Towards 100% renewables: market and system operation practices

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

Hannele Holttinen, Operating Agent Task25

Partner, Recognis

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iea wind

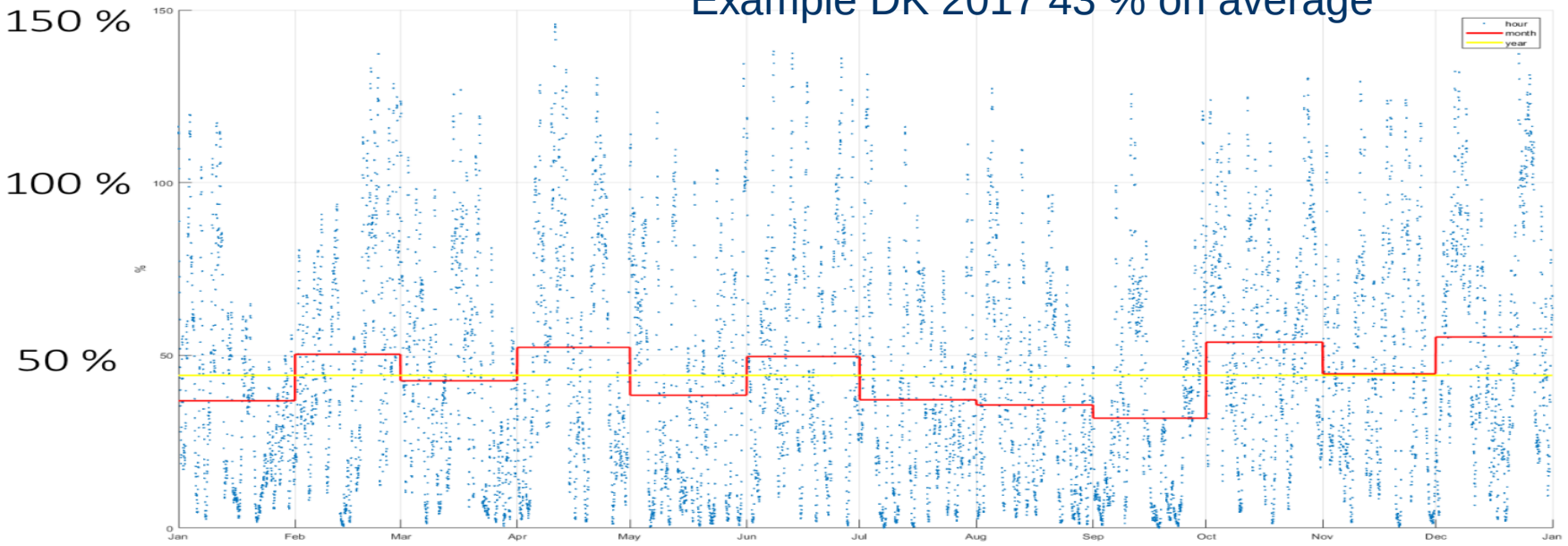
Contents

- What do we know about 100% renewable systems?
- What do we need to know and find out for the transition?

100% means…

- Average yearly demand
- BUT, while reaching that goal, instant 100% will be faced already when less than 25 % on average

