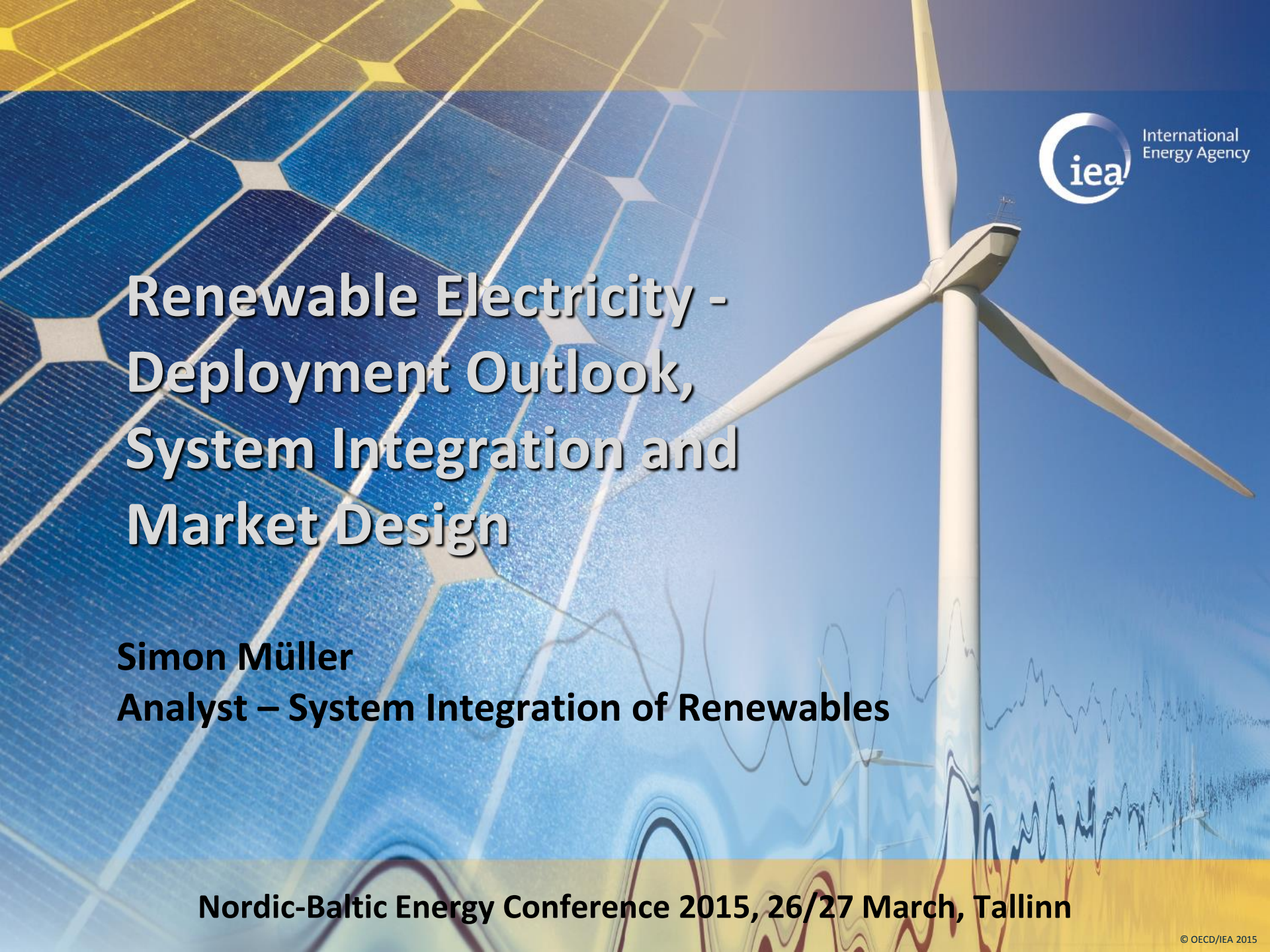

Renewable Electricity - Deployment Outlook, System Integration and Market Design

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Outline

- **Global context**
  World Energy Outlook and *Medium Term Renewable Market Report*

- **Integration of wind and solar PV**
  System transformation strategies for secure and cost-effective integration

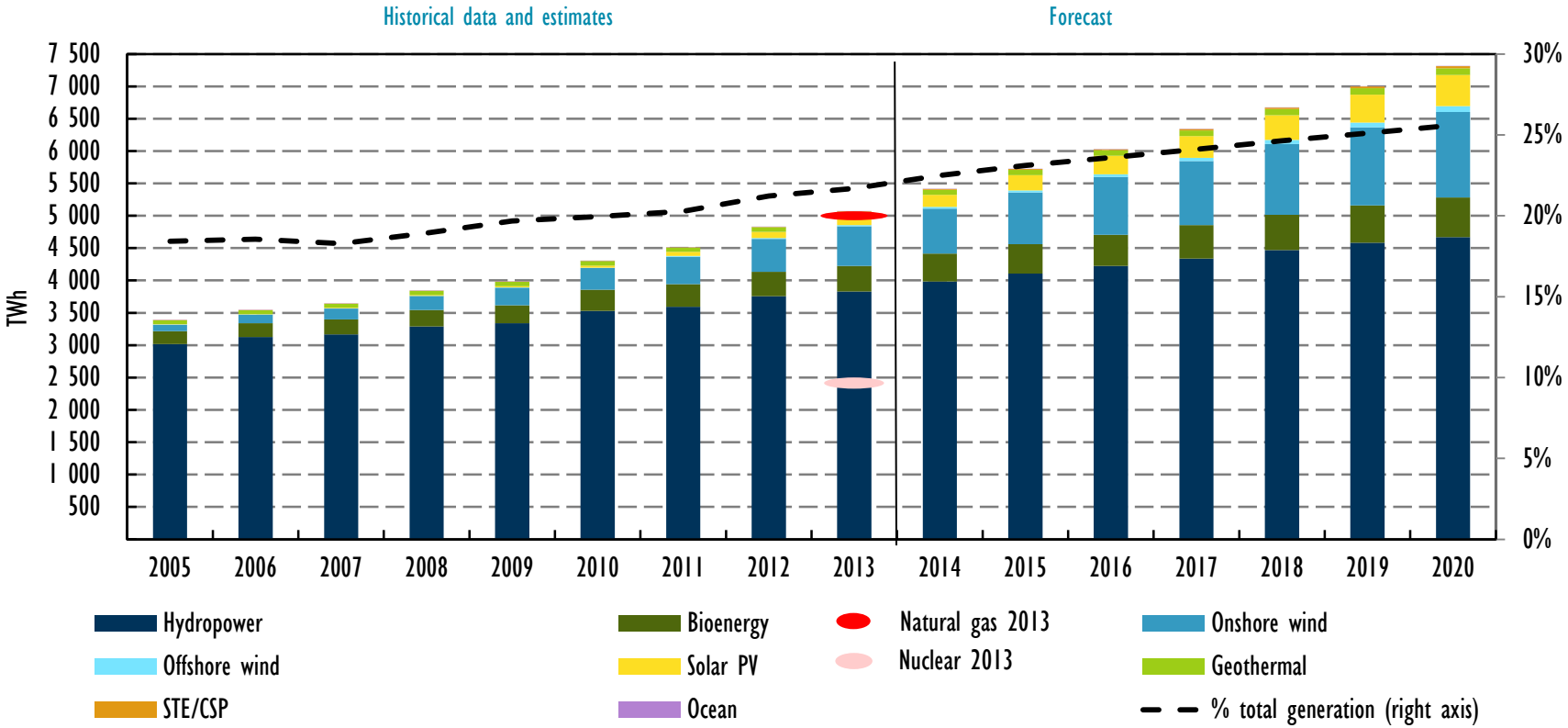
- **Well-designed policy and market frameworks**
  Towards an integrated approach for the power sector as a whole

