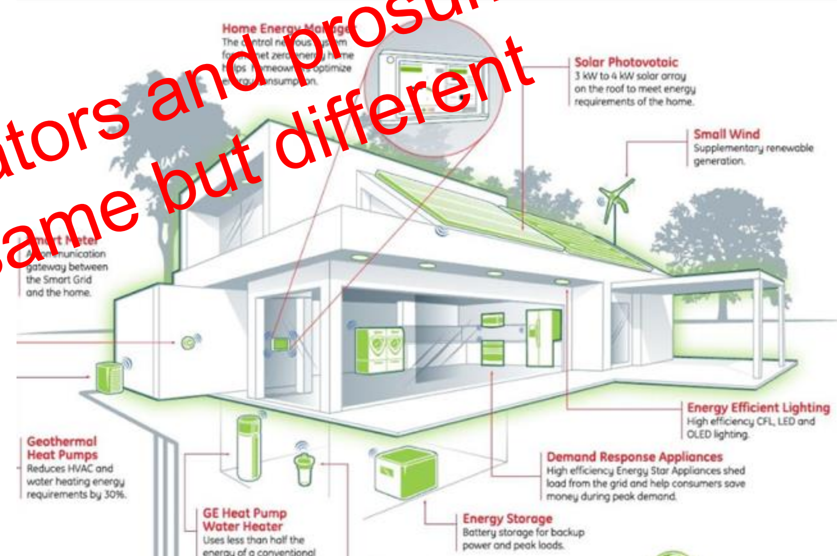


- Value of All less than sum of individual options
- Detail of simulation has impact on the benefit estimated

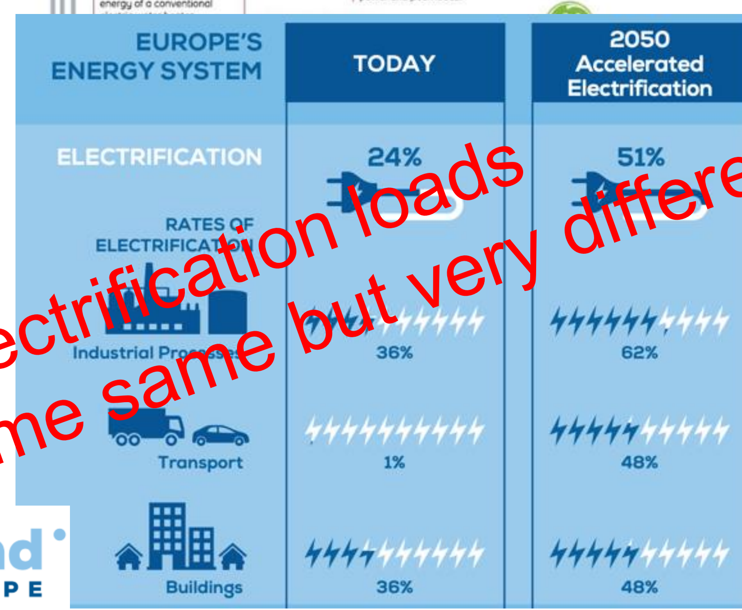
Kiviluoma, J., Rinne, E., & Helistö, N. (2018). Comparison of flexibility options to improve the value of variable power generation. *International Journal of Sustainable Energy*, *37*(8), 761–781. https://doi.org/10.1080/14786451.2017.1357554

Energy transition - opportunities

- Smart grids:
  enabling distributed resources, prosumers, HEMS/BEMS operating with price signals
- Load transition:
  changing the fixed load paradigm. Most new loads come with storage