Example DK 2017 43 % on average



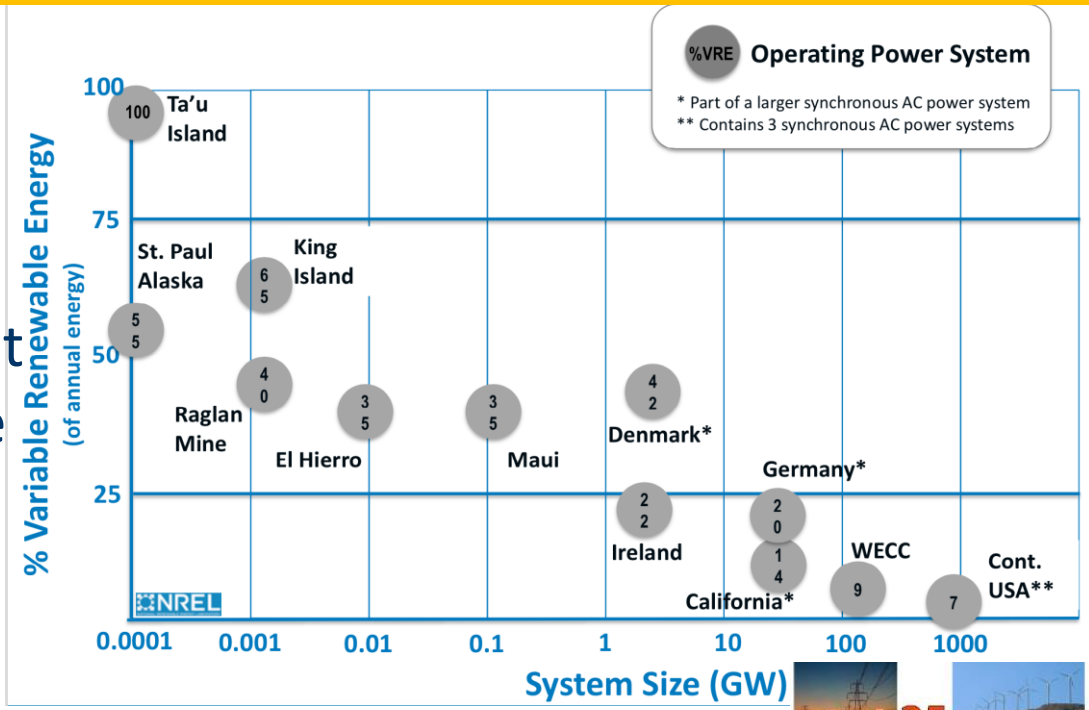
ENERGINET

Experience from close to 100% renewables

- Systems with hydro/geothermal: operated with conventional power plants (Iceland, Hawaii, …)

VIBRES: Variable Inverter Based Renewable Energy Sources

- Higher shares of wind/PV:
  - Smaller areas of larger synchronous systems: Denmark coping without larger generators online with high wind
  - Hawaii / island systems



Source: NREL

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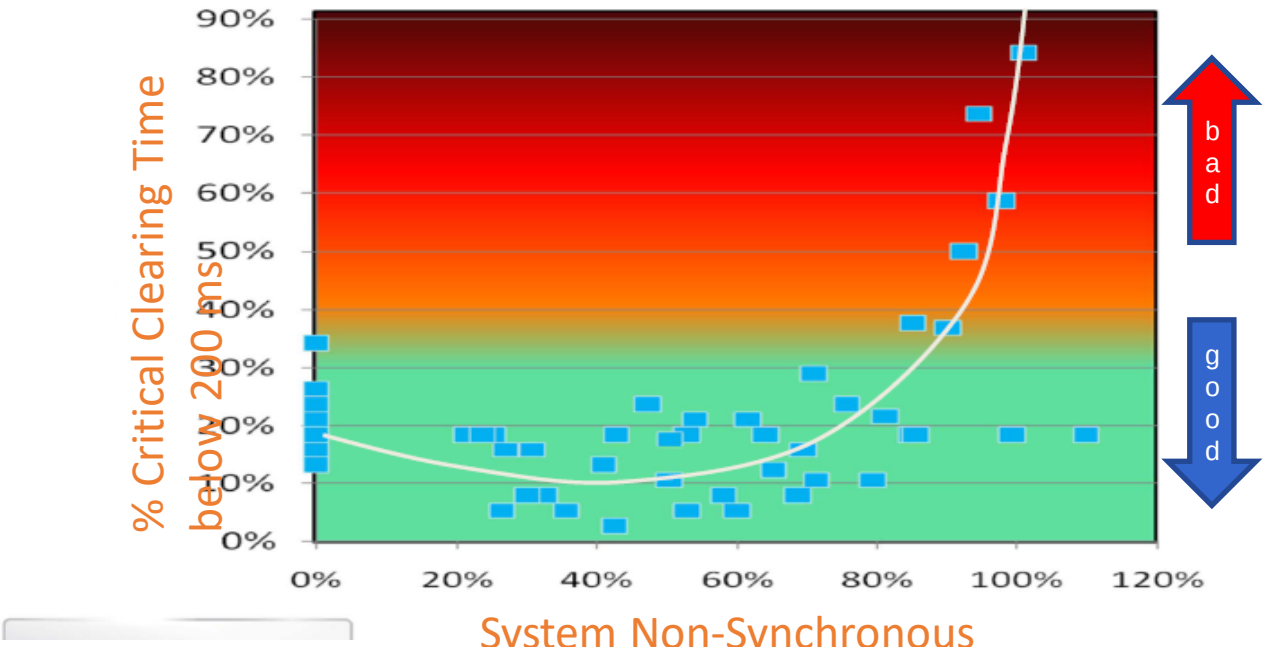
Ireland study: ok for 80-90%

