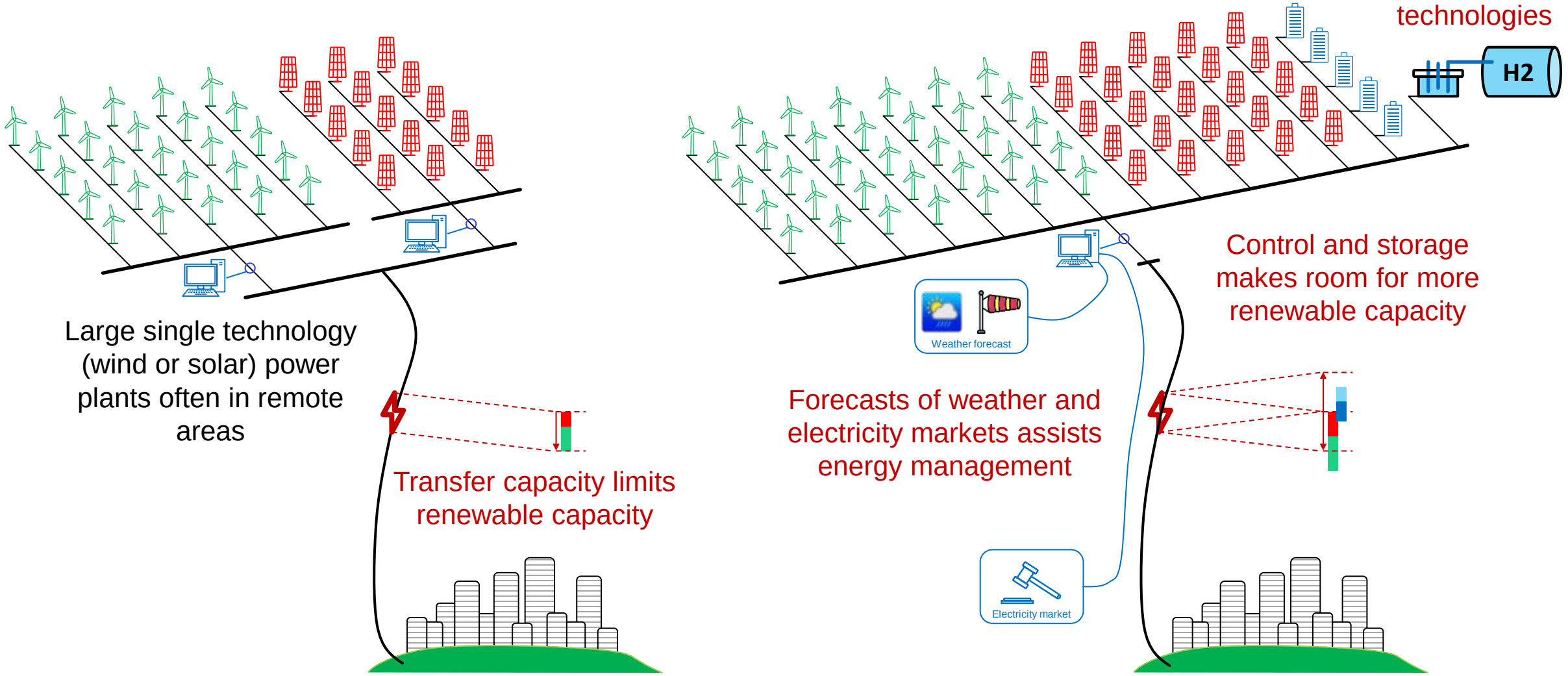
Prof. Poul Sørensen

Hybrid Power Plant, best practise and international standards

Why utility scale hybrid power plants?