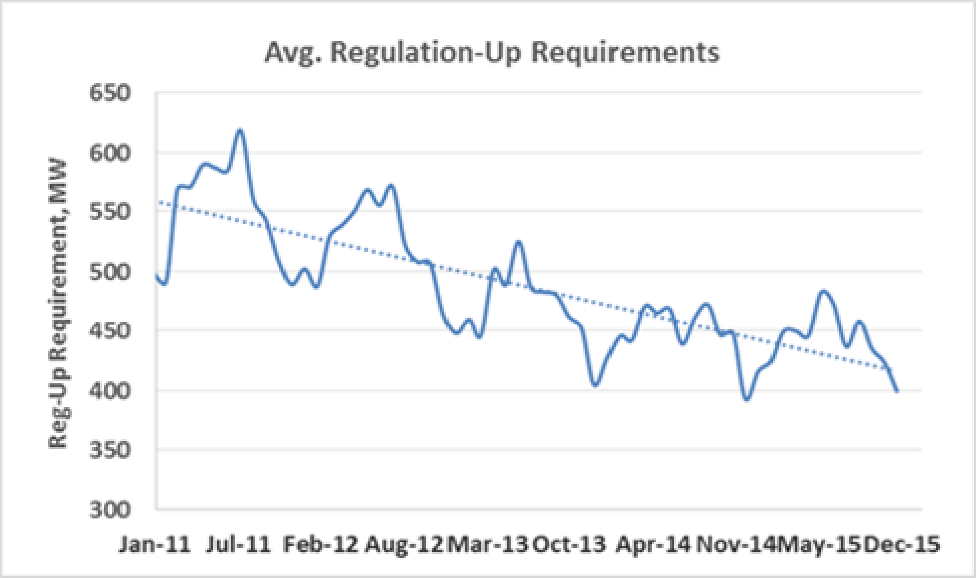
Aggregators and prosumers
same same but different



New electrification loads
not same same but very different

Opportunities for grid support services from wind and solar

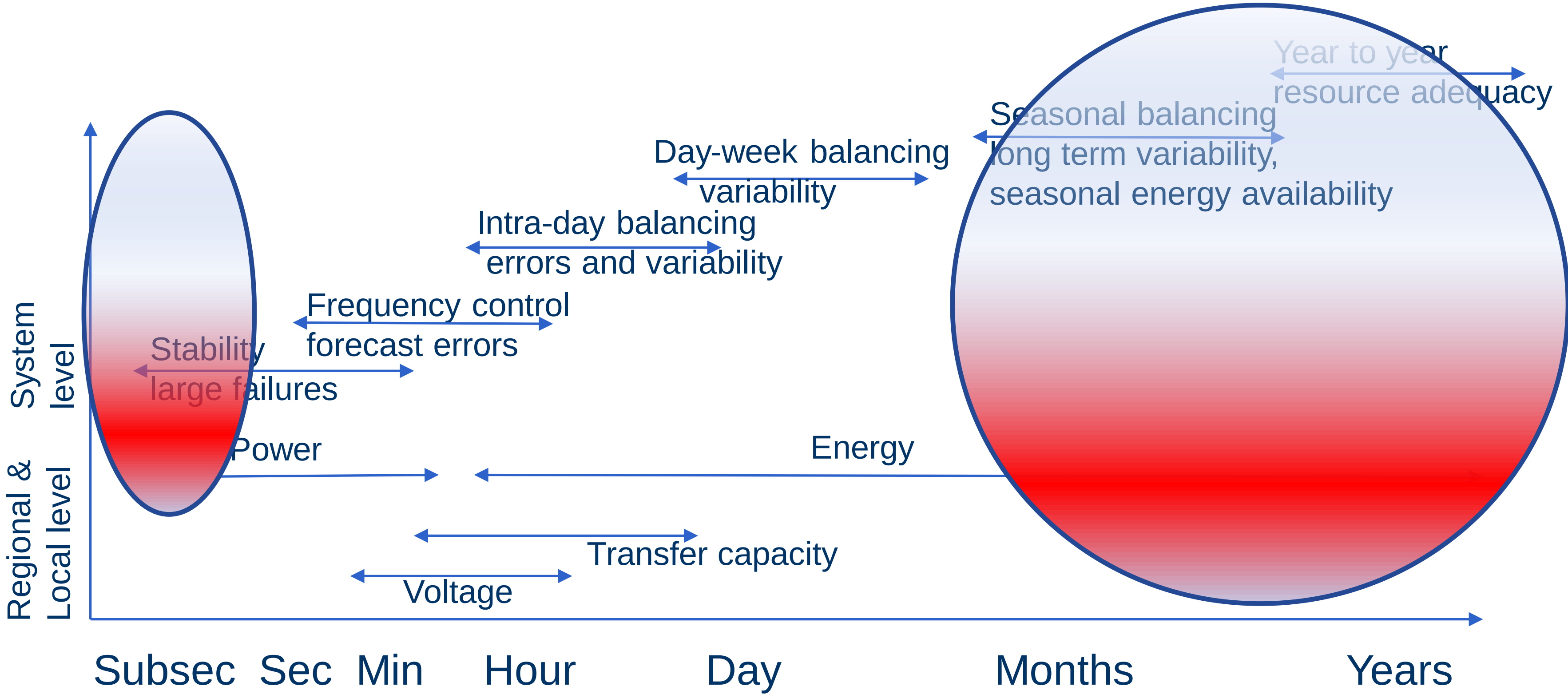
- Asking for capabilities in grid codes, and paying for services of system support if needed/used. Using curtailments smartly.
  - Texas: fast response of WPPs help reduce the overall need for automatically activated frequency support services
  - California: responses from PV better than conventional generators
  - Spain: 14 GW wind compliance tests. Wind providing ~ 5 % of downward reserves in 2017
  - Europe: Utilizing large numbers of PV + storage systems in a VPP configuration to provide flexibility and fast frequency control



