System impact studies for near 100% renewable energy systems dominated by inverter based variable generation

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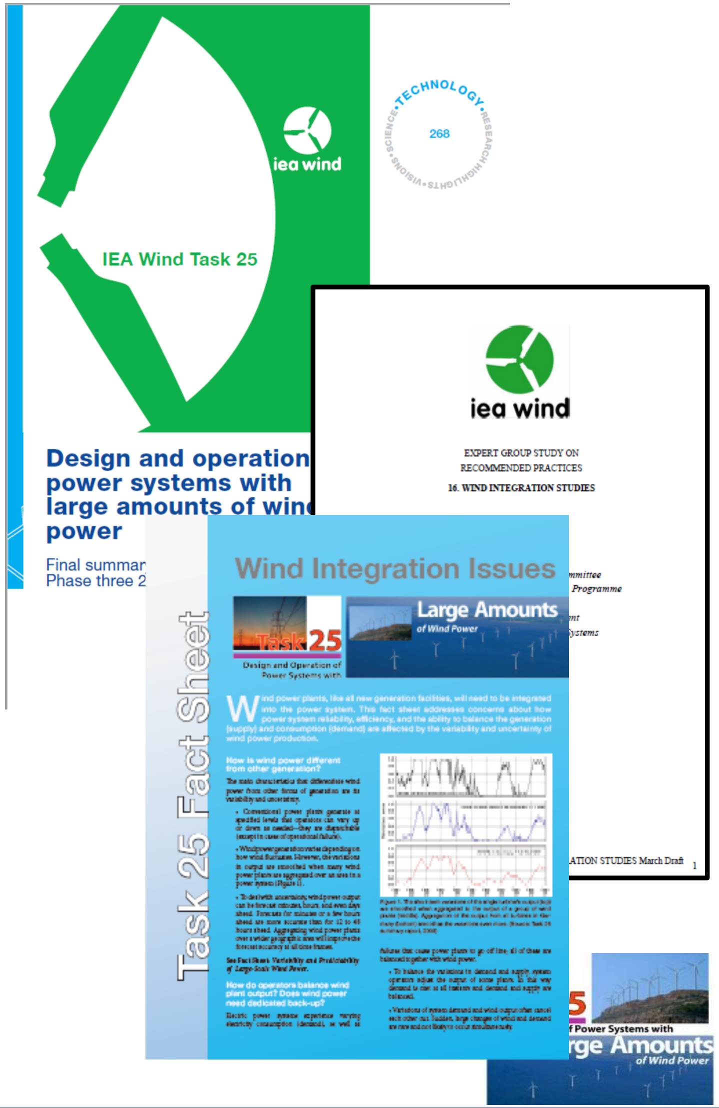
IEA Wind Task 25 –
Best practice of VG integration

- Started in 2006, now 17 countries + WindEurope participate to provide an international forum for exchange of knowledge
- State-of-the-art: review and analyze the results so far (Jan 2019)
- Formulate guidelines- Recommended Practices for Wind/PV Integration Studies (RP Ed.2 July 2018)
- Fact sheets and integration study time series (wind, solar, load…)



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

IEA Wind Task 25 collaborative article

"**System impact studies for near 100% renewable energy systems dominated by inverter based variable generation**", by Holttinen, H., Kiviluoma, J., Flynn, D., Smith, C., Orths, A., Eriksen, P. B., Cutululis, N. A., Soder, L., Korpas, M., Estanqueiro, A., MacDowell, J., Tuohy, A., Vrana, T. K., & O'Malley, M.

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***Abstract*—The demand for low carbon energy calls for close to 100% renewable power systems, with decarbonization of other energy sectors adding to the anticipated paradigm shift. Rising levels of variable inverter-based renewable energy sources (VIBRES) are prompting questions about how such systems will be planned and operated when variable renewable generation becomes the dominant technology. Here, we examine the implications of this paradigm shift with respect to planning, operation and system stability, also addressing the need for integration with other energy vectors, including heat, transport and Power-to-X. We highlight the knowledge gaps and provide recommendations for improved methods and models needed as power systems transform towards 100% VIBRES.**

***Index Terms*— Power system operation, variable inverter based renewables, power electronics, energy systems integration.**

