Integration of Clean & Green Energy – Learnings for India

Integrating Clean and Green Energy in Power

India Pavilion, COP 22, Marrakesh, 16 November

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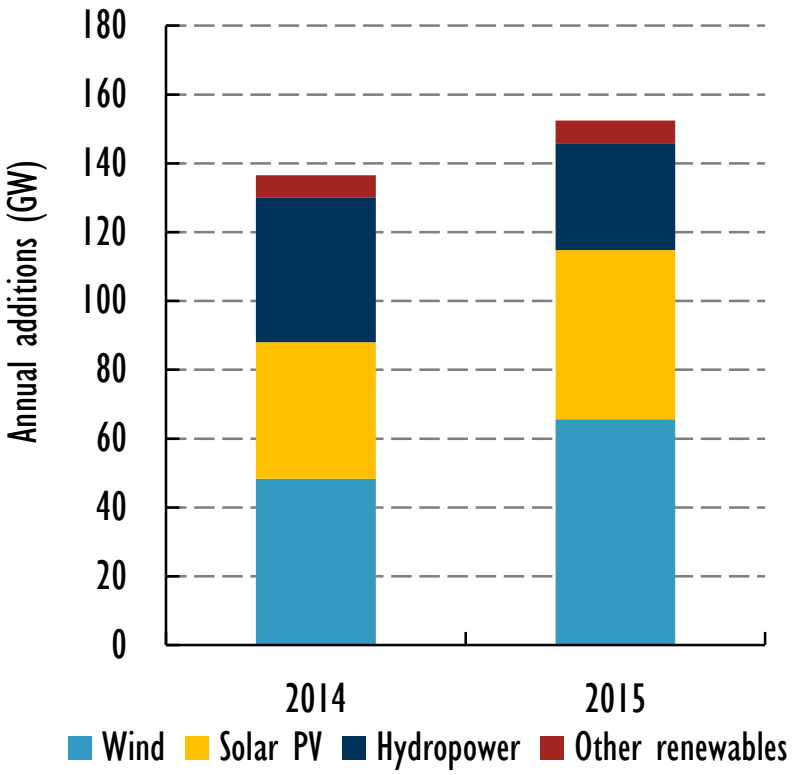
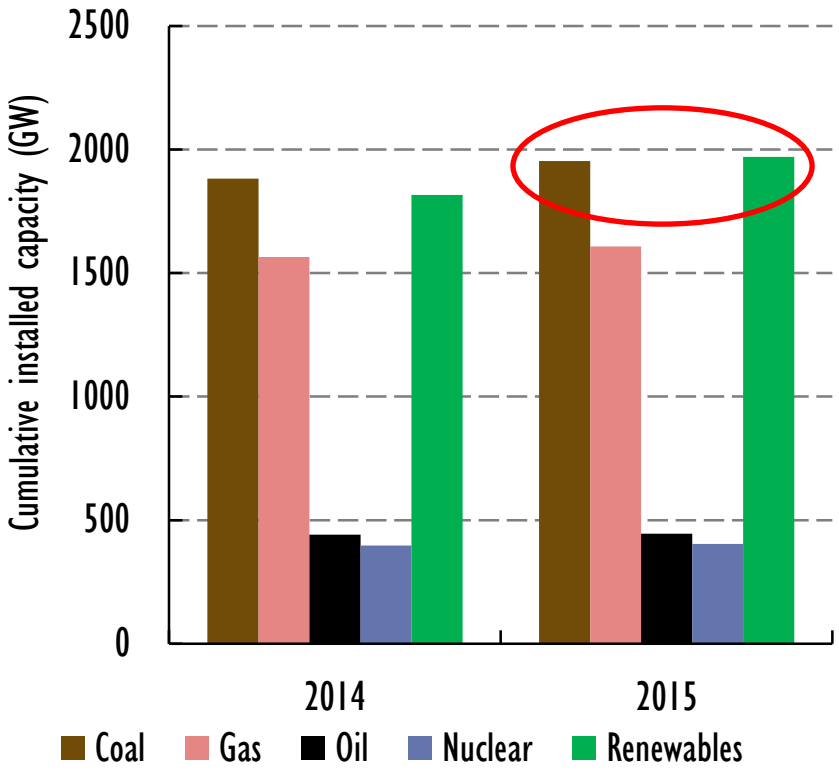
2015: a record year for renewables

