RENEWABLES

Integrating large shares of variable Renewables

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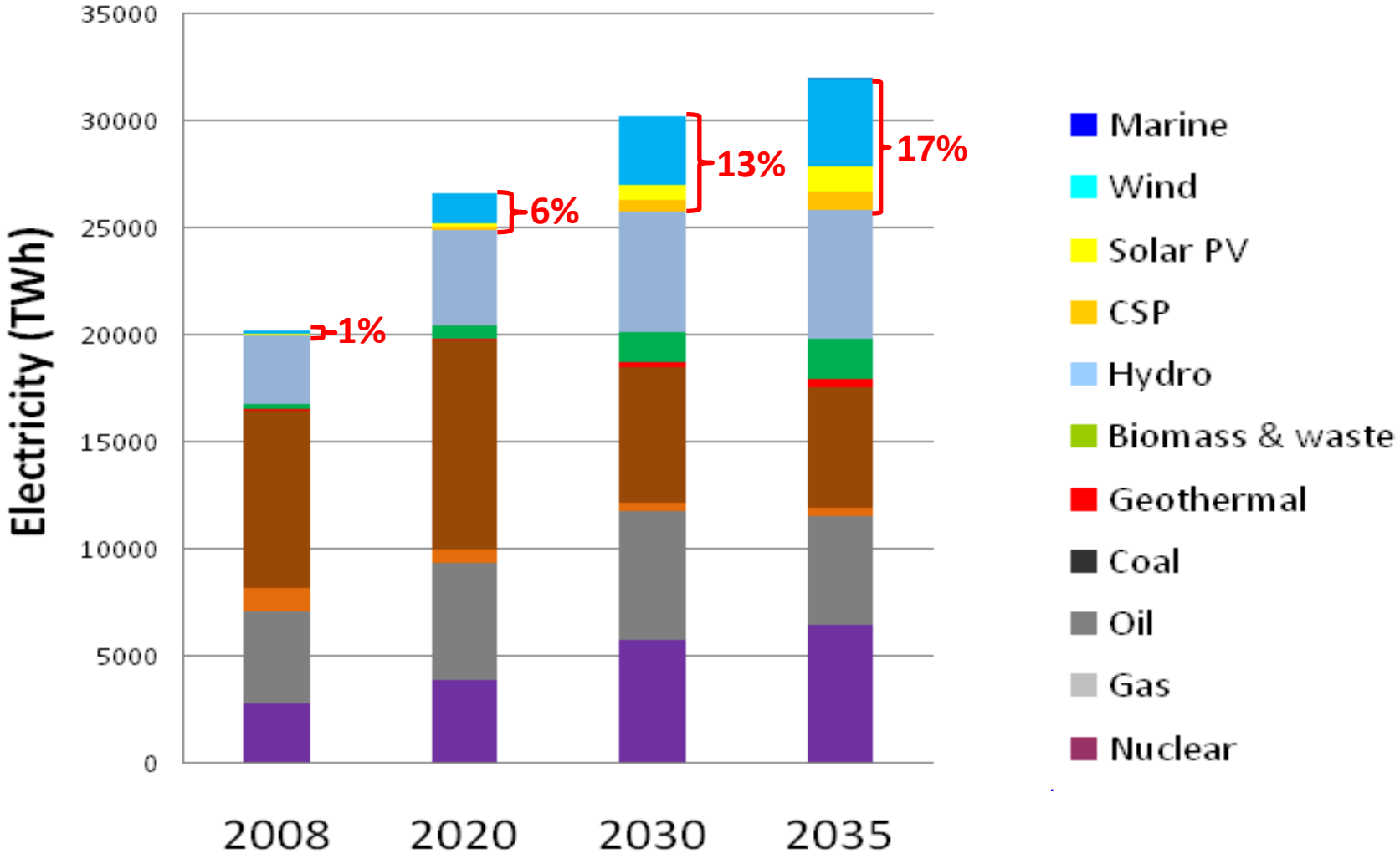
International Energy Agency