- Transient stability (as measured by critical clearing time) first slightly improves, until around 80-90%, where instability becomes a big issue.



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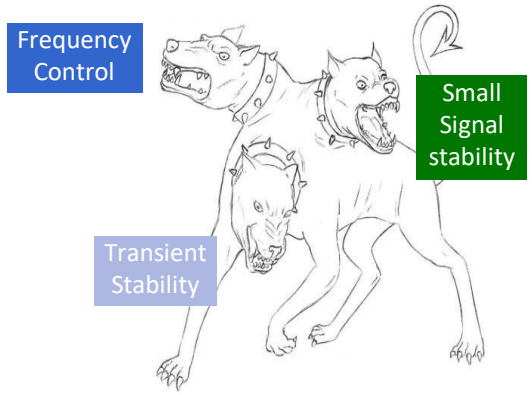
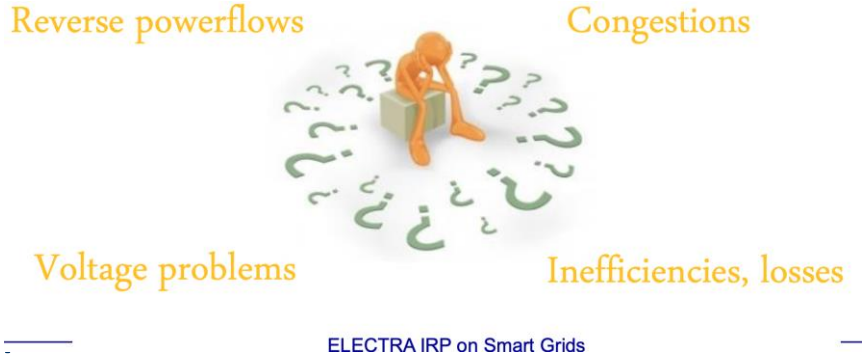
Challenges to tackle