RENEWABLE ENERGY
Medium-Term Market Report 2016

Renewable additions (2014-15) and cumulative installed power capacity





Cumulative renewable capacity surpassed coal at the end of 2015

Record low price announcements

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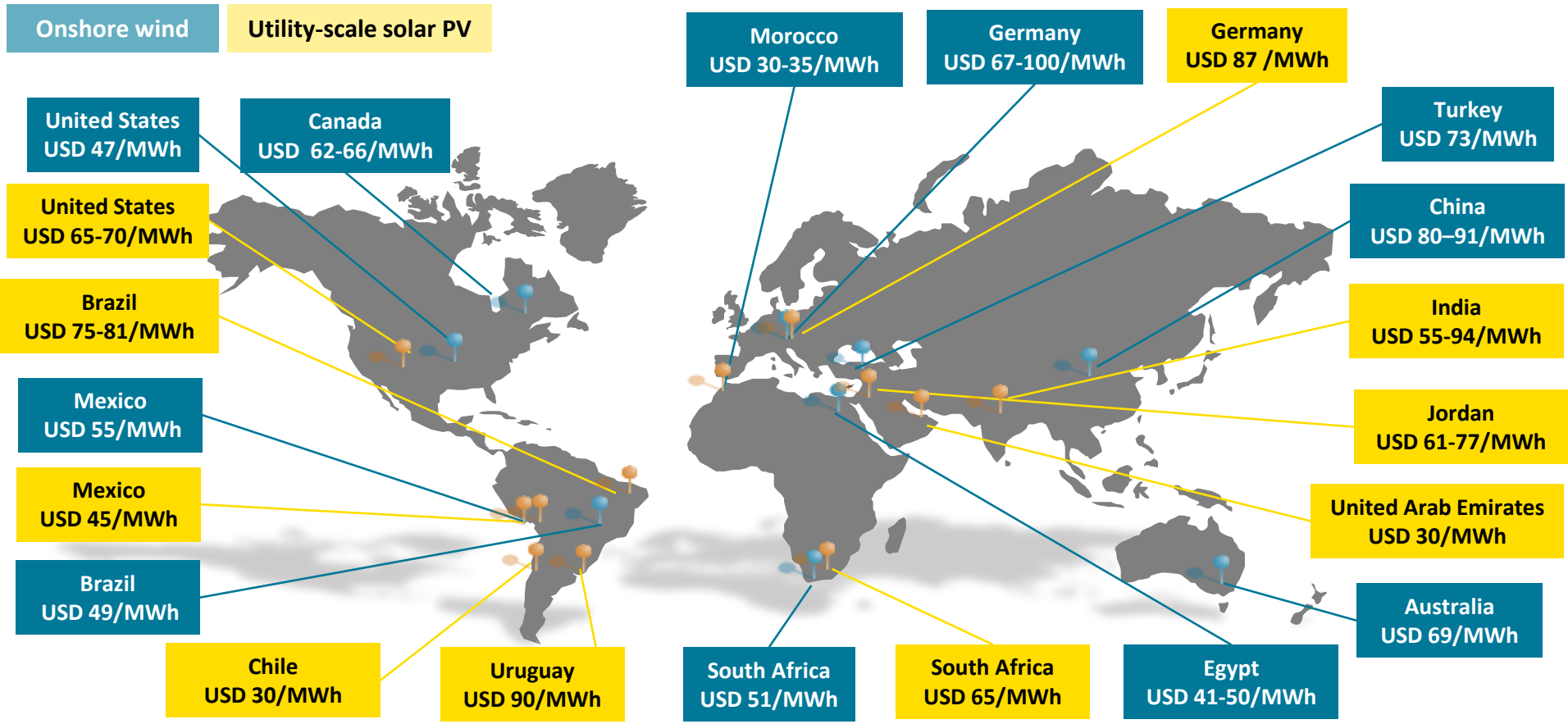
Recent announced long-term contract prices for new renewable power to be commissioned over 2016-2019

