RENEWABLES

Smart grids and flexibility

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International Energy Agency

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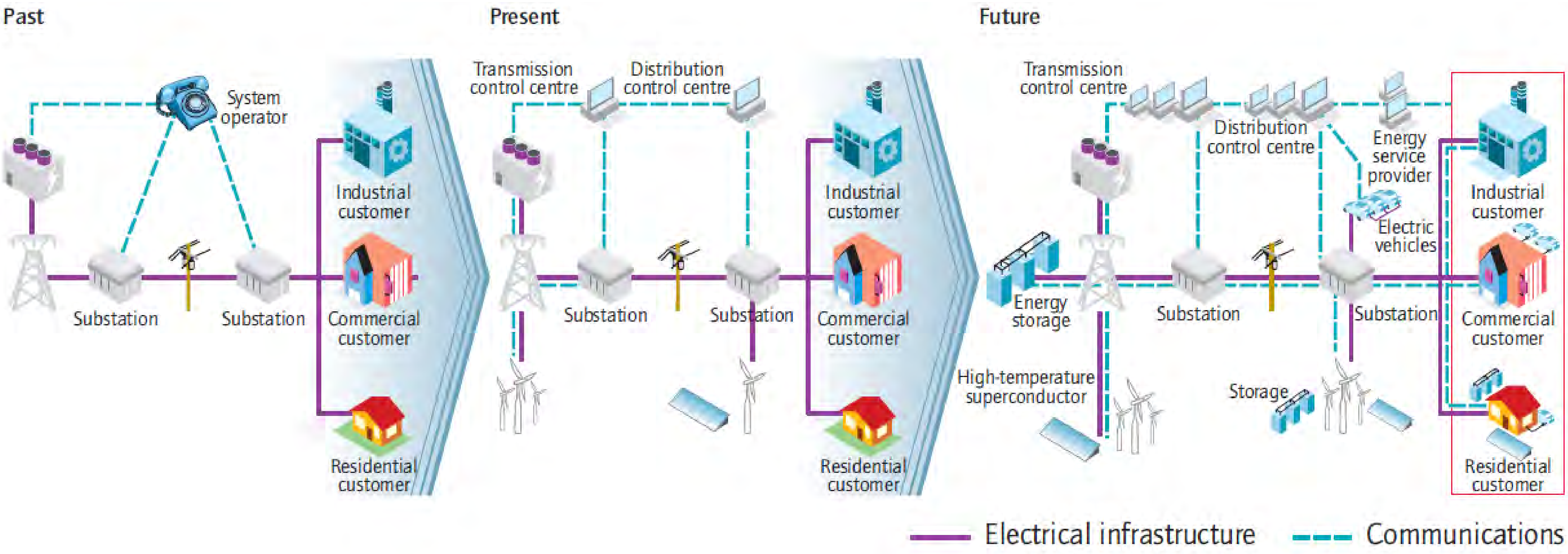
Electricity Systems are in evolution



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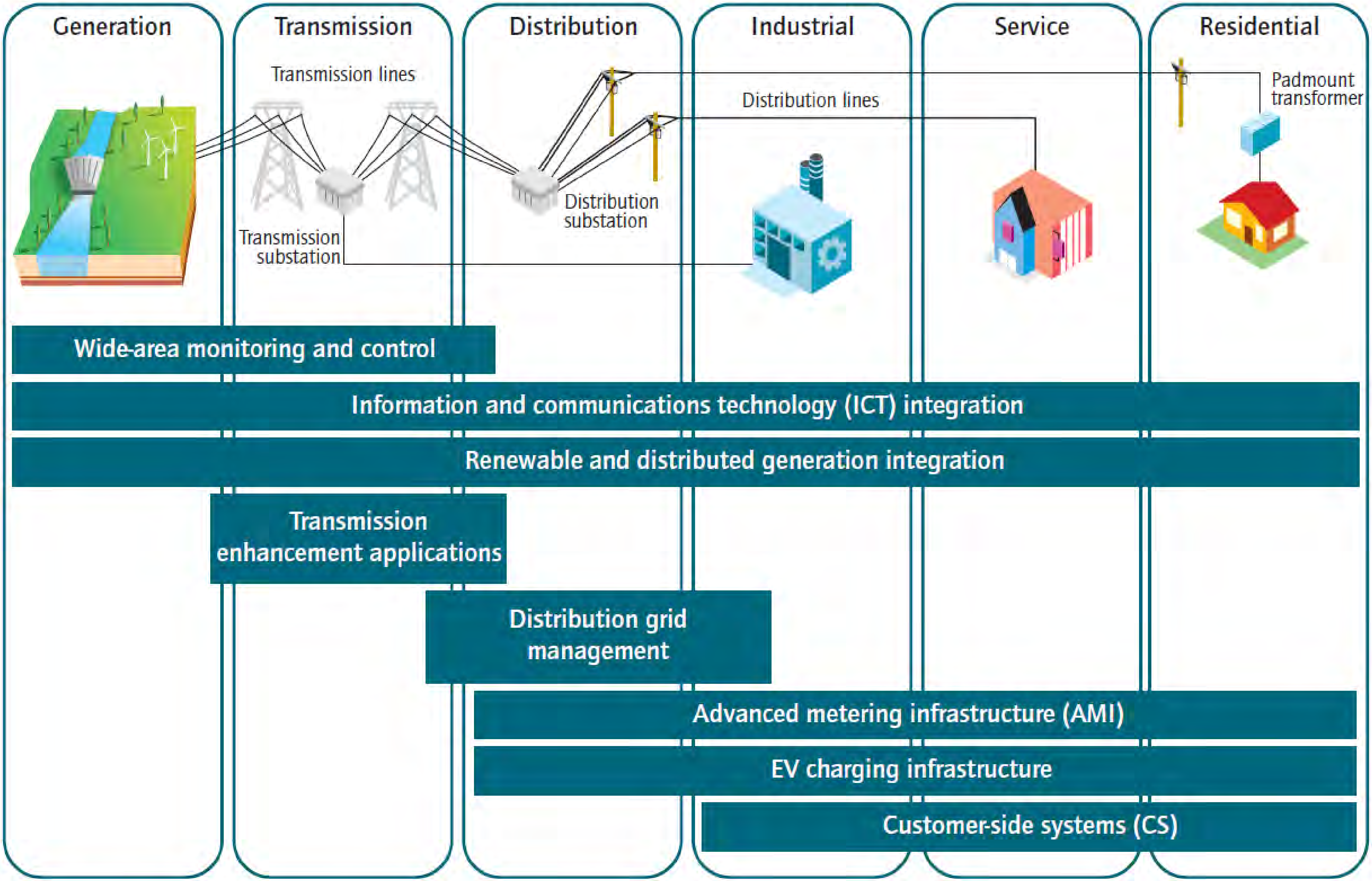
Smart SYSTEM



Source: Technology categories and descriptions adapted from NETL, 2010 and NIST, 2010.

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What can smart grids do?

SUPPORT SYSTEM FLEXIBILITY

- **Activate demand side**
- **Optimise T&D asset use**
- **Accommodate all generation and storage options (inc. VRE)**
- **Enable new products, services and markets (*e.g.* EVs)**
- **Increase resilience / security (contingencies, congestion, attacks, natural disasters)**
- **Safeguard power quality**

CO_2 benefits of smart grids

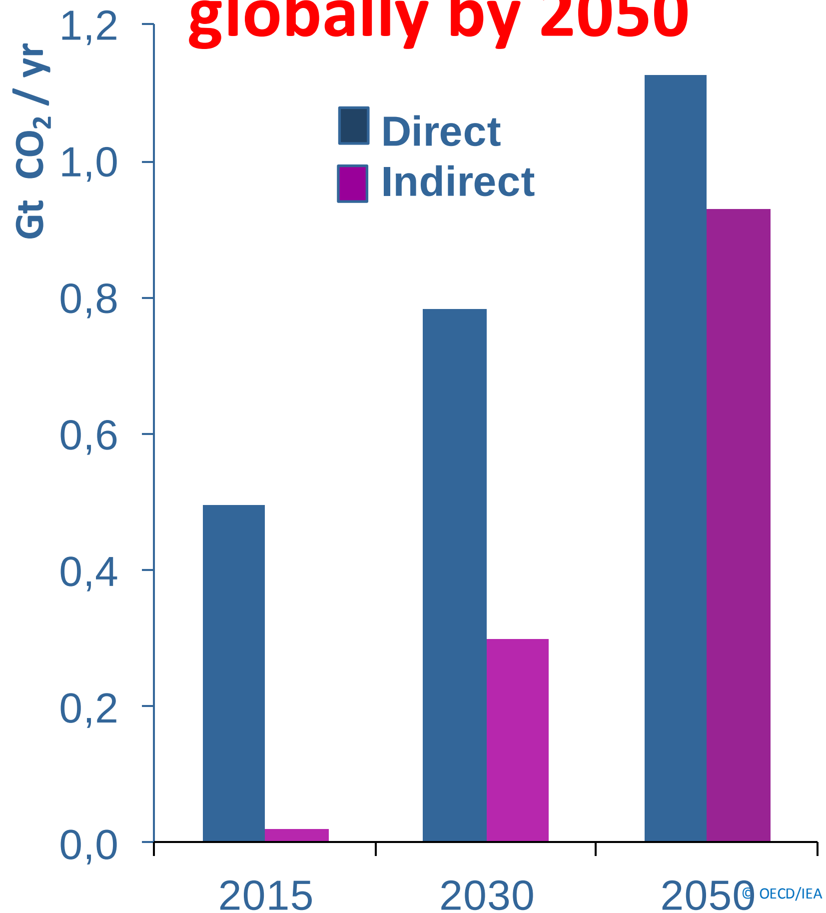
Direct reductions:

