International Energy Agency

# The Integration Challenge

*How can power system remain reliable and cost-effective while supporting high shares of variable renewable energy?*

**Simon Müller**
**Analyst – System Integration of Renewables**

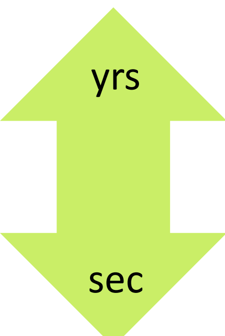
**Expert workshop in support of implementing a wind energy technology roadmap for India**

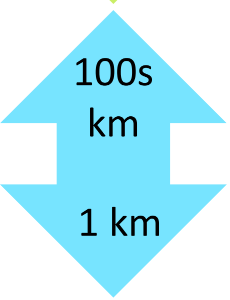
**16 September 2015, Delhi, India**

# Interaction is key

**Properties of variable renewable energy (VRE)**

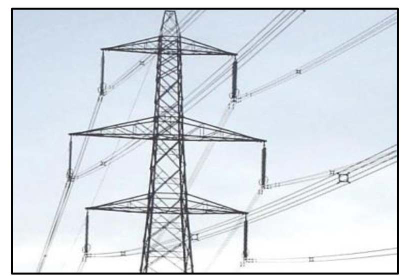
**Flexibility of other power system components**



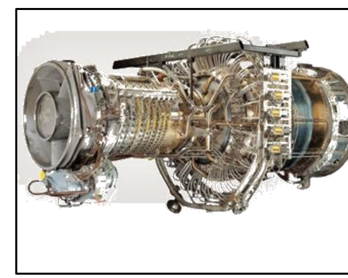




- **Variable**
- **Uncertain**
- **Non-synchronous**
- **Location constrained**
- **Modularity**
- **Low short-run cost**