Source: Julia Matevosjana, ERCOT

https://www.caiso.com/Documents/UsingRenewablesToOperateLow-CarbonGrid.pdf

Flexibility need – time scales



At high shares of VRE (>50%) main challenges are for stability, and for long term flexibility

Options to support stability

- Maintain inertia
  - Keep synchronous generators running (and curtail surplus)
  - Find other sources of synchronous inertia (i.e. synchronous condensers)
- Speed up frequency response
  - Faster primary frequency response
  - Fast frequency response and other clever frequency controls, especially on inverters
- Make inverter behavior “better”
  - Grid forming inverters and Virtual synchronous machines
- New paradigm of operating in sync/async modes still needed– G-PST https://globalpst.org/

Courtesy of Nick Miller

Long term flexibility challenge

- Traditionally build gas turbines for back up – expensive use as peakers <1000h/a
- With wind/solar dominating, this over-capacity will be expensive. Two other pathways possible:
  - Load becomes flexible – also in weeks time scale, electrolysers for power2X, thermal storages for heat etc
  - Electric storage becomes very cheap, and new seasonal options for storage developed
- Transmission, larger interconnected systems will be more and more cost effective
- Probably future will see a mix of all these?

Conclusions

- There are flexibility options to replace the conventional thermal generators used today
  - Options available at lower cost may differ for system to system. Operational practices also important: larger faster markets, sharing balancing, enabling smaller local resources, allowing cross sectoral links
  - Enable and incentivise all inherent and new flexibility!
- Going towards 100% renewable systems:
  - Inverter based resources, wind/PV/Batteries can be a backbone of future systems
  - Smart integration of energy sectors: also long term flexibility
  - Cost effective planning needs to take into account future load flexibility, storages, and interconnectors to neighbours

Thank You!!

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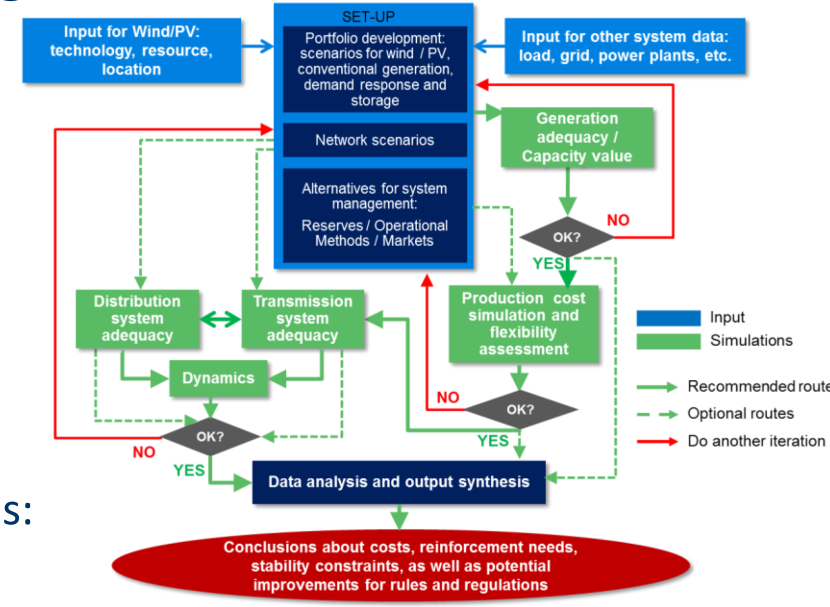
Capturing flexibility needs and sources in simulations

Needs: temporal/spatial resolution of VG

- Not to overestimate: Smoothing of variability
- Not to underestimate: Uncertainty/forecast errors

Sources: capture characteristics

- Not to underestimate:
  - Sharing flexibility with neighbouring areas: take into account interconnections, but model the limitations
  - Generation flexibility in future, also VG providing
  - Demand response, storages, energy sector coupling
- Not to overestimate, model all limitations, technical and economical!



