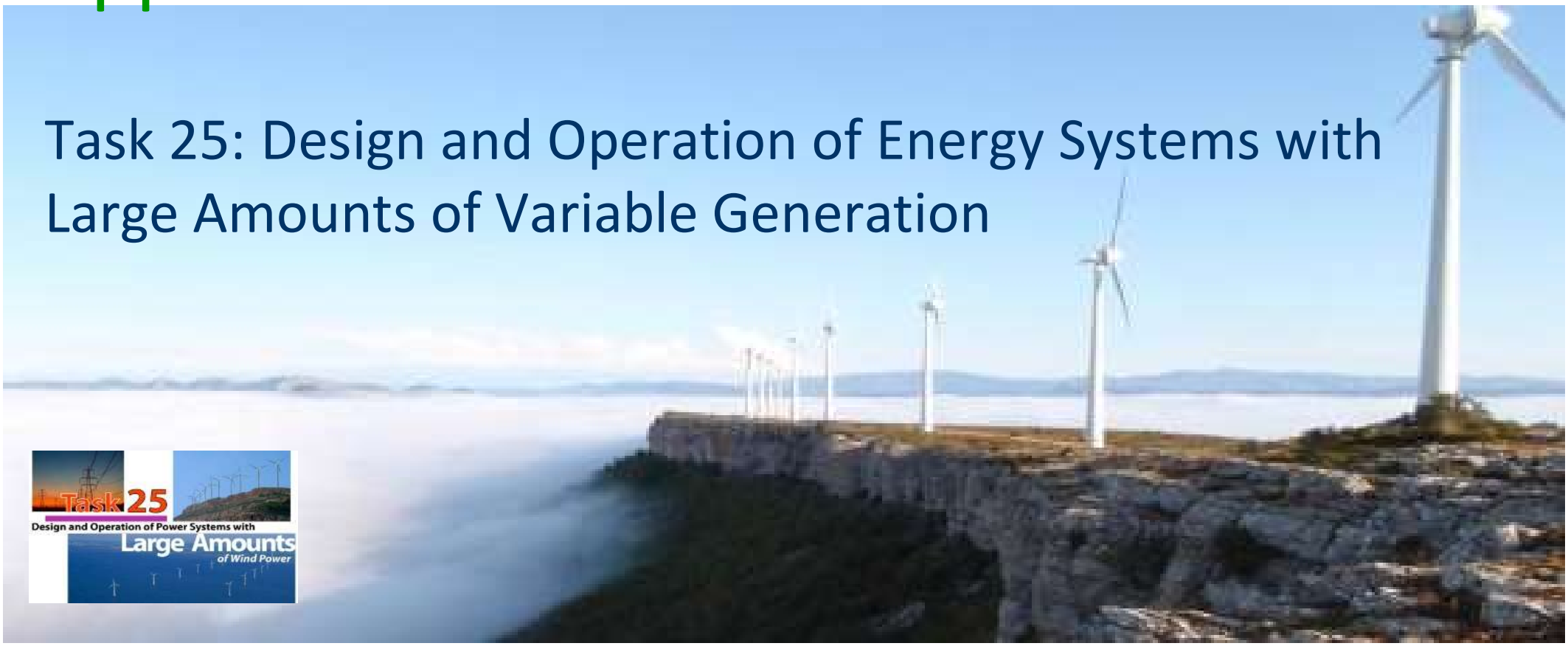
Grand challenge Grid –challenges and opportunities for offshore wind



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

Hannele Holttinen, Operating Agent Task25

Partner, Recognis

Deepwind conference keynote, 18 Jan 2023

iea wind

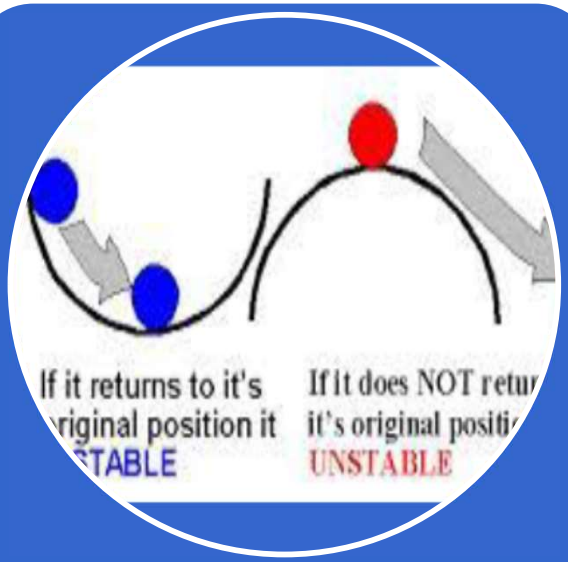
Grand challenge Grid –challenges and opportunities for offshore wind