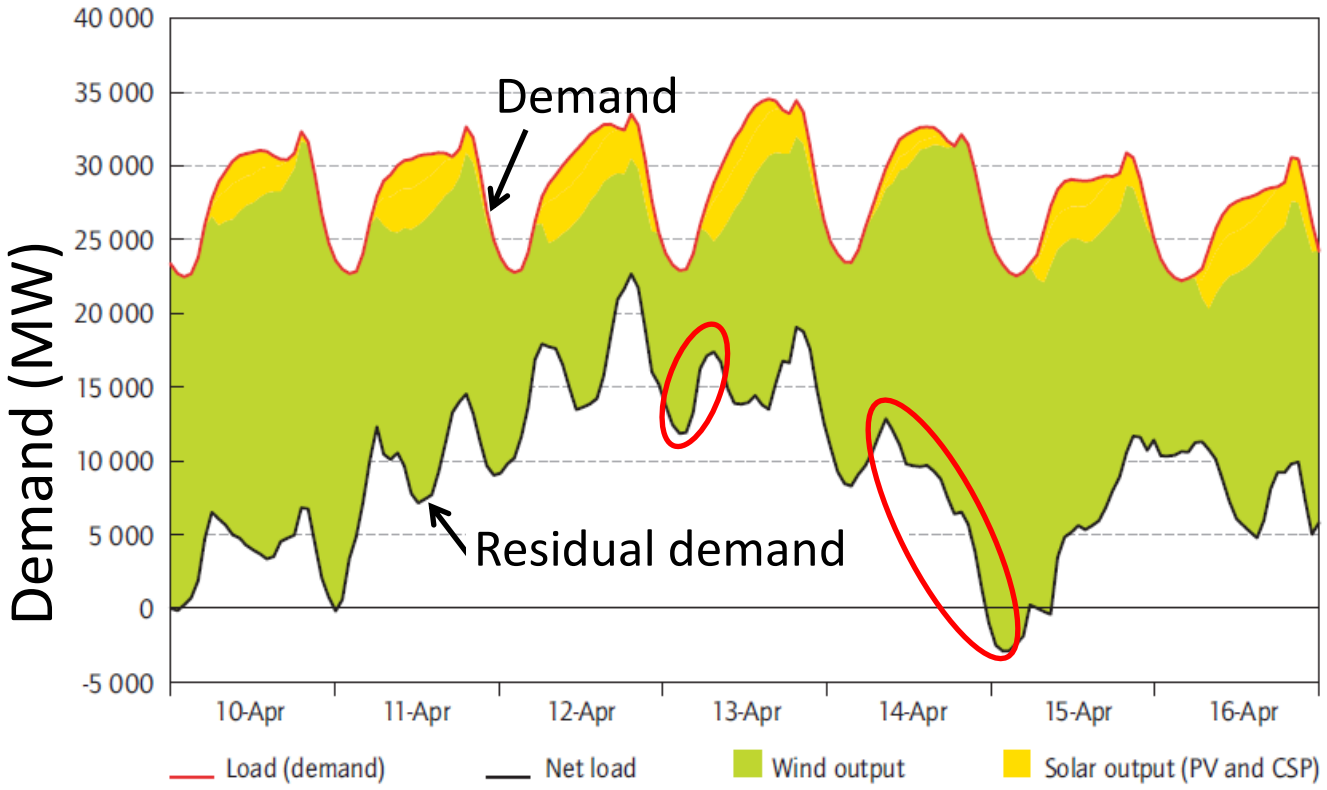
WEO 450 global electricity – variable renewables



[Source: IEA World Energy Outlook 2010]