Part 1: Global context

World Energy Outlook and Medium Term Renewable Energy Outlook

Strong momentum for renewable electricity

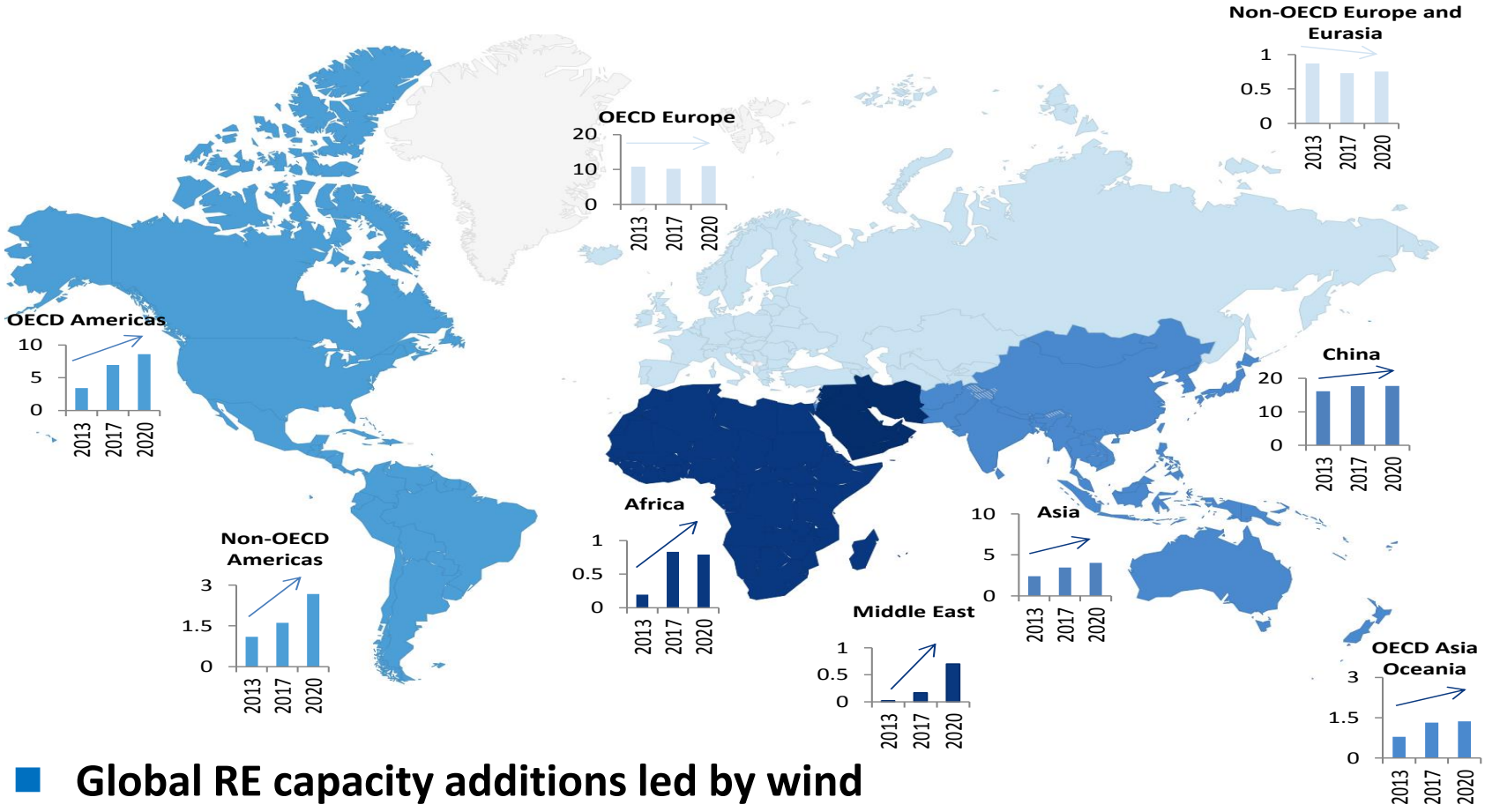
Global renewable electricity production, historical and projected