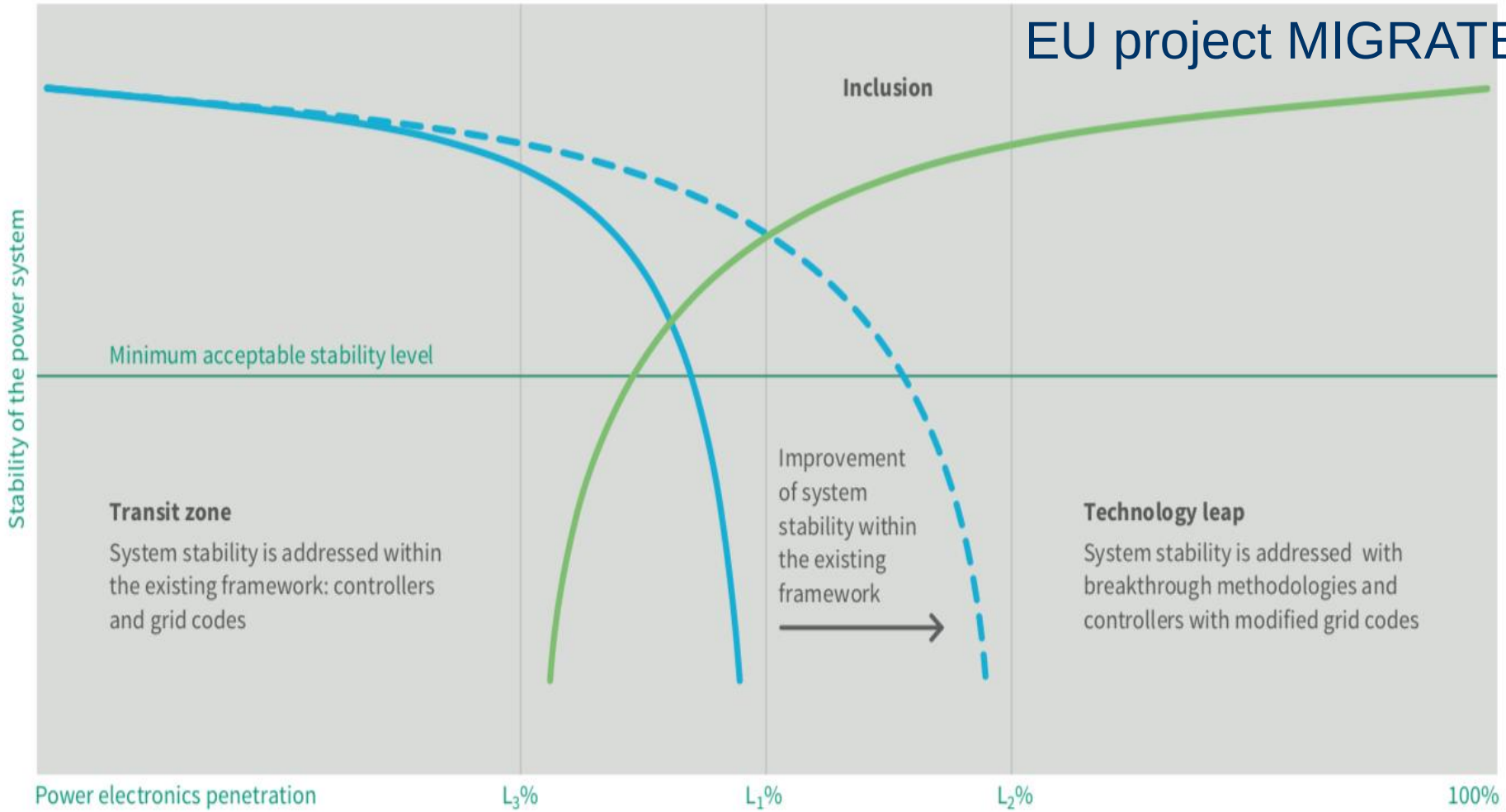
- Stability: solving all 3 at same time at high VIBRES. What new methods and technologies to use?
- Balancing, flexibility and adequacy: how much new loads can help, for short term operation and for seasonal mismatch?
- Market operation: market design with new services, how to design so that paying for the new services as they become beneficia for the system? Local versus global, DSO/TSO collaboration