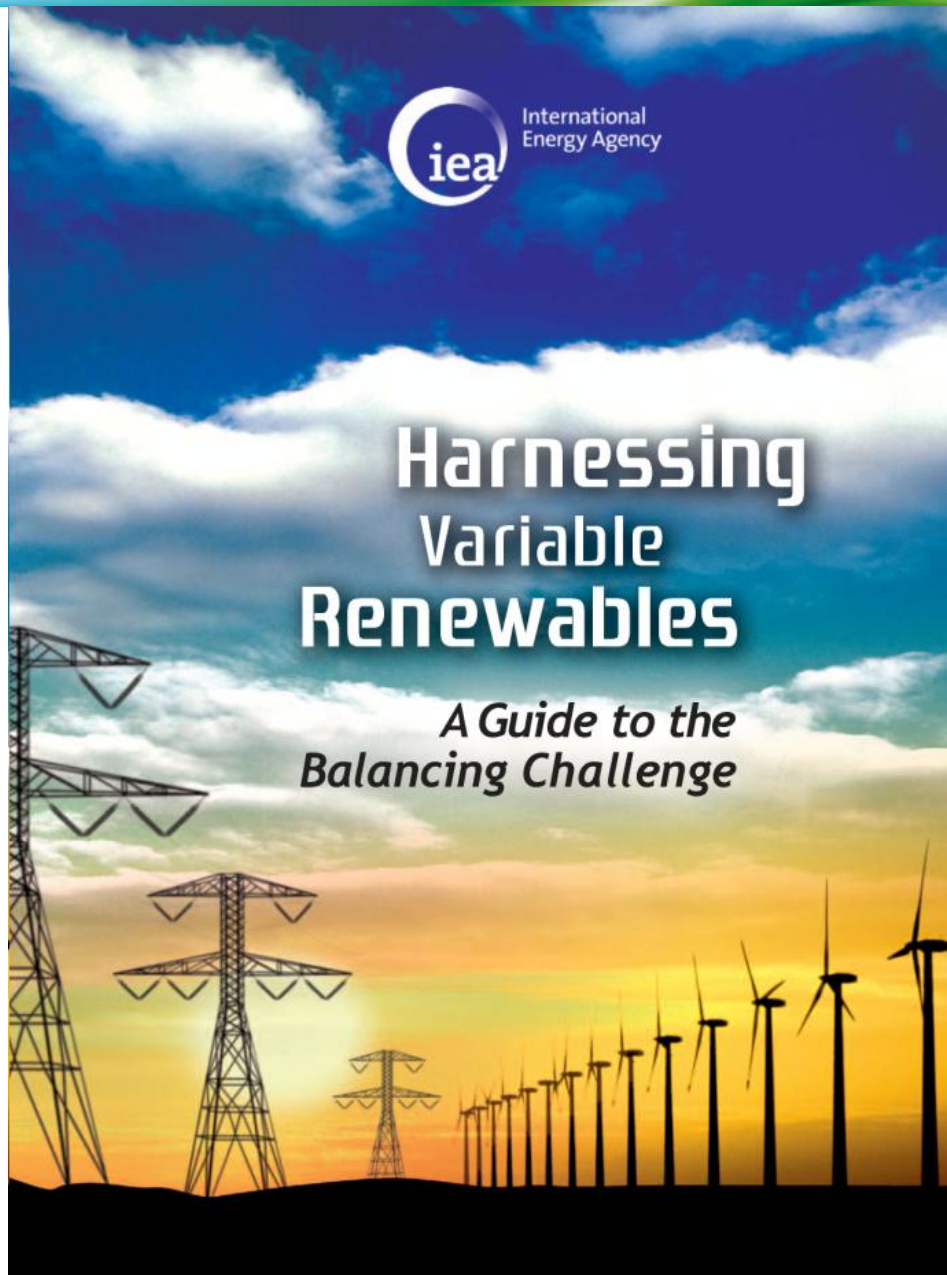
A power system perspective is important

- **Variability is not new** to power systems
- But, at high shares of variable renewables such as wind, it does get **bigger**