- **Renewable electricity projected to scale up by 45% from 2013 to 2020**

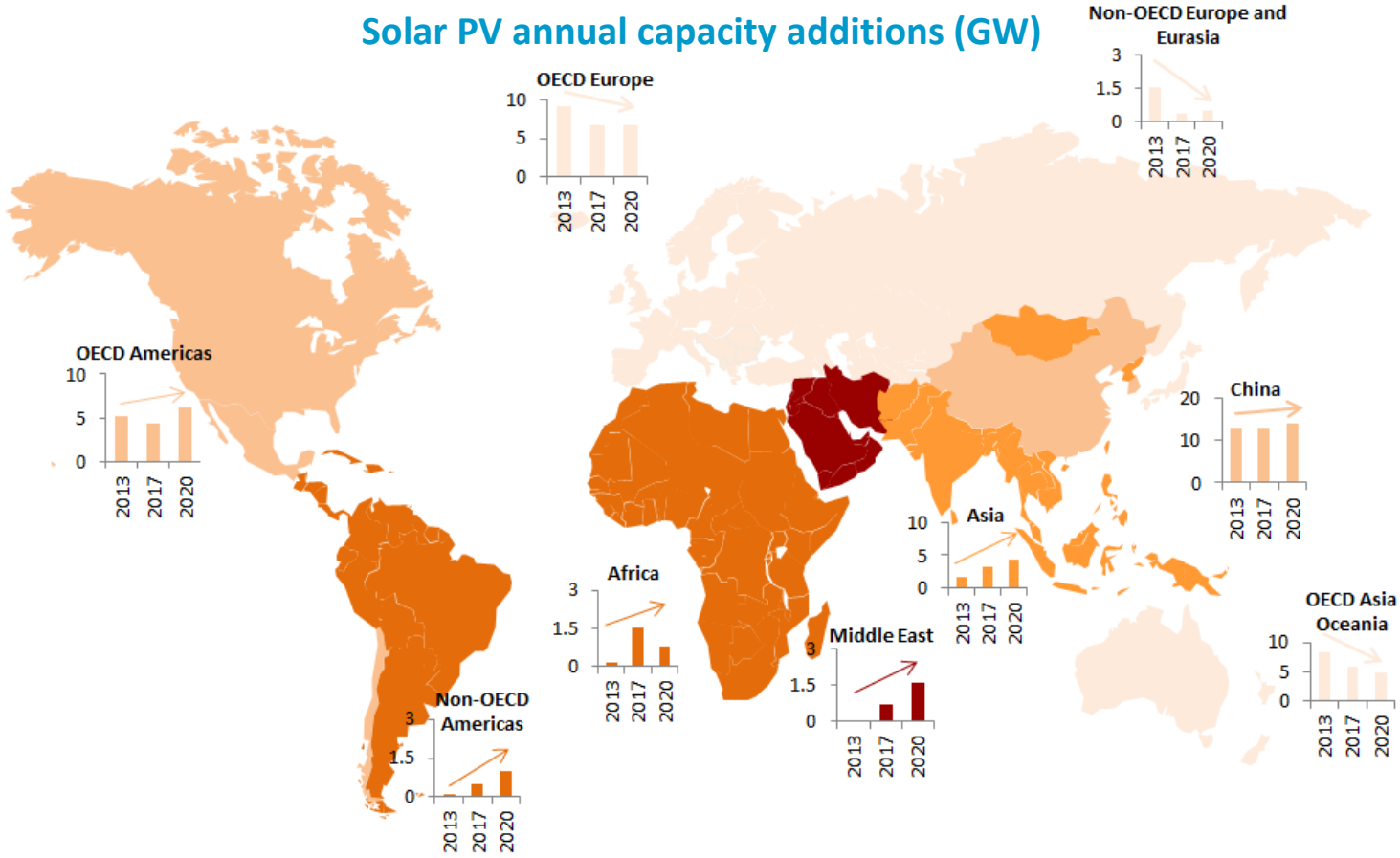
Wind growth continues to strengthen in emerging markets

Total wind (onshore + offshore) annual capacity additions (GW)



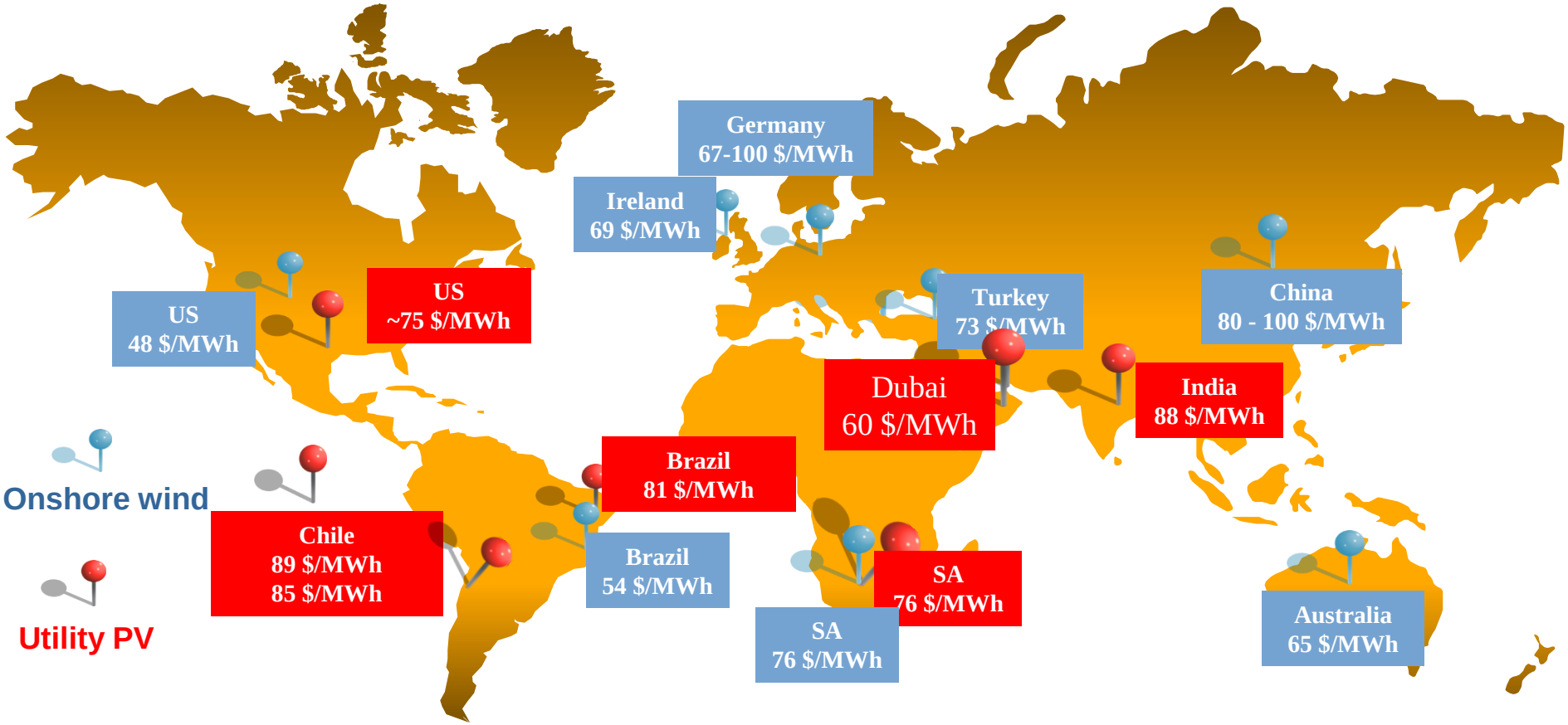
- Global RE capacity additions led by wind
- Still outlook is somewhat more pessimistic than in MTRMR 2013 due to policy uncertainties, integration and financing challenges in some areas