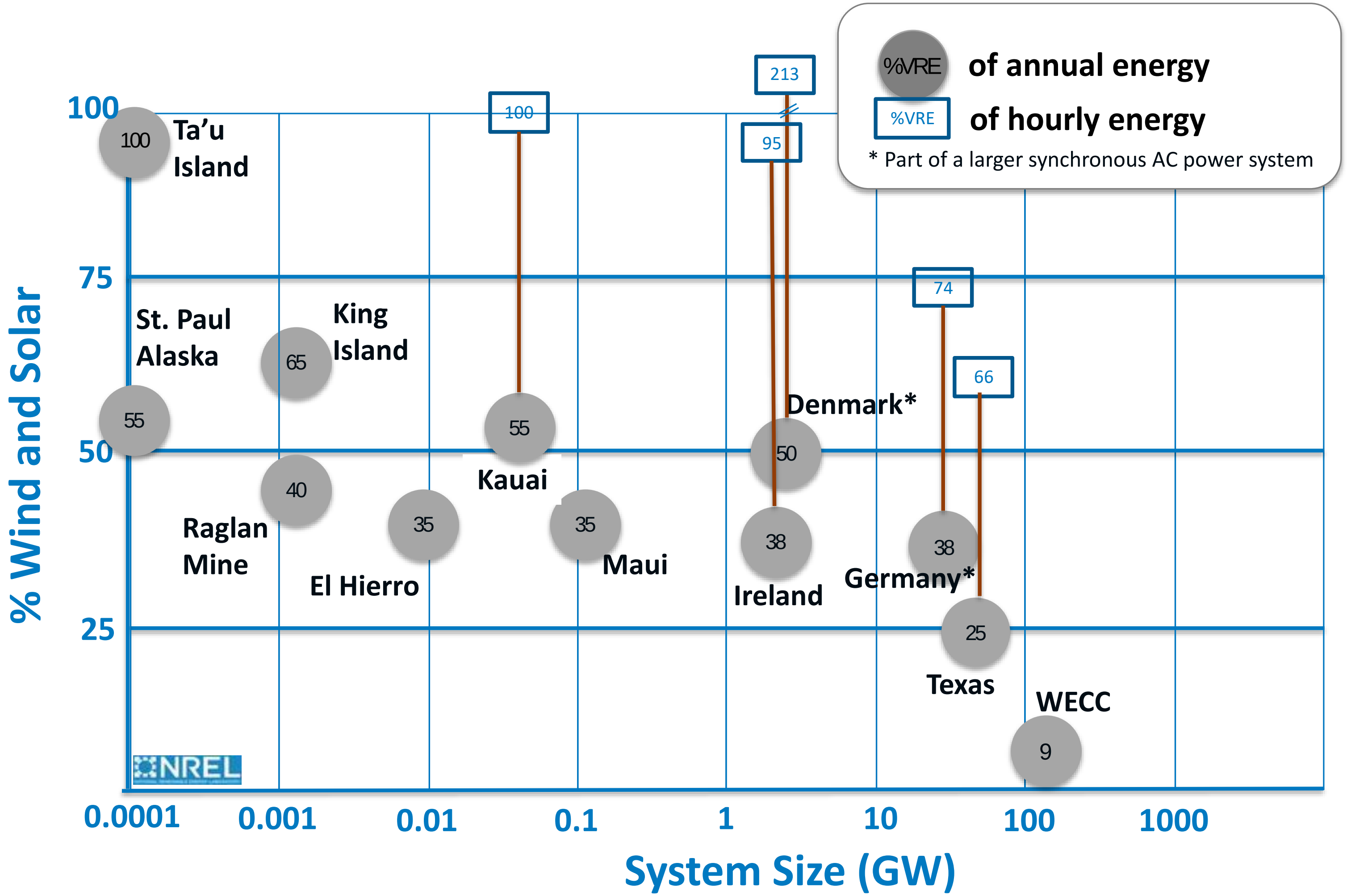
power system. Some of these studies use unit commitment and economic dispatch to capture wind/solar energy variability/ uncertainty, and investigate system and market behavior [6][7]. A number of studies have coupled other energy sectors, e.g. the heat sector [8][9]. Often these studies optimize investments in conversion, transmission, and storage of energy, although the operational detail can vary greatly depending on the applied methodology [10]. However, power system stability is often overlooked as part of 100% (energy-balancing) studies, where the main focus is on hourly comsumption-generation matching. No study comprehensively addresses these short term challenges. Exploring possible operational practices with high VIBRES shares, including power system stability, has only started [11].