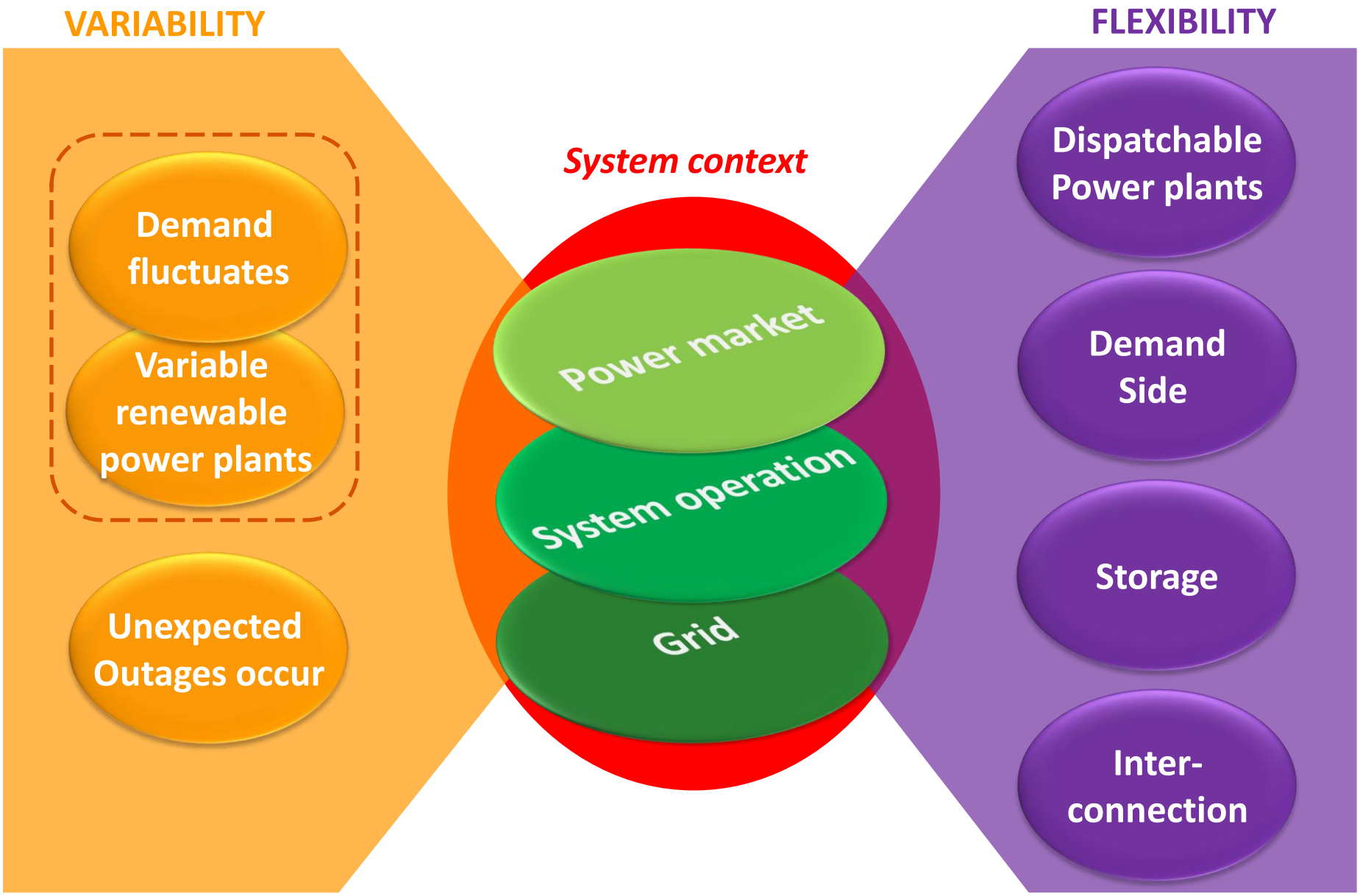
System integration issues

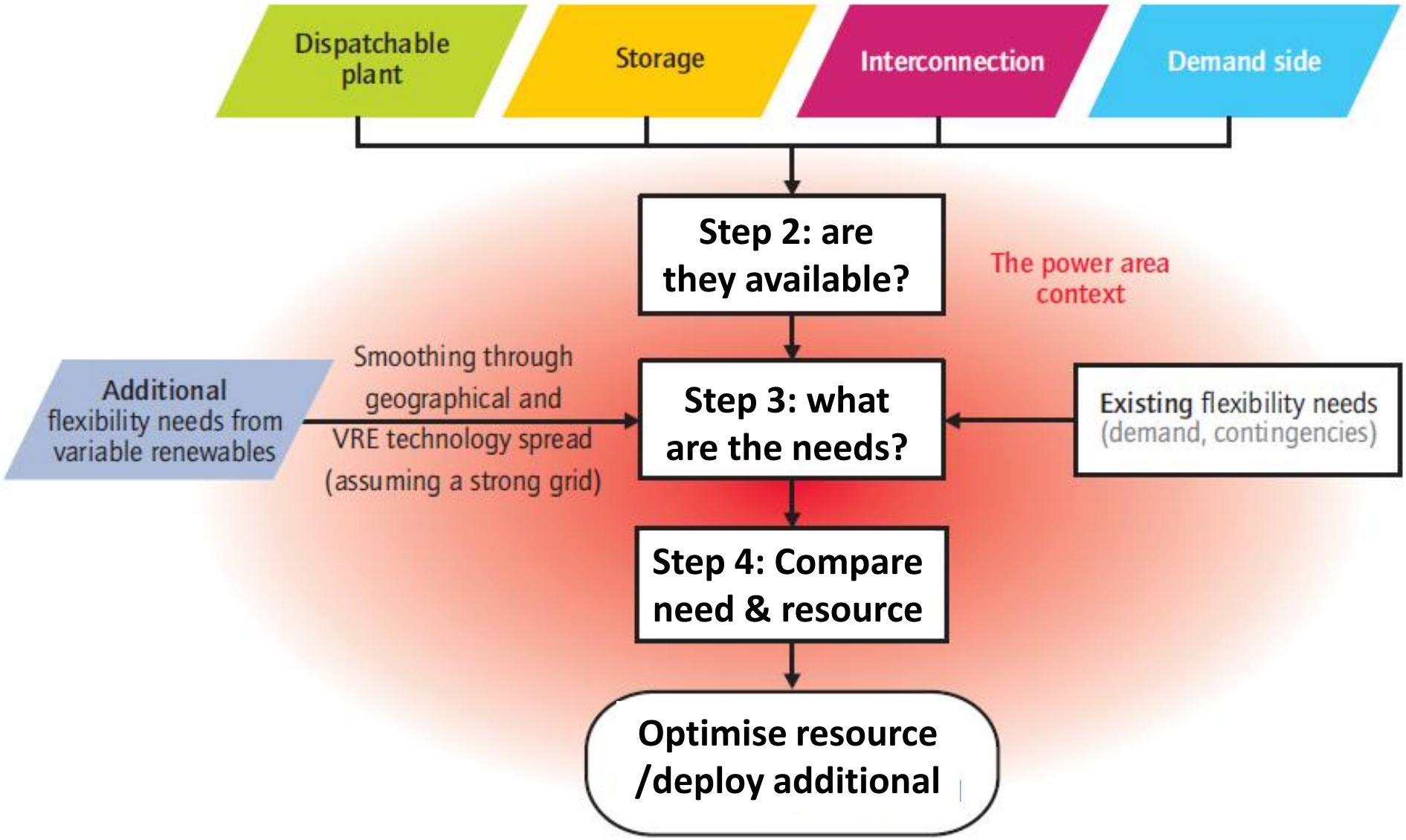
Focus of the IEA's ongoing project *Grid Integration of Variable Renewables*