Stronger outlook for solar PV



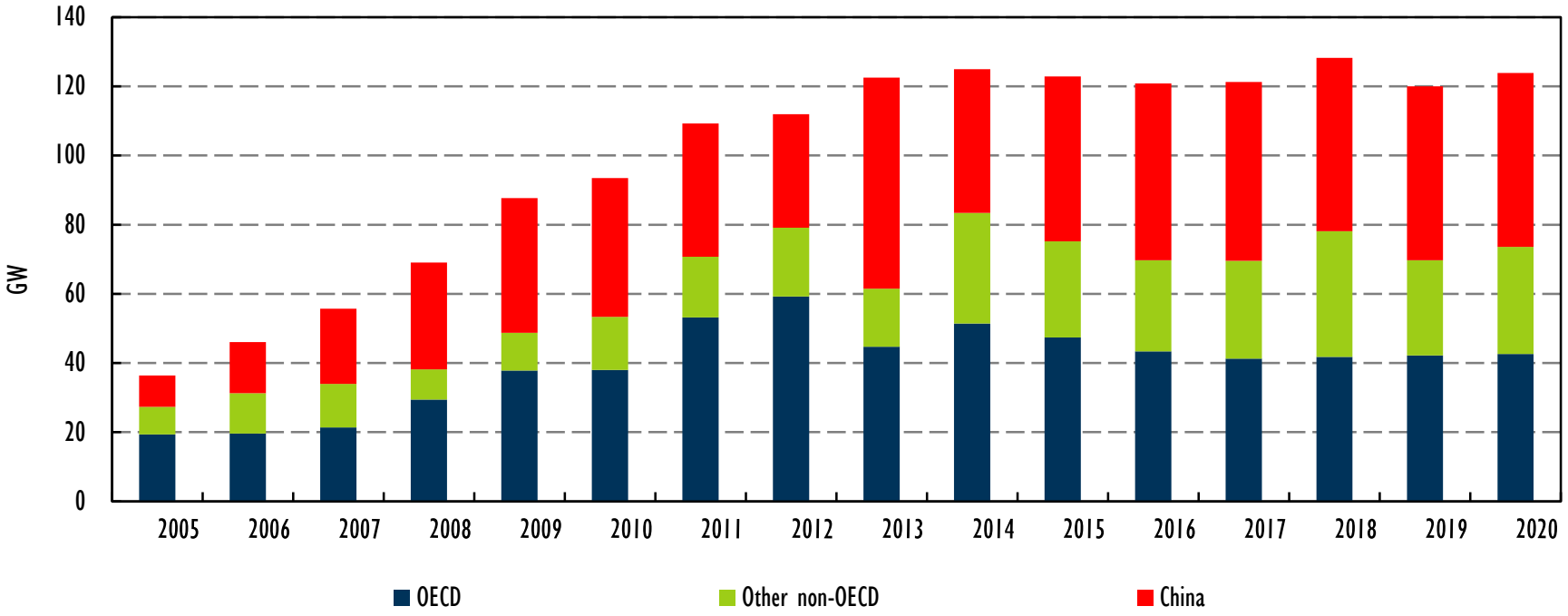
- Strong growth in emerging markets and some OECD areas
- Policy debates over distributed PV a source of forecast uncertainty

Cost reductions are increasingly putting wind and solar PV on par with fossil alternatives