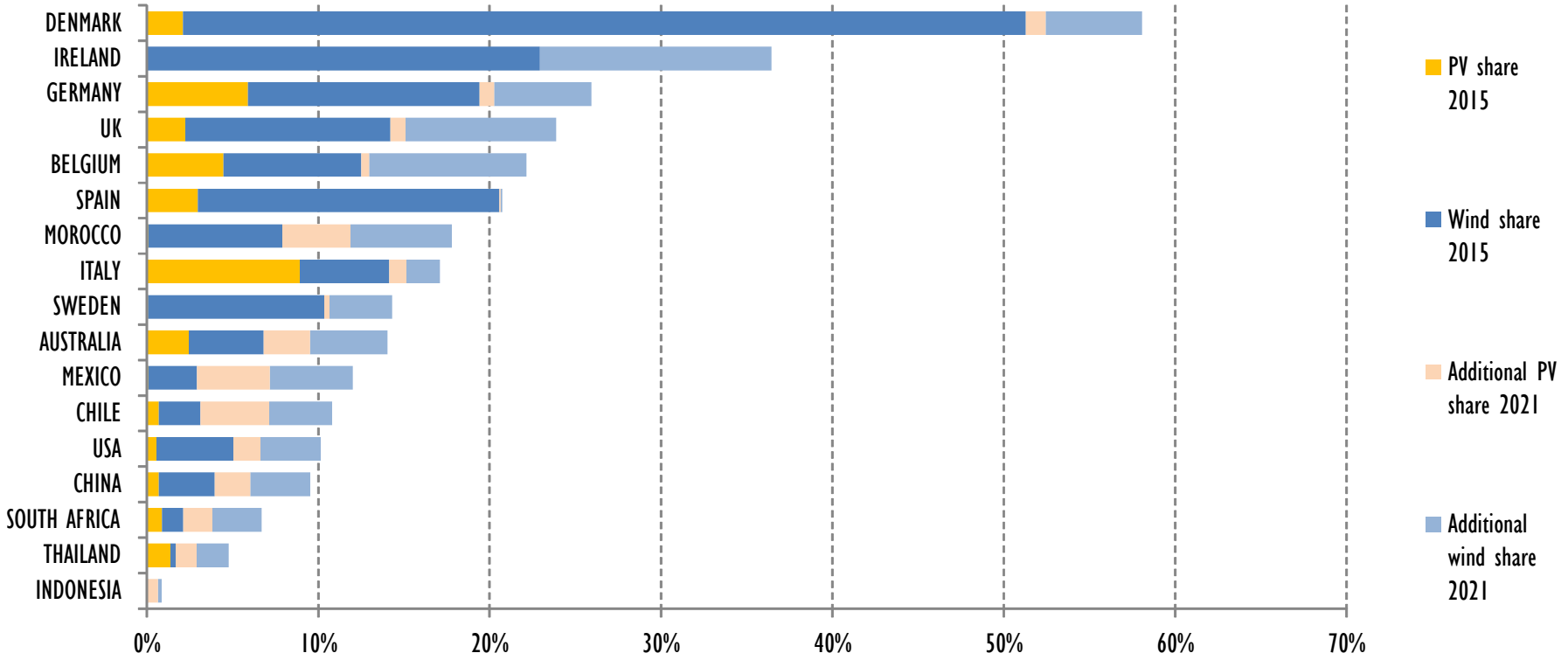


This map is without prejudice to the status or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area

Note: Values reported in nominal USD includes preferred bidders, PPAs or FITs. US values are calculated excluding tax credits. Delivery date and costs may be different than those reported at the time of the auction.

Best results occur where price competition, long-term contracts and good resource availability are combined