Concurrently, real-world experience on operating power

Towards 100% renewables

1. 100% VIBRES region that is part of a larger non-100% VIBRES synchronous power system
   – challenges are about balancing, local aspects of stability and efficient sharing of electricity and reserves with neighbouring areas. Highlights importance of how the neighbouring regions are presented in studies
2. A synchronous system getting closer to 100% VIBRES for short periods of time
   – a challenge on top of these: system-wide stability issues
3. 100% yearly energy from VIBRES
   – a challenge on top of these: the adequacy issue, to meet high demand at low VIBRES contribution

Experience is growing

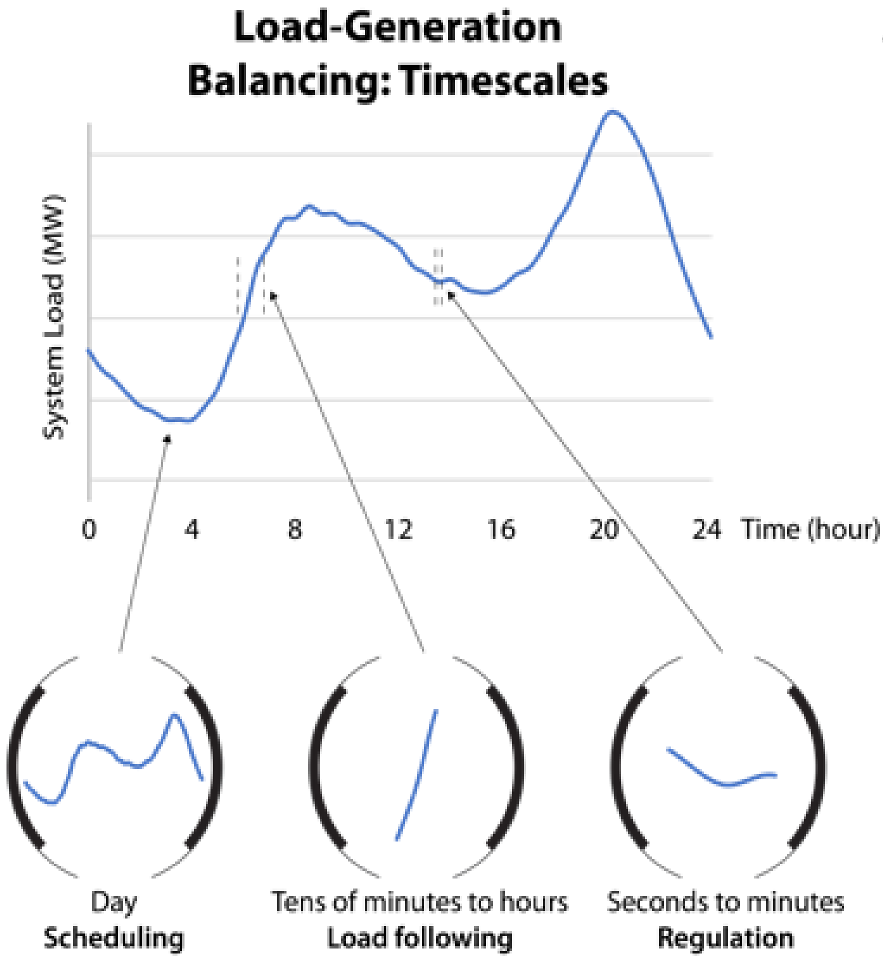


Transition to a (nearly) 100% annual VIBRES system gradually during the next decades

Planning – resource adequacy

- Resilience
  - More data to capture all weather related extreme events
  - integrated planning and operations tools and data. Greater overlap btw operational and planning time scale models
- Cost versus risk: reliability interface needs revisiting
- New metrics, not just LOLP as load not fixed
  - energy system coupling, flexible loads and storages: how to take to models to assess adequacy