Increasing risks are expected to slow renewable growth

Renewable power annual net capacity additions, historical and projected

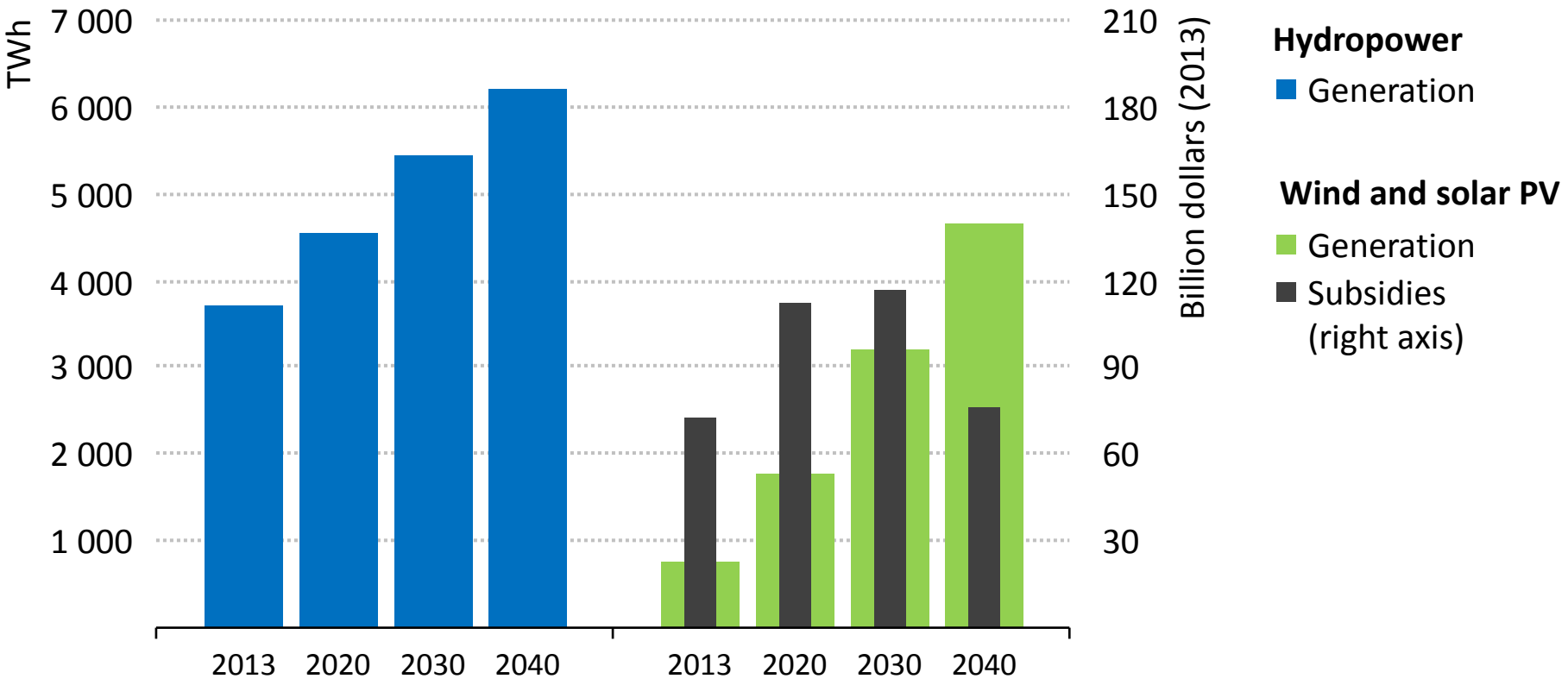


- **Policy and market risks threaten to slow deployment momentum for renewables**

Renewables overtake coal to become the leading source of power

World Energy Outlook 2014

Renewables-based power generation and subsidies



Renewables supply half of the growth in global power demand; wind & solar PV subsidies decline from 2030 as costs fall & recent higher-cost commitments expire

Summary – global context

- Renewable energy bound to become the primary source of electricity by 2040 in the WEO *New Policies Scenario*
- Costs of key technologies have come down dramatically and deployment moving to emerging economies
- But: policy and market risks cloud medium-term forecasts

Part 2: Integration of wind and solar PV

System transformation strategies

Interaction is key

Properties of variable renewable energy (VRE)