Large shares of VRE in some countries

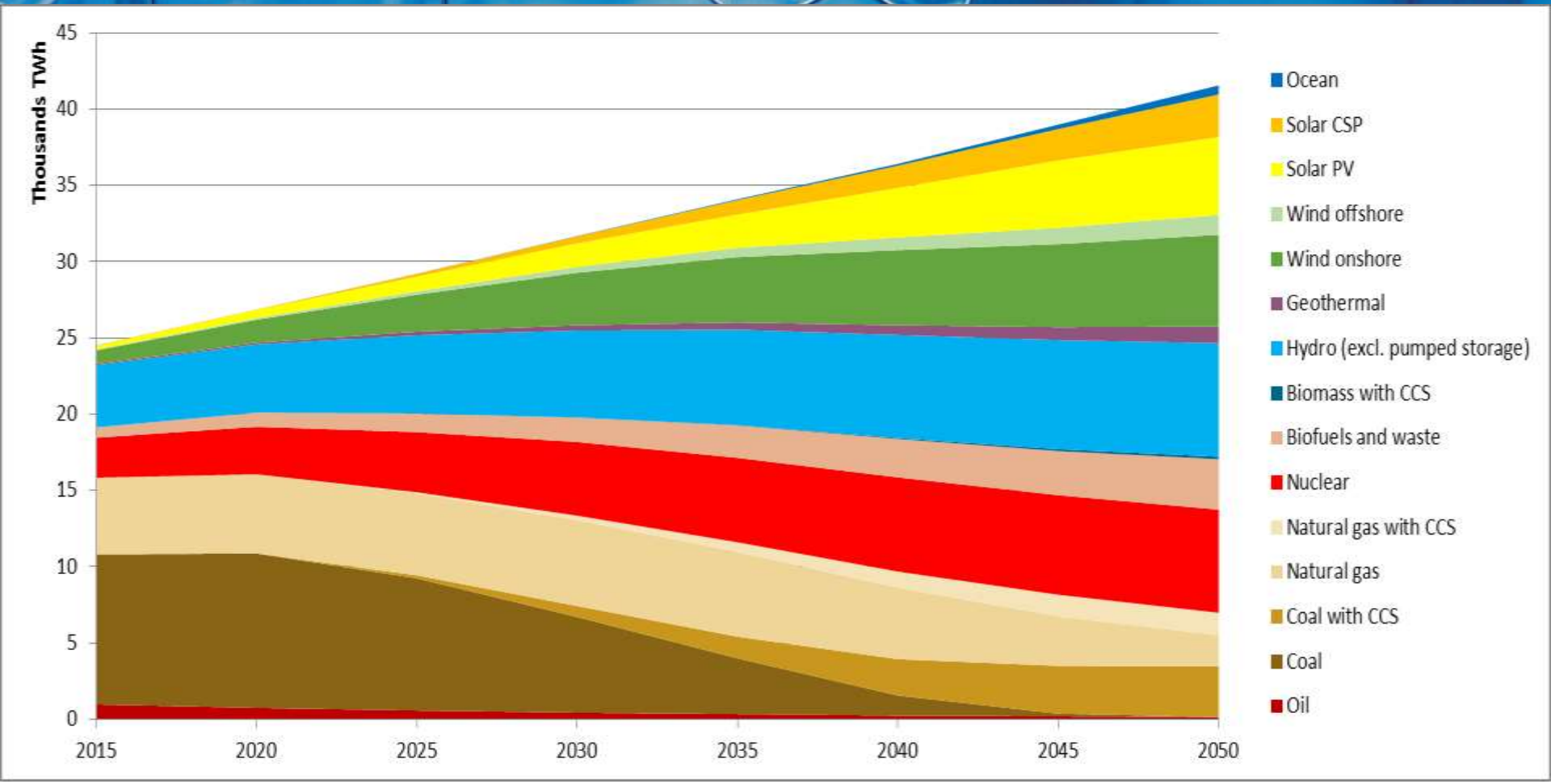


- **Experience in a number of countries available how to integrate significant shares of VRE**
- **According to latest available forecasts in 2021:**
  - VRE is forecasted to exceed 20 % of annual generation in at least 6 countries
  - Double-digit shares becoming new normal for many power systems