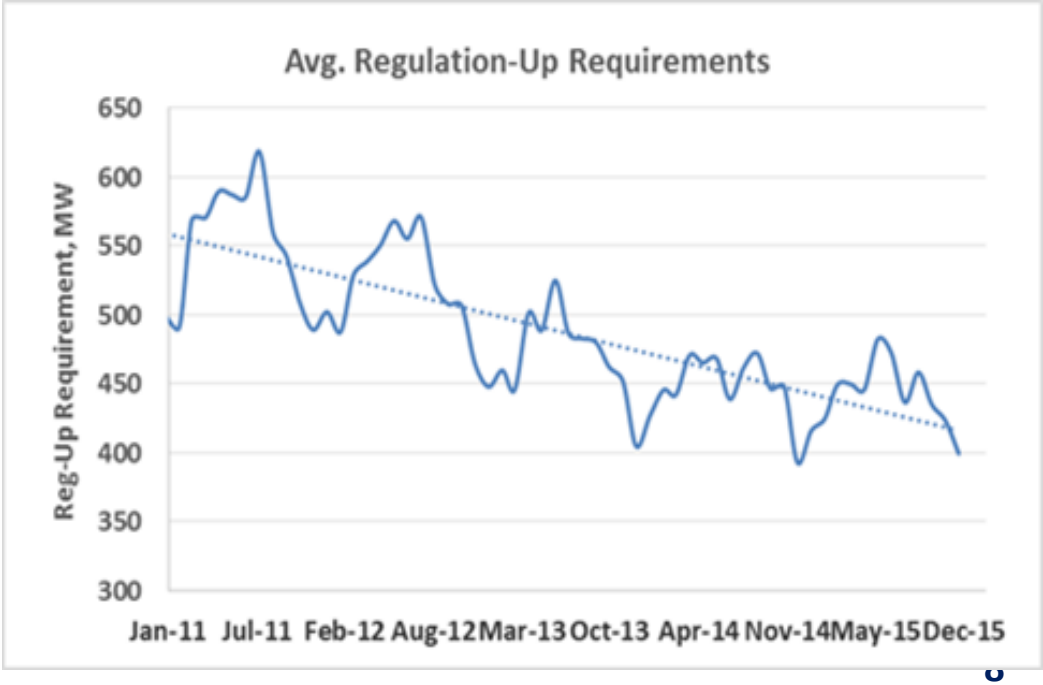
Transition?

- Can we get there from here?



Opportunities: development happening at the same time

- Load transition: changing the fixed load paradigm
- Smart grids, DSO role
- Inverter controls: rapid responses, synchronous machine characteristics and they don't swing against each other (more stable).



Texas experience, less need for fast frequency support after wind power plants provide good response (Source: Julia Matevosjana, ERCOT)