- Peak load management
- Modulation of service-sector loads
- Energy efficiency programs
- Reduced line losses
- Direct feedback on energy usage

Enabled reductions

- Integration of variable RE
- Enabled electric vehicles

Potential: 2 Gt /year globally by 2050



Needs

Technology

- Commercial-scale **demonstrations** across sectors; **smart appliances**
- Global technology **standards**
- Integrate with **existing** electricity infrastructure

Policy Regulation

- Address **changing system needs**, acknowledge **new technology**
- Address system-wide, cross-sector **barriers**, cyber **security** issues
- Encourage **smart consumers** through best practice, price signals for response

Consensus

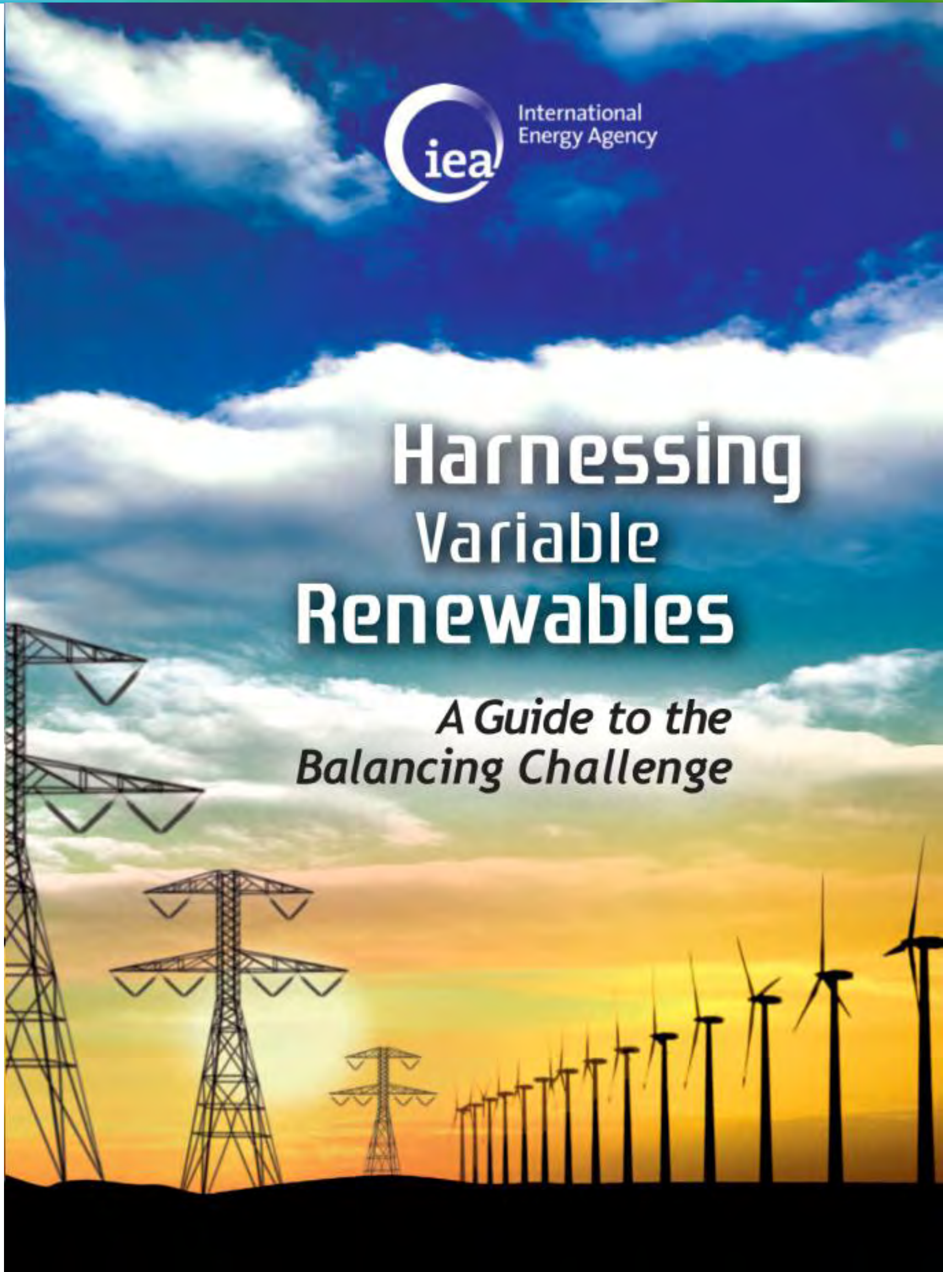
- Accelerate **education** of consumers and their advocates, utilities, regulators
- Develop **business models** addressing cost, security and sustainability

International Collaboration

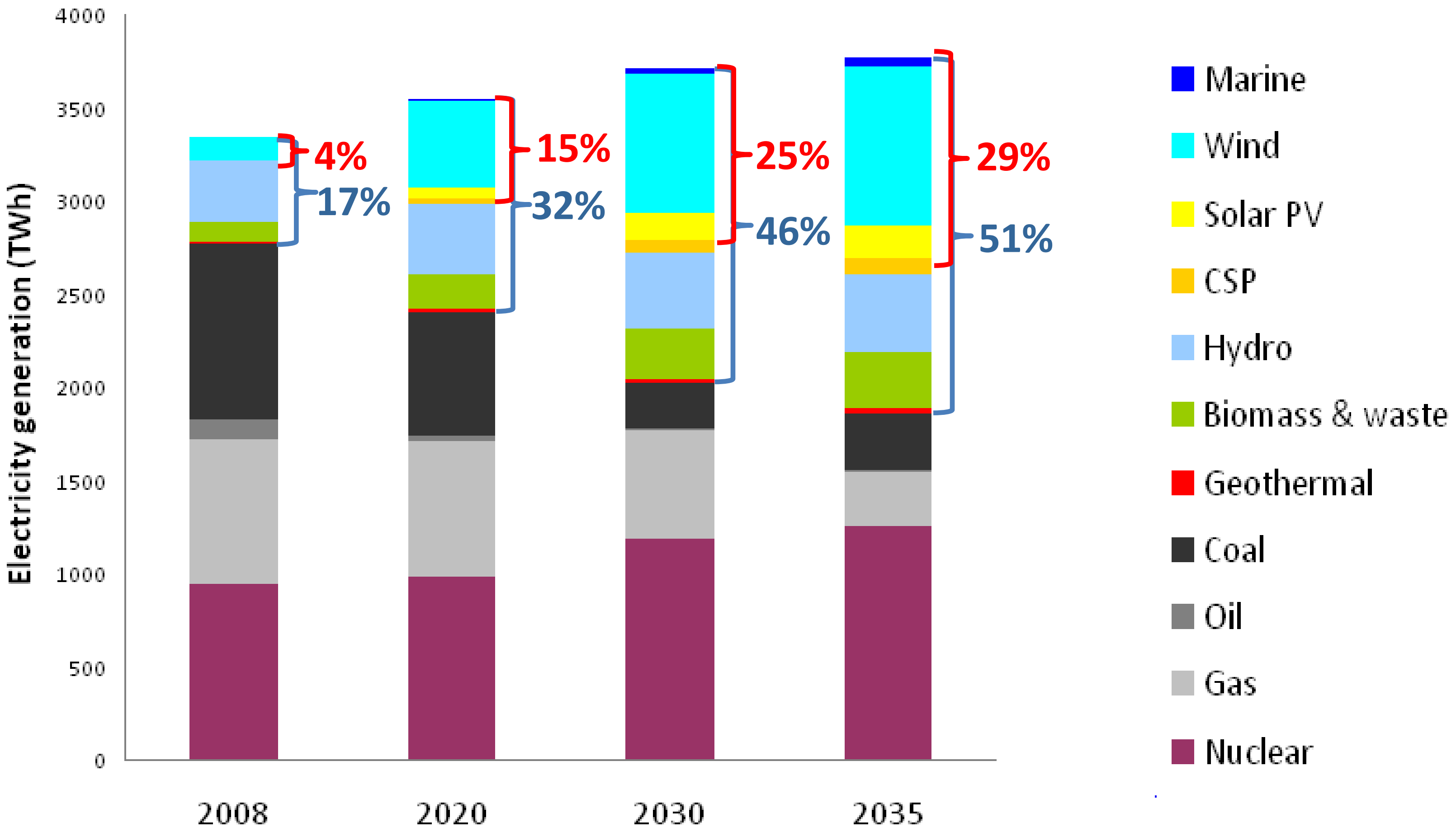
- **Share standards**, technology, policy and business models
- **Capacity-building** in developing countries, tailored to context: rural electrification, island systems, and alternative billing approaches

