Is it Really Possible to Integrate High Levels of VRE at Moderate Incremental Cost? Are the Integration Challenges Really so Country Specific?

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Integrating Variable Renewable Energy into Power Grids
ESMAP Knowledge Exchange Forum, 21 October 2014, Copenhagen

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**

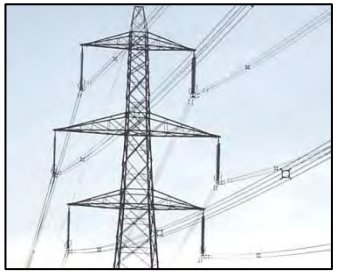
yrs

sec

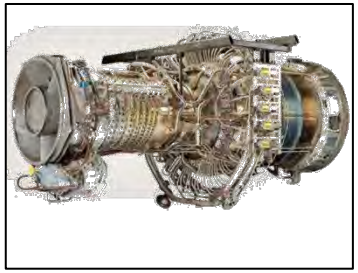
100s km

1 km

Grids



Generation



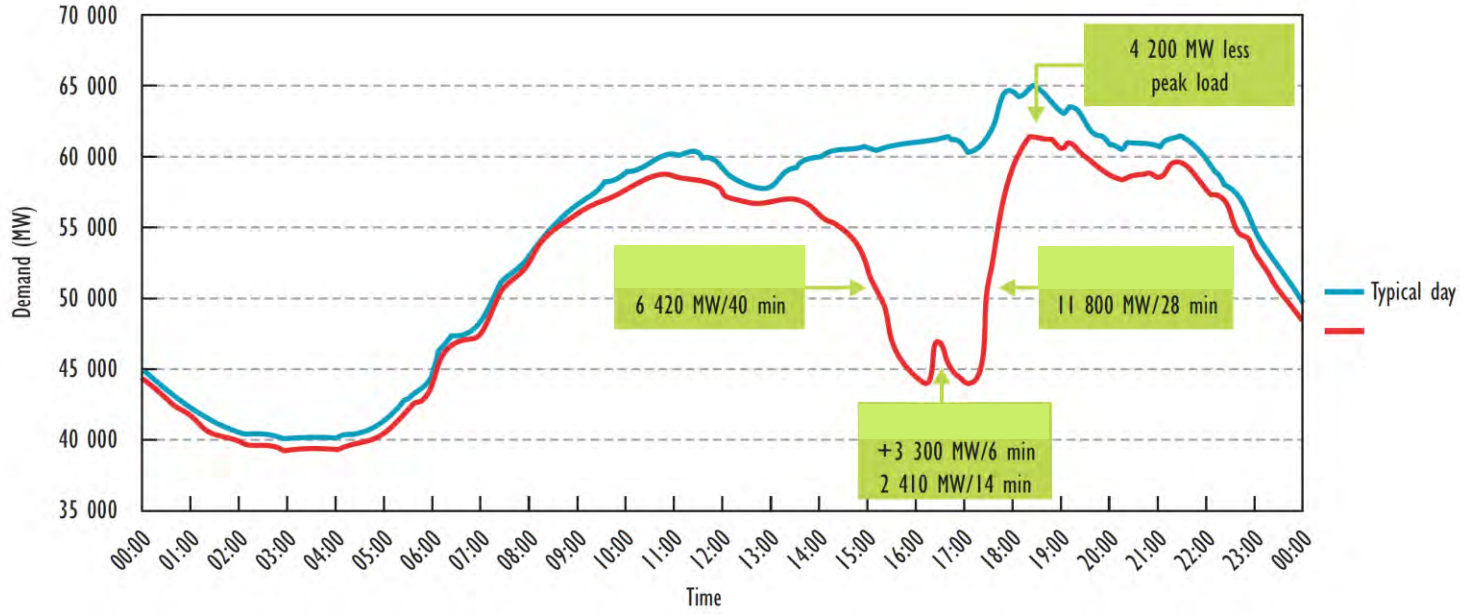
Storage

Demand Side

No problem at 5% - 10%, if …

- **Power systems already deal with a vast demand variability**
  - **Can use existing flexibility for VRE integration**

Exceptionally high variability in Brazil, 28 June 2010



- **No technical or economic challenges at low shares, if basic rules are followed:**
  - **Avoid uncontrolled, local 'hot spots' of deployment**
  - **Adapt basic system operation strategies, such as forecasts**
  - **Ensure that VRE power plants are state-of-the art and can stabilise the grid**