- Starting point: future where Inverter Based Resources (IBR) dominate power systems

Contents

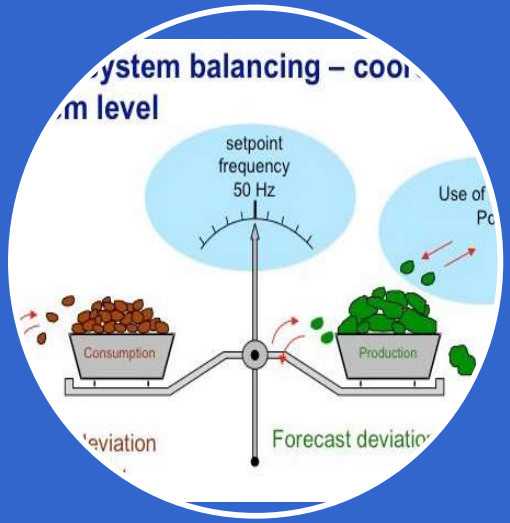
- Challenges and solutions
- Offshore wind opportunities

Challenges – short and long term



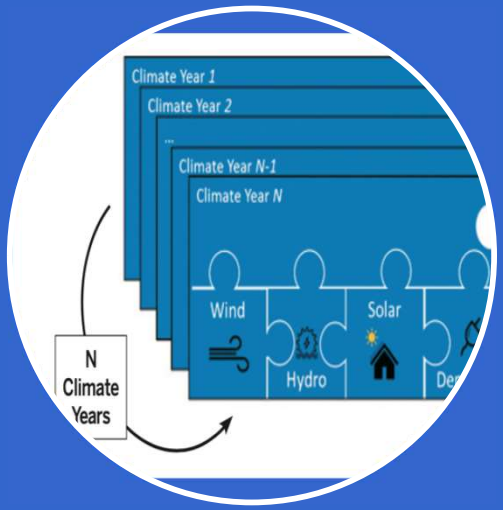
Stability

power system resilience - disturbances and external events; control interactions



Short term balancing

demand and supply in balance – flexibility



Long term balancing

increased weather dependency, extreme events of long wind, solar, hydro scarcity

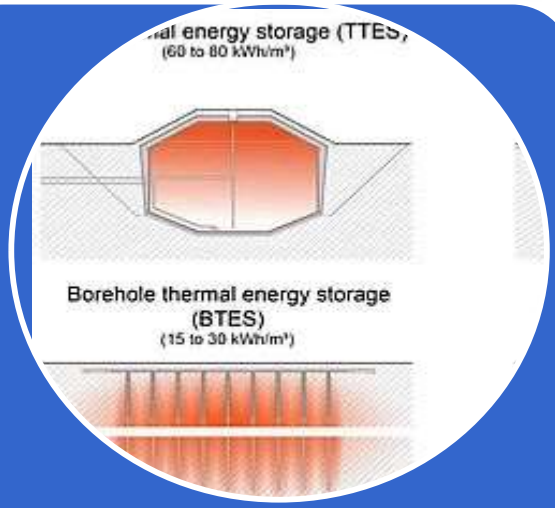
seconds, minutes, hours, days seasons/years

Solutions

Stability: How to operate non synchronous system?

How to get resilience from wind, solar, batteries? exploit wider flexibility of inverters, not just replicating synchronous machine features

Short term balancing: technology solutions for flexibility are there (use demand, wind and solar and storage) - how to incentivise?



Long term balancing:

no more fixed load paradigm, optimise a combination of peakers, storage and demand side. How to incentivise smart sector coupling with all power2X storage options?