System integration issues

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

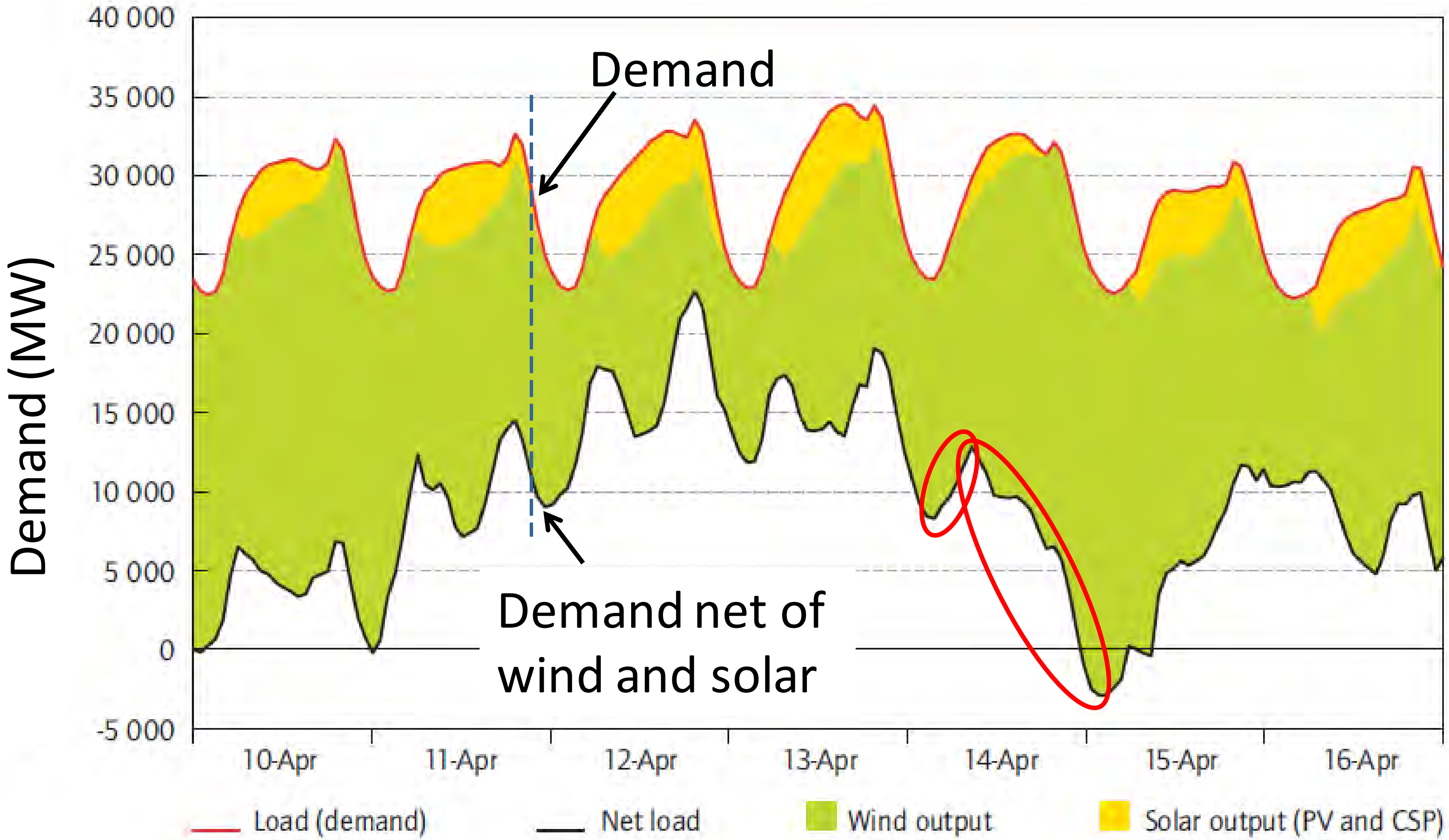


WEO 450 Scenario electricity projections – EU

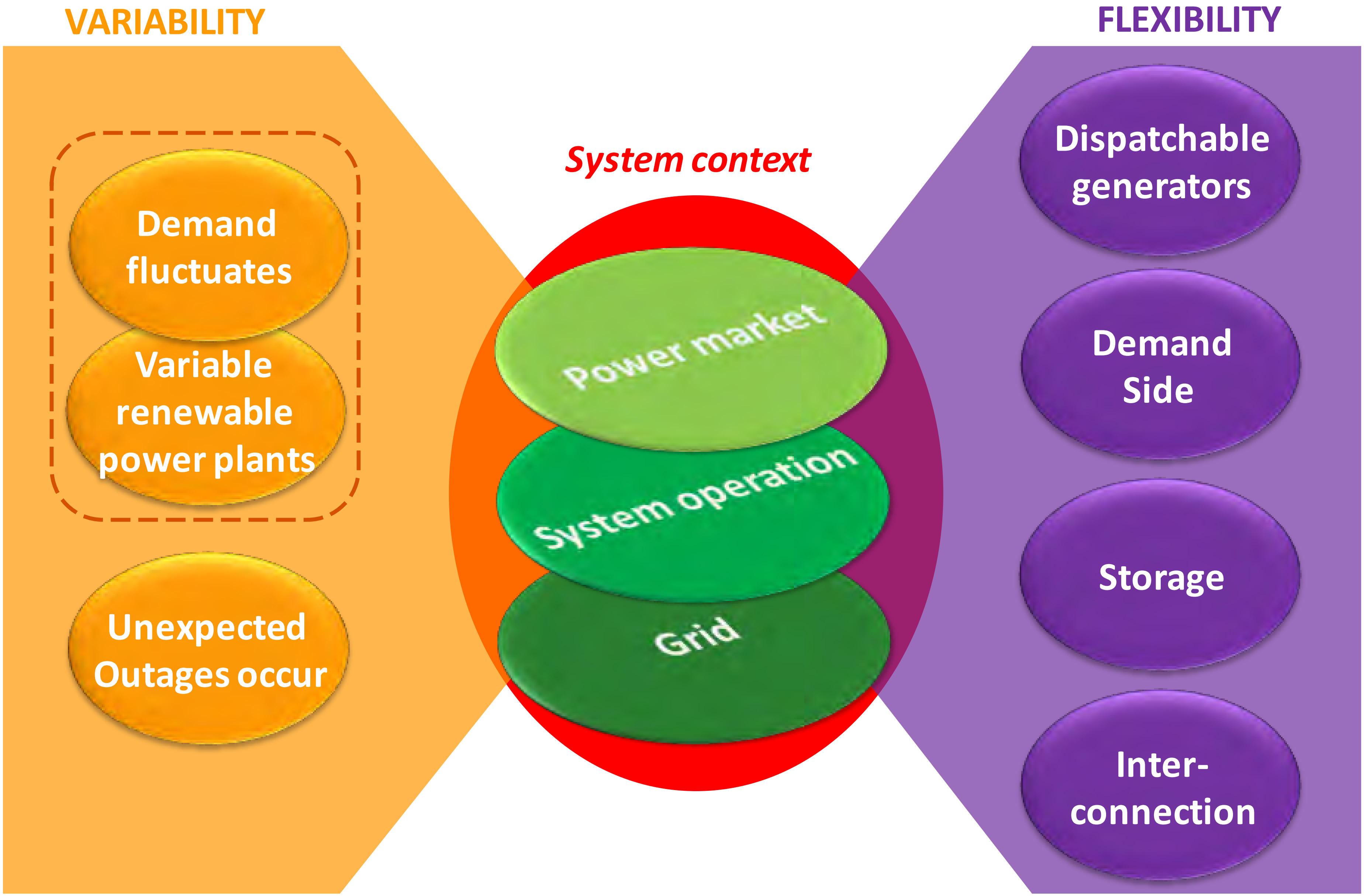


[Source: IEA World Energy Outlook 2010]

Variability is not new, but it does get bigger



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


VARIABILITY
FLEXIBILITY
System context
Demand fluctuates
Variable renewable power plants
Unexpected Outages occur
Power market
System operation
Grid
Dispatchable generators
Demand Side
Storage
Inter-connection

Demand response

What capacity is likely to be responsive to a real time price signal?

