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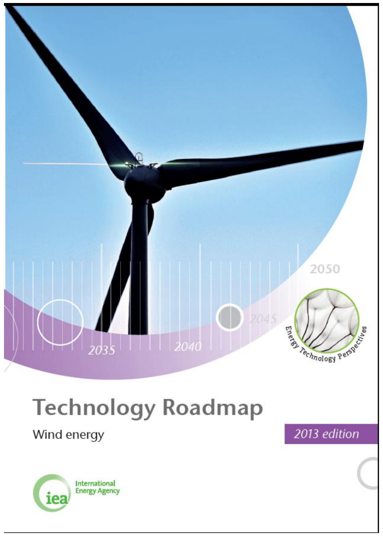
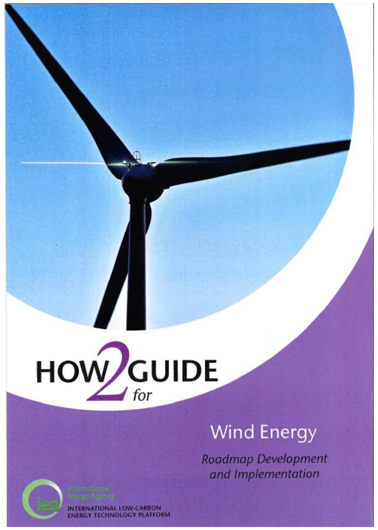
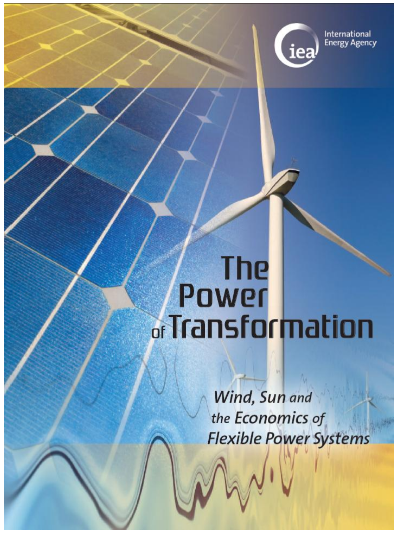
Perspectives for the Deployment of Wind Energy: Overview of Global Trends by 2050 and Guidance to National Roadmapping Efforts

IEA Panelists:

- Ingrid Barnsley
- Cédric Philibert
- Simone Landolina
- Simon Müller







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Paris, 22 May 2014

INTERNATIONAL LOW-CARBON ENERGY TECHNOLOGY PLATFORM

IEA Wind Power Roadmap 2013

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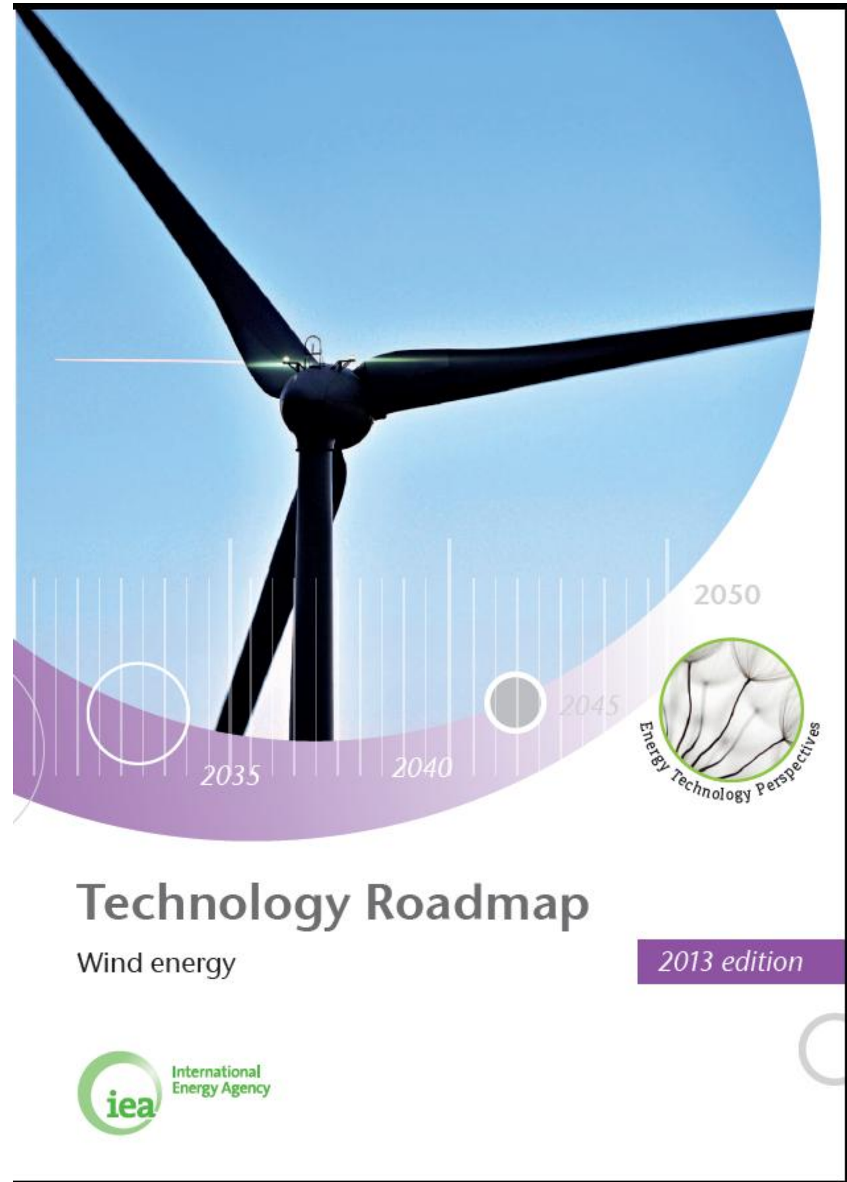

Cédric Philibert

Renewable Energy Division

International Energy Agency

Paris, 22 May 2014

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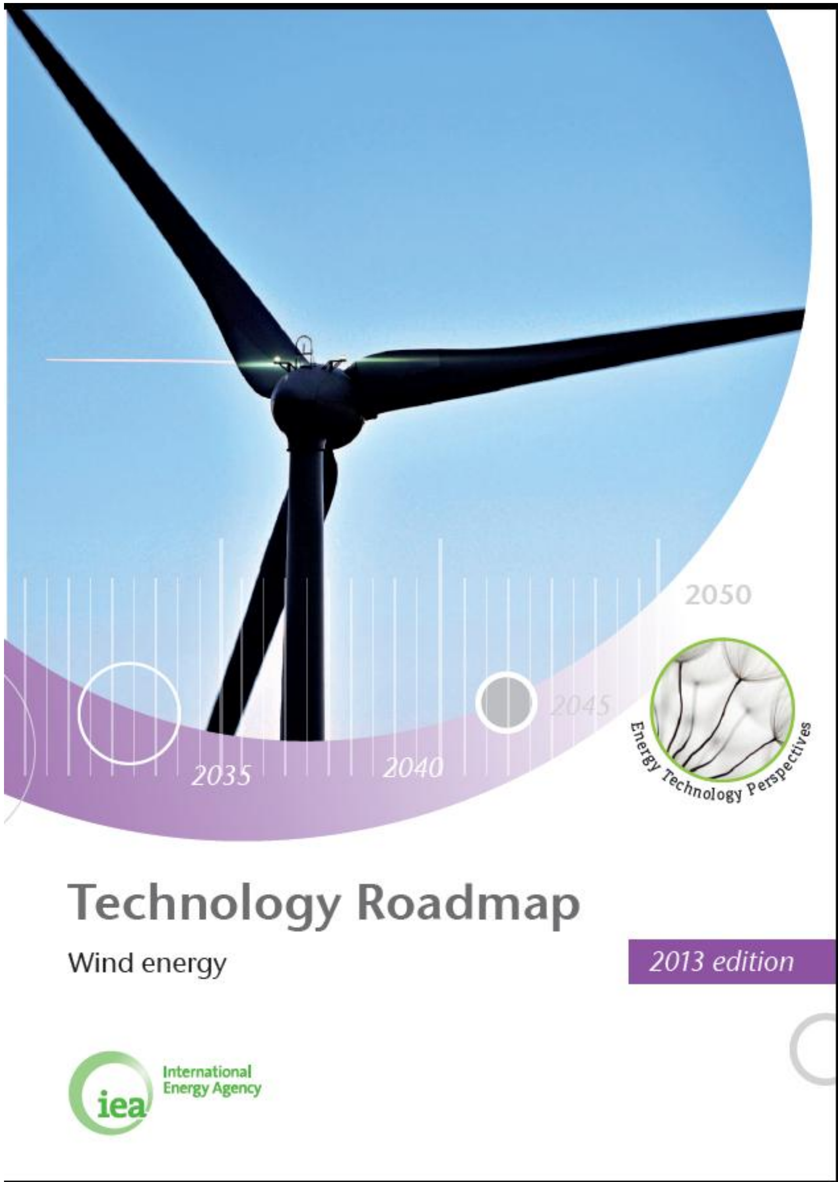
IEA Wind Power Roadmap 2013