Grids



Generation



Storage

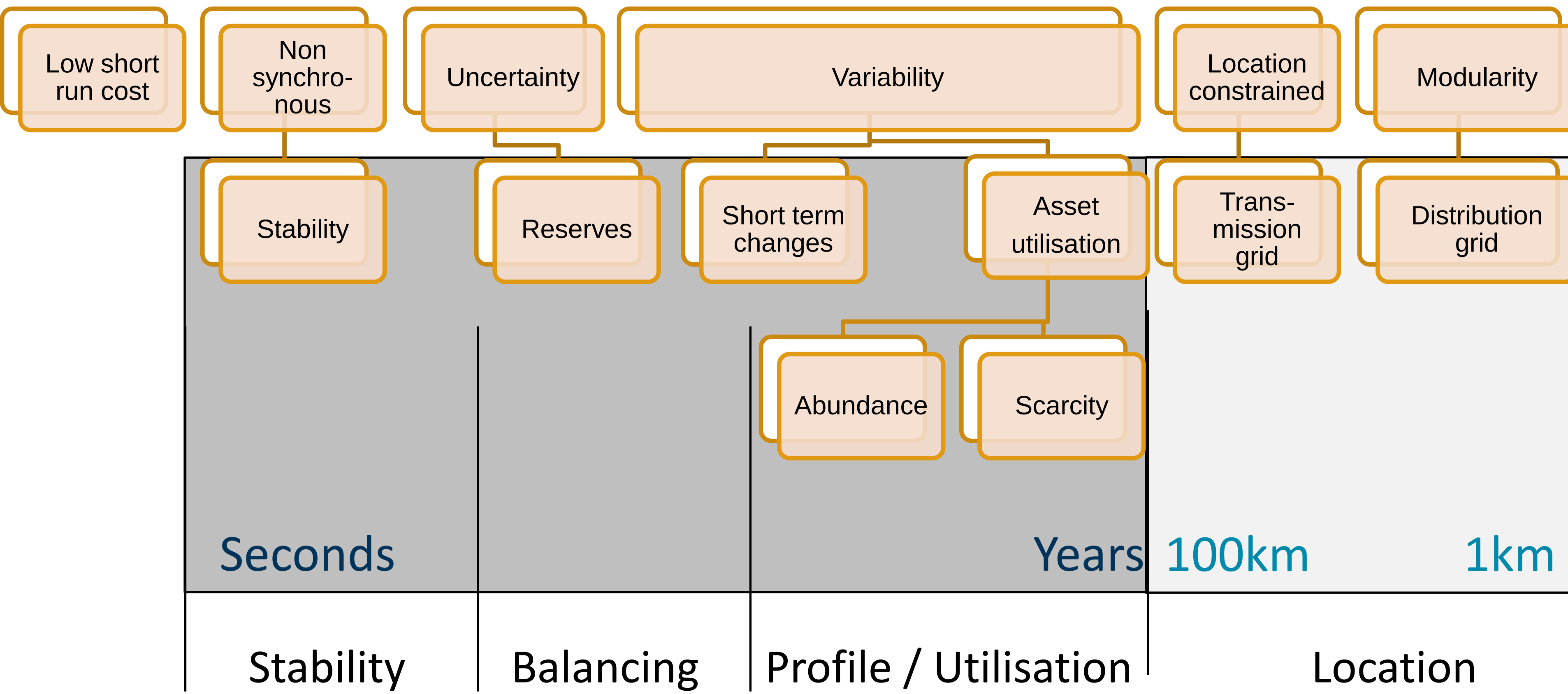
Demand Side



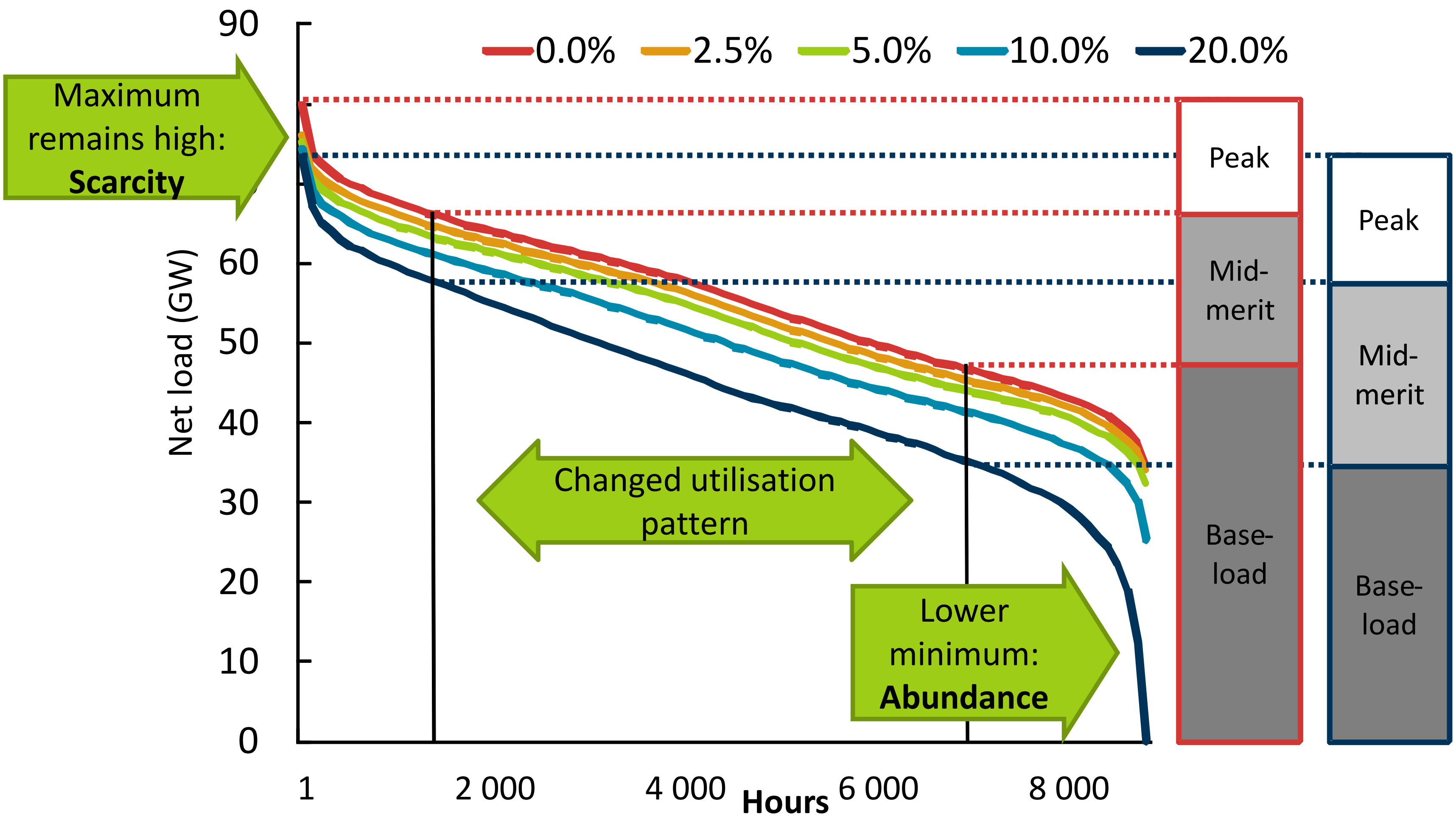
# Properties of variable renewables and impact groups

