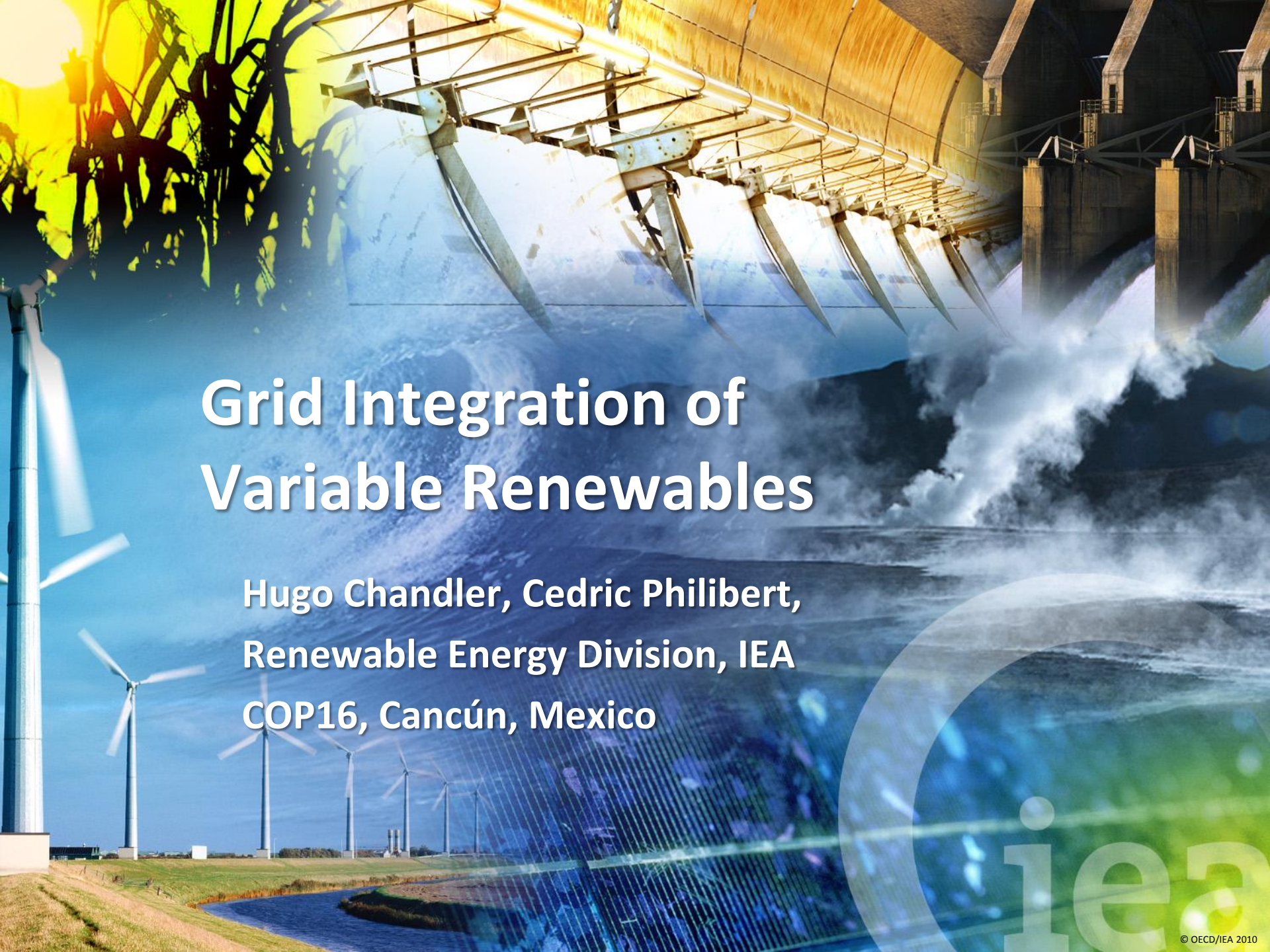


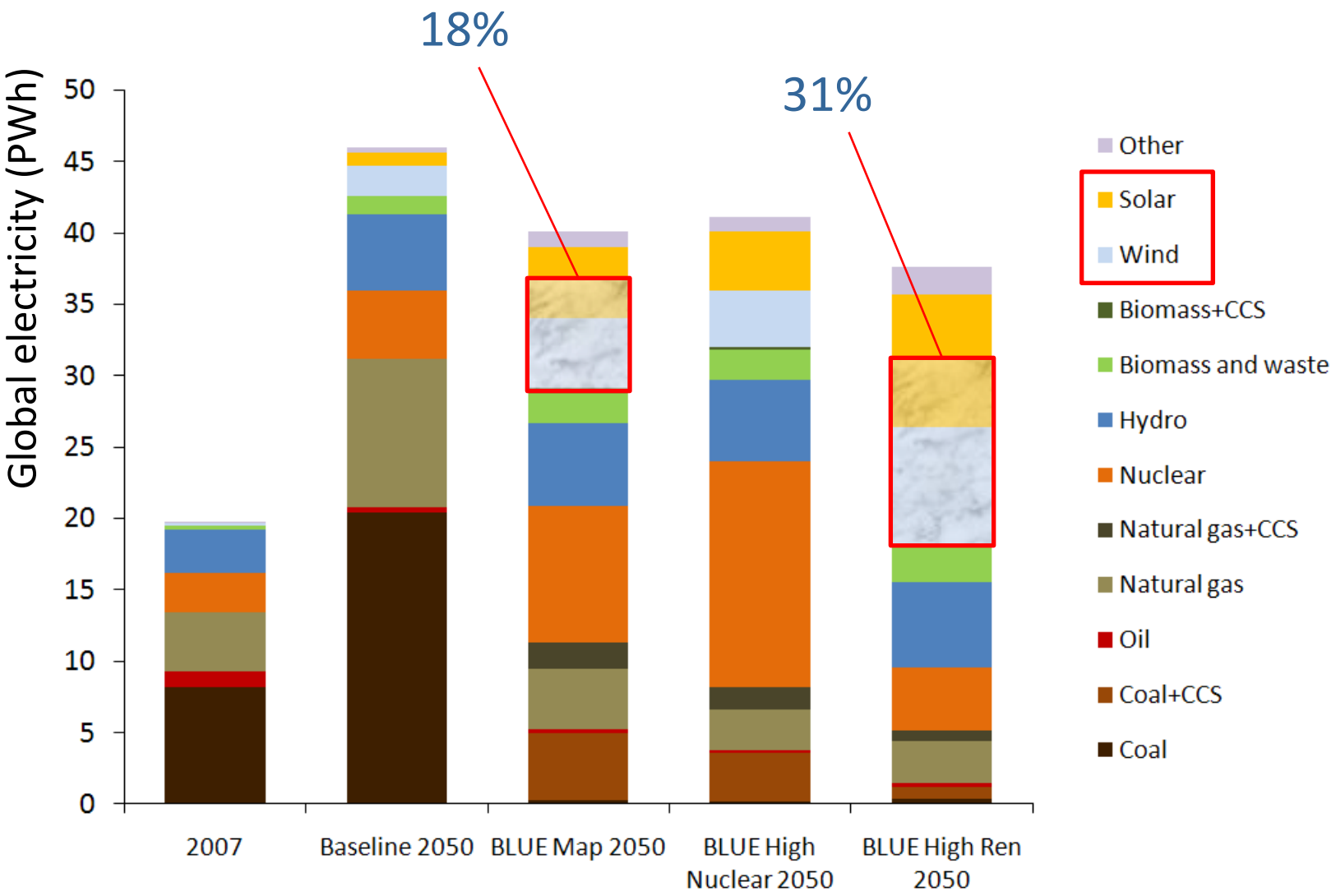
Grid Integration of Variable Renewables

Hugo Chandler, Cedric Philibert,
Renewable Energy Division, IEA
COP16, Cancún, Mexico