Source: Medium Term Renewable Energy Market Report, 2016

Global electricity mix changes in the 2DS

ETP 2016

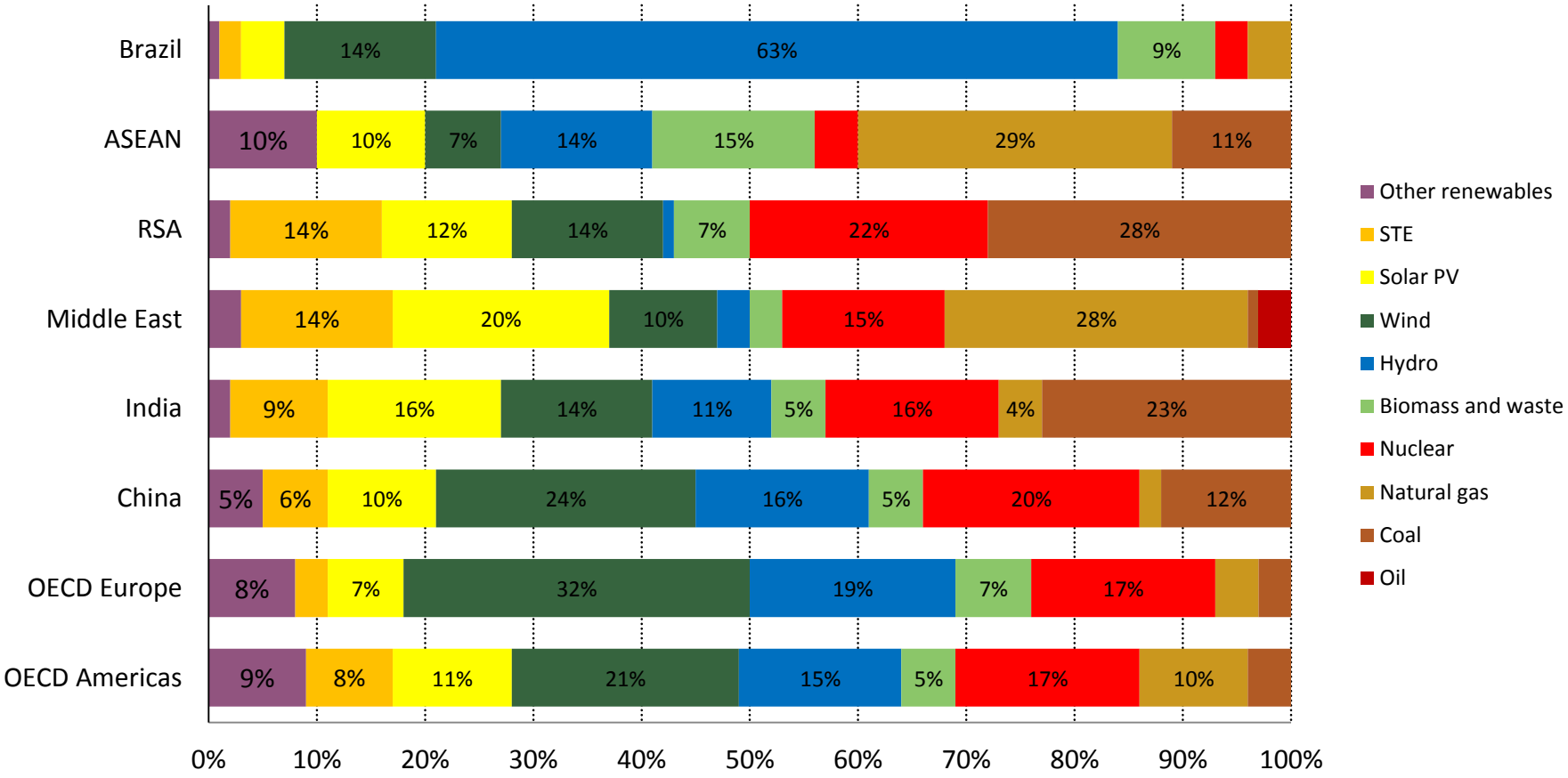


A shift reversal is needed with renewables providing over 60% of global electricity by 2050 or before