Flexibility of other power system components

yrs

sec

- **Variable**
- **Uncertain**
- **Non-synchronous**

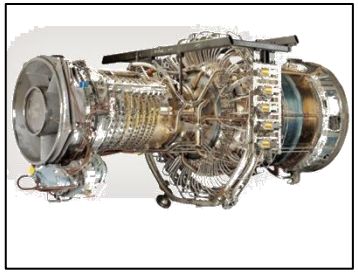
100s km

1 km

- **Location constrained**
- **Modularity**
- **Low short-run cost**

Grids

Generation



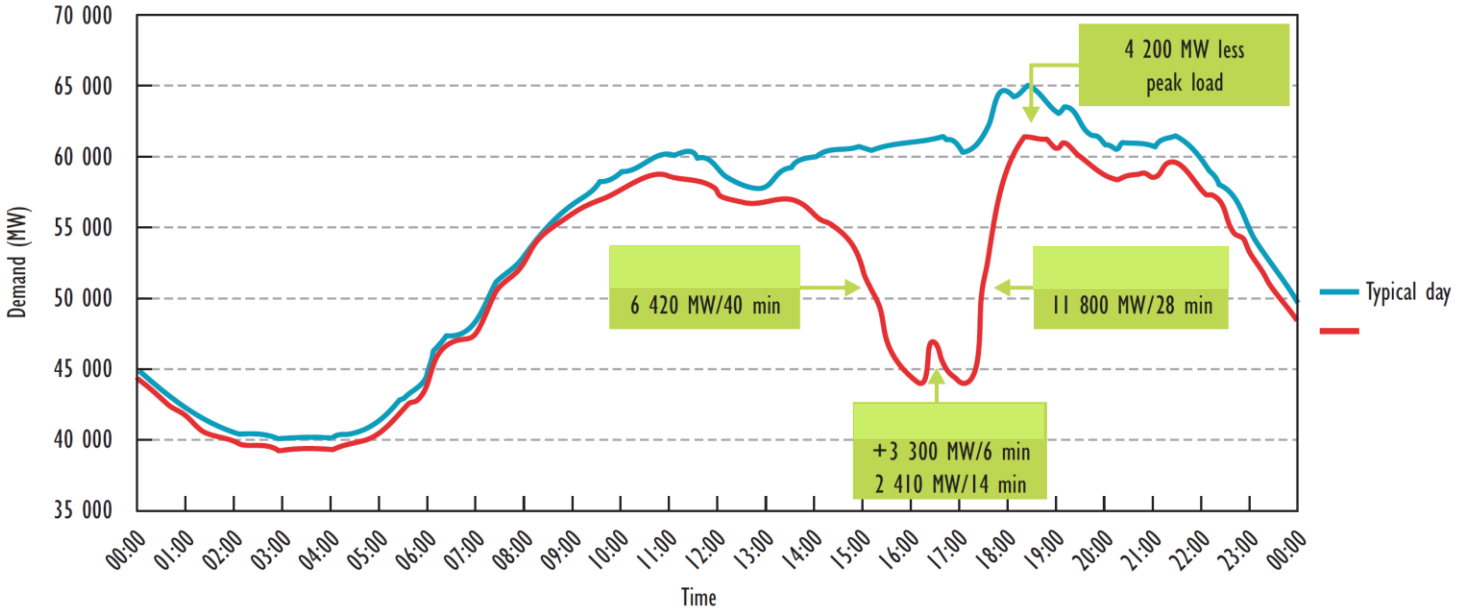
Storage

Demand Side

No problem at 5% - 10%, if …

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

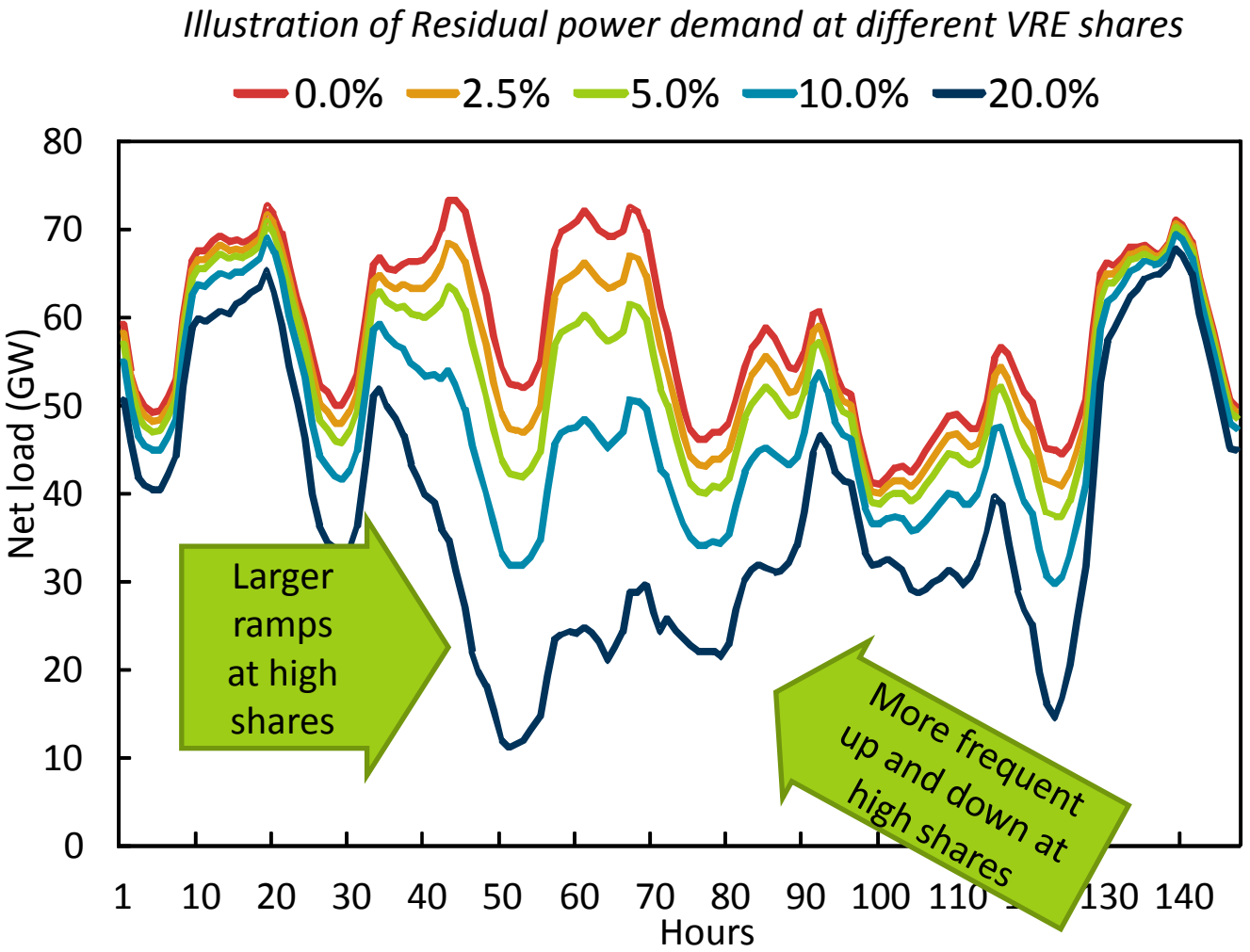
Exceptionally high variability in Brazil, 28 June 2010