GIVAR Steering Committee

- Implementing Agreements
  - Wind, PV, storage, transmission, demand side
- Funding countries
  - Norway, Canada, Ireland, Mexico
- Private sector
  - Iberdrola, GE Energy, ENEL

Variable renewables in 2050



Objectives and focus

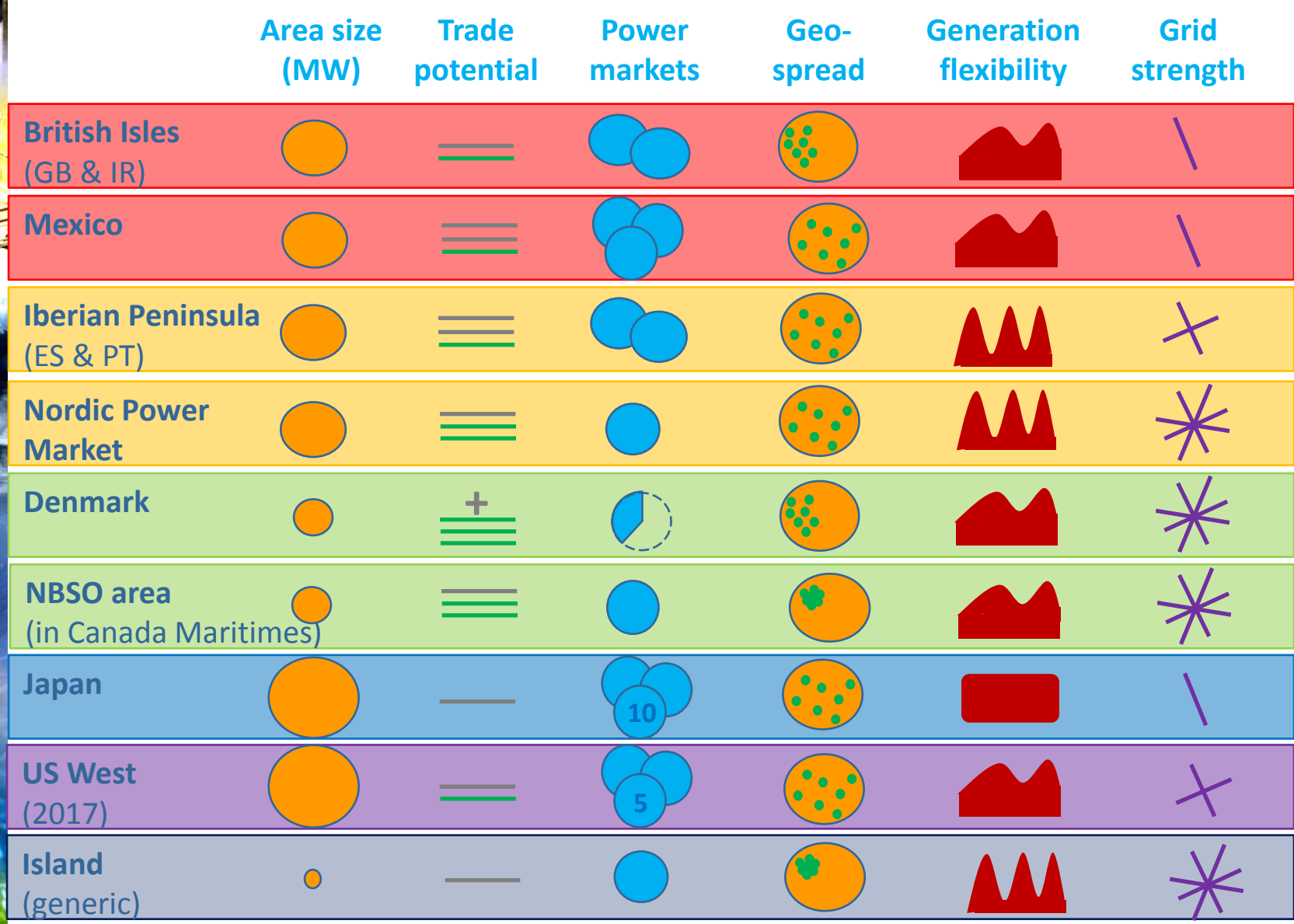
- Identify requirements of **power systems** for **reliable** integration of **large shares** of **variable** renewable energy (VRE)
  - Focus: balancing of fluctuating output (mins to days)
- Identify **specific attributes** of power systems which drive / constrain deployment potential of VRE
- Signal measures to optimise the use of **existing** resources to balance VRE
- Signal **priority actions** in a number of **case study** power areas
  - To maximise *current* VRE penetration potentials
- Shed light on **costs** of variable renewables integration