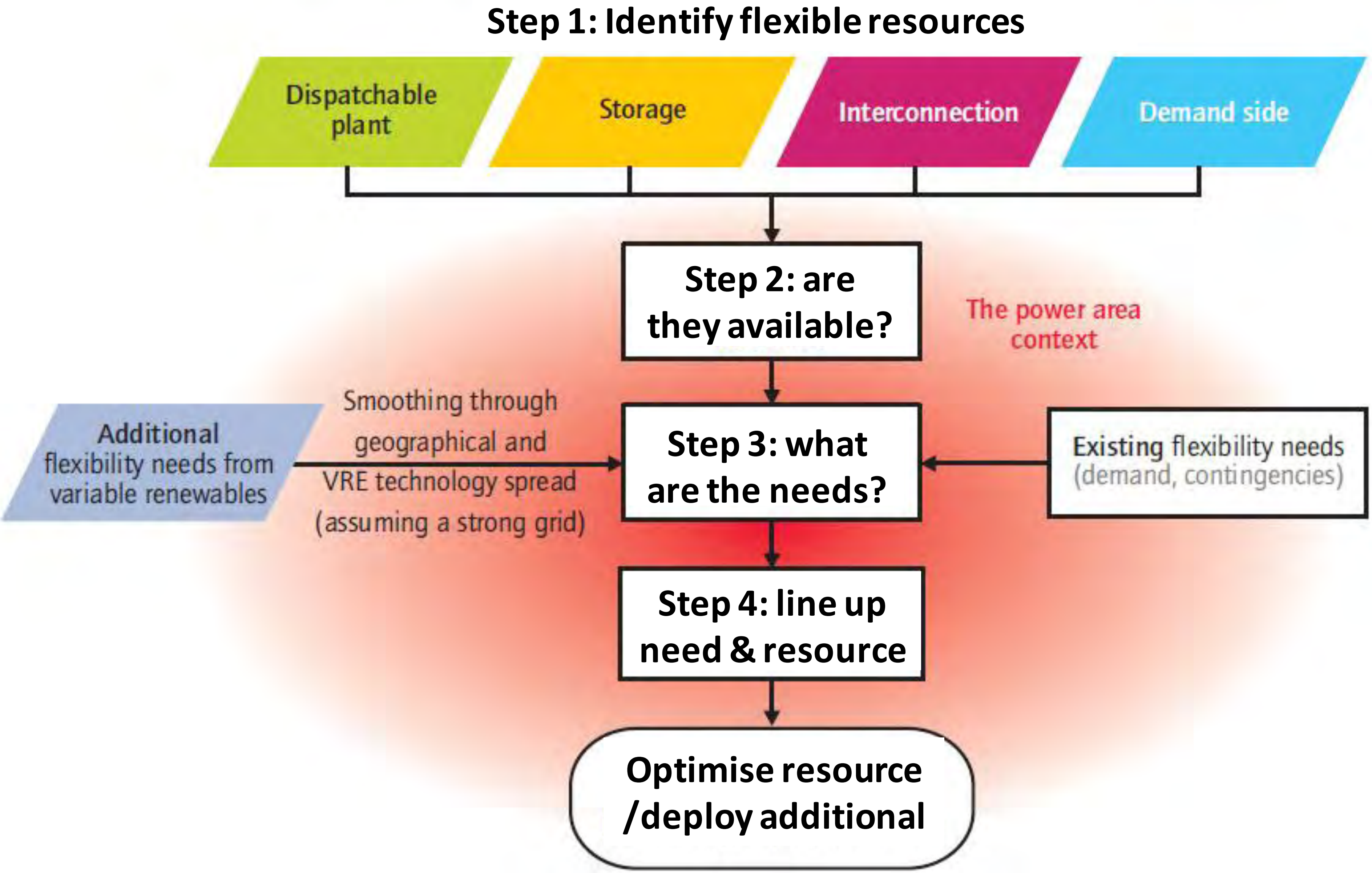
↓

Is real time price available to the consumer (through *e.g.* smart grid)?

↓

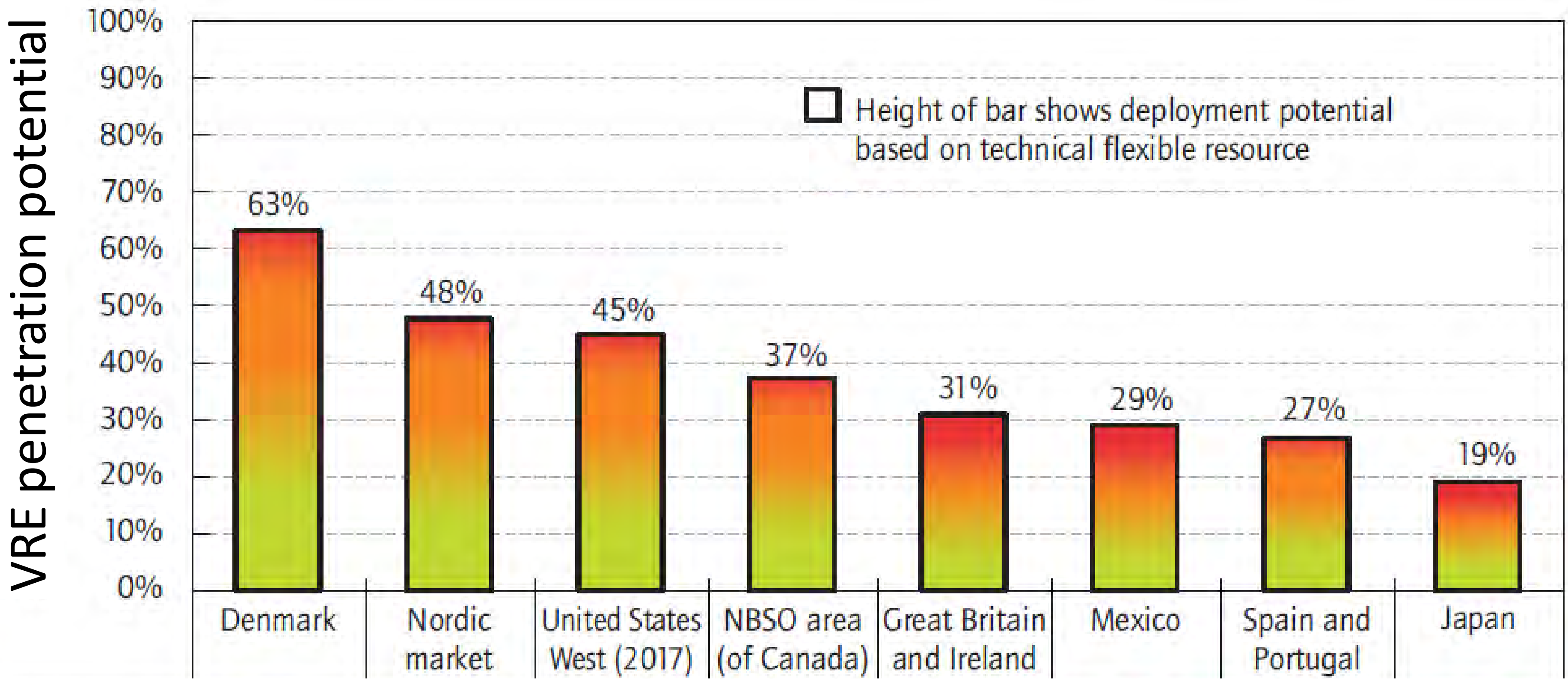
Are small (*i.e.* residential) consumers aggregated into larger block(s)?