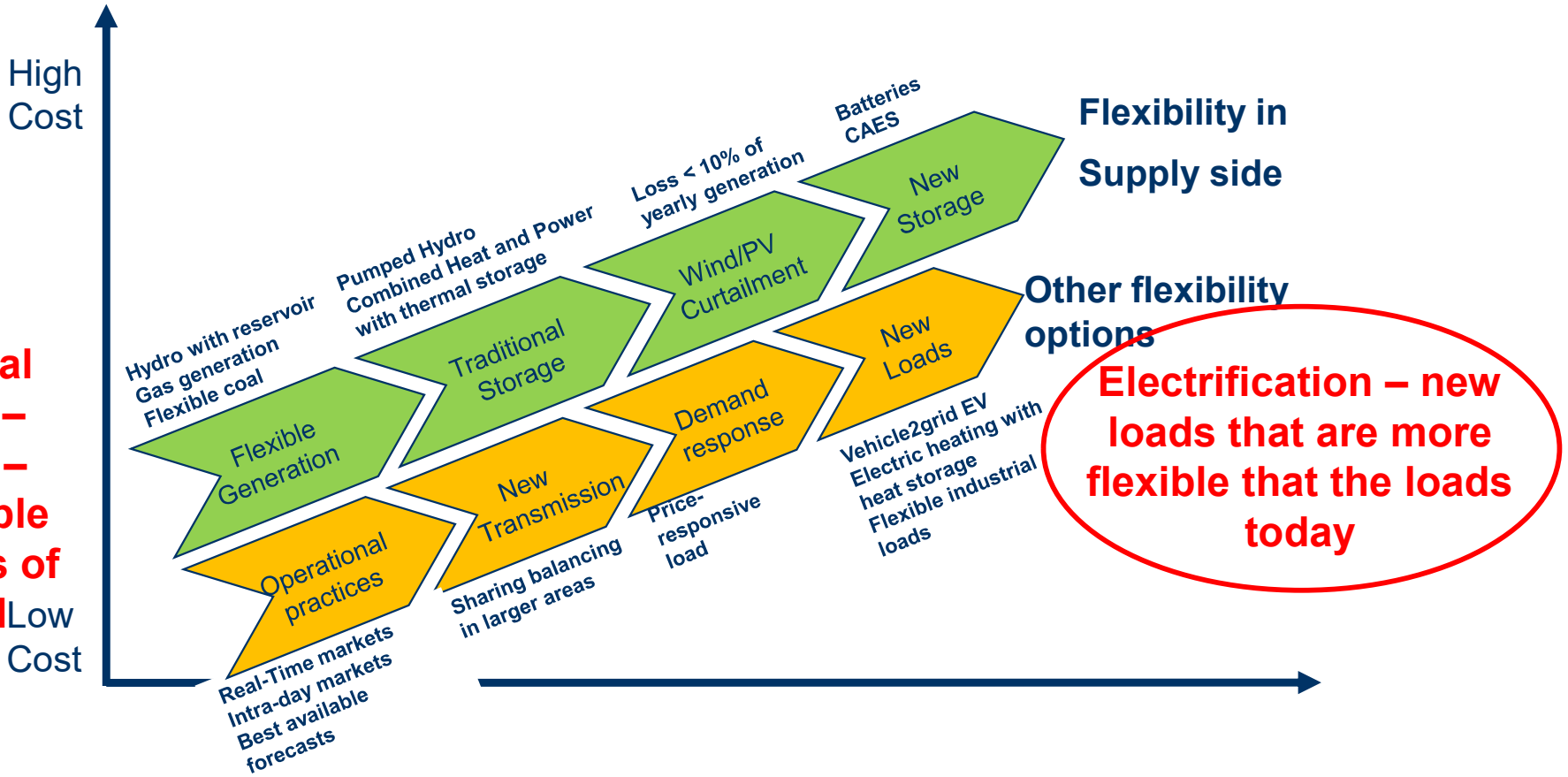
no mass
all brains

large and
fast markets

huge energy systems
power, heat, gas,…

More complexity and amount of data is exploding - digitalisation

Balancing challenge: Using more of the flexibility solutions we know