Flexibility: the response to variability

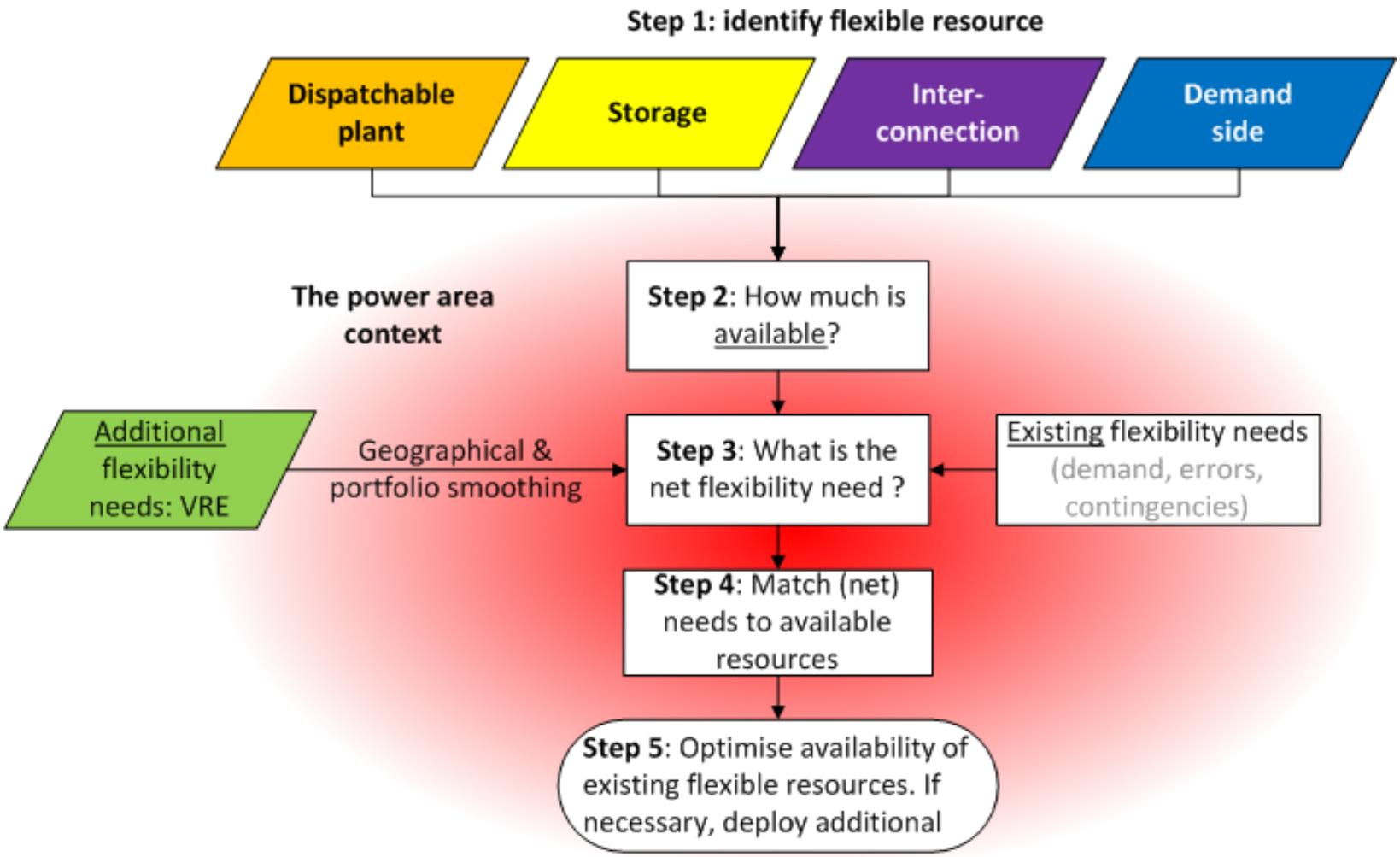
- **Flexibility**: the capability of the **power system as a whole** to ramp electricity **supply or demand** up or down, in response to **variability and uncertainty** in either