Potential extension with emerging energy conversion technologies

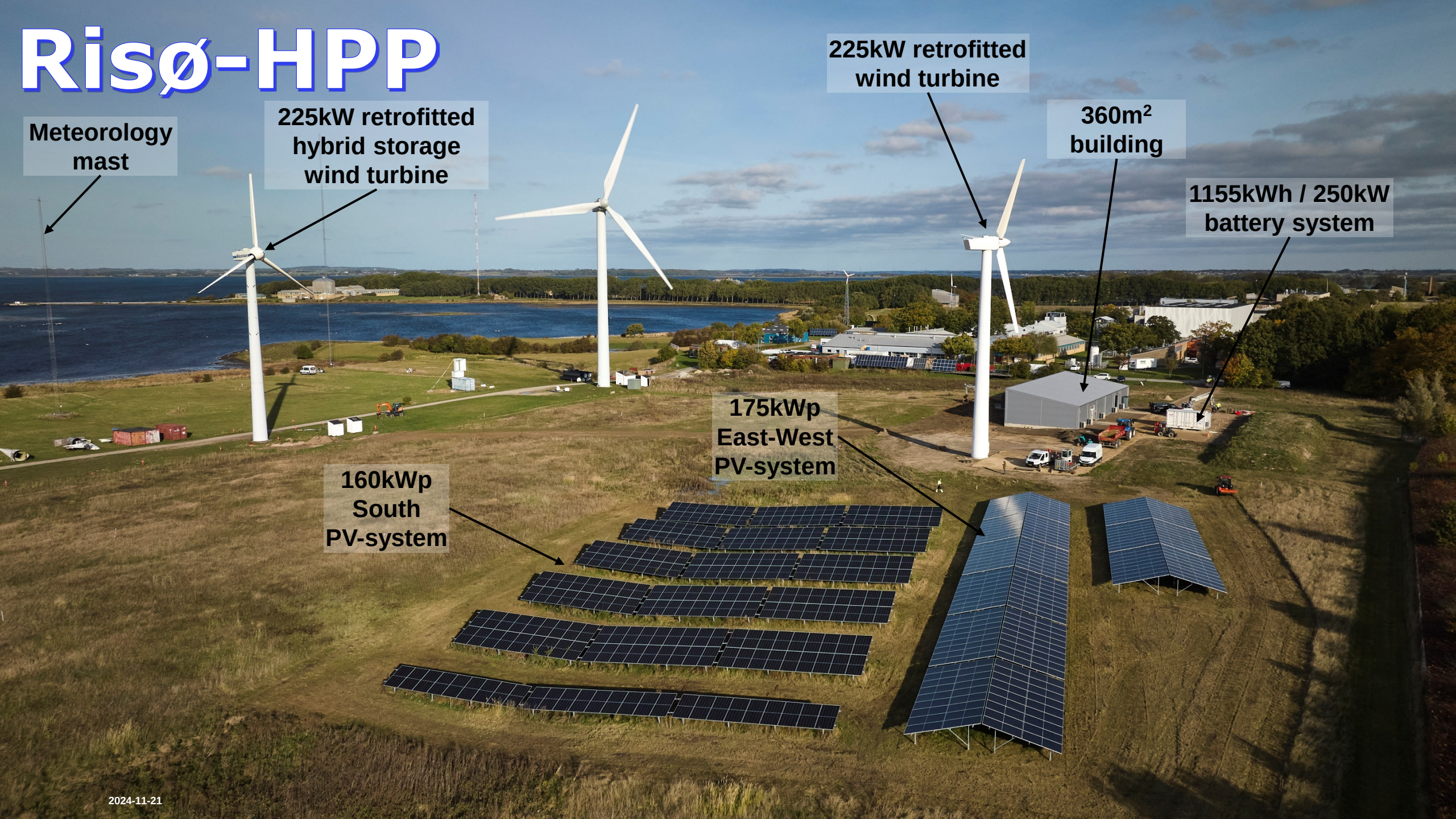


Large single technology (wind or solar) power plants often in remote areas

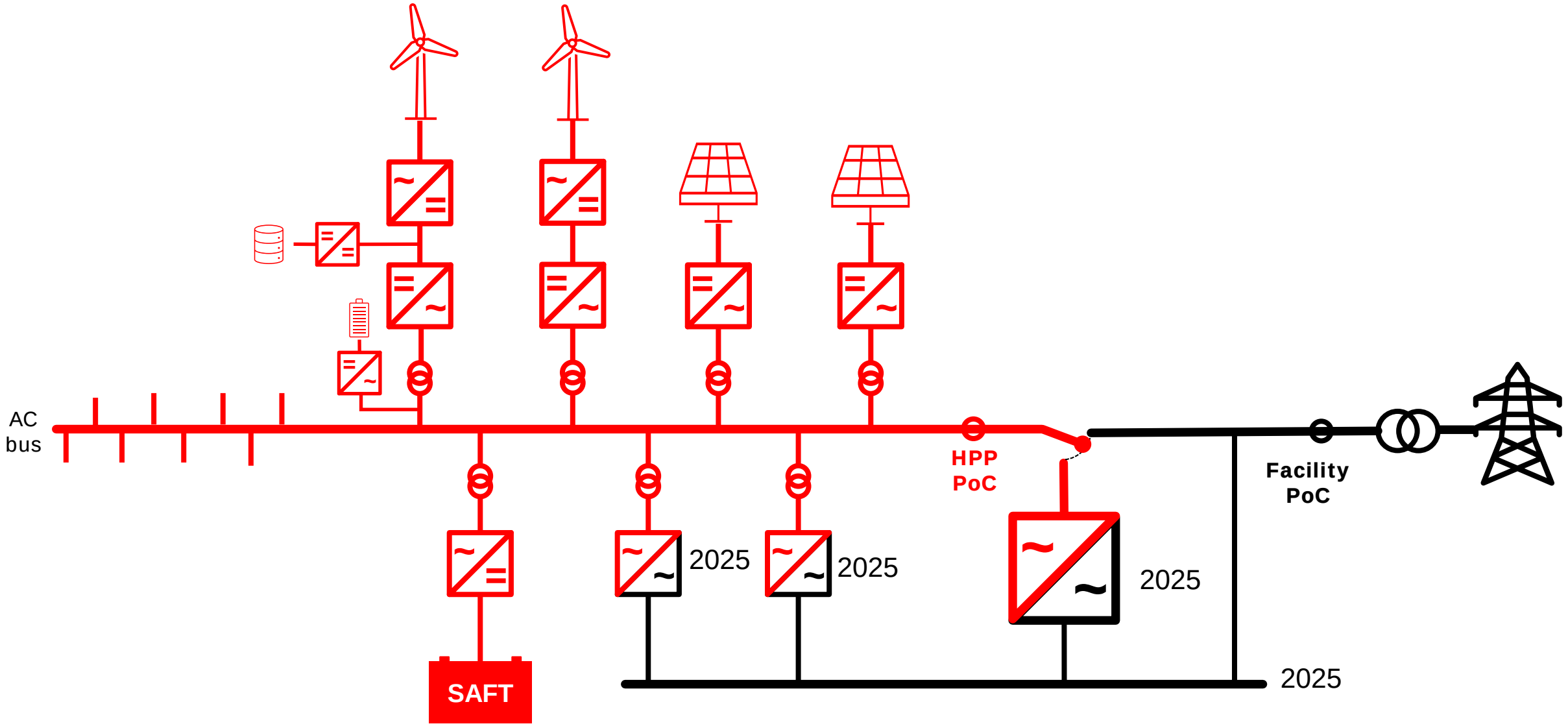
Transfer capacity limits renewable capacity