- **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**

Main persistent challenge: Balancing

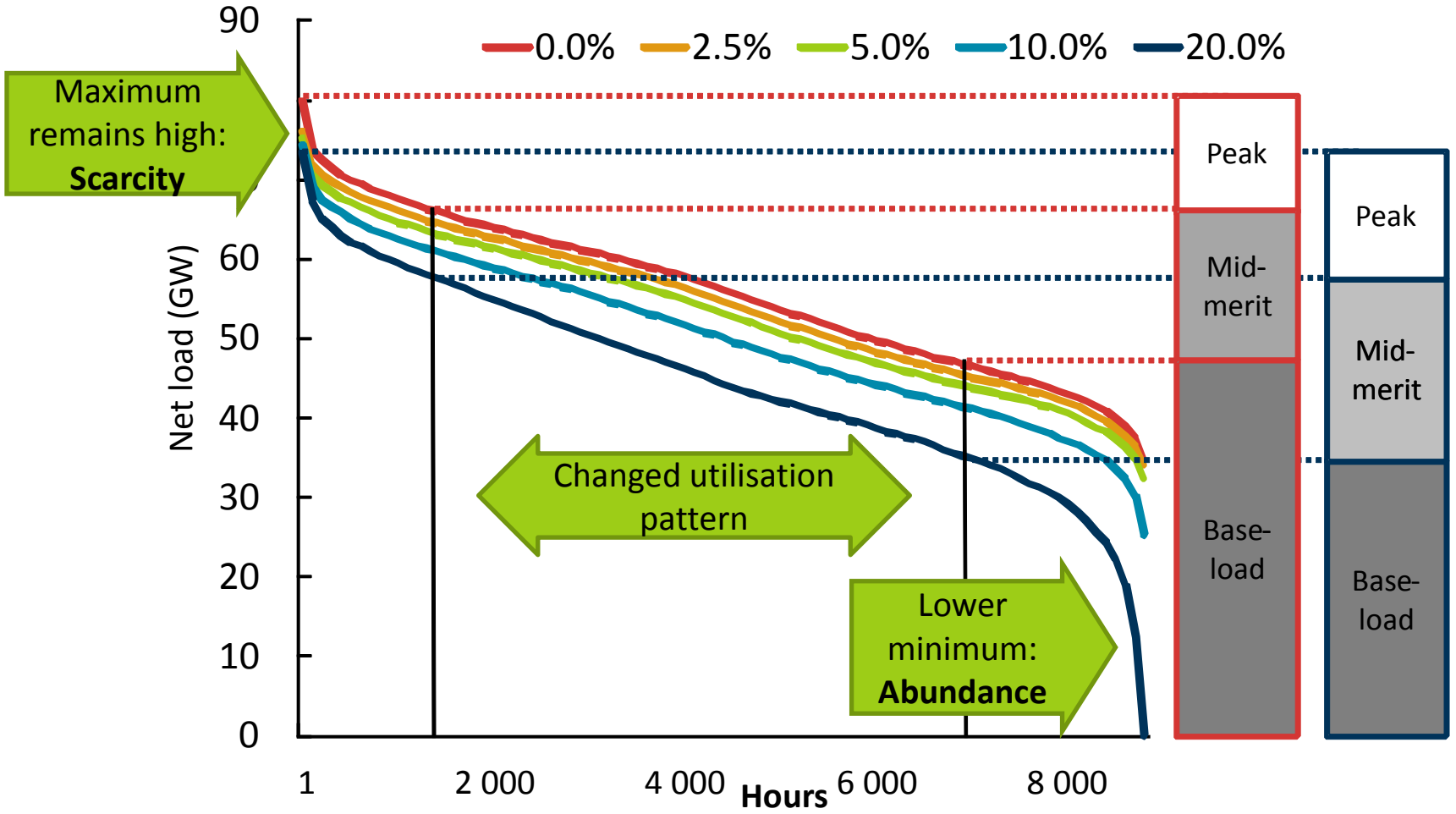
- Higher uncertainty
- Larger and more pronounced changes



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.

Main persistent challenge: Utilisation

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



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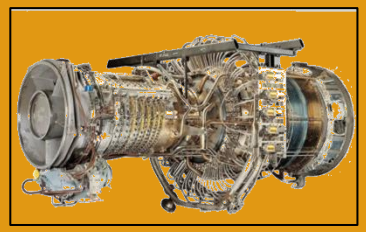
Three pillars of system transformation

Technology spread

Geographic spread

Design of power plants

System friendly VRE



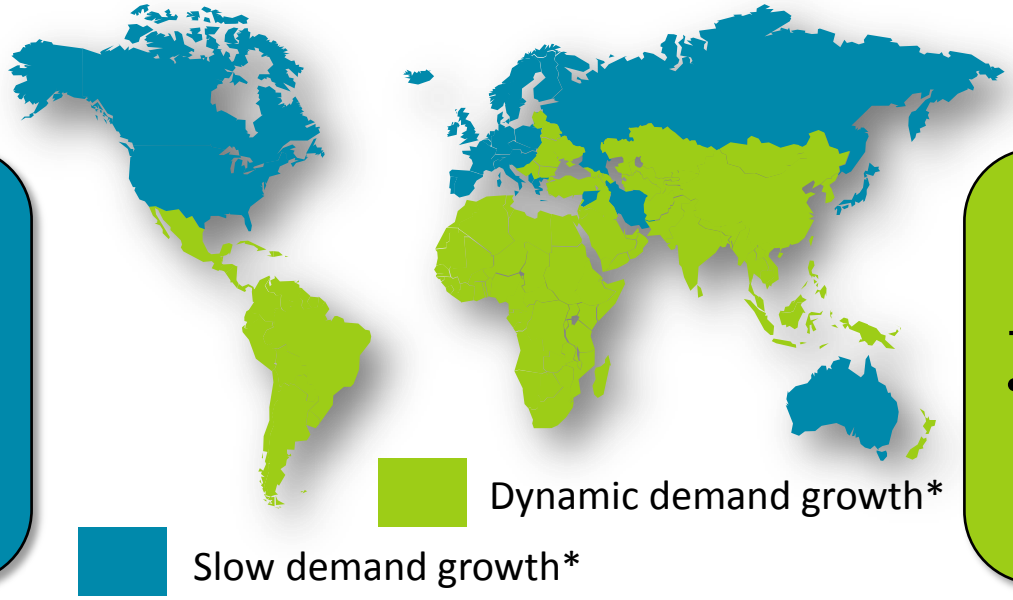
Investments

Operations

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

Summary – system integration 1/2

- Very high shares of variable renewables are technically possible – there is no technical maximum limit
- No problems at low shares, if best practice rules followed
- Reaching high shares cost-effectively calls for system-wide transformation, which depends on country context

Part 3: Well-designed policy and market frameworks

Towards an integrated approach for the power sector as a whole

What is market design?

- A functioning market design achieves a social optimum via price signals for market participants
- Asking for a functioning "market design" already implies intervention
  - But degree of intervention can be very different
- Policy instruments and regulation set the playing field in which markets operate
  - If policy instruments pre-determine the outcome, not much market is left

➔ We are looking for the right market, policy and regulatory framework

What do frameworks need to deliver?