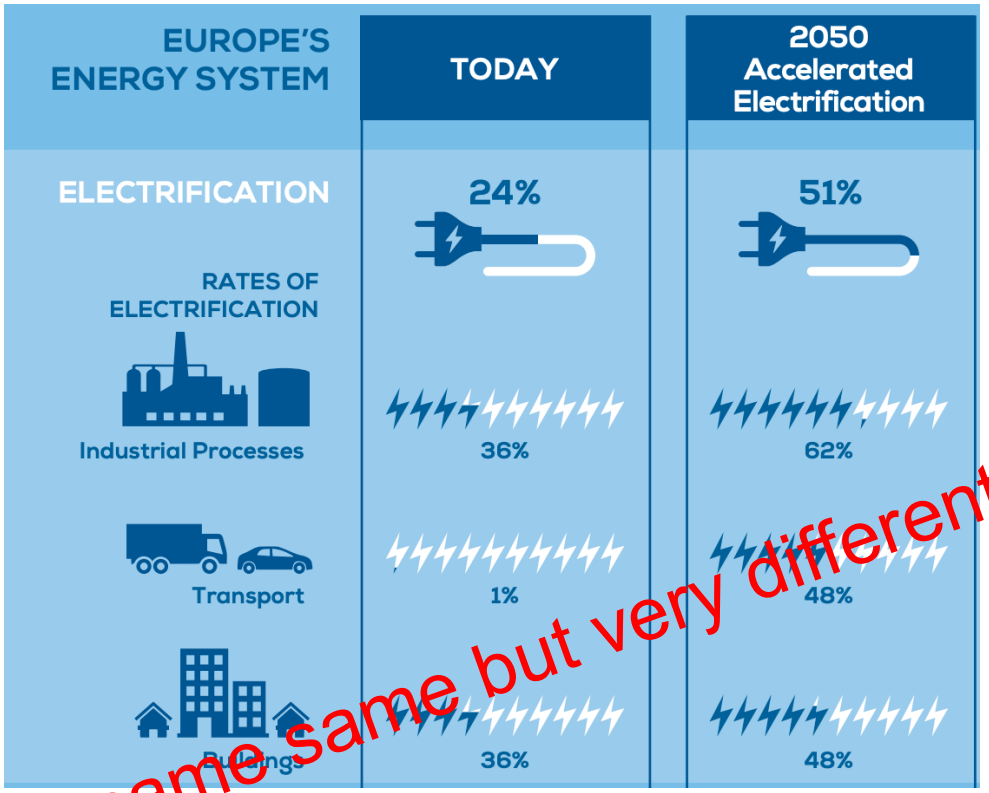
The traditional load becomes active

- Aggregators: offering same comfort/service and aggregating flexibility
- Prosumers: optimise use of (solar) generation. HEMS, BEMS, energy communities, local markets

same same but different

Sector coupling will more than double electricity demand

- Heating and cooling with air pumps
  - Combined with thermal storage
- Electric transport
  - Vehicles used less than 50 % of time
- Electrolysers for synthetic gas, industry processes



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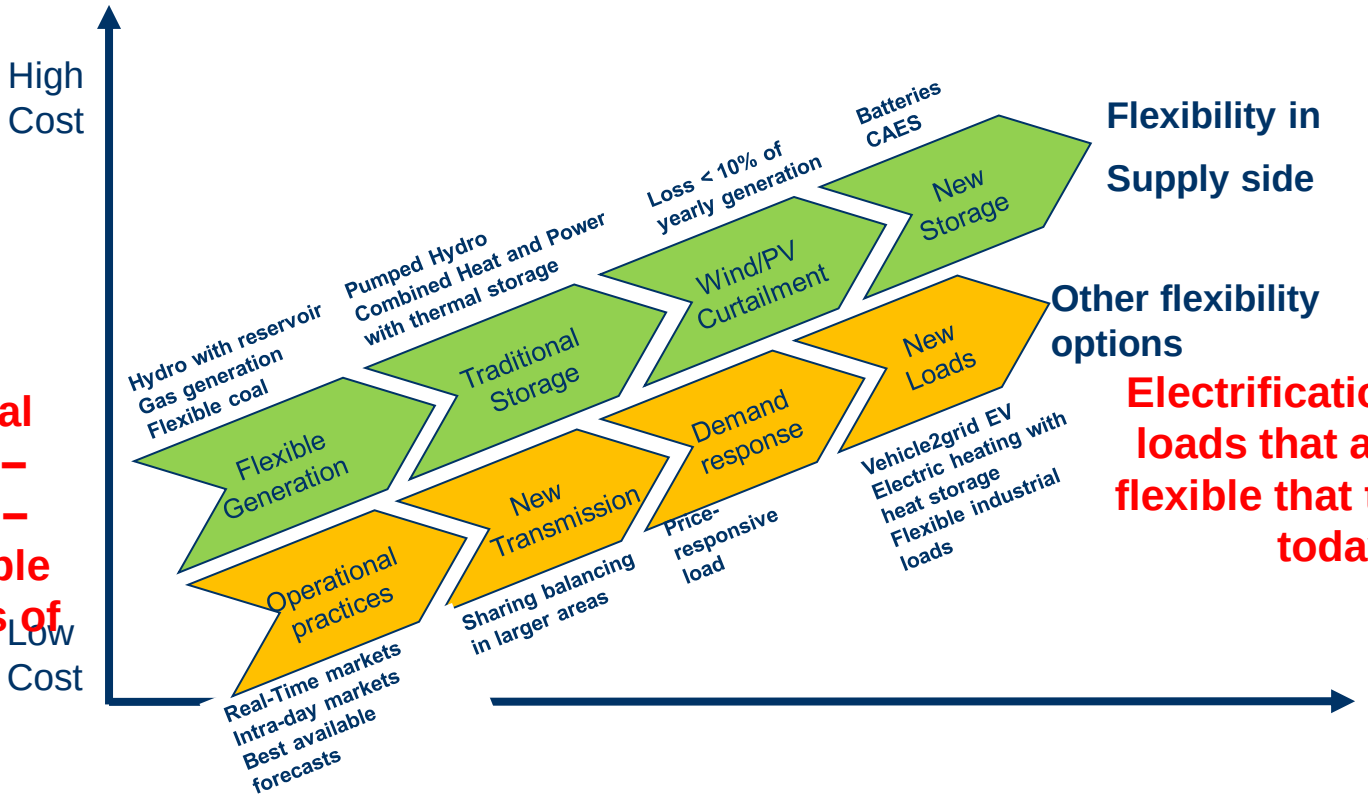
Balancing and flexibility – using more of the solutions we know