Operational practices – and tools – key to enable high shares of wind and solar

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

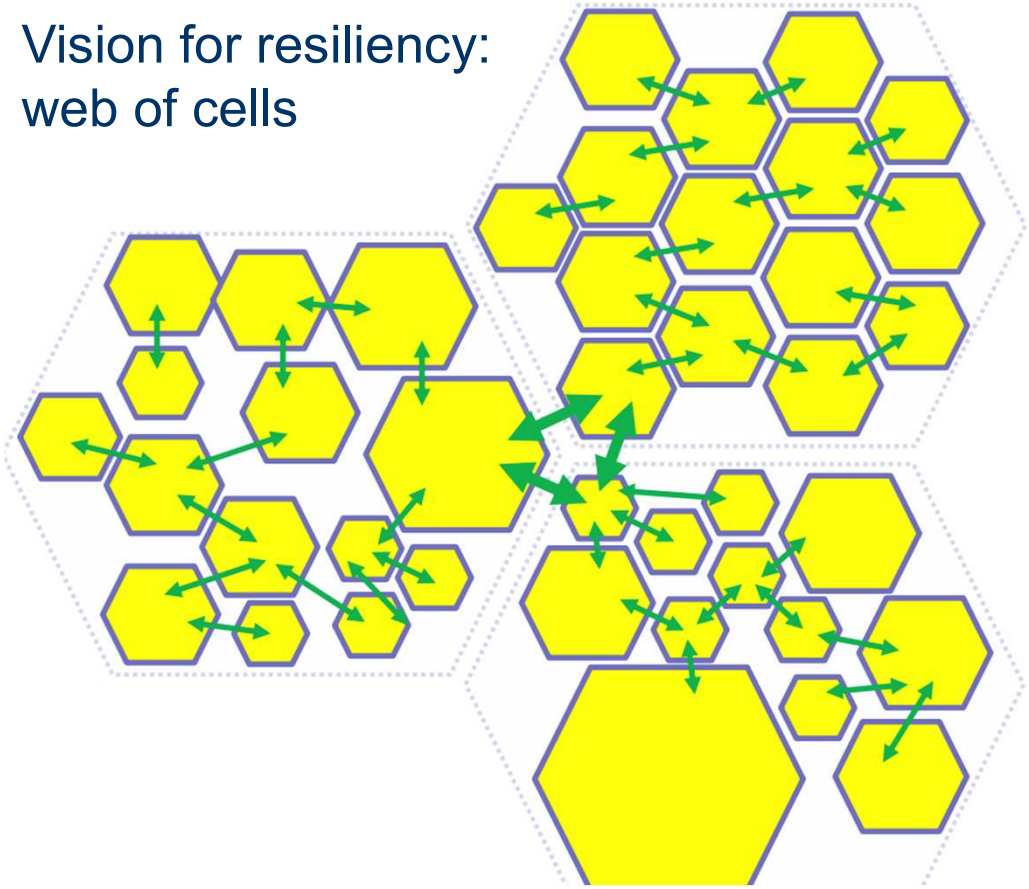
Wind and solar – and loads and electrical storage can provide the system support services provided by generators today