Recommended practices for Wind/PV Integration Studies RP16 Ed 2
https://community.ieawind.org/publications/rp
Collaboration btw IEA TCPs Wind and PVPS

Task 25
Design and Operation of Power Systems with Large Amounts of Wind Power

Challenges in system simulations to capture flexibility adequacy

- Data for costs, and technical limitations of flexibility options
  - Hydro power river coupling constraints
  - Demand response costs? Rebound
- Time scales are different and bring a complexity
  - Short term flexibility needs and options require sub-hourly resolution
  - Long term flexibility related to security of supply
- Details cost computation time

Modelling enablers:

Transmission and operational

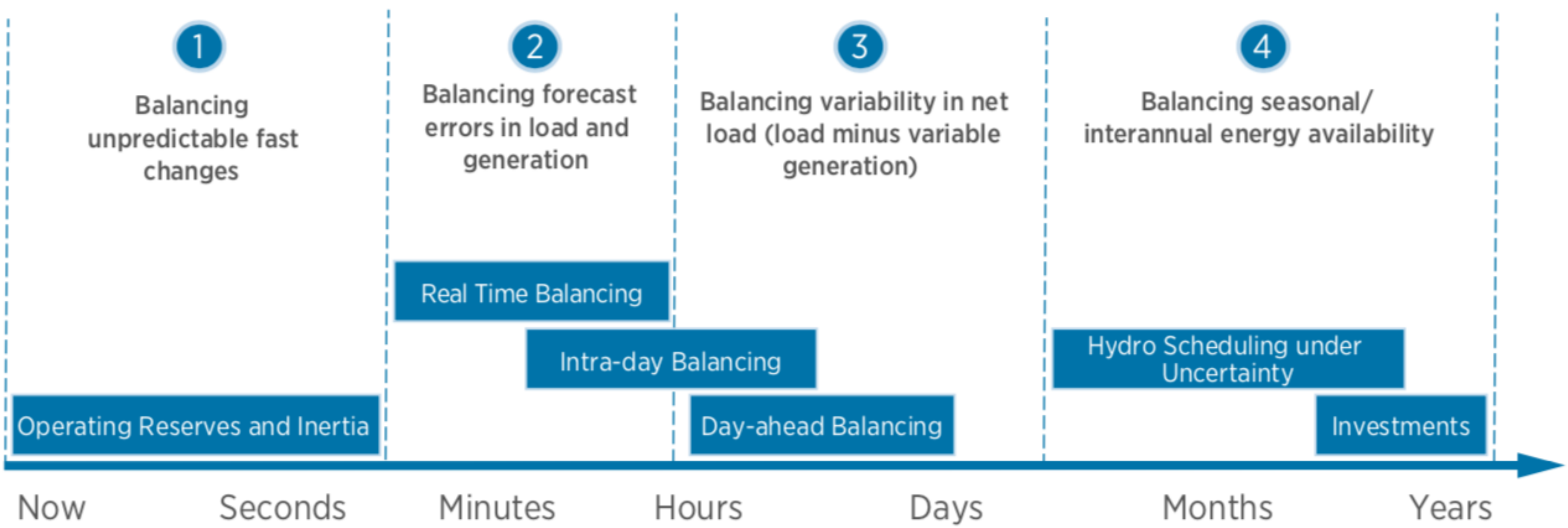
- Reduction of variability
- Benefits from using flexible resources in neighboring countries

Smart grids/ digitalization

- local flex resources, DR

Value of flexibility

- Short term: increasing AS payments: for frequency control, but also new services like inertia and black start
- Medium term: paid through ability to pick the highest priced energy-only-market hours: future markets see higher (scarcity) prices more hours of the year
- Long term: capacity payments (and scarcity pricing)



https://www.irena.org/publications/2018/Nov/Power-system-flexibility-for-the-energy-transition