FAST Method



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: line up need & resource
Optimise resource /deploy additional

Snapshot of present penetration potentials



Conclusions

- Variability is not a showstopper
  - **Flexibility** is the antidote to variability
  - Flexible resources are **greater** than believed
  - **Smart grid** is a key enabler for their **availability**

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

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

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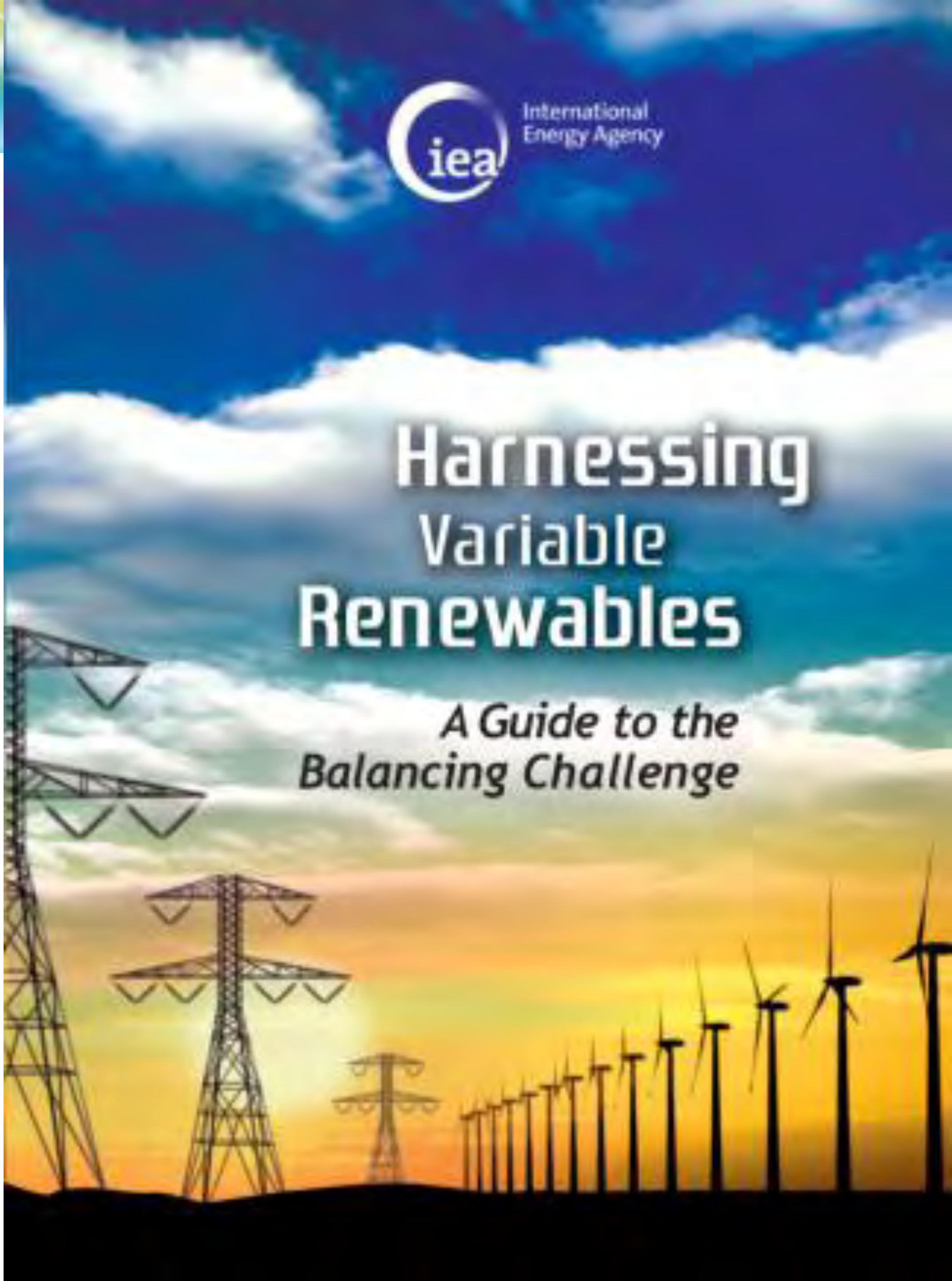
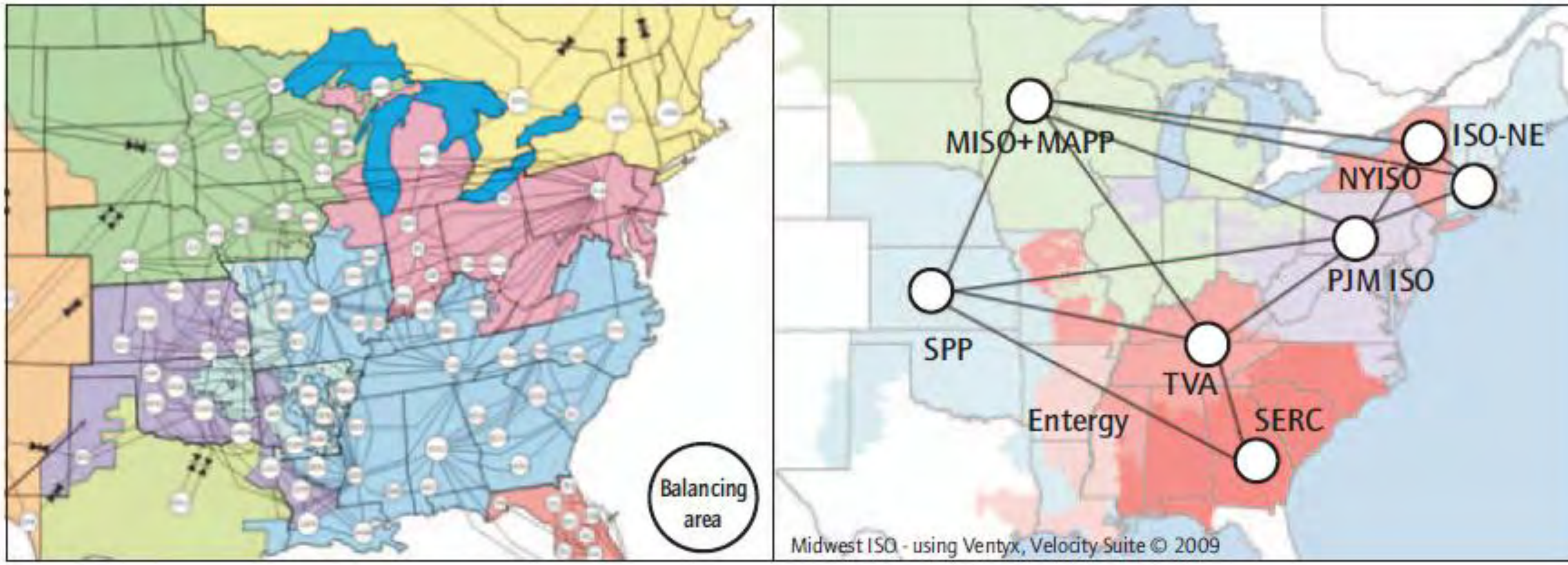


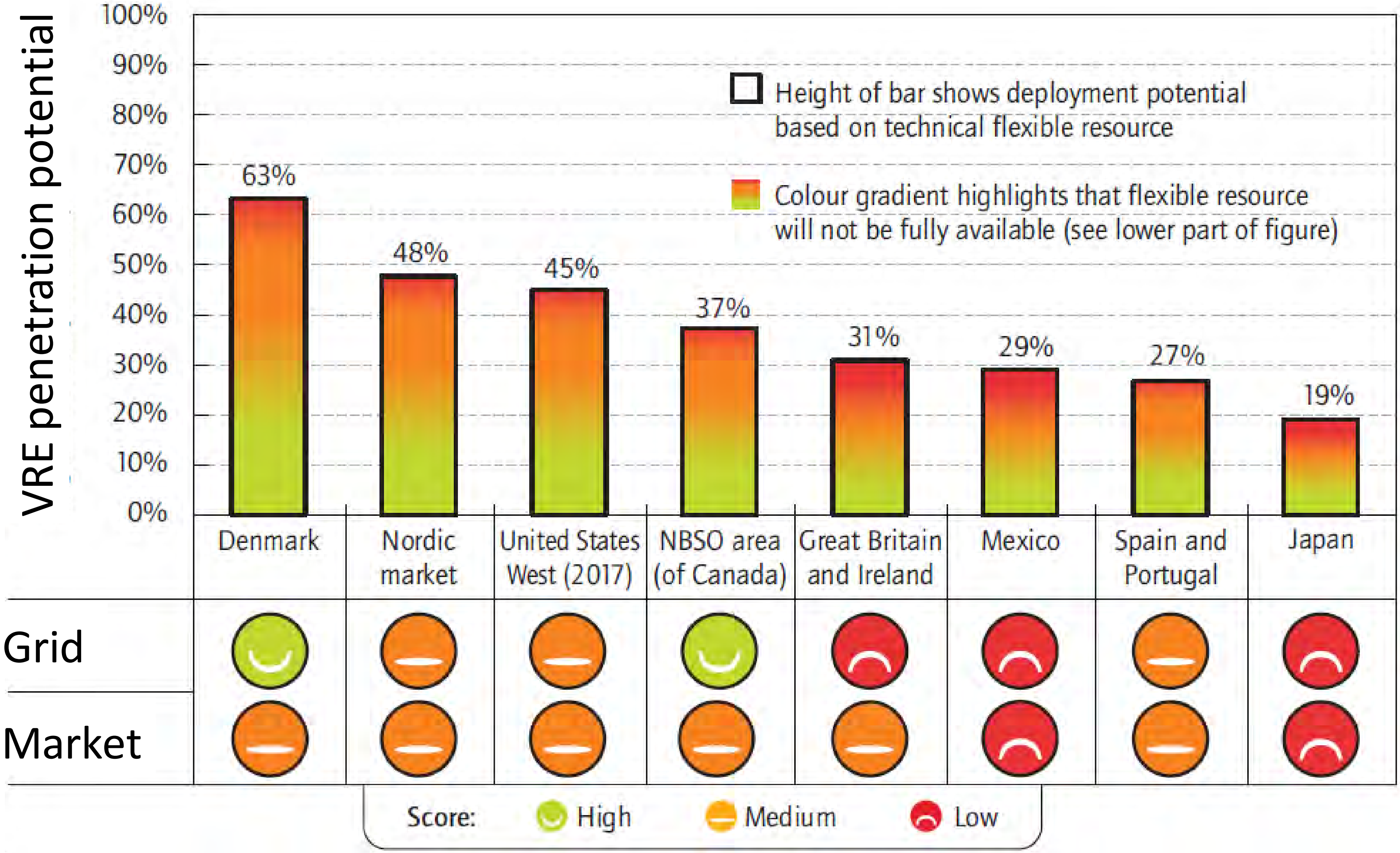
Larger balancing areas means shared resources and less variability