- Systems are different – impacts will vary too
- But common groups of effects



# Main persistent challenge: Utilisation

- **Netload implies different utilisation for non-VRE system**




Note: Load data and wind data from Germany 10 to 16 November 2010, wind generation scaled, actual share 7.3%. Scaling may overestimate the impact of variability; combined effect of wind and solar may be lower, illustration only.

# Integration vs. transformation

- **Classical view: VRE are integrated into the rest**
  - **Integration costs: balancing, adequacy, grid**

**Remaining system**

**VRE**

- **More accurate view: entire system is re-optimised**
  - **Total system costs**

**FLEXIBLE**
**Power system**

- **Generation**
- **Grids**
- **Storage**
- **Demand Side Integration**

→ **<u>Integration is actually about transformation</u>**


© OECD/IEA 2014

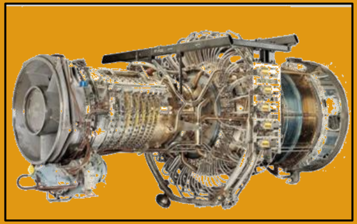
# Three pillars of system transformation

Technology spread

Geographic spread

Design of power plants

*System friendly VRE*



**Investments**

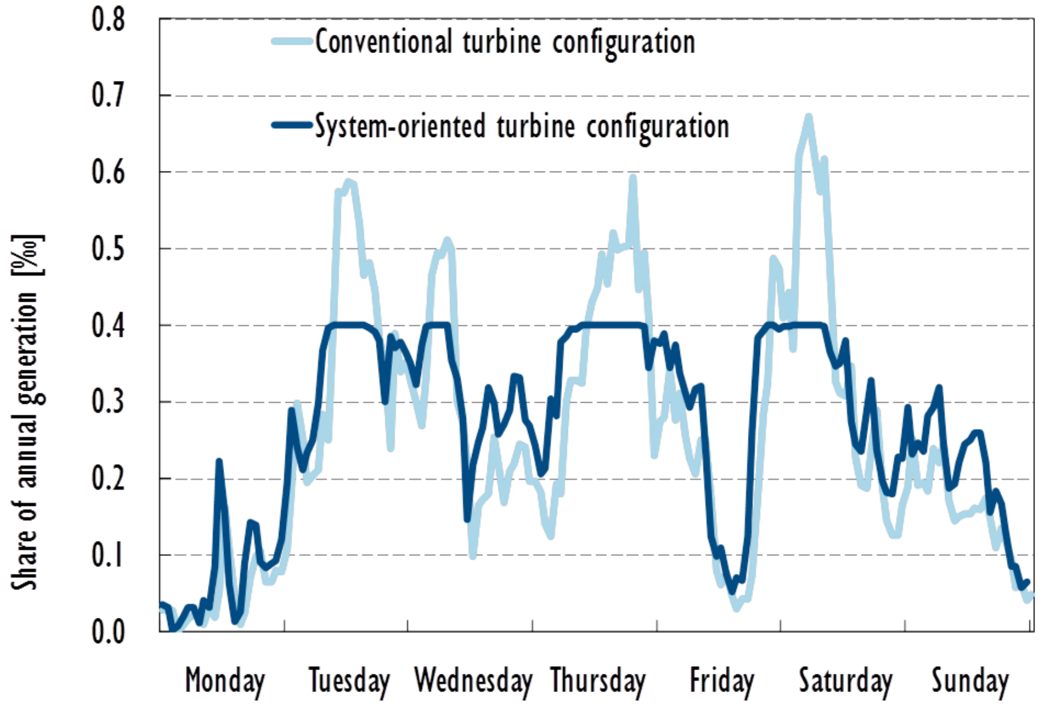
**Operations**

# 1) System friendly VRE deployment

- Wind and solar PV can contribute to grid integration
- But only if they are allowed and asked to do so!