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

Demand Response: energy transition is also load transition

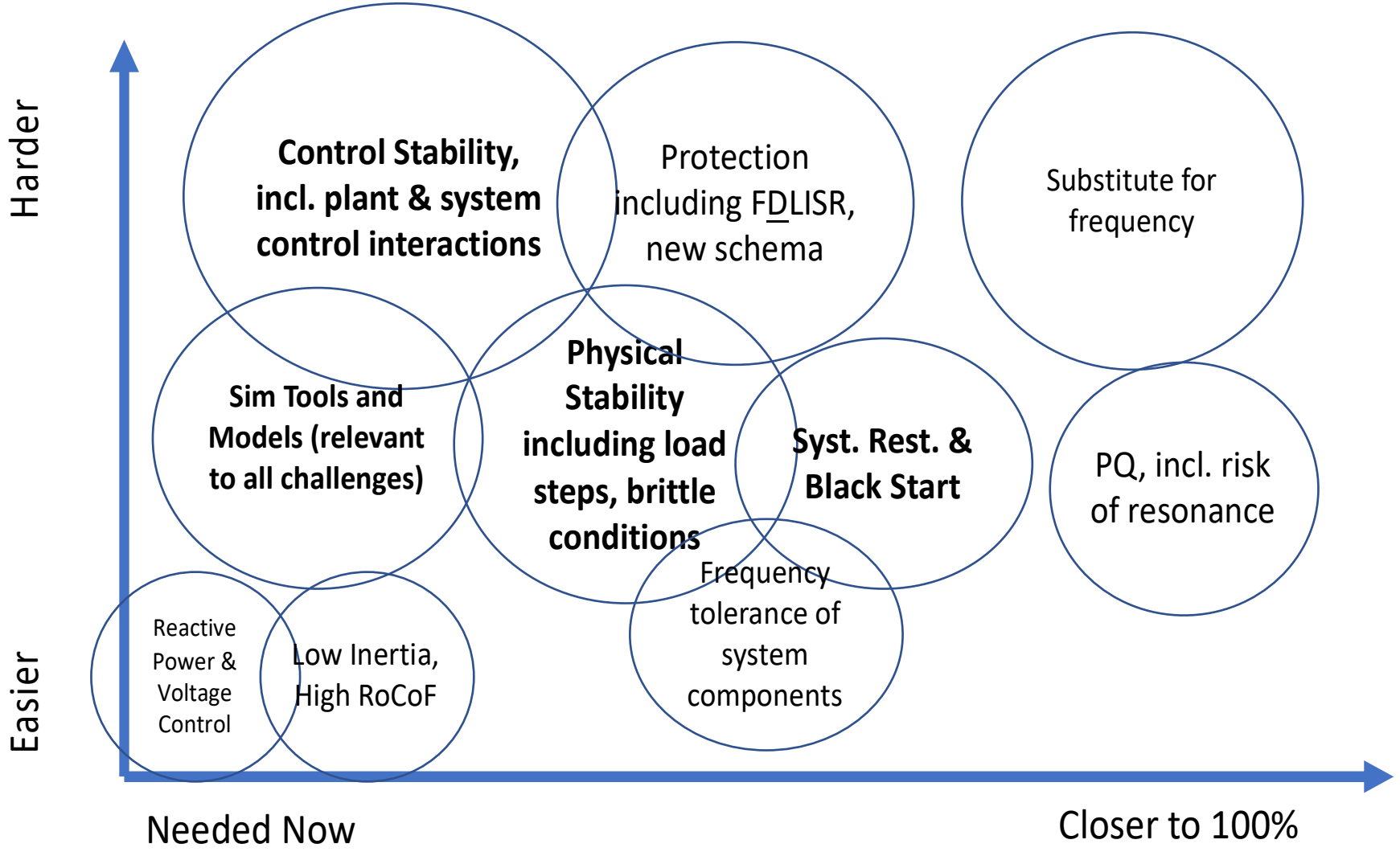
- Smart grids and digitalization for short term flex: enabling distributed resources, prosumers. AI, HEMS, BEMS responding to local and system wide price signals
- P2X can offer also longer term flexibility: changing the fixed load paradigm LOLP

Vision for resiliency: web of cells



Vision: dispatch loads for available generation

Stability – new paradigm of operating non synchronously



FDLISR fault detection, location, isolation and recover;
RoCoF Rate of Change of Frequency
PQ Power Quality

Holttinen et al. 2020 System Impact Studies for Near 100% Renewable Energy Systems Dominated by Inverter Based Variable Generation https://ieeexplore.ieee.org/document/9246271