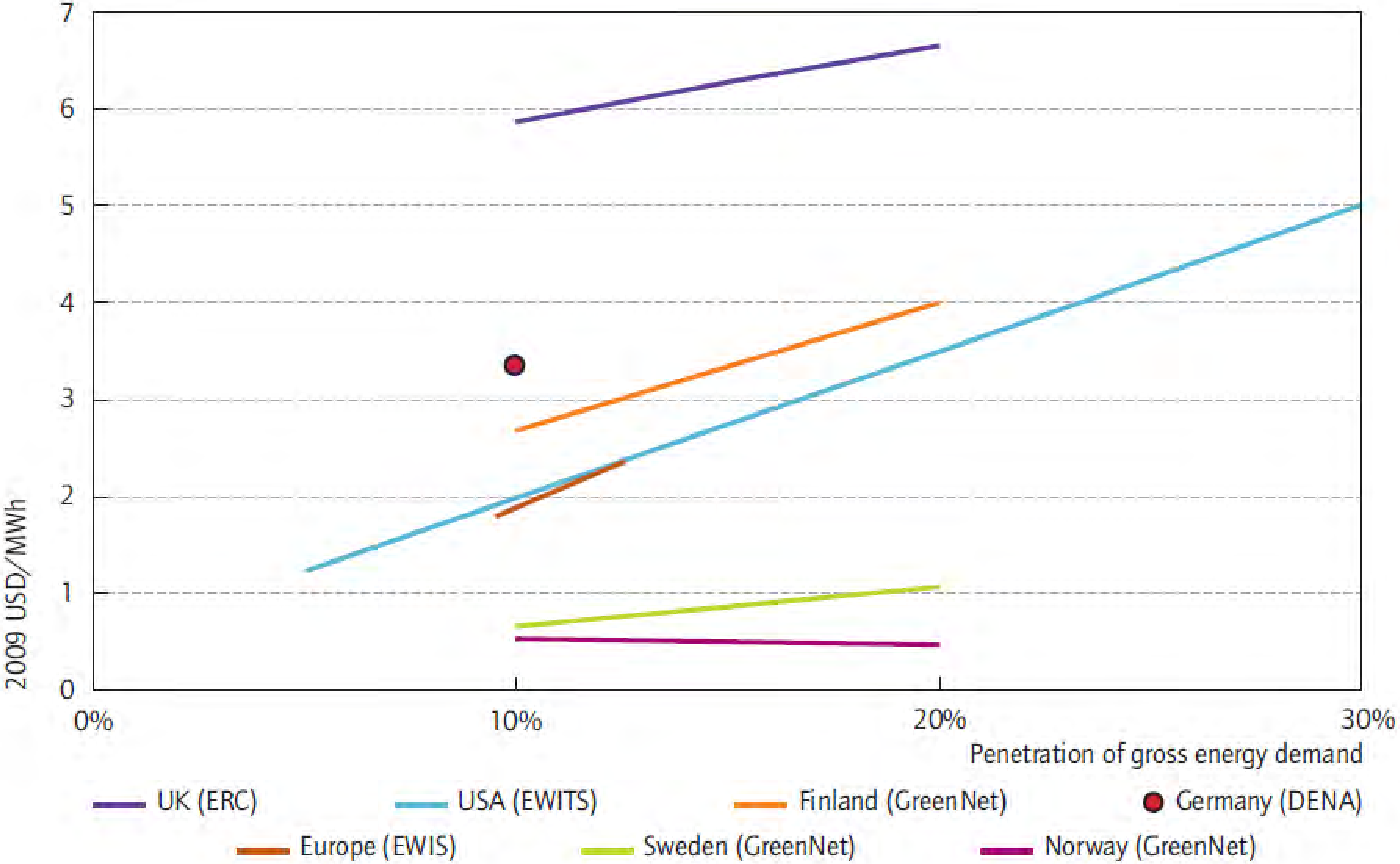
Markets in the Eastern United States today and in 2024

Source: *Eastern Wind Integration and Transmission Study*, EnerNex Corporation for NREL (2010)

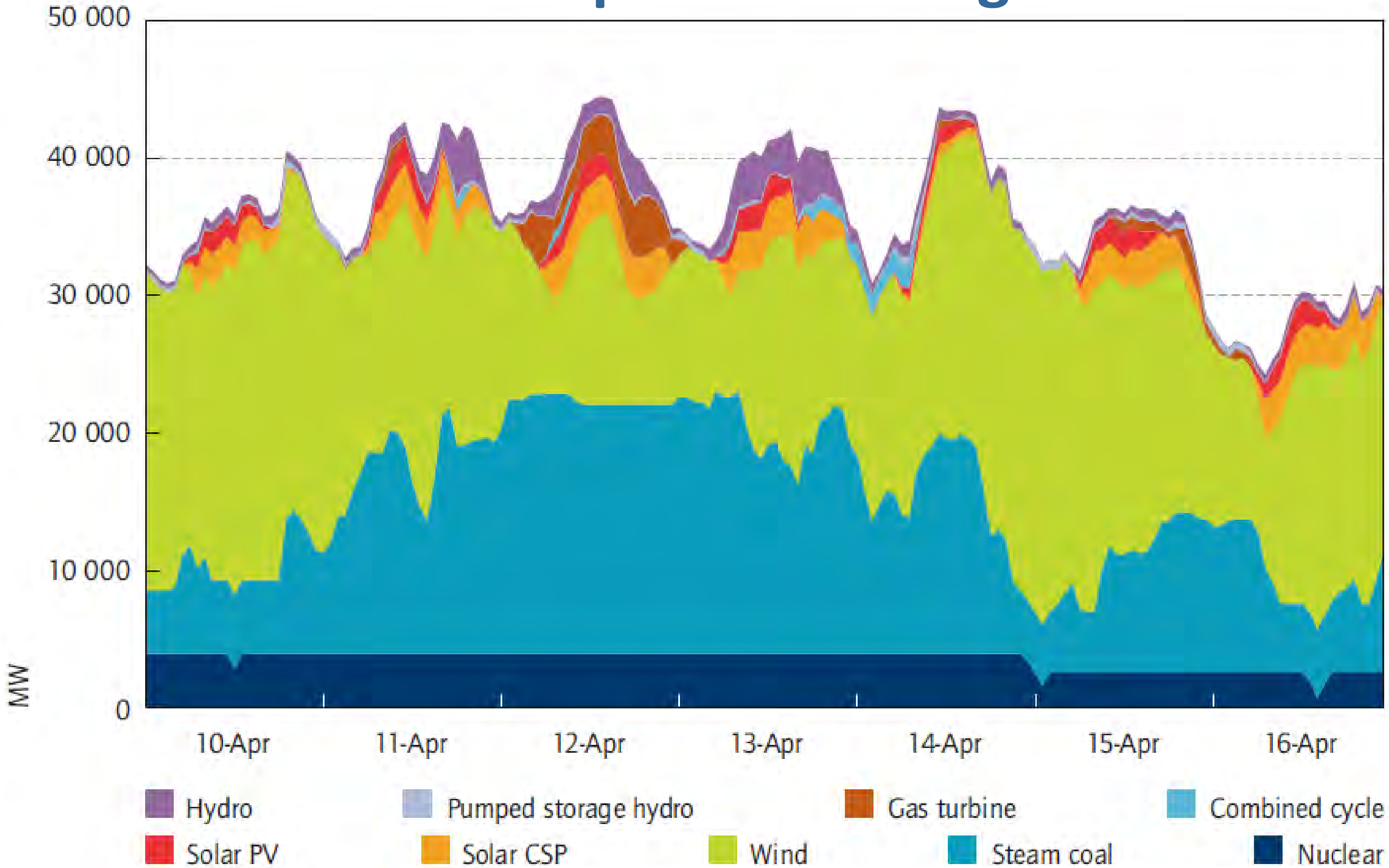
Snapshot of present penetration potentials



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)