Forecasts of weather and electricity markets assists energy management

Control and storage makes room for more renewable capacity

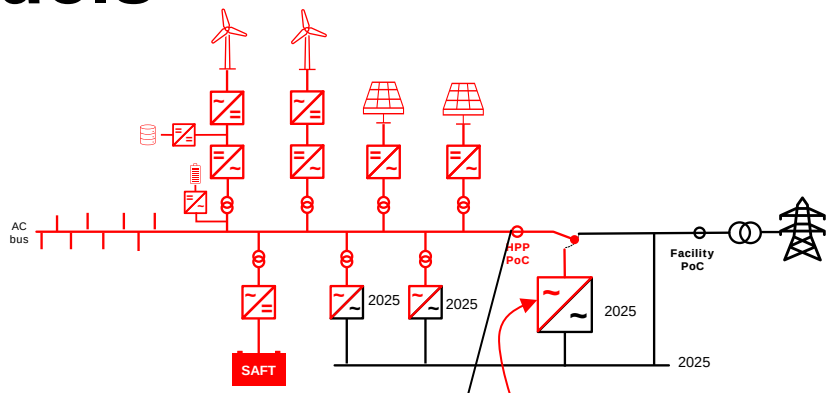

Risø-HPP
Meteorology mast
225kW retrofitted hybrid storage wind turbine
225kW retrofitted wind turbine
360m²
building
1155kWh / 250kW battery system
175kWp East-West PV-system
160kWp South PV-system
2024-11-21

Risø Hybrid Power Plant – phase 1



Validation of grid connection models

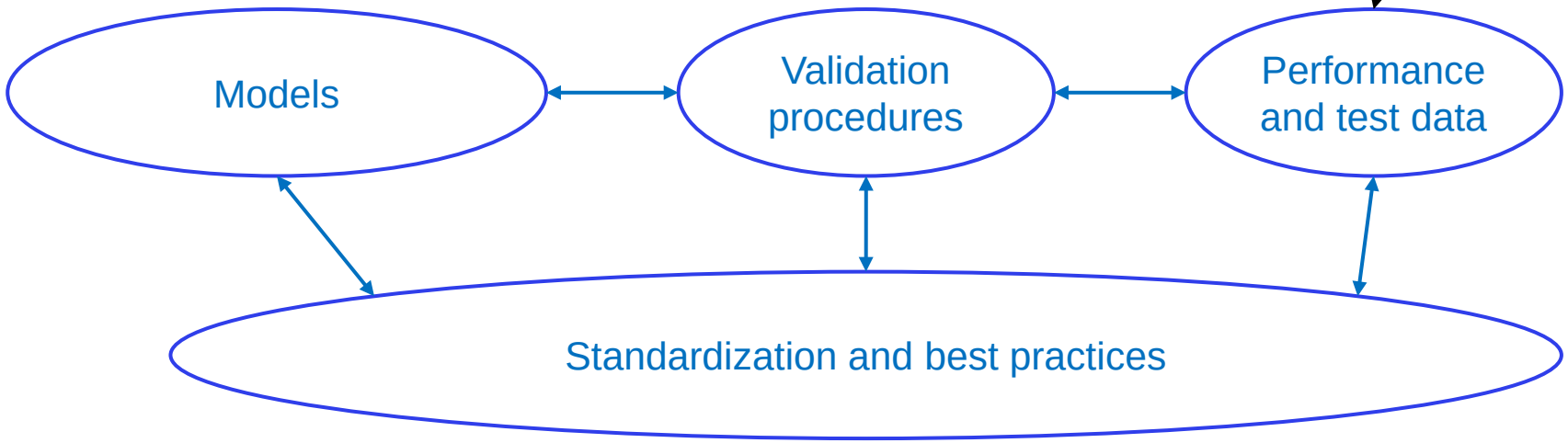
- Grid operators require validated plant models to simulate stability in power system:
  - Traditional stability:
    - RMS (ms time step) models
  - New stability needs with high shares of IBR :
    - EMT (µs time step) models
    - Frequency domain (up to 9kHz) models