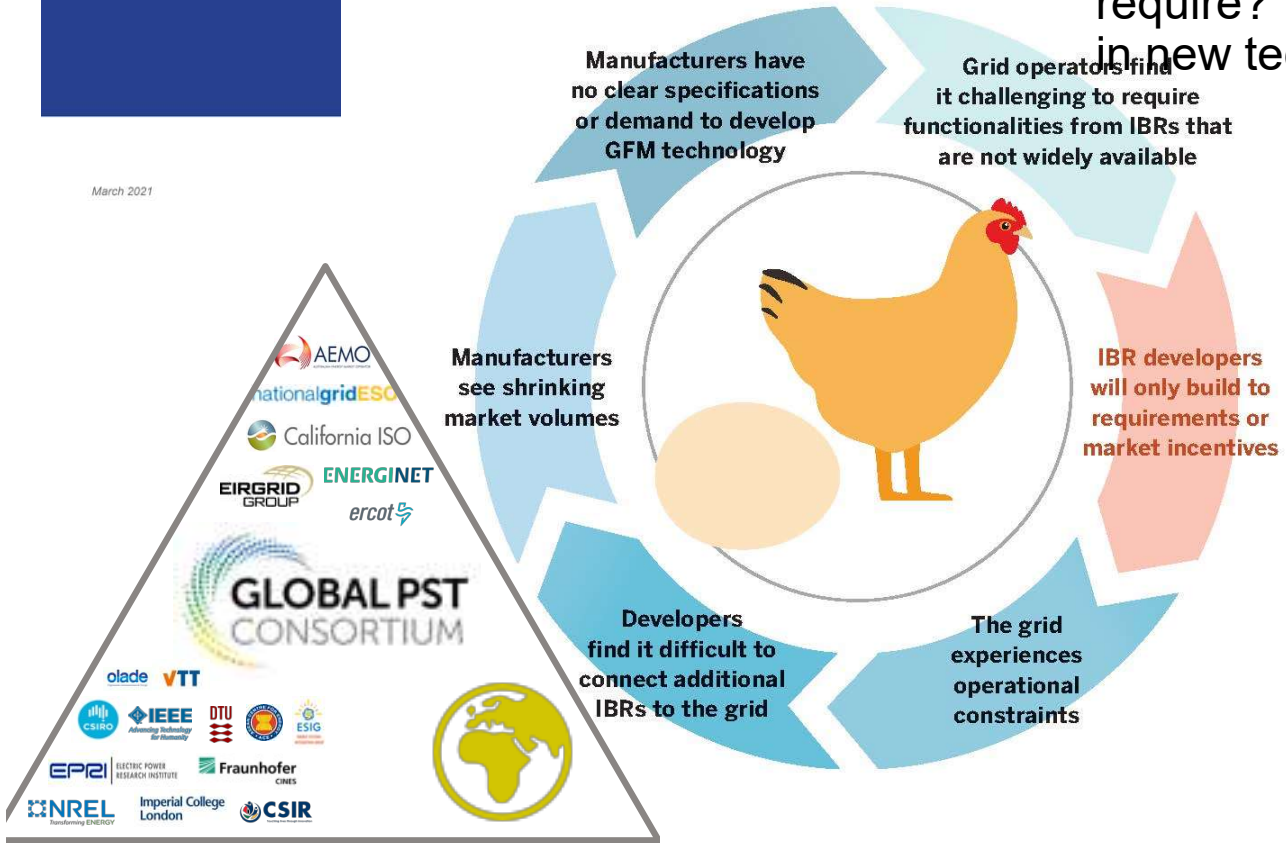
G-PST looking for reliability and resilience, new paradigms for system operation and planning

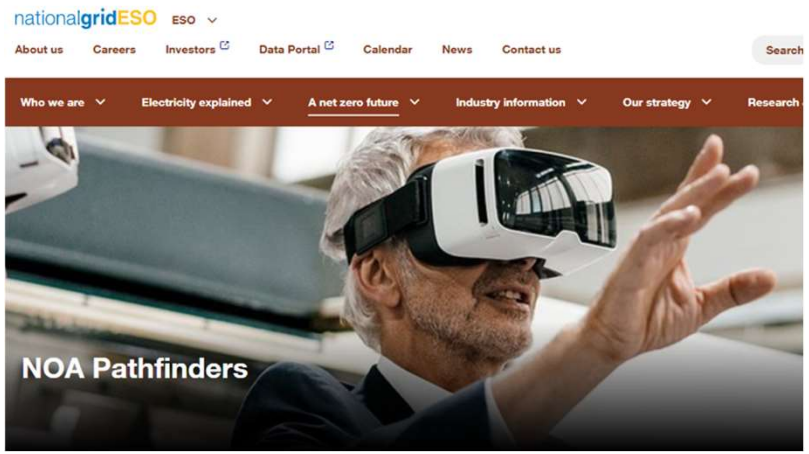
Power system operator focused view on challenges

- enough services to ensure reliability and resilience

Current chicken and egg problem for IBR Grid forming: Which comes first, the requirement for a capability or the capability itself?

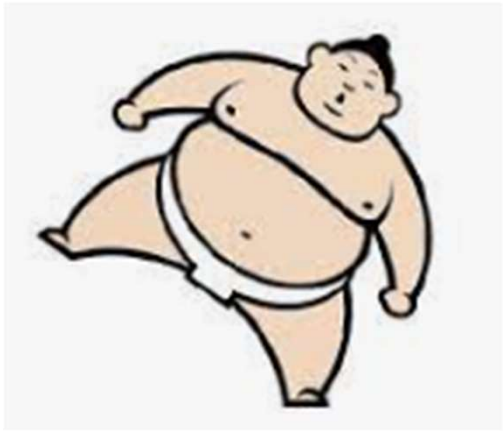
- How do grid operators know what they could require? What drives manufacturers to invest in new technology?