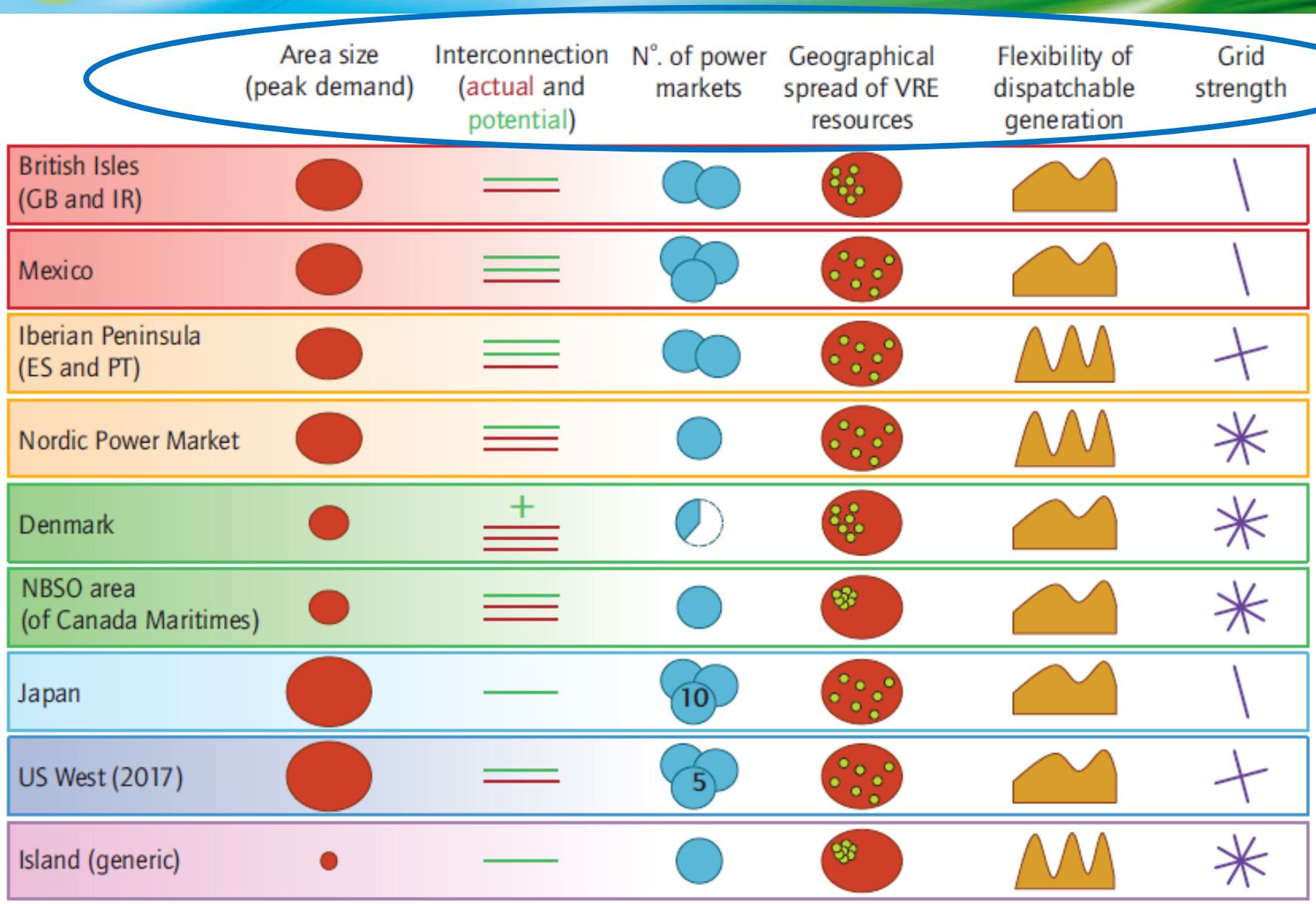


Central concept: power system FLEXIBILITY

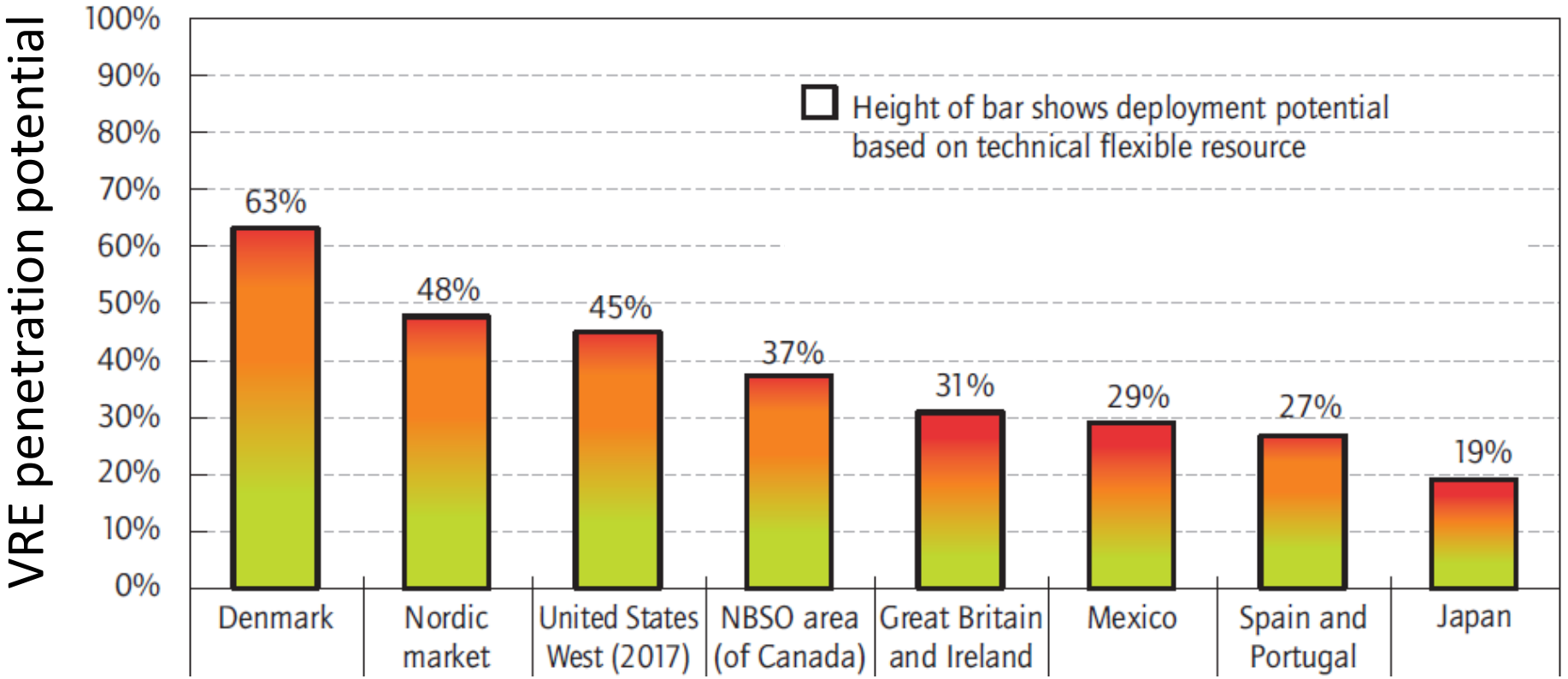
- The **ability to increase/decrease supply or demand** – in response to fluctuations in either
  - To a large **extent**, **rapidly**, **frequently**
  - E.G.: if wind output drops by 1GW over 2 hours, that 1GW must be made available from other flexible resources on the system within that period
- So, the greater the flexibility of the system, the greater its tolerance for variability
- Variability and flexibility are two sides of a balancing equation