Integration studies to date

- Eastern Wind Integration and Transmission Study
- Western Wind & Solar Integration Study
- NERC: Accommodating High Levels of Variable Generation
- GE ERCOT study (Texas)
- Solar Integration Study for PSCo (Colorado)
- Avista Corporation Wind Integration Study
- Wind Integration Study for PSCo (Colorado)
- California ISO Integration study
- Minnesota Wind Integration Study

- UK ERC Costs and Impacts of Intermittency Study
- EWEA Large Scale Integration of Wind Energy
- DENA study (Germany)
- All Island Grid Study (Ireland)
- European Wind Integration Study

- Sri Lanka Wind Integration Study (forthcoming)

- Multi-regional: IEA Wind Task 25

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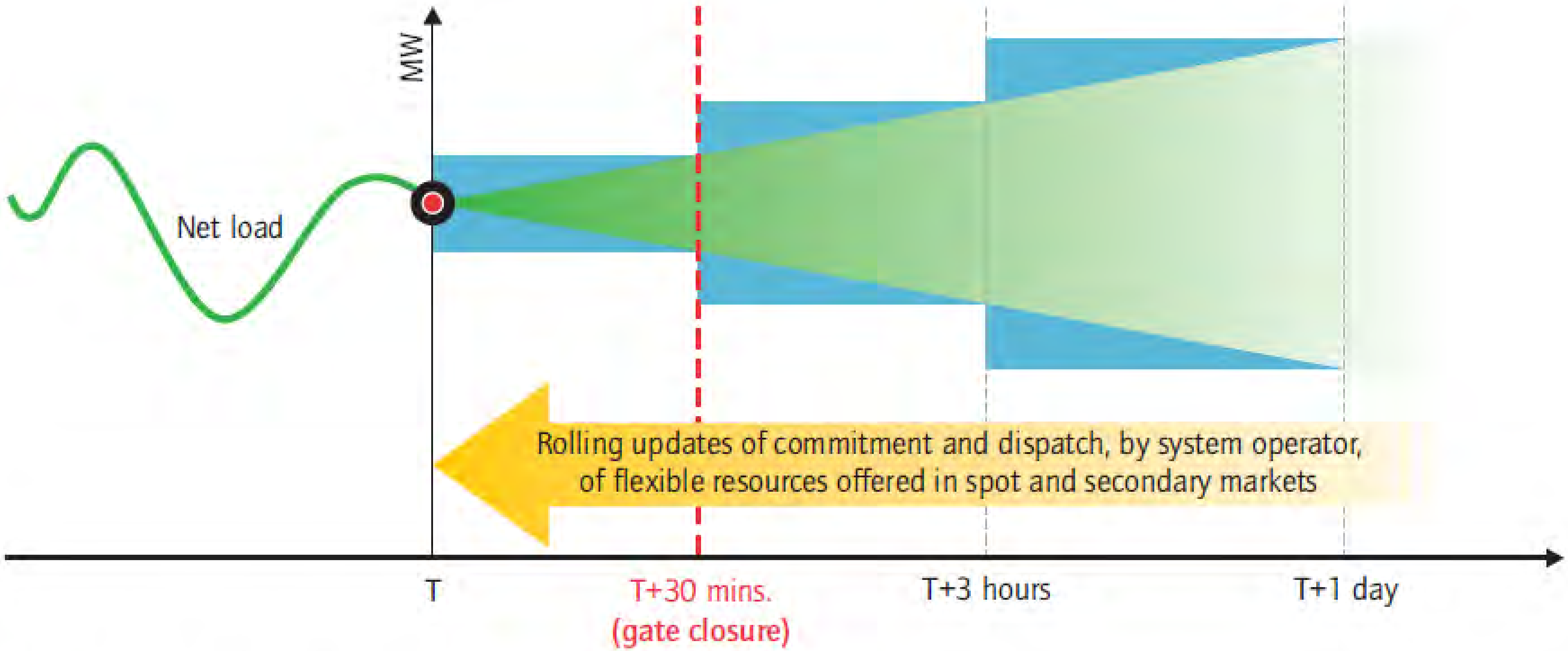
Key messages

- First off: little concern at **low shares**
- No one-size-fits-all definition of **high share**
- **More flexible resources** exist then commonly thought
  - Gas and hydro, but also coal, even nuclear in some cases
  - Demand response, interconnections, storage
- A **strong, intelligent grid** is critical
- **Larger, 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



T: Time of operation (instant when electricity is produced and consumed)

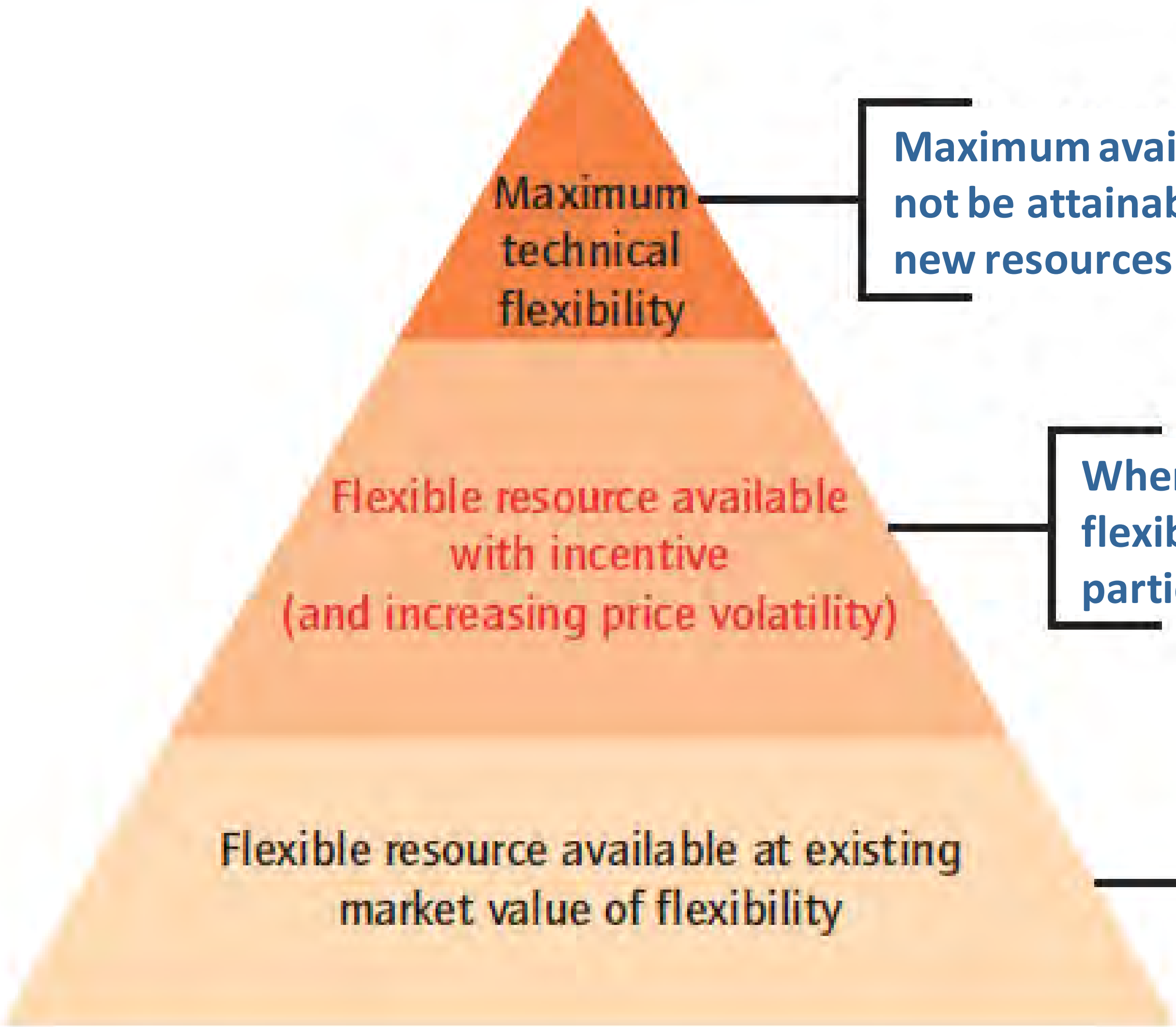
Uncertainty of net load at time T (MW)

Flexible resource held against uncertainty of net load at time T (MW)