A tender process for new services needed in high-IBR power system, to gain experience and understanding of new technologies available to provide these services

The superpowers of future power systems



Stability:
no mass
all brains,
controls

Short term
balancing:
flexibility,
large and
fast markets

Long term balancing:
longer flexibility from
smart coupling, huge
energy systems
power, heat, gas, ..

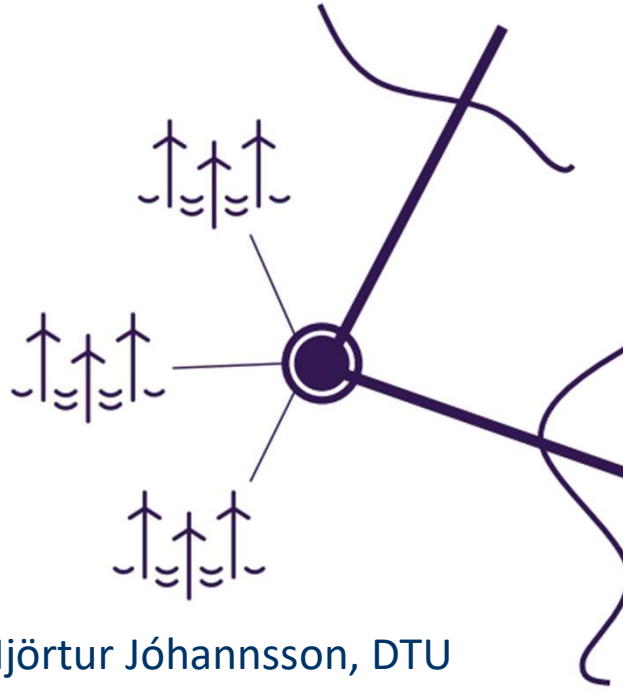
How can offshore wind help?

Stability

- Opportunities: offshore wind power plants options to provide grid forming support
  - Turbine and plant level
  - HVDC converters
  - Storage and electrolyzers
- Optimising, cost and reliability, where to provide the services?
- Challenge:
  - control interactions in power system
  - Offshore grids non synchronous operation

Short term flexibility

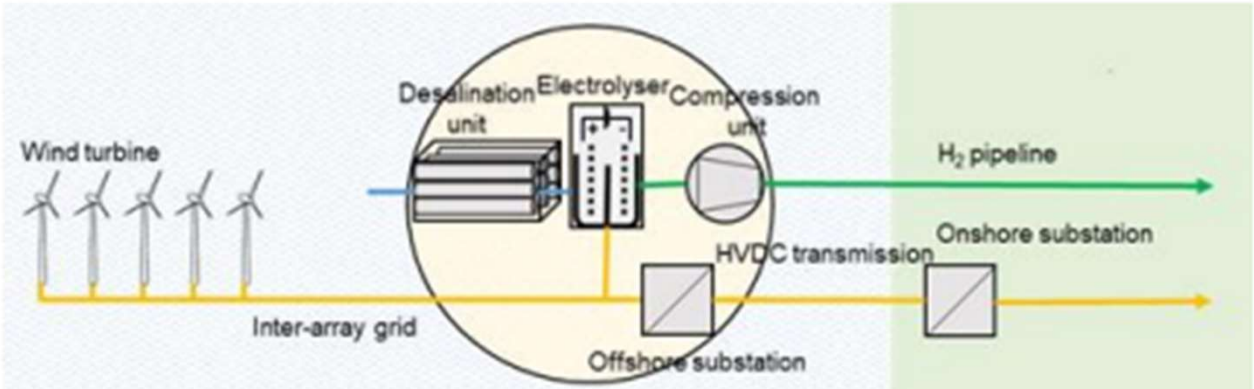
- Frequency control,balancing services
  - Day ahead and intraday markets
  - Real time (balancing) markets
  - Fast and well complying frequency control services
- Interconnectors as an enabler
- Optimising, market design
  - to minimise curtailments when providing balancing
  - to maximise value



Hjörtur Jóhannsson, DTU

Long term flexibility

- Power 2 X coupling at offshore wind power plants, and energy hubs
  - Surplus energy to e-fuels and other hydrogen derivatives, at sea
  - Scarcity situations, generate electricity to demand on shore
- Optimise for long term flexibility?