➔ Take a system perspective when deploying VRE

*Example: System friendly design of wind turbines can reduce variability*

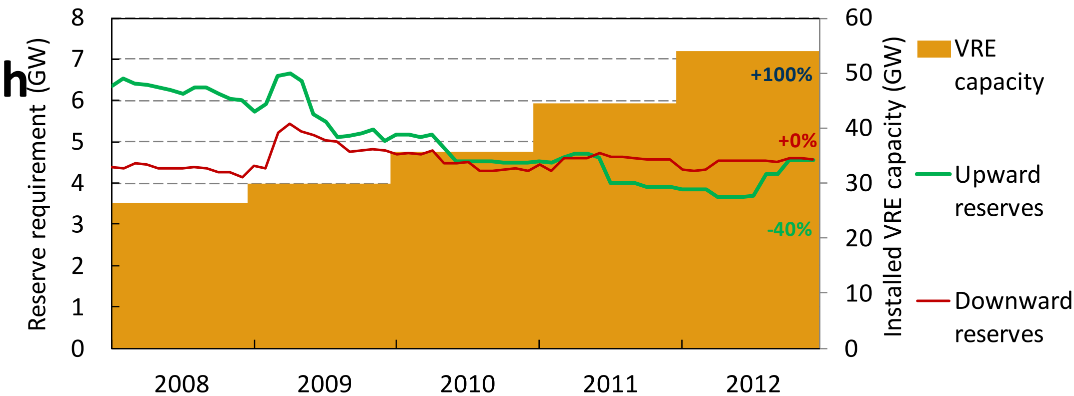



Source: adapted from Agora, 2013

# 2) Better system operation

- **VRE forecasting**
- **Better system operations:**
  - **Dynamic generation scheduling**
    *Update schedules close to real time*
  - **Dynamic generation dispatch**
    *Short dispatch intervals*
  - **Dynamic use of the grid**
    *Update interconnection schedules close to real time; sub-hourly scheduling*
  - **Reward flexible operation**
    *Make payments based on what is helpful for the system, not just MWh*