Electricity mixes by 2050 in the 2DS vary widely

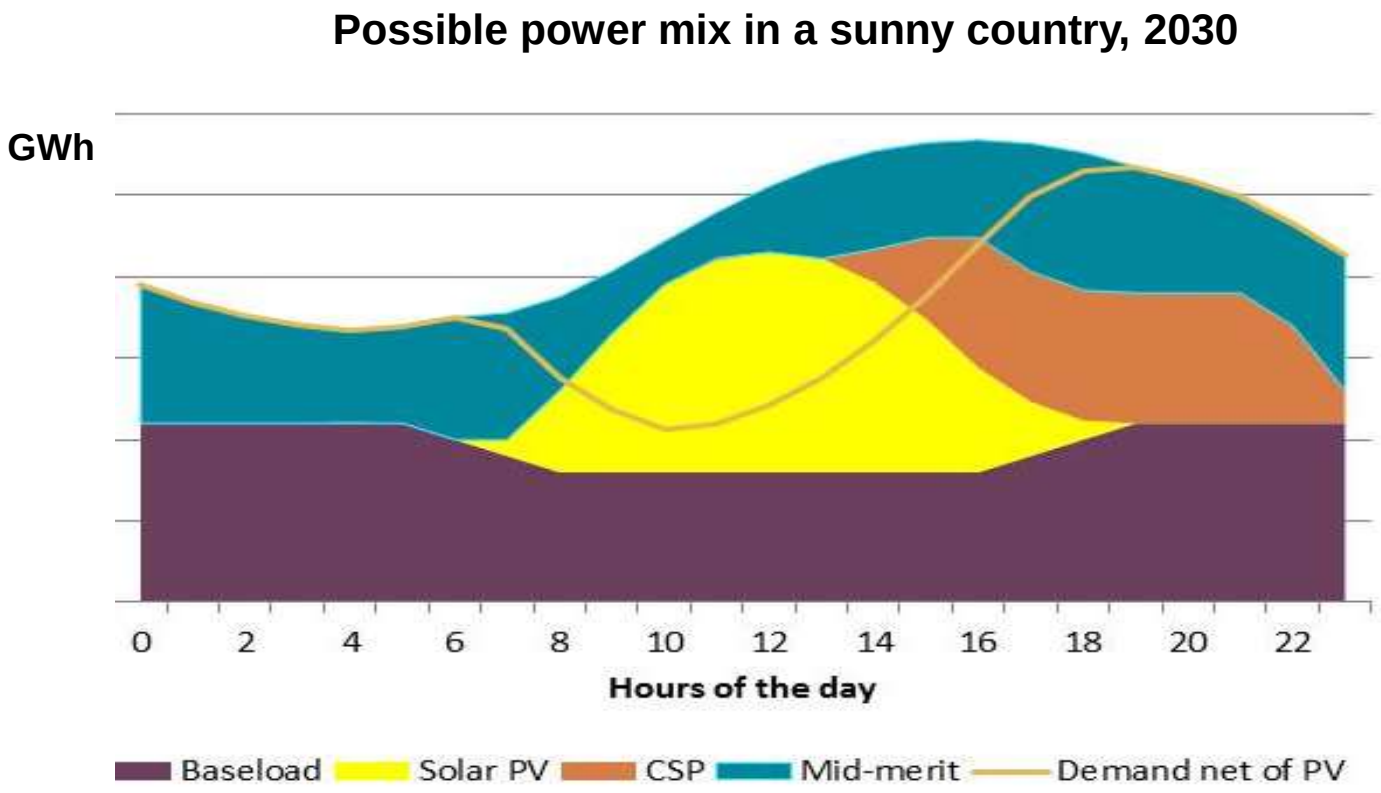
ETP 2016

Electricity mixes by 2050 in the 2DS in selected regions



Resources and shape of the demand explains the variations

Complementary roles of PV and STE

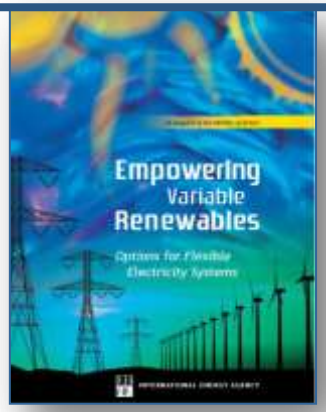


Source: *IEA Technology Roadmap (2014)*

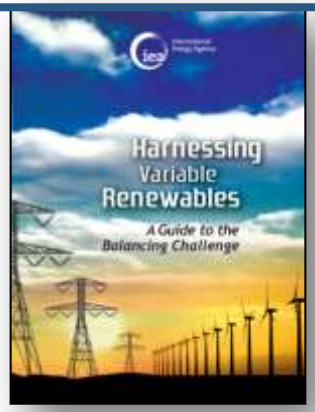
Thanks to thermal storage, STE is generated on demand when the sun sets while demand often peaks and value of electricity increases