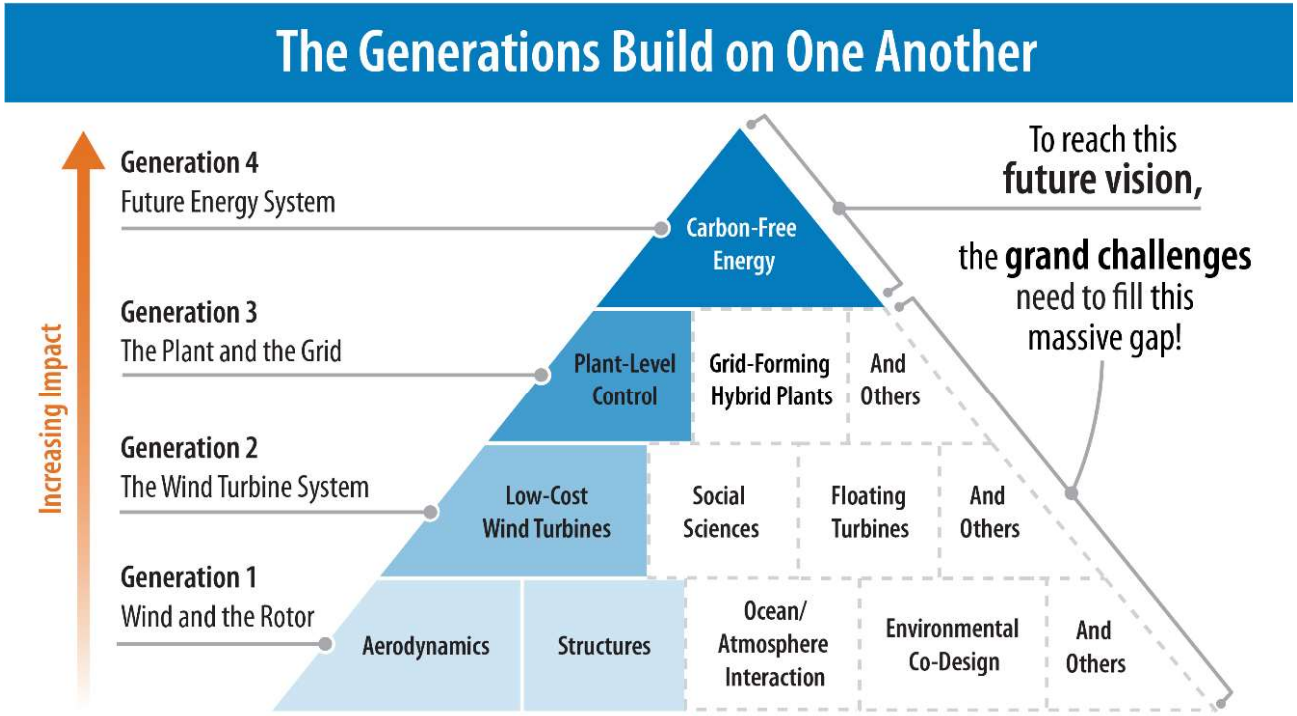
https://orbit.dtu.dk/en/publications/onshore-offshore-or-in-turbine-electrolysis-techno-economic-overv

Grand Challenge Grid – for wind energy science

- Securing 8 fundamental needs for power systems:
  - Energy and Capacity adequacy
  - Technical ancillary services: Frequency, Voltage, Angle stability, Protection, Damping, Restoration

Wind power plants can provide most needs/services

- For some storage is required – this makes other options more cost effective
- Plant level and hybrids give more opportunities
- Offshore grids and HVDC opportunities



Graphic by the National Renewable Energy Laboratory https://wes.copernicus.org/articles/7/2491/2022/

Thank you!

Hannele.Holttinen@recognis.fi

+44 7864336354 +358 40 5187055

Partner, Senior Adviser

Operating Agent of IEA Wind

Task 25 ”Design and operation of energy systems with large amounts of variable generation”

https://iea-wind.org/task25/

G-PST Pillar 5 lead “Open Source Tools and Data”

https://globalpst.org/