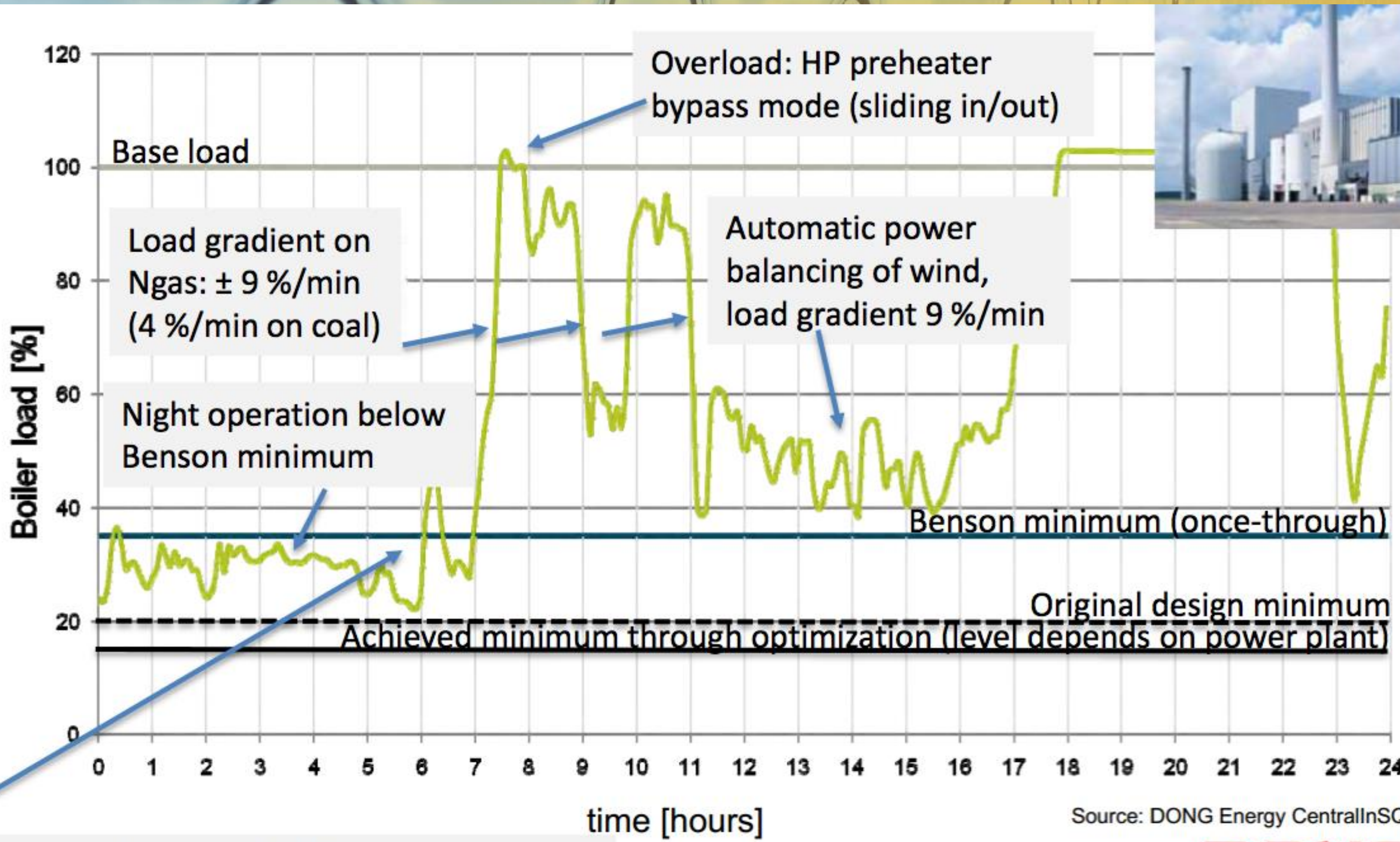
*Required frequency restoration reserves in Germany*




- **Germany has four balancing areas (historic reasons)**
- **Reserve sharing mechanism across four areas**
- **Reduced requirements despite rapid increase of VRE**

**→ Make better use of what you have already!**

# Experiences from coal in Denmark

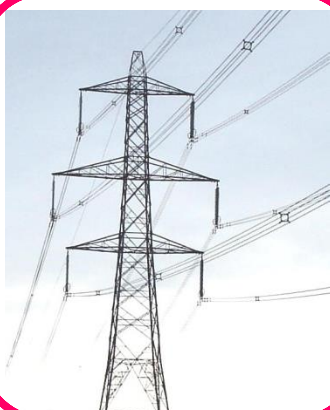



Several Benson-pass cycles in one day! Components designed for 50 passes year. Redesign of component required due to fatigue. Assessment concluded no problem with life time in this case. In other cases the assessment may conclude that component must be replaced after X years.