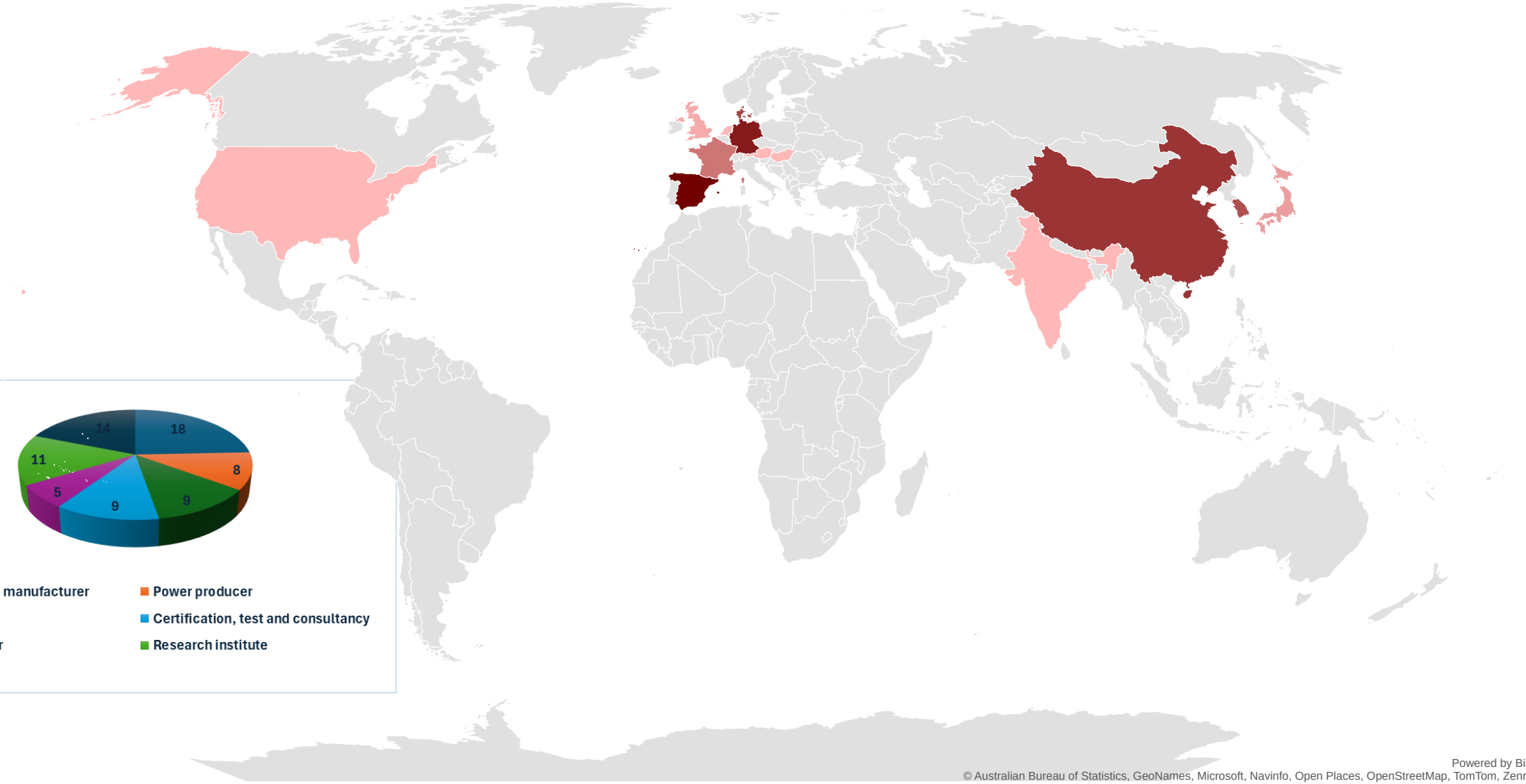
Advanced individual units tests

and HPP level tests

Controlled grid scenarios