System Integration of Renewables analysis at the IEA at a glance

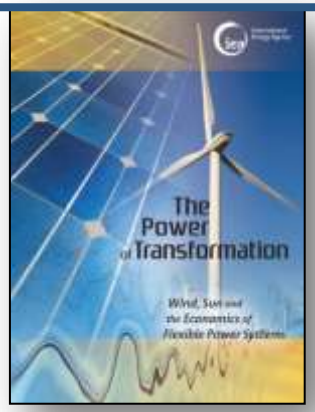
2008 2011 2014 2016



Fundamentals



Technical



Economic

Policy

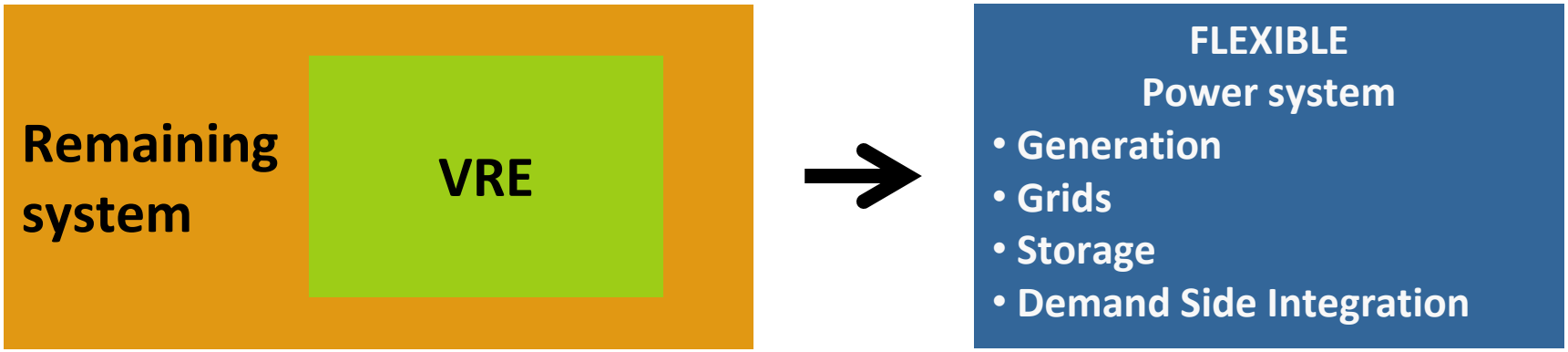
- **Global expert network covering policy making, engineering and modelling analysis, including IEA Technology Collaboration Programmes**
- **Analysis based on extensive research on current global state of play and dedicated modelling tools**
  - Covering four continents and over 25 countries
  - India case study on grid integration in 2014, several expert workshops held since
- **Fostering exchange in international fora (G20, CEM) and capacity building (regional trainings)**

Main messages

1. **Very high shares of variable renewables are technically possible**

2. **No problems at low shares, if basic rules are followed**

3. **Reaching high shares cost-effectively calls for a system-wide transformation**



System transformation

Policy and market framework

Level of VRE penetration

System-friendly VRE deployment

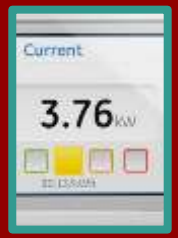
- Distributed resources integration
- 24 /7 System services
- Generation time profile
- Technology mix
- Location
- Integrated planning

Flexible resources
planning & investments


Grids


Generation


Storage



Demand shaping

System and market operation

Actions targeting VRE

Actions targeting overall system

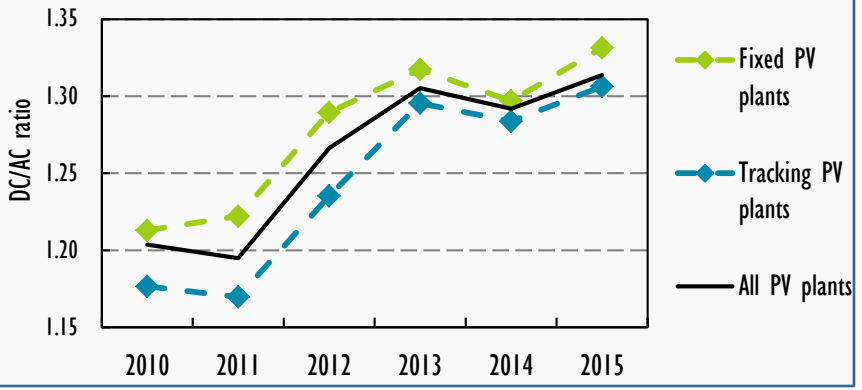
Optimising generation time profile

- **The design of wind and solar plants can be optimised to increase value**
  - Spreading the energy on more hours
  - Making generation match the demand more closely
- **Policy mechanisms need to signal difference in value depending on time**
  - Partial exposure to market prices via premium systems
  - Power purchase agreements adjusting remuneration to time of delivery (TOD)
  - Premiums for system friendly deployment choices

Policy example: California, USA

- West-facing PV systems produce closer to peak demand and receive payments up to 15% higher than south-facing systems
- TOD factors integrated into PPAs for large scale solar systems