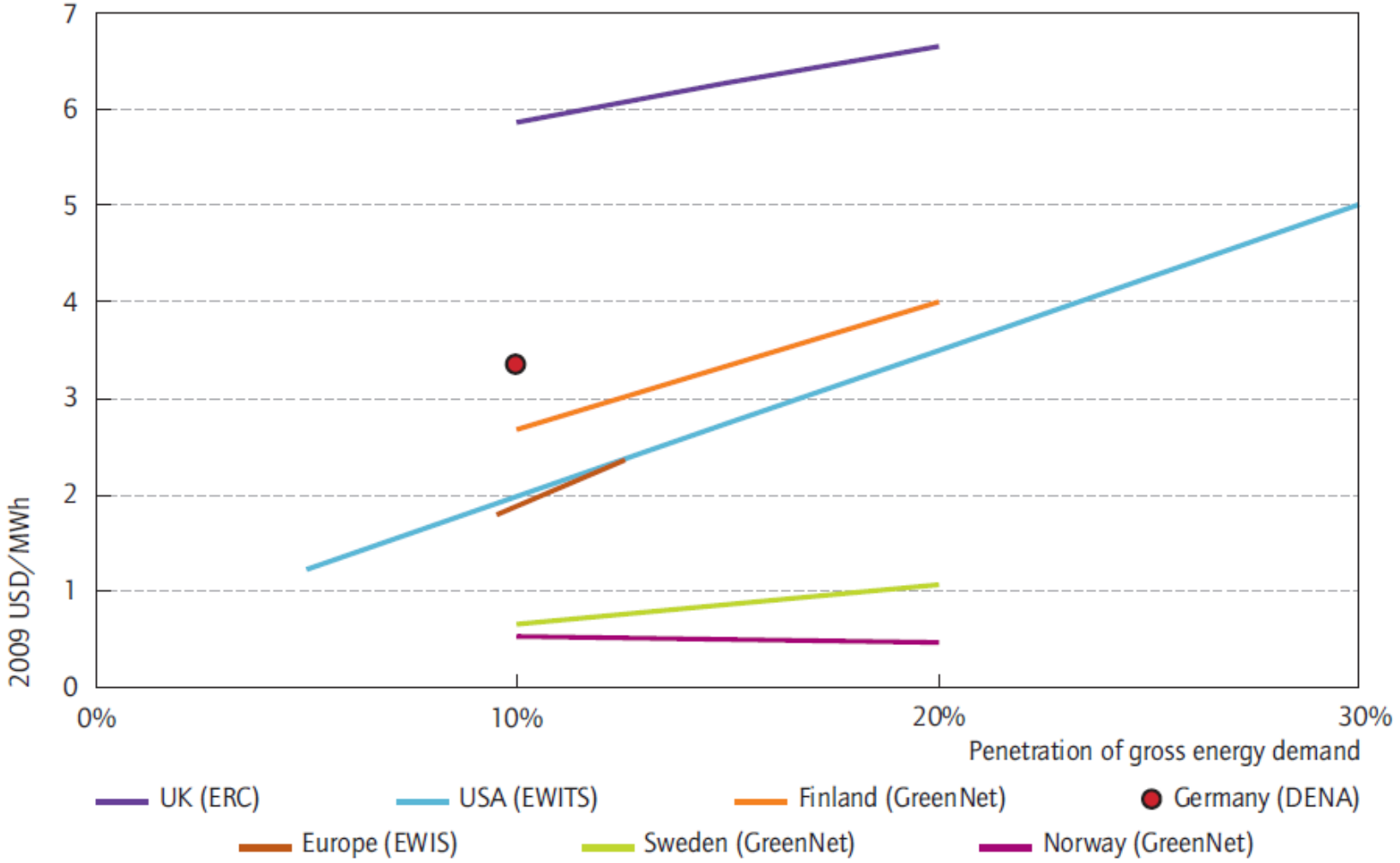

Step 1: Identify flexible resources
Dispatchable plant
Storage
Interconnection
Demand side
Step 2: are they available?
The power area context
Additional flexibility needs from variable renewables
Smoothing through geographical and VRE technology spread (assuming a strong grid)
Step 3: what are the needs?
Existing flexibility needs (demand, contingencies)
Step 4: Compare need & resource
Optimise resource /deploy additional


Area size (peak demand)
Interconnection (actual and potential)
N°. of power markets
Geographical spread of VRE resources
Flexibility of dispatchable generation
Grid strength
British Isles (GB and IR)
Mexico
Iberian Peninsula (ES and PT)
Nordic Power Market
Denmark
NBSO area (of Canada Maritimes)
Japan
10
US West (2017)
5
Island (generic)