Net load at time T

Givar_Fig24

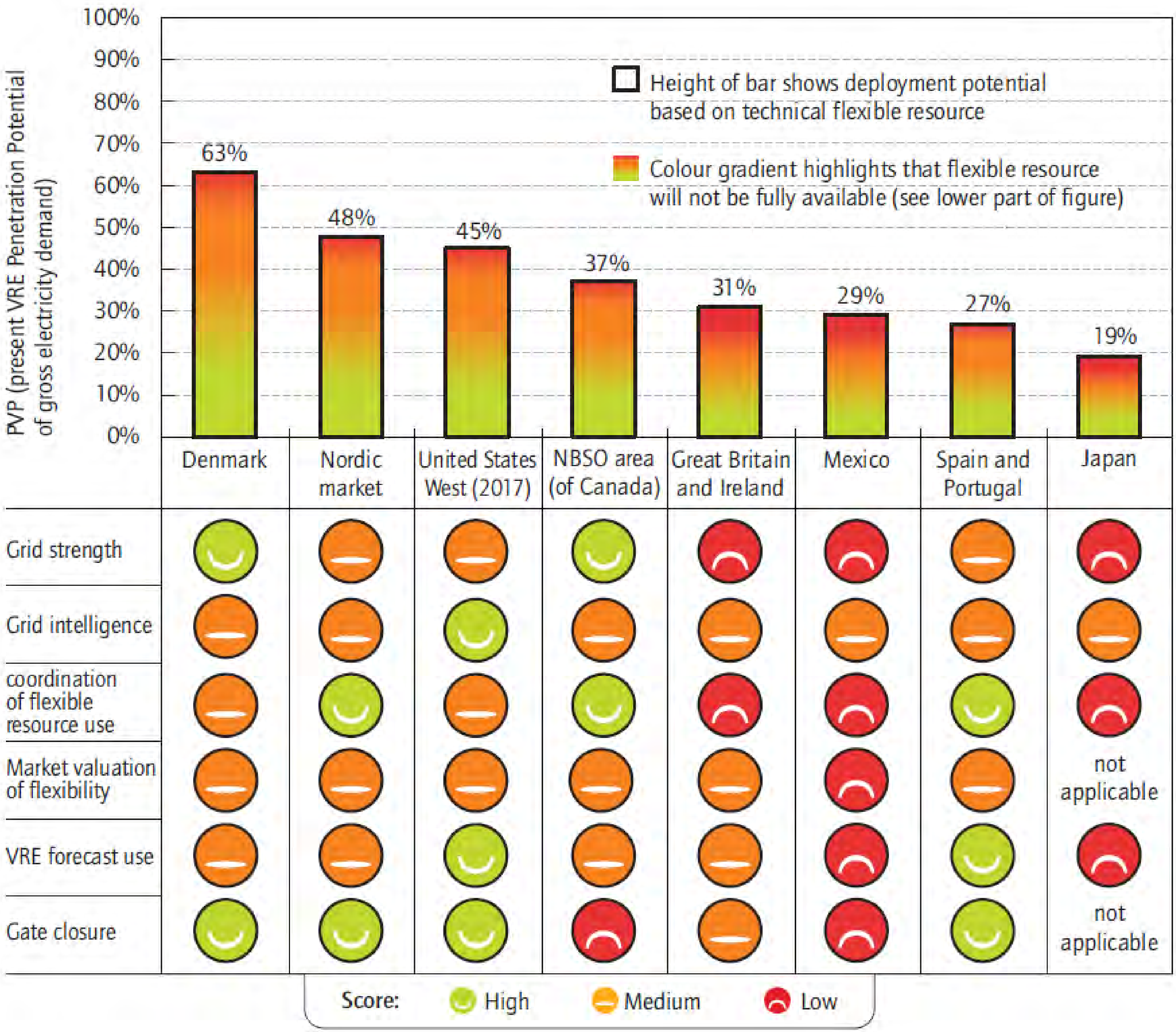
The flexible resource pyramid



Maximum availability of flexible resources: may not be attainable, and may be more costly than new resources

Where we need to get to: all four flexible resources have incentive to participate

Where we are today: OCGT, hydro, storage


PVP (present VRE Penetration Potential of gross electricity demand)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Height of bar shows deployment potential based on technical flexible resource
Colour gradient highlights that flexible resource will not be fully available (see lower part of figure)
63%
48%
45%
37%
31%
29%
27%
19%
Denmark
Nordic market
United States West (2017)
NBSO area (of Canada)
Great Britain and Ireland
Mexico
Spain and Portugal
Japan
Grid strength
Grid intelligence
coordination of flexible resource use
Market valuation of flexibility
VRE forecast use
Gate closure
not applicable
not applicable
Score:
High
Medium
Low

A 2011

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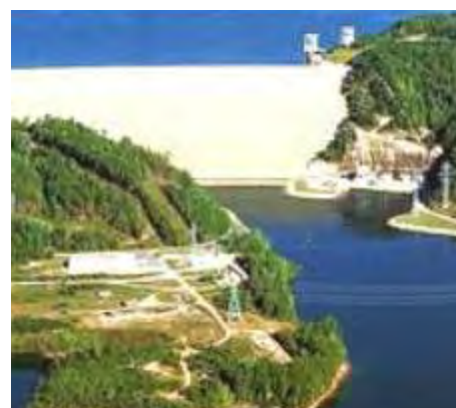
There are 4 flexible resources

- **Dispatchable power plants**
- **Demand side Response (via smart grid)**
- **Energy storage facilities**
- **Interconnection with adjacent markets**

A biomass-fired power plant

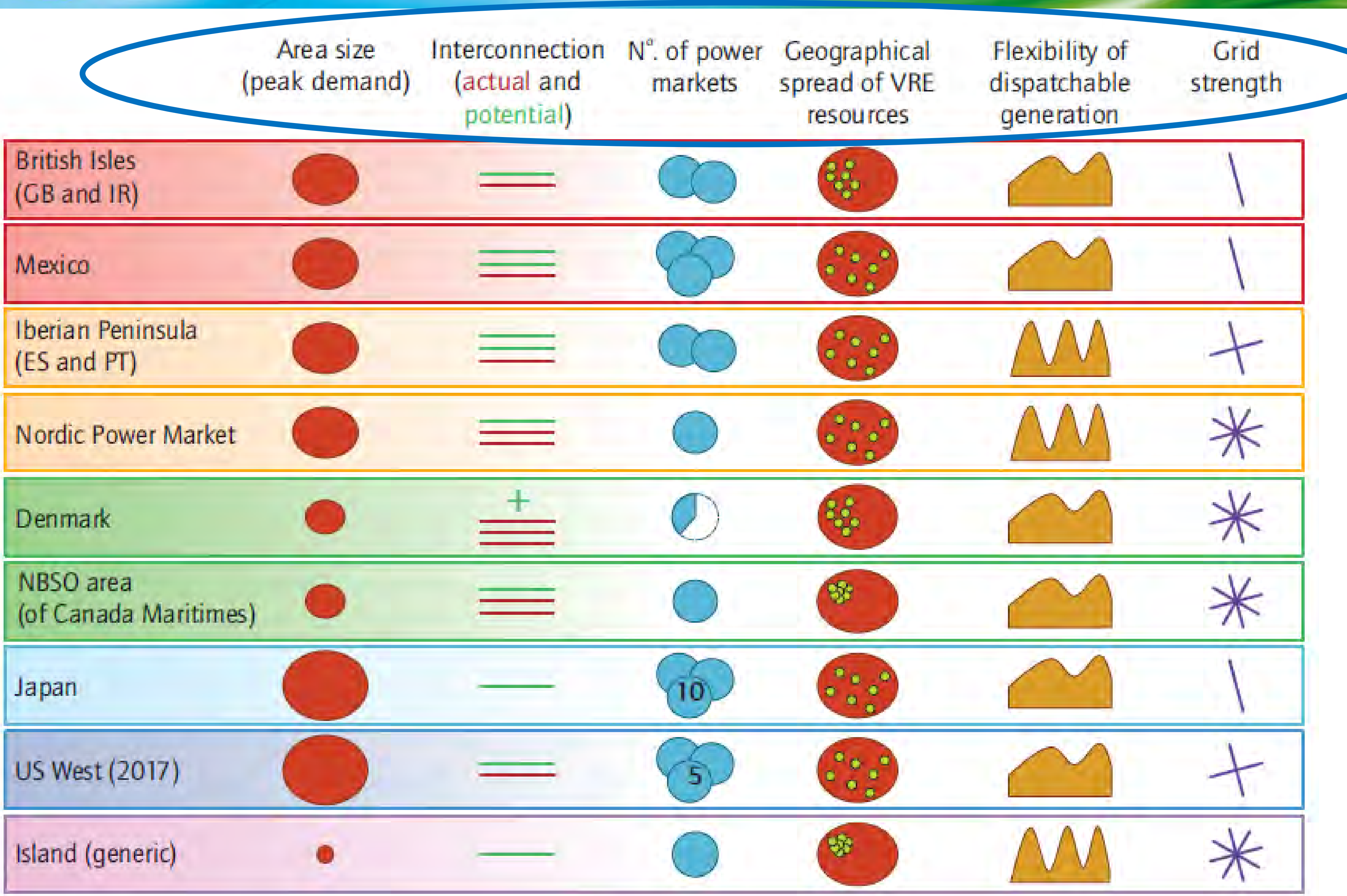
Industrial

residential



A pumped hydro facility

Scandinavian interconnections


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
US West (2017)
Island (generic)
+
10
5