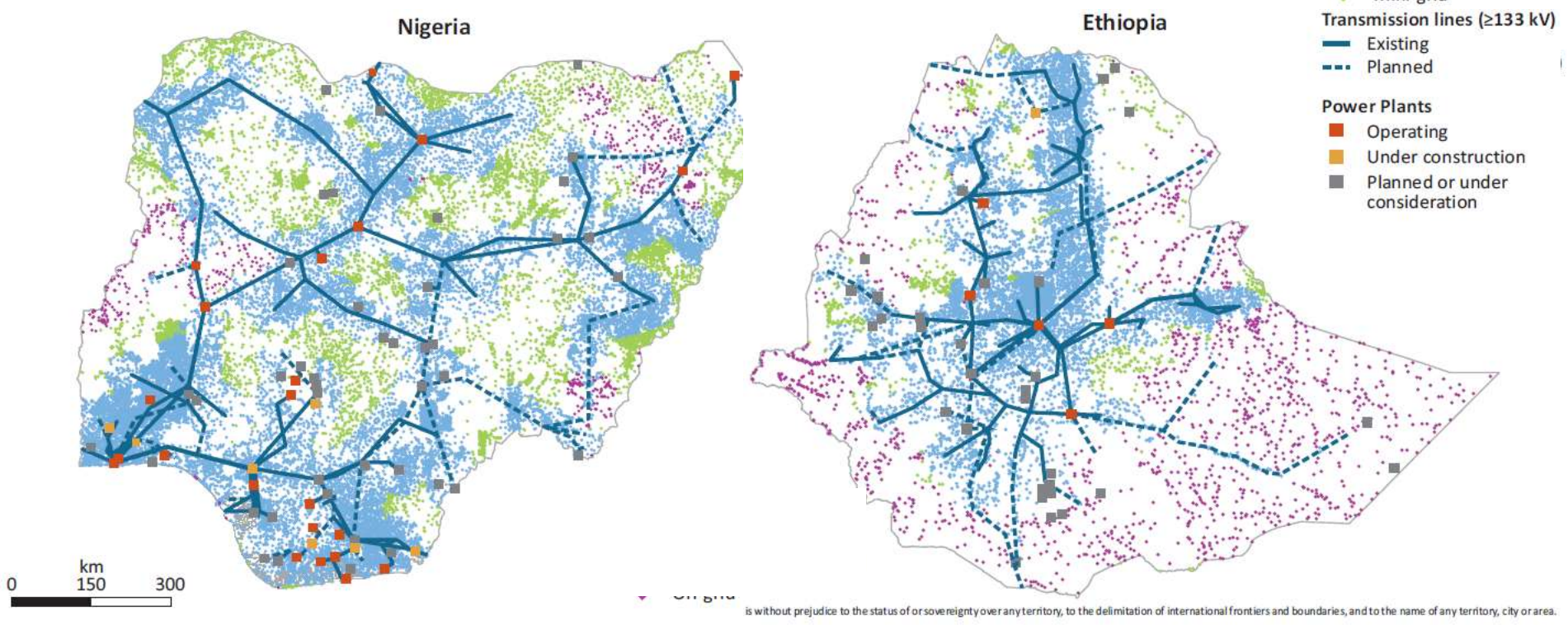
DC to AC ratio by mounting type and installation year, United States



Grid extensions and distribution solutions

Africa Energy Outlook

Optimal shares by 2040



In the long run various combinations of on-grid, mini-grid and off-grid technologies will subsist

Super-grids or mini-grids? Both

- Most solar and wind capacities connect to the low and medium voltage distribution grids
- Distributed energy solutions can substitute to grid extensions in providing access
- They can also strengthen the grids and improve the quality of truly intermittent power in some markets
- Super-grids enlarging balancing areas are also helpful in facilitating the integration of variable renewables
- Mini- and super- grids all need to be « smart » - convey information as well as energy, both ways, and coupled with other energy forms/networks

Conclusions for India

- **System integration no show stopper for reaching ambitious wind and solar targets**
  - But a co-ordinated approach is crucial for managing integration challenges
- **India has an opportunity to transition to a clean energy system**
- **IEA has long-standing expertise on strategies to integrate renewable energies into the grid**
  - Possible collaboration on sharing best practices, expert consultations for policy implementation and regional capacity building
  - Relevant topics includes:
    - *Unlocking thermal power plant flexibility*
    - *Optimising power system dispatch;*
    - *Power market design*
    - *Deploying distributed energy systems cost-effectively*
- **The IEA is "opening its doors" to emerging economies**