Integration vs. transformation

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

- **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>**

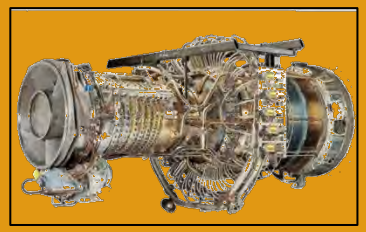
Three pillars of system transformation

Technology spread

Geographic spread

Design of power plants

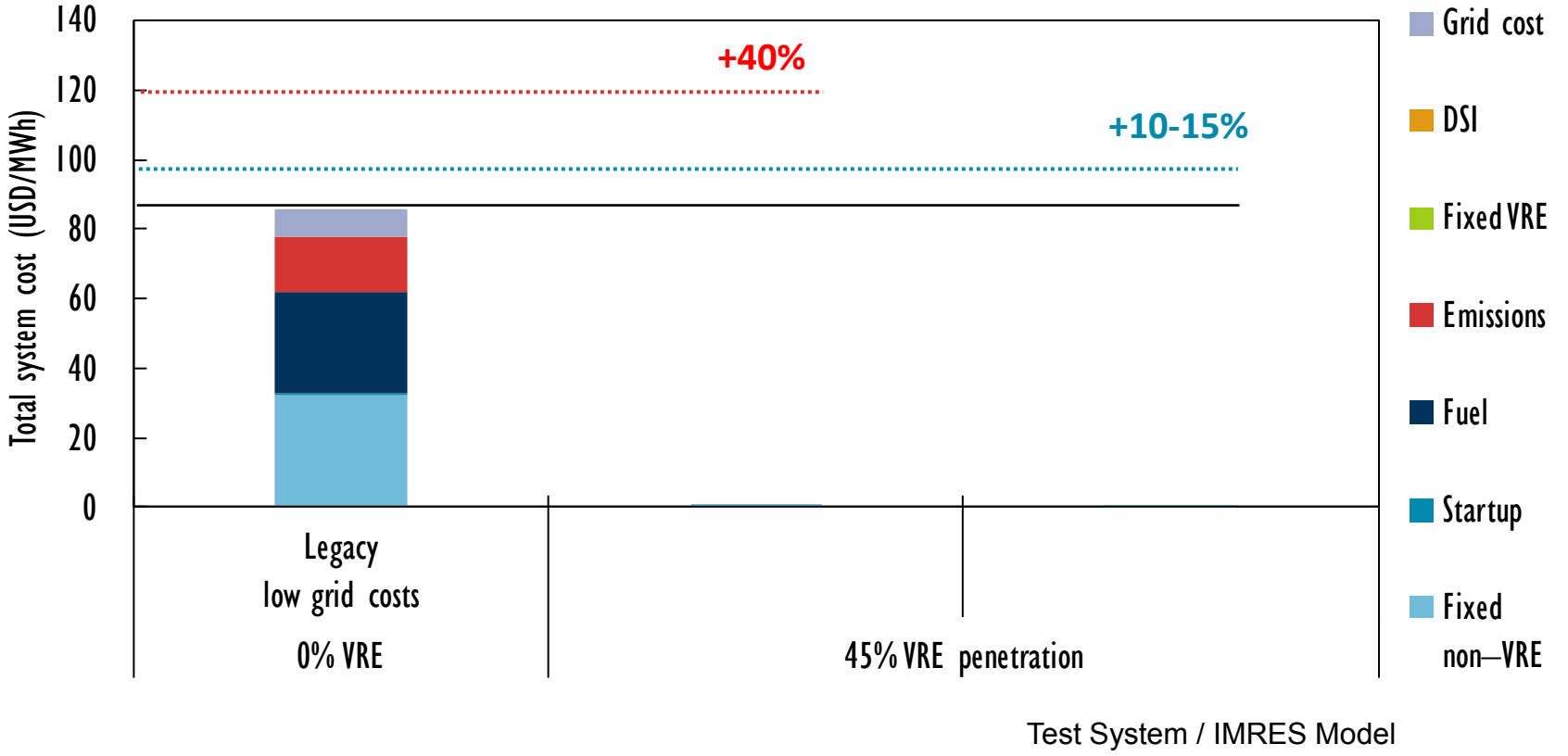
System friendly VRE



Investments

Operations

Cost-effective integration means transformation of power system



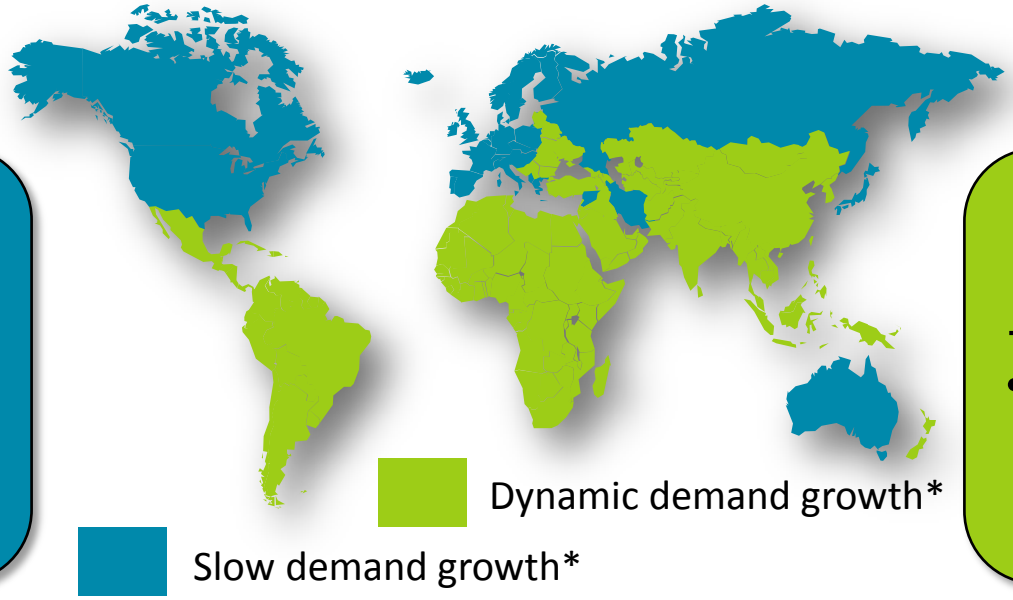
Test System / IMRES Model