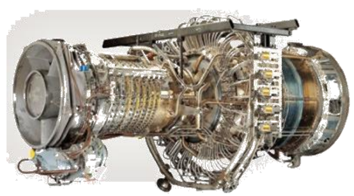
DONG energy

# 3) Investment in additional flexibility

## Four sources of flexibility …



Grid infrastructure



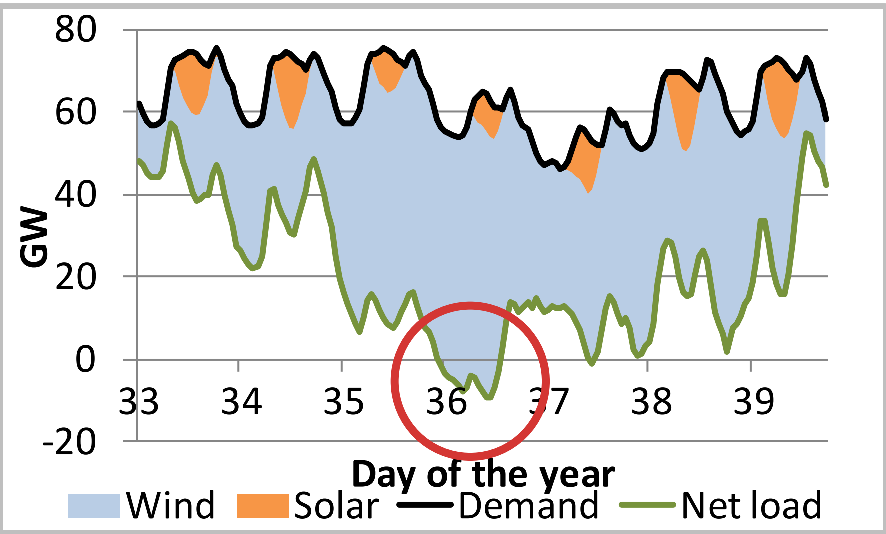
Dispatchable generation

Storage

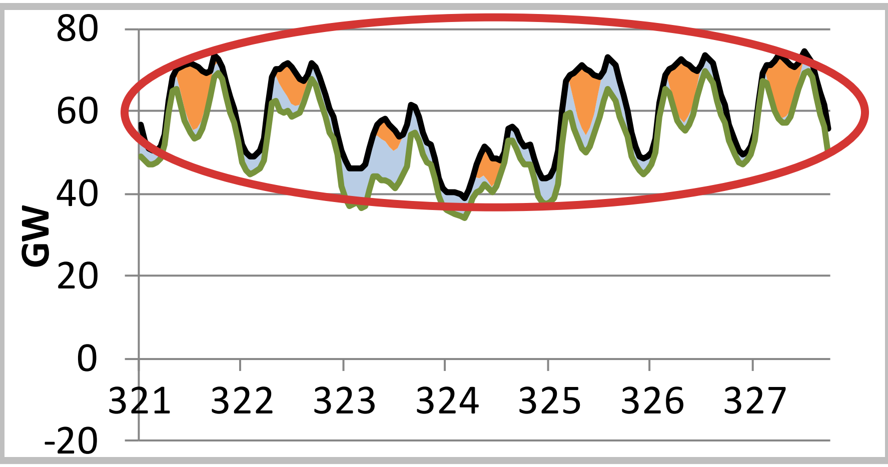
Demand side integration

# Investments in system flexibility – Need for a mix of solutions

- **Abundance**
  - Flexible generation ✗ ✗
  - DSI ✓
  - Storage ✓
  - Curtailment ✓




- **Multi-day scarcity**
  - Flexible generation ✓ ✓
  - DSI o
  - Storage ✓
  - Curtailment ✗ ✗