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

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

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

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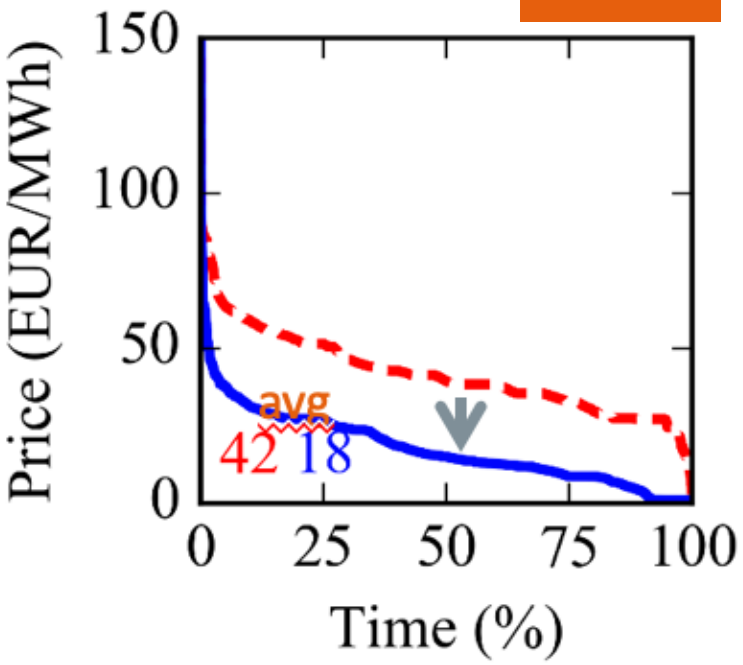
Reaching 100% VIBRES shares

- Synchronous condensers: sync machines rotating without producing electricity
  - May cause transient stability problems
- Grid forming converters: promising technology letting VIBRES set the frequency
  - Transition from grid-forming to grid-following mode, as share of VIBRES changes?
  - For loss-of-load, frequency cannot be used as control variable, voltage?

Market challenge: revenue sufficiency

- Due to 0 marginal cost renewables
- Due to flexible loads
- Stakeholder changes
- Can P2X loads change the picture?
  - If timing when wind/PV available
- Storage may be an option

VTT



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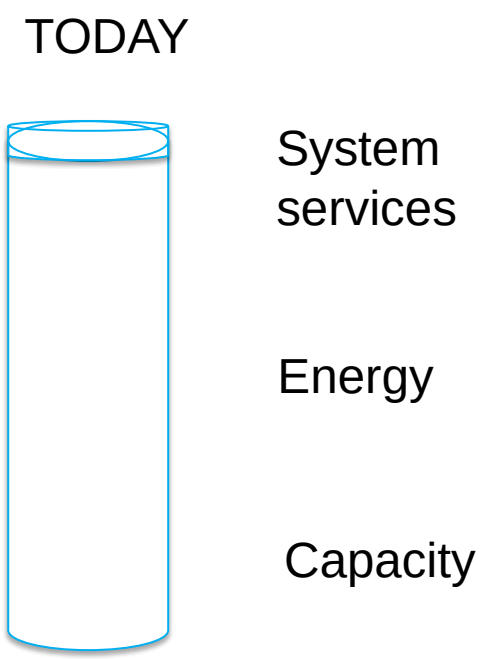
Market challenge: paying for services