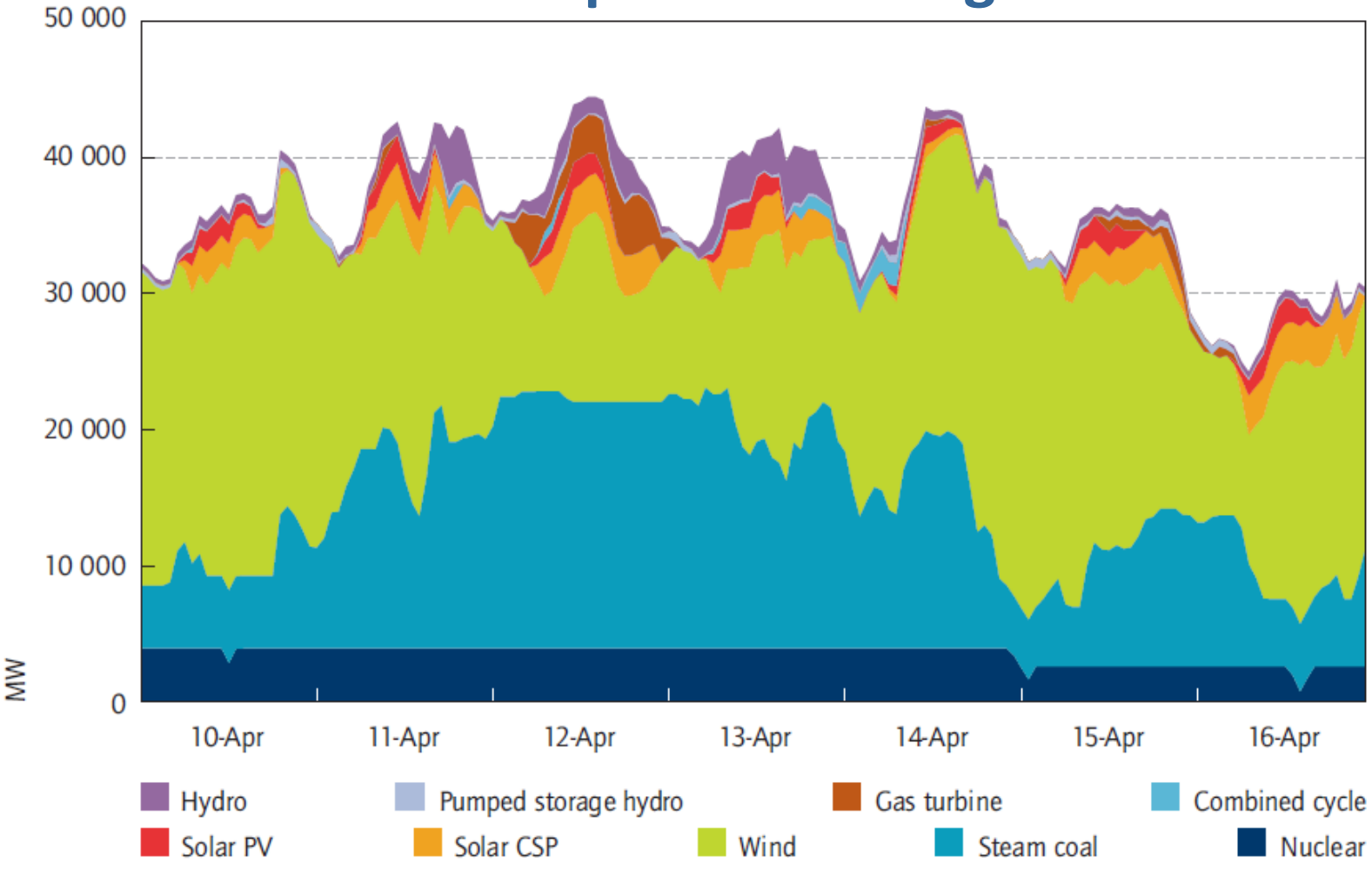
Snapshot of present penetration potentials



Balancing costs appear to range from USD 1 – 7 per MWh at 20% wind, depending on region



Impact of variable renewables on output of conventional plants – a tough week



Source: *Western Wind and Solar Integration Study*, GE Energy for NREL (2010)

Key messages

- Variability unlikely to be an issue at low shares, and high shares are manageable
  - No general ceiling on VRE potential
- Flexibility is the antidote to variability
- More flexible resources exist then commonly thought
  - Gas and hydro, but also coal, even nuclear for extreme cases
  - Demand response, interconnections, storage
- A strong, intelligent grid is critical
- Large, liquid markets using forecasts are better
  - Balancing costs are likely to be lower
- But lost revenue may drive off key flexible plants
  - A flexibility incentive may be the solution
  - Power market (re)design will at the core of future work

- **GIVAR III** (through 2012) will:
  - Identify **principals** of good market design
  - Study impact of VRE on the viability of **flexible power plants**, and system **adequacy**

- **Publication**
  www.iea.org/publications
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