- Variable RE plants can also offer flexibility to a certain extent – through *e.g.* curtailing , clustering
  - But this is not the focus of this phase of the Grid Integration of Variable Renewables (GIVAR) project.

Contexts differ – so do the challenges!

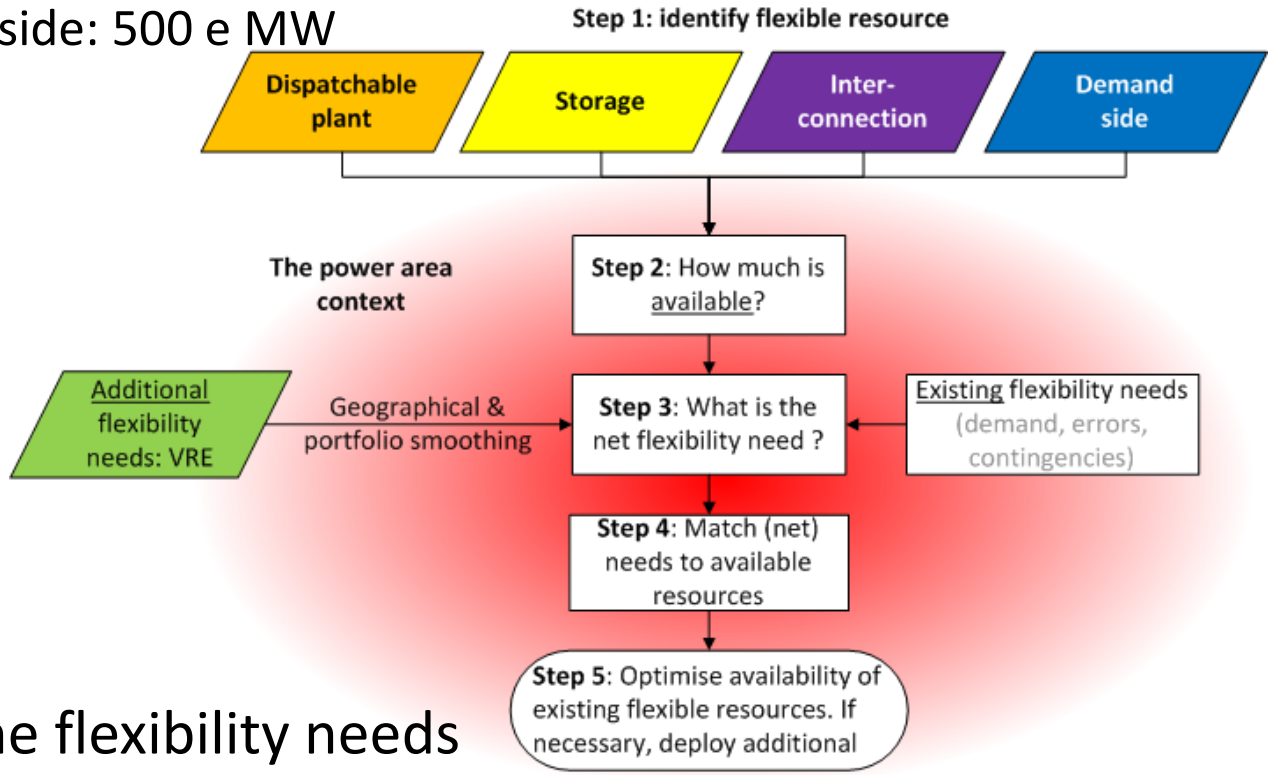


The Flexibility Assessment Tool (FAST)