- Paying for new services
  - More grid support services: inertia, ramping, voltage,..
  - Transition, introducing services when system benefits seen, otherwise service provided not reflected in payments
- Scarcity pricing or capacity payment



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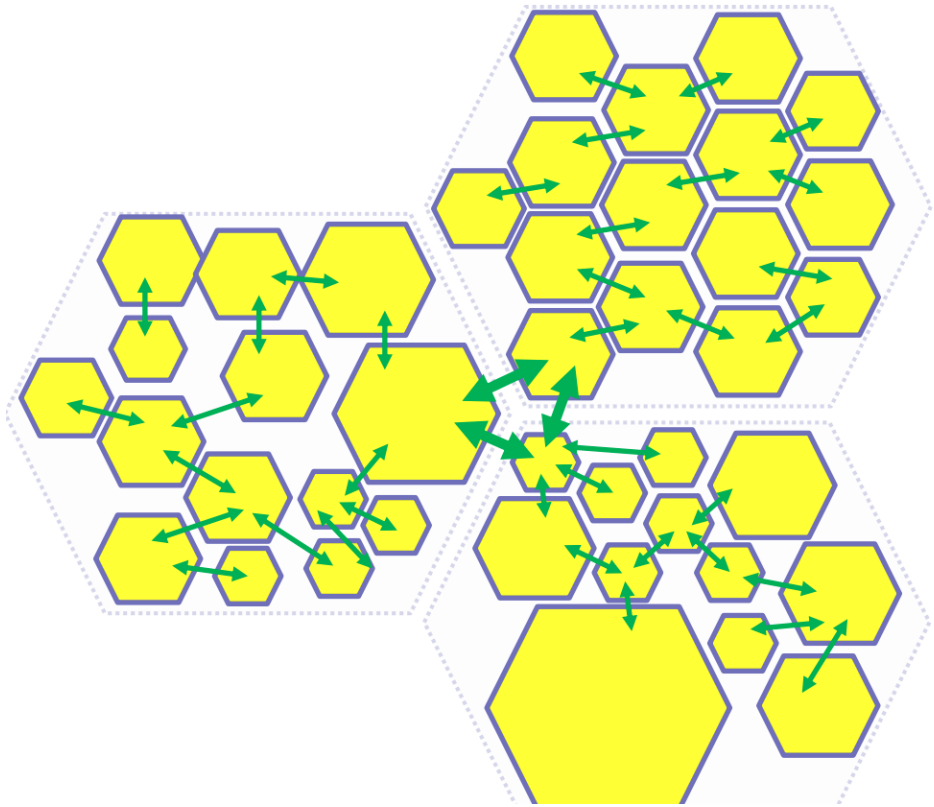
Using the local flexibility to system benefits

- DSO/TSO collaboration
- Flexibility should have a value not only locally
- Consumer behaviour?
- Towards web of cells, with local smartness, utilising large system benefits when no grid bottlenecks



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European Energy Research Alliance
Smart Grids Joint Programme

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Need for research

- Stability: better understanding, which requires improved simulation tools and generator models and better predictive tools and metrics
- System operation: agile market rules to make revenue from solutions that are optimal for the system – also taking benefits from local trade
- Adequacy: new methods to optimise the varying generation and flexible loads (from LOLP metrics)
- New ways of modelling loads for all of these!

Based on

- ESIG workshop material, background document ”100% Renewables” by GE, Debbie Lew and Nick Miller

- IEA WIND Task 25 collaborative article (submitted): ” Towards 100% Variable Inverter-based Renewable Energy Power Systems” by Bri-Mathias Hodge, Carlo Brancucci, Himanshu Jain, Gabsu Seo, Benjamin Kroposki, Juha Kiviluoma, Hannele Holttinen, James Charles Smith, Ana Estanqueiro, Antje Orths, Lennart Söder, Damian Flynn, Magnus Korpås, Til Kristian Vrana, Yoh Yasuda

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Thank You!!

Hannele Holttinen

Hannele.Holttinen@recognis.fi

+66 61 473 5255

+358 40 5187055