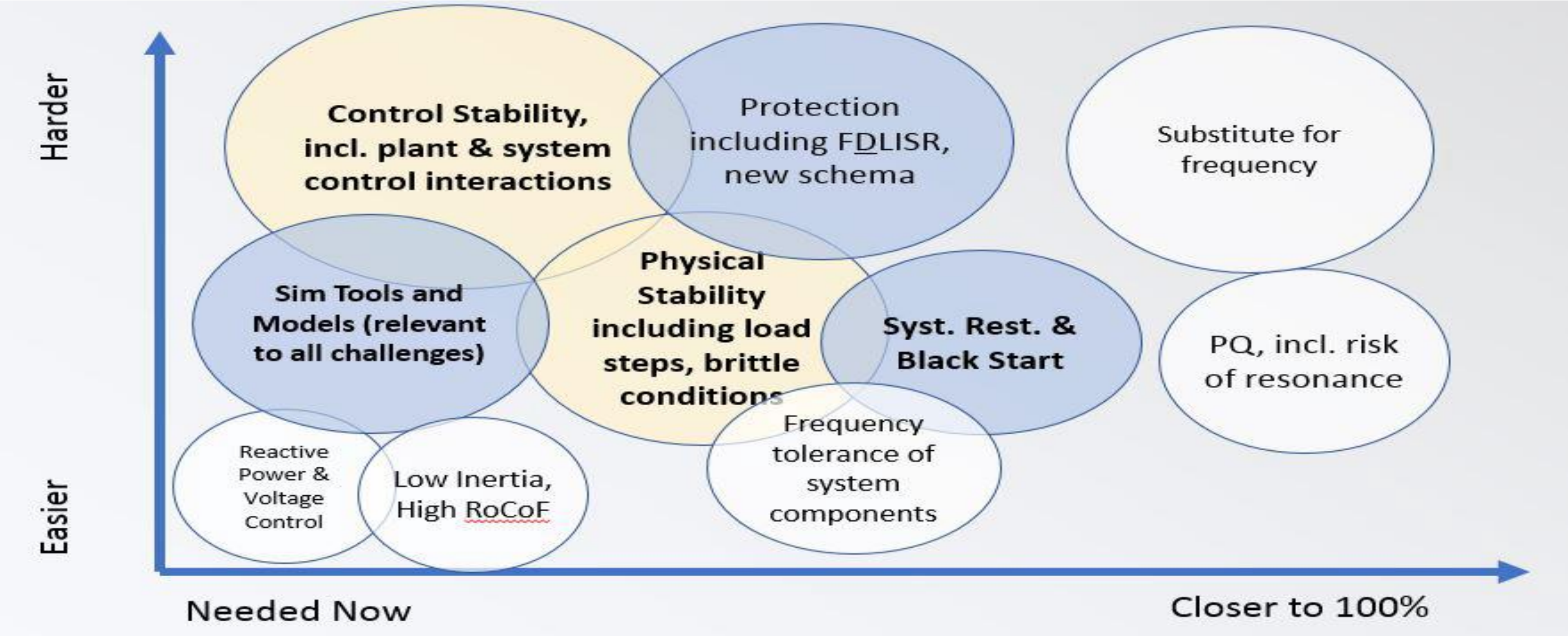
Balancing - flexibility



- Operational challenge: increased need for balancing in all time scales
- Also new flexibilities available, from VIBRES, from loads, from storages
- Increasing need to consider energy sector coupling: requires that not only the 'production' side of a generator modelled, but also the fuel storage and consumption side, as the fuel might be delivered by, or have alternative uses in, a different sector

100% renewables studies so far look at days/hours time scale balancing

Stability challenges map



Summary of recommendations

Larger areas

- the entire synchronous system for stability
- sharing of resources for balancing and adequacy purposes

Complexity

- increasing computational burden capturing VIBRES detail
- higher resolution for larger areas, with extended time series for weather dependent events

Demand and storage

- new types of (flexible) demand and storage,
- further links through energy system coupling

Model integration

- integrated planning and operations methodologies, tools and data. Greater overlap btw operational and planning time scale models
- Flexibility needs and plant capabilities within adequacy methods, and stability concerns for network expansion planning and operating

Cost vs. risk

- reliability interface needs revisiting
- evolution of flexibility and price responsive loads

Thank you

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