Denmark's flexible resources (36 hrs)

- Sum the flexible resources from:
  - Dispatchable generation: ~ 4 600 MW
  - Storage: none
  - Interconnection: ~ 5 440 MW
  - Demand side: 500 e MW



- Subtract the flexibility needs
  - Existing (demand variation and contingency): 2 600 MW
  - From variable generators: 90% of installed variable capacity

Availability of resources

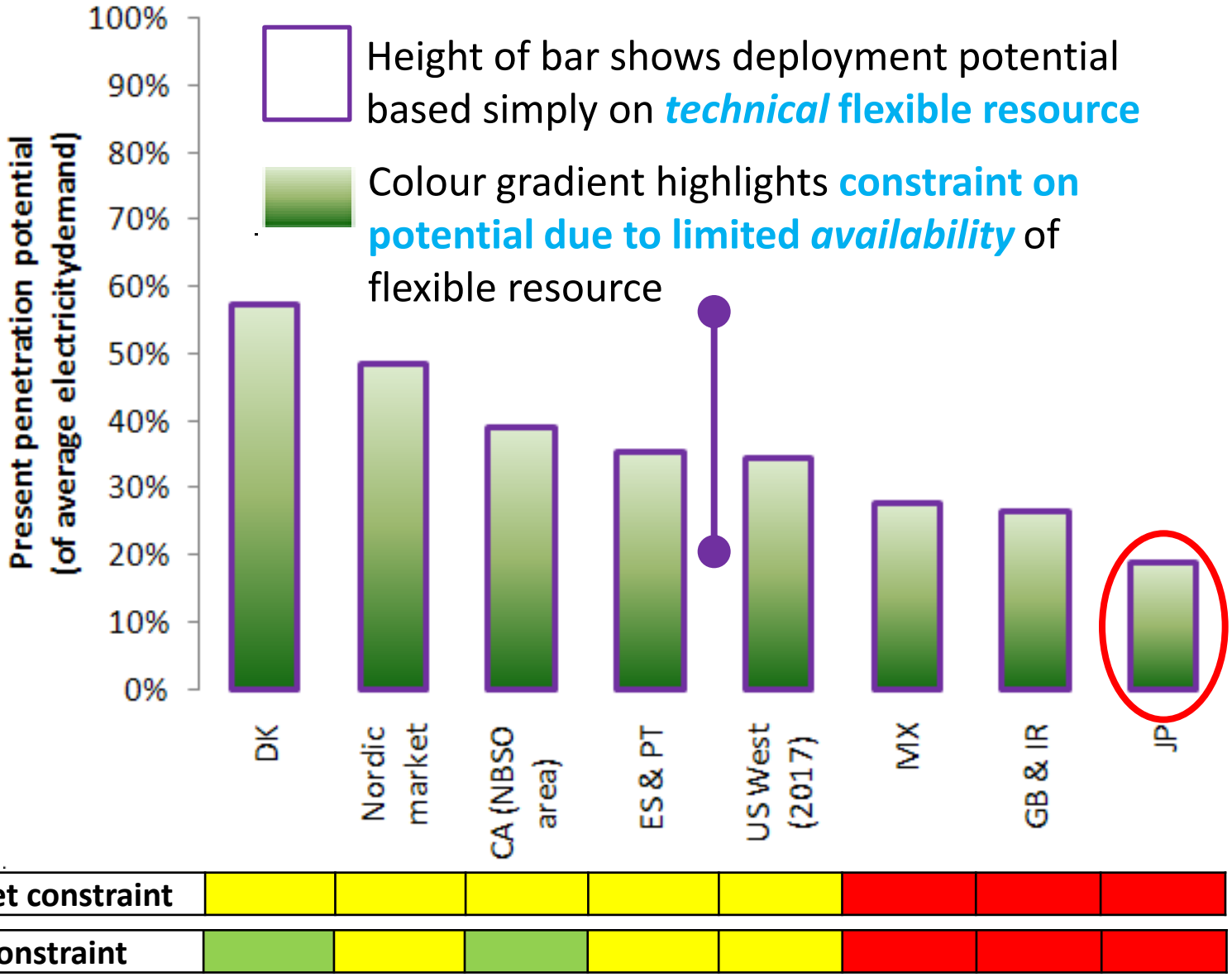
- **What are the attributes that may constrain availability?**
- **How much constraint do they represent?**