- Large shares of VRE can be integrated cost-effectively
- But adding VRE rapidly without adapting the system is bound to increase costs

Transformation depends on context

Stable Power Systems

- Little general investment need short term



Dynamic Power Systems

- Large general investment need short term

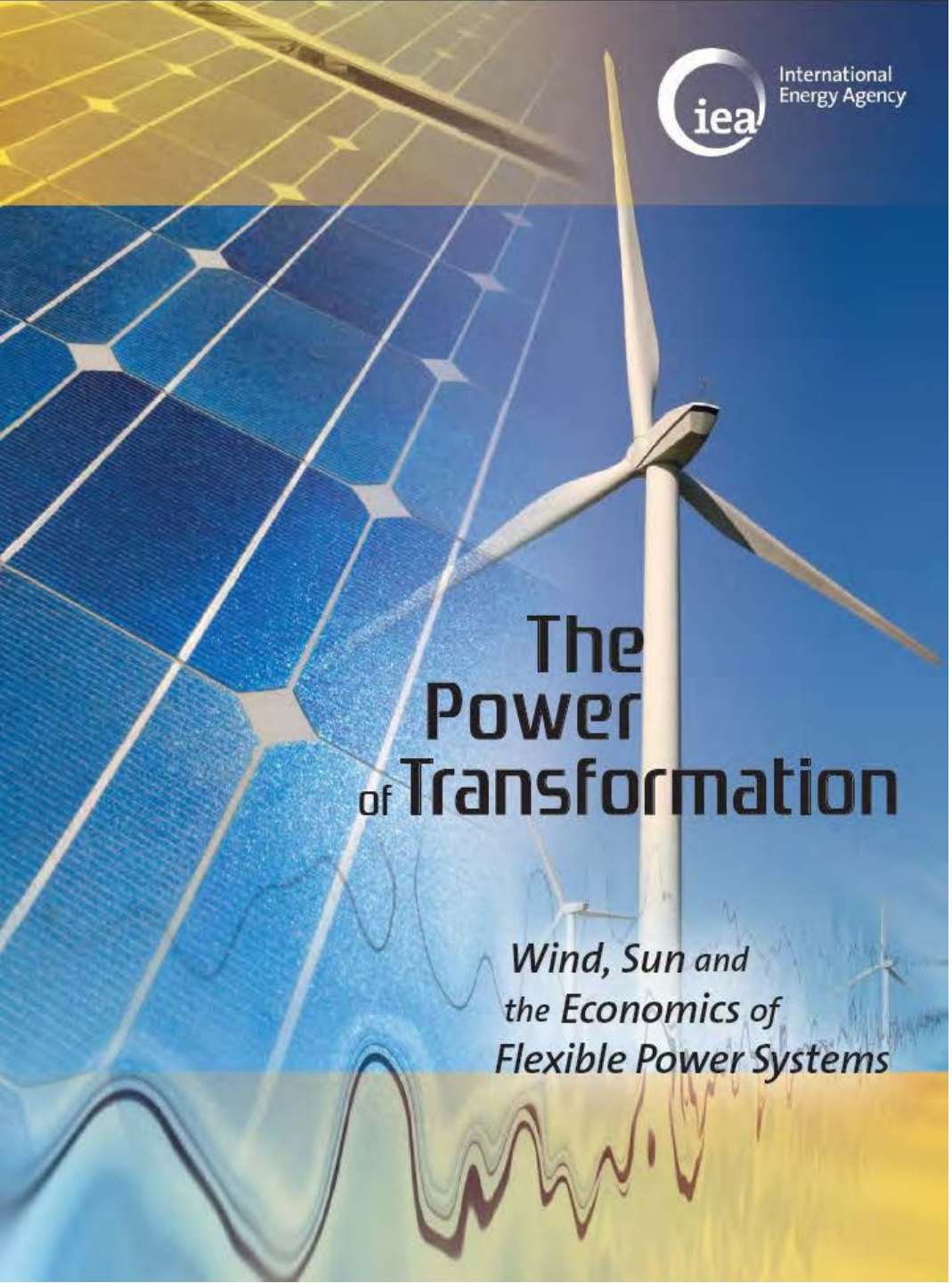
➔ **Maximise the contribution from existing flexible assets**

➔ **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



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