Towards a new market Paradigm

- incentivising new technologies and services to support a grid with 100% renewables

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Towards 100% renewables - vision

- Power system operation without synchronous machines
  - Replace mass /inertia with brains /fast controls
  - Capability of shifting from having synchronous machines and not having them – many systems with hydro/geothermal/biomass
- Wind and solar will support the grid in all the ways
  - Grid forming converters
- Combining local smartness of grids with large power systems
  - Capability of autonomy locally when needed,
  - Capability of shifting back to interconnected system

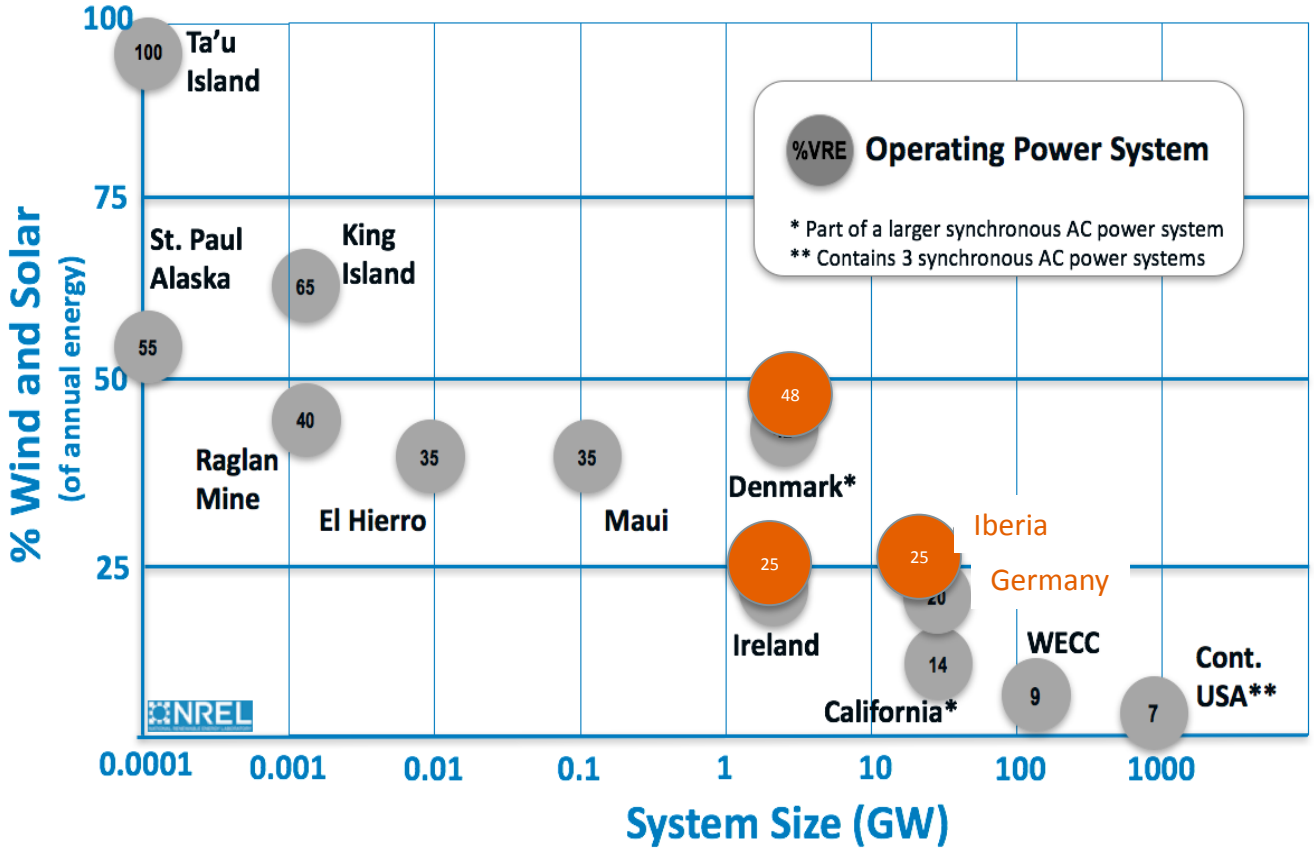
Market (r)evolution

- Towards real time
  - utilising real time information from loads/prosumers
- Adding local markets
  - Use of flexibility also locally – not just for TSOs
  - Peer-to-peer emerging
- Markets set prices and value for flexibility, in all time scales
  - Incentivise offering to markets instead of ”local islands as black boxes”
- New products: Faster products, reactive power, grid forming, ..

Towards 100% renewables – how much storage?

- Amount of storage needed for wind and solar will depend on future flexible loads
  - Also how large systems with max smoothing from combining wind and solar, and using their flexibility and grid support
- Electrification, power-to-X, and other industrial processes where full load hours is less than 6000h/a
  - Consumption that is used when wind/solar available
  - Heat demand with help of thermal storages
  - Electric vehicles with V2G could bring most of short term storage needs

Experience of high shares of variables – need to have system operators' confidence



Operational practices from experience of integration

- First 10-20 % share of wind:
  - Updated information from on-line production and forecasts. Possibility to curtail in critical situations
  - Transmission recognized as a key enabler, with regional planning efforts
- Higher shares of wind:
  - Technical capabilities of wind power plants used in grid support, also stability
  - Generation flexibility and adequacy
  - Market design and value of wind