- For all low-carbon technologies:
  1. Pricing of externalities
  2. Unlocking investments in capital-intensive technologies
  3. Overcome existing lock-in of fossil fuel generation
- For wind and solar PV in particular:
  1. Ensuring operational efficiency with high shares of
     - variable and
     - distributed generation
  2. Securing sufficient investments in flexible resources

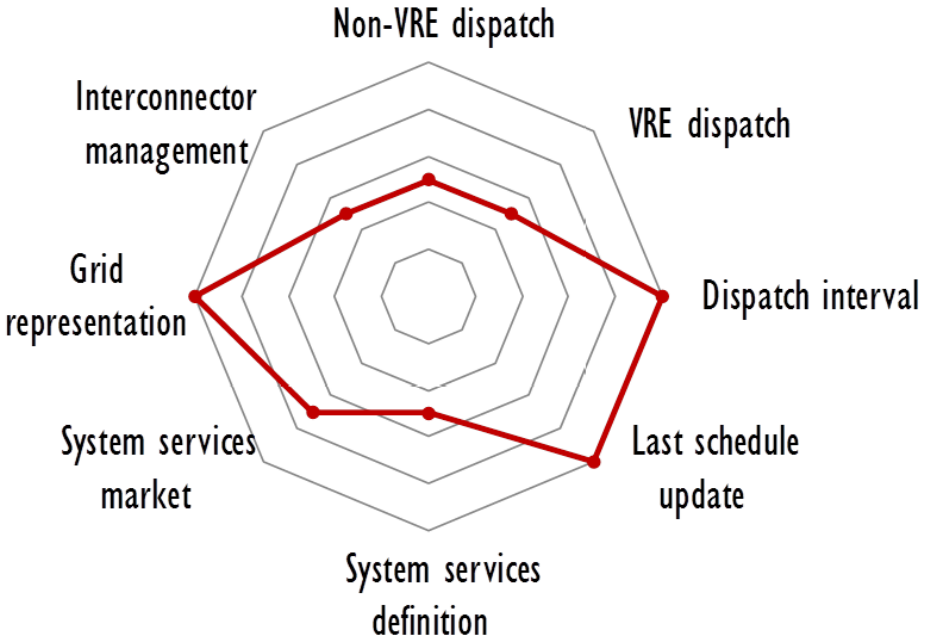
➔ Well-designed markets and a carbon constraint are necessary but will likely not be enough

➔ Additional instruments to attract investments likely to be required

Improving existing electricity markets

Example: ERCOT (Texas) market design

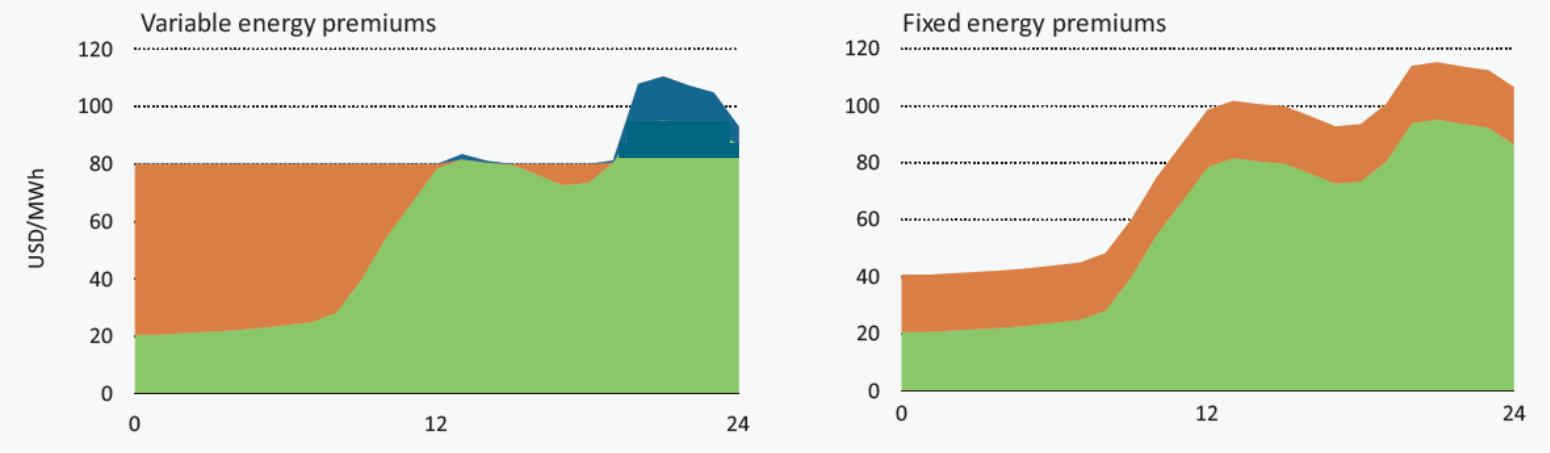
- **Fast trading**
  Best practice:
  US (Texas) – 5 minutes
- **Price depending on location**
  Best practice: US –
  Locational Marginal Prices
- **Better flexibility markets**
  Example: Fully remunerated reserve provision



- **Align system and market operation**
  Example: US Independent System Operators

Improved renewable support policies

- System approach and well designed interface between policies and markets is key
- Market premiums promising option, but type of premium matters
  - Variable premiums tend to pass less market risk onto generators:



- The role of policies is shifting:
  - away from bridging a large cost-gap vis-à-vis fossil alternatives
  - towards providing revenue certainty for capital-intensive technologies and deployment of enabling technologies

Inevitable policy side-effects

- Adding generation to a ‘stable’ market must come at the detriment of established players
- Adding large quantities of VRE to a system that was not designed for them de-values existing assets
- Mind re-distribution effects:
  - Likely losers:
    - End-consumers or tax-payers paying for scale-up of RE and other low-carbon generation
    - Incumbents exposed to low prices and reduced market share (or both)
  - Likely winners:
    - RE-generators
    - Buyers on the wholesale market

Summary – policy and market frameworks

- We are looking for the right market, policy and regulatory framework
- Improving current electricity markets and a more stringent carbon constraint are necessary but additional instruments likely required
- The role of policies is shifting away from bridging a large cost-gap towards providing revenue certainty for capital-intensive technologies during the transformation of power systems

Main conclusions

Main conclusions

- Renewables are bound to become the globally leading source of electricity
  - But policy action needed to overcome medium-term uncertainties and secure long-term success
- System integration no significant challenge for initial deployment
  - But reaching high shares cost effectively calls for a comprehensive approach to transform the system
- Improved markets and a carbon constraint necessary
  - But additional instruments likely needed during transformation to provide revenue certainty for capital intensive investments

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