System / market attribute	Significance of attribute	DK	JP
Grid "smartness"	Activates demand side. Improves operation of grid		
Coordination of flexible resource	Area shares flexible resource		
Market valuation of flexibility	Flexible resources stimulated to respond to needs		n/a
VarRE forecasting	System operator can plan the use of flexible resources		
Rolling delivery schedules (gate closure)	Reduces flexibility need (forecasts are more accurate)		n/a

Scores
High
Intermediate
Low

Weights
Major constraint on availability of flexible resource
Significant constraint
Little constraint

Present VRE penetration potentials



Key optimisation measures

- VRE deployment should be **dispersed widely** over collaborating, strongly connected markets
  - Collaborating power markets sharing flexible resources will have a reduced need for them (relative to installed VRE capacity) – because variability is smoothed, and uncertainty reduced, over larger areas
- Power trading should run up to **within the hour** before time of operation, using latest **forecasting** technology to schedule flexible resources efficiently
- Flexible resources may need **incentive** to respond to increasing flexibility needs
  - A flexibility premium may be required to ensure that existing flexible resources are available, and that new resources are deployed when / if required

In summary

- The answer to the question “how much variable renewable energy can our system take?” is… “It depends – but probably more than you thought.”
  - **Large potentials** exist for balancing variable generation, based on flexible resources which differ in **size** and **availability**
  - **Optimisation strategies** will differ
- It’s not about megawatt for megawatt back-up
  - But rather holistic planning of flexible resources to cover **net system** variability
- **Policy makers should drive flexibility assessment** to complement RE target setting
- Key drivers to make best use of *existing* flexible resources include **strong grid and flexible markets**
- Wind balancing cost estimated to lie between USD 1 - 7 per megawatt hour at 20% penetration of electricity.

Next steps

- Publication early in 2011
- Scoping GIVAR Phase III
  - Continuing development of FAST tool
    - Additional focus on adequacy
    - Impact of new energy trends on flexibility (e.g. E.V.)
  - Cost curve of flexibility measures
  - Deeper analysis of market mechanisms
- Fund raising

Other on-going RE work at the IEA

- Technology roodmaps:
  - Published: Wind, PV, CSP
  - Forthcoming: geothermal, hydropower, biomass for heat and power, biofuels, solar heating and cooling
- Deploying Renewables
  - Extended update of the 2008 publication
- Web based RET Essentials and database
- Energy Security and RE
  - Electricity security
  - Energy security in transport
- CO_2 price and RE incentives
- In-depth study solar energy

Forthcoming RE work at the IEA

- Country regional roadmaps, RE strategies of non-member countries
- Mapping RET technology potential
  - With IRENA and other international institutions
- In-depth study bioenergy&biofuels
- Mid-Term Renewable Energy Market Report
- Full costs and benefits of renewables
  - Focus on environmental benefits, merit order effects, impacts on fossil fuel demand and price, hedging value against price volatility
  - Subject to funding
- Deploying renewables & integration: phase 3