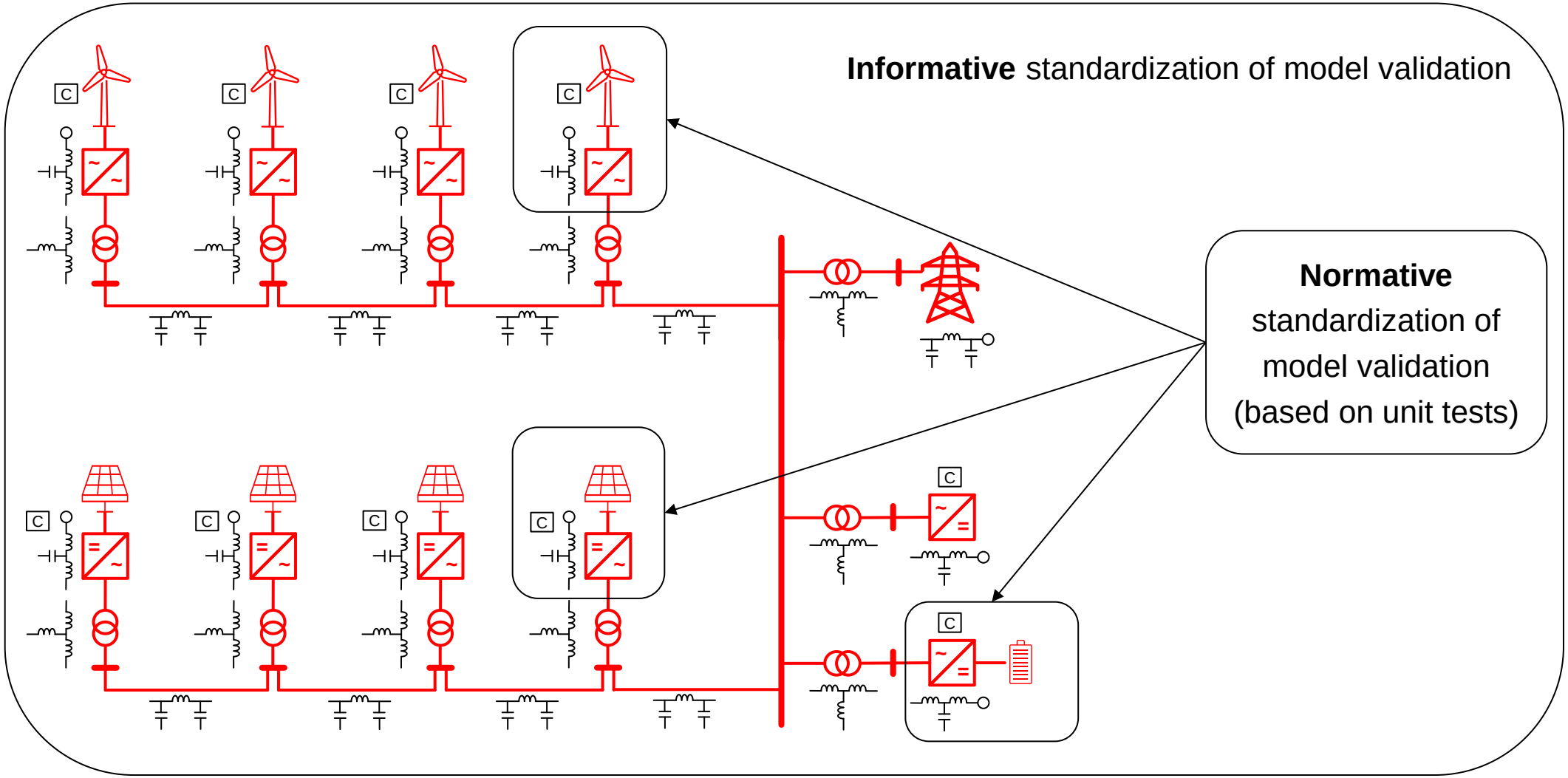
IEC 61400-27 working group members



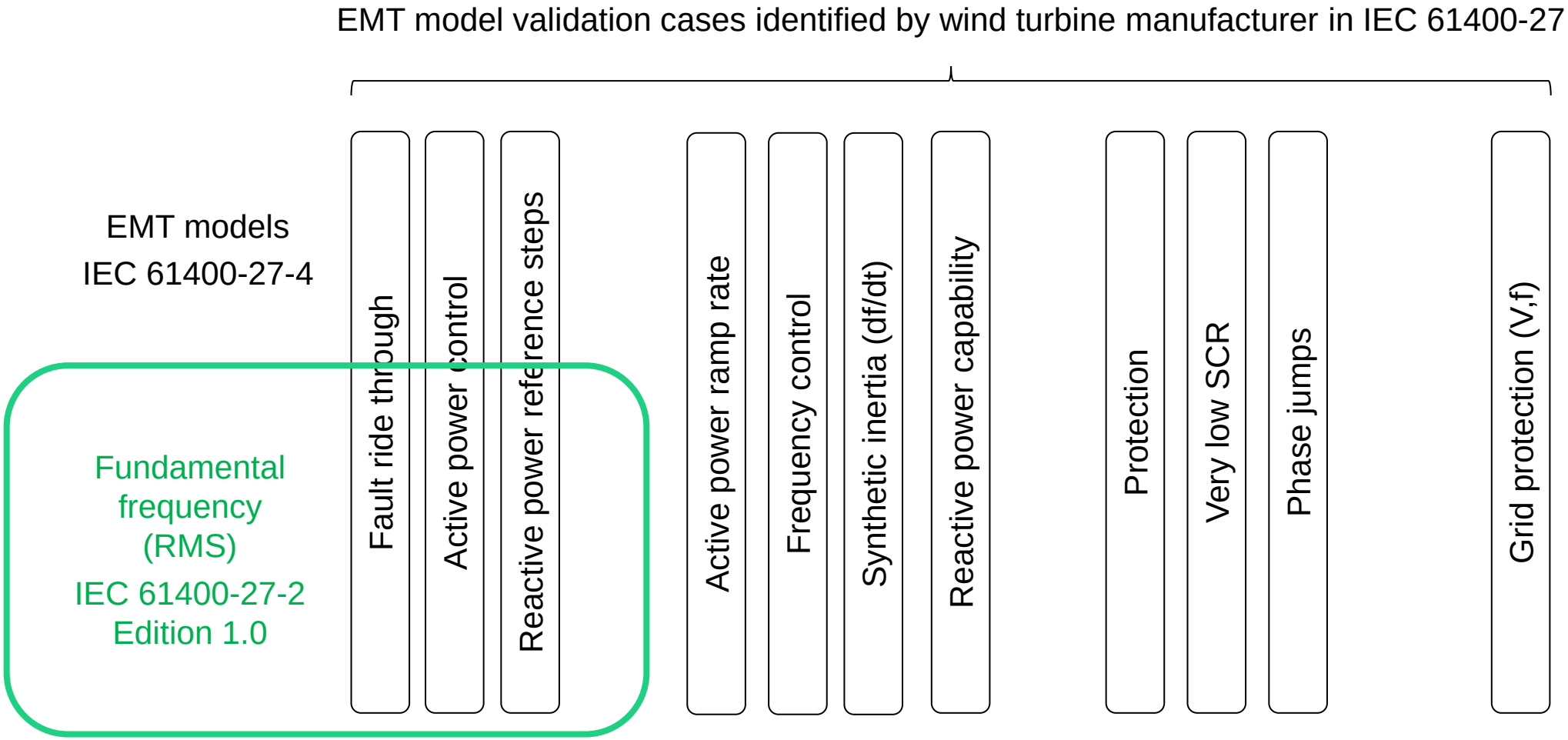