- <u>**No single resource does it all!**</u>

✓ ✓ : very suitable, ✓ :suitable, o : neutral, ✗ ✗ : unsuitable

Data: Germany 2011, 3x actual wind and solar PV capacity

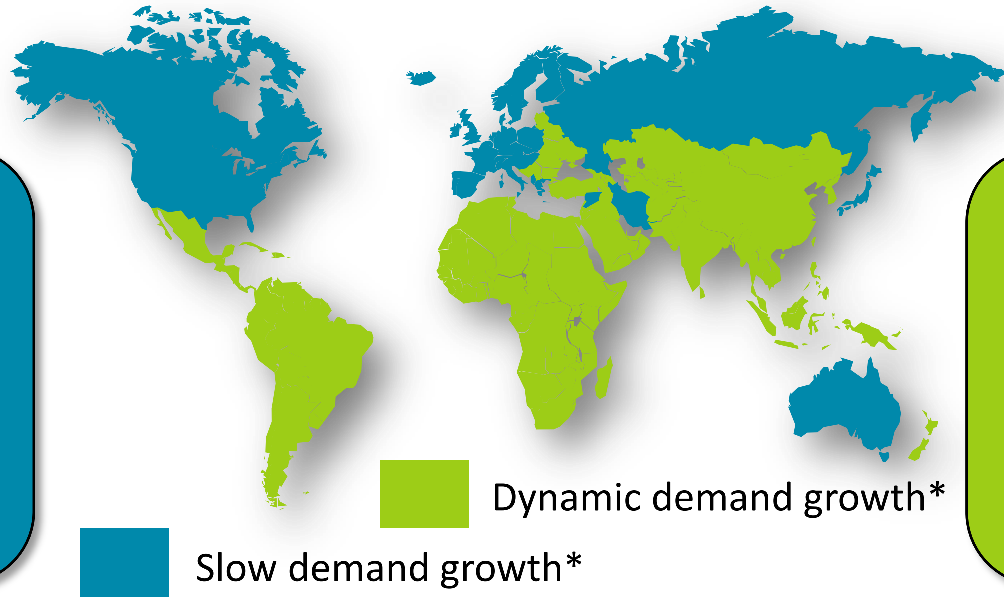
# Recommendations 1/2

- All countries where VRE is going mainstream should:
  - Optimise system and market operations
  - Deploy VRE in a system-friendly way to maximise their value to the overall system
- Countries beginning to deploy VRE power plants (shares of up to 5% to 10% of annual generation) should:
  - Avoid uncontrolled local concentrations of VRE power plants ("hot spots")
  - Ensure that VRE power plants can contribute to stabilising the grid when needed
  - Use state of the art VRE forecast techniques

# Transformation depends on context Recommendations 2/2

**Stable Power Systems**

- Little general investment need short term




**Dynamic Power Systems**

- Large general investment need short term

➔ **Maximise the contribution from existing flexible assets**

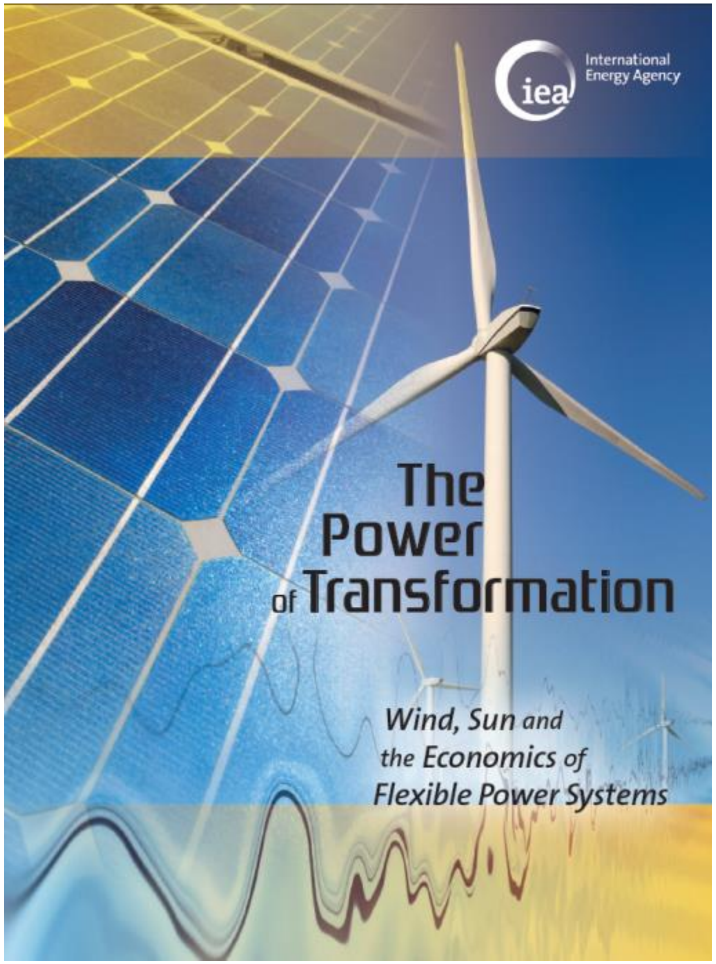
➔ **Decommission or mothball inflexible polluting surplus capacity to foster system transformation**

➔ **Implement holistic, long-term transformation from onset**

➔ **Use proper long-term planning instruments to capture VRE's contribution at system level**

* Compound annual average growth rate 2012-20 , slow <2%, dynamic ≥2%; region average used where country data unavailable

This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.




- **Thank you**
  - **simon.mueller@iea.org**