www.iea.org

- IEA Wind Technology Roadmap first published in 2009
- Update considers recent trends and revised long-term targets
- Technology and cost evolution
- 2050 “Vision” based on global energy context and system optimization
- Barriers and policy recommendations



Global cumulative growth

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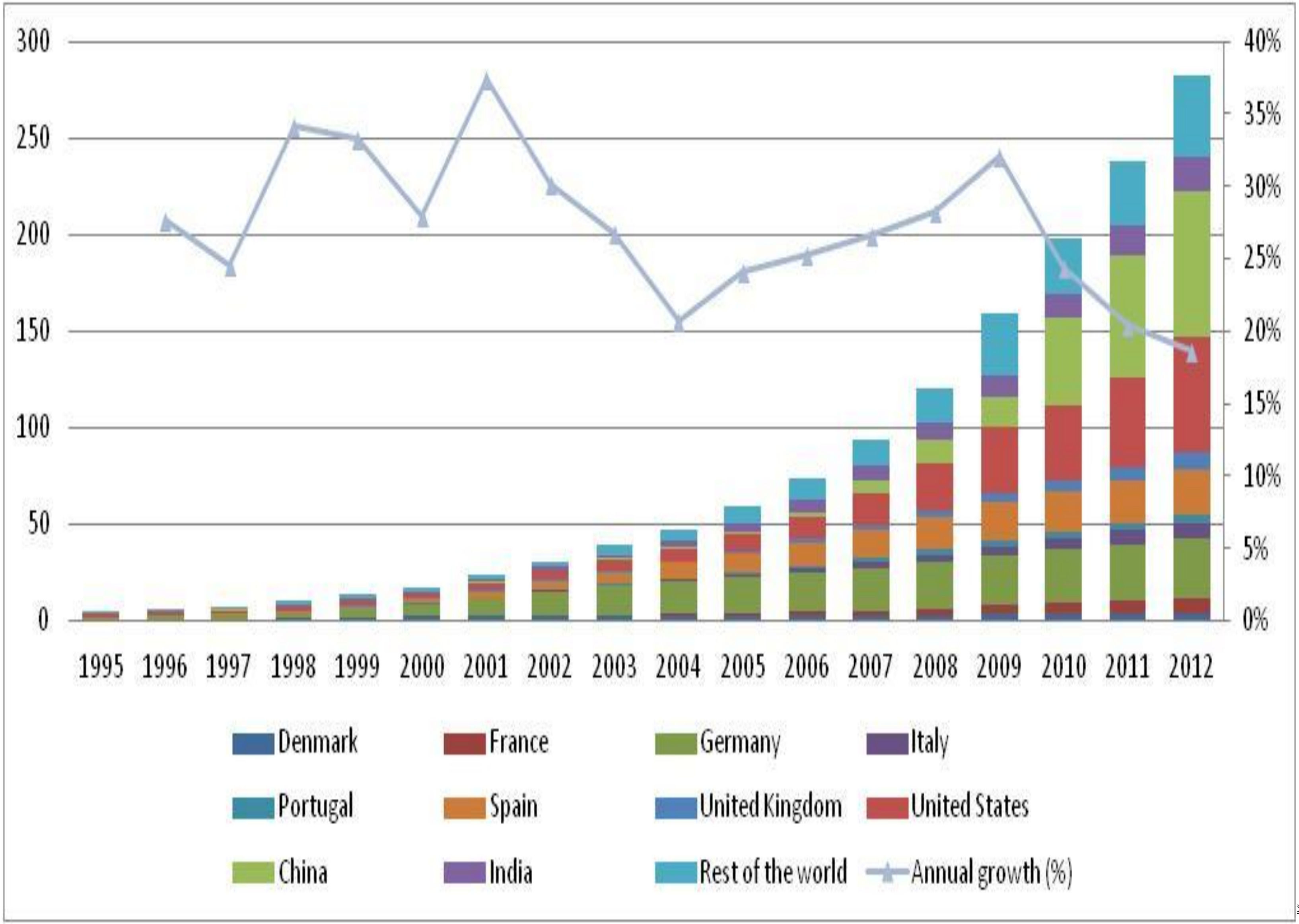
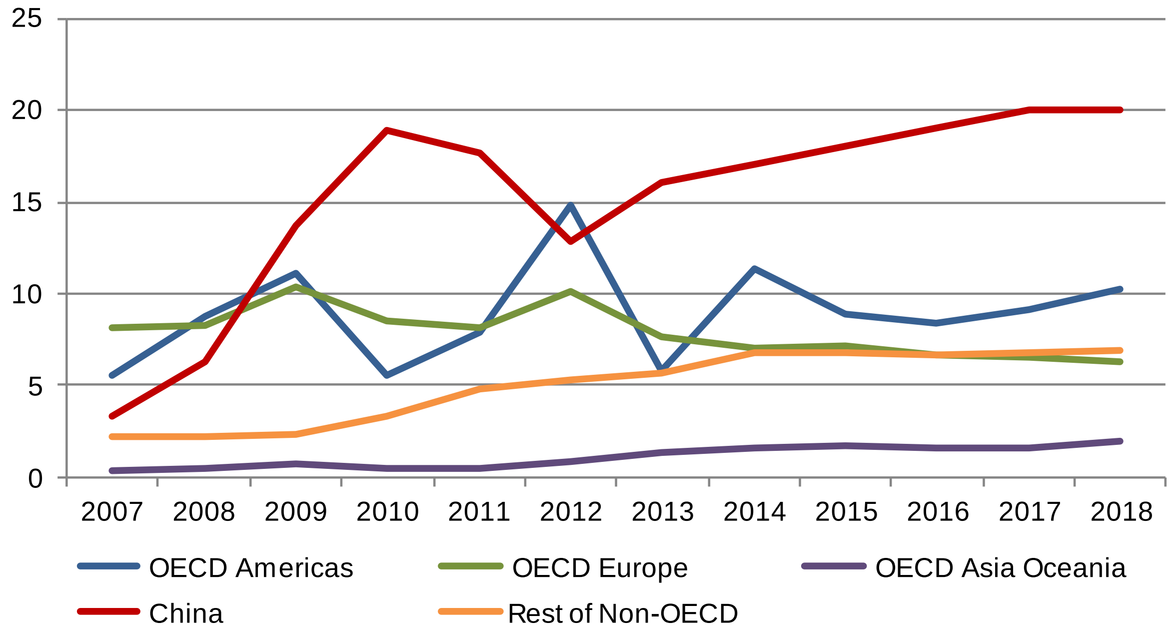


Land-based wind is largest RE capacity additions over 2012-18

- Annual deployment remains stable in OECD Europe with (6-7 GW)
- China to lead onshore wind market but other non-OECD countries to grow
- OECD Americas to grow fast but uncertainty over US federal incentive makes the outlook volatile