WG27 meeting 2024-10-07 at Fingrid



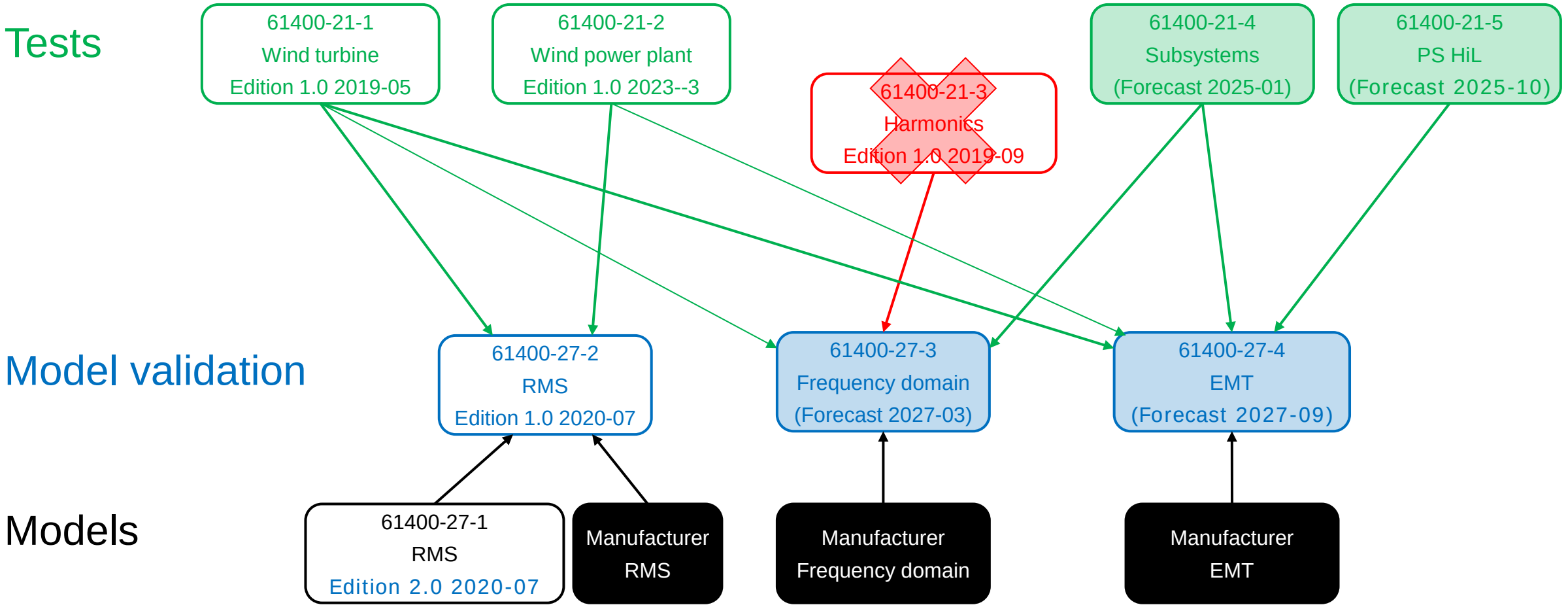
IEC 61400-27-3
Frequency domain modelling complexity



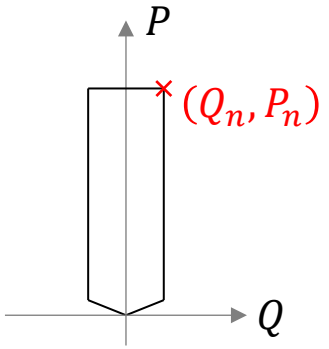
IEC 61400-27-4
Validation cases for time series simulations



IEC 61400 Wind Energy Generation Systems
Standards supporting grid connection
– also for solar, storage and other IBR



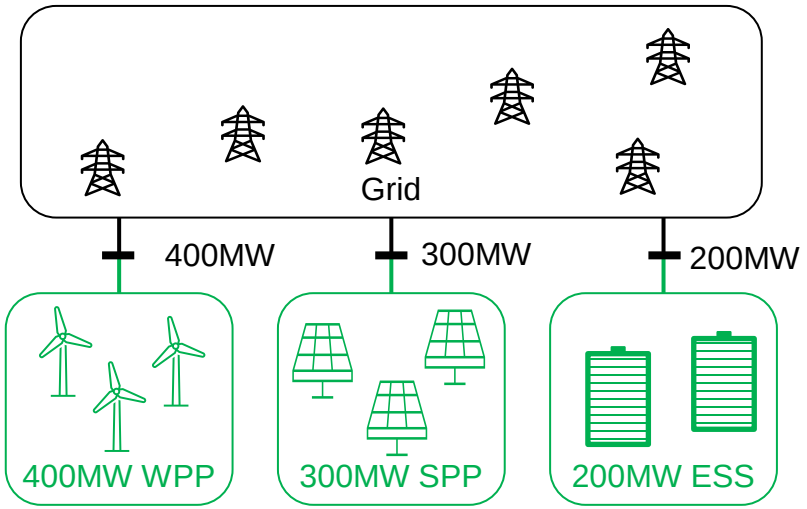
Reactive power capability requirement



General requirement to reactive power capability Q_n

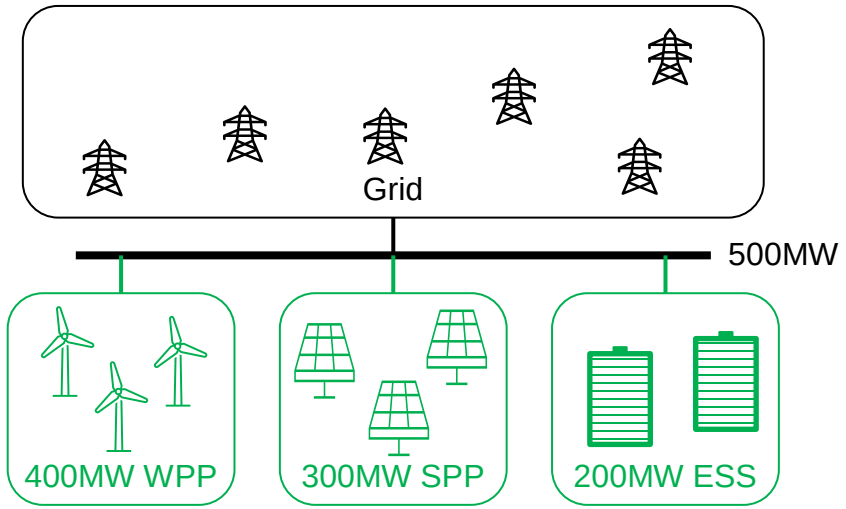
$$\cos(\varphi) = 0.95 \implies Q_n/P_n = 0.33\text{MVAR/MW}$$

Individual grid connections



- Total required reactive power capability
  $Q_n = 400 \cdot 0.33\text{MVAR} + 300 \cdot 0.33\text{MVAR} + 200 \cdot 0.33\text{MVAR} = 297\text{MVAR}$

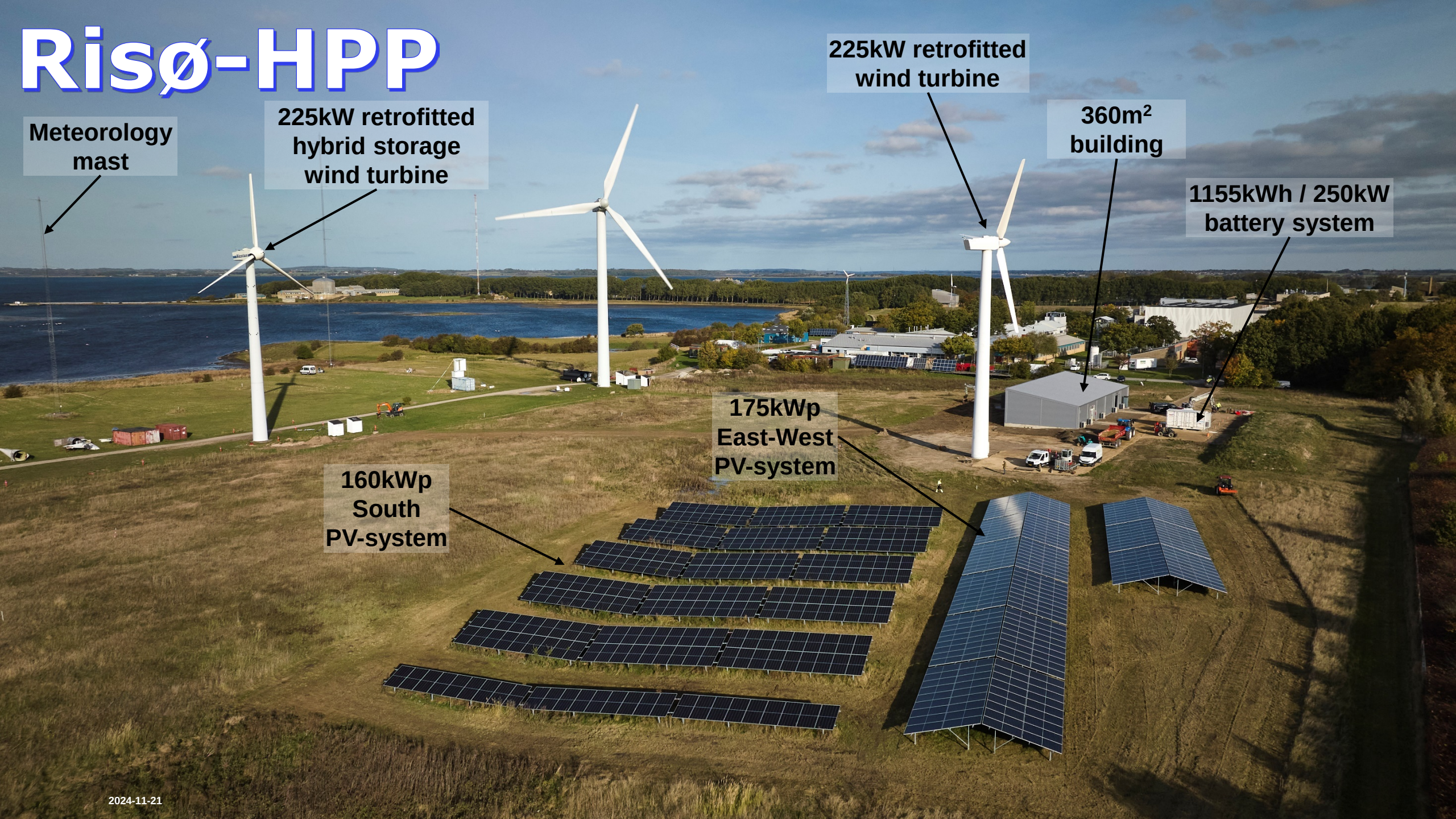
Co-located grid connection



- Required reactive power capability of co-located plant
  $Q_n = 500 \cdot 0.33\text{MVAR} = 165\text{MVAR}$

Regulatory challenge

- **Grid codes recognizing the value of overplanting and co-location**
  - Indian Electricity Grid Code Regulations. Published 2023 by Central Electricity Regulatory Commission
  - DRAFT Energinet requirements to co-located and/or overplanted production, consumption and storage facilities
  - DRAFT ACER (European regulator) recommendations to update Requirements for Generators:
    - “The requirements on electricity storage are considered to be the same as those on power generation modules unless explicitly stated otherwise in this Regulation”
    - “Electricity storage integrated to a power-generating module” ... “should be considered as part of such module while its capacity should not count towards the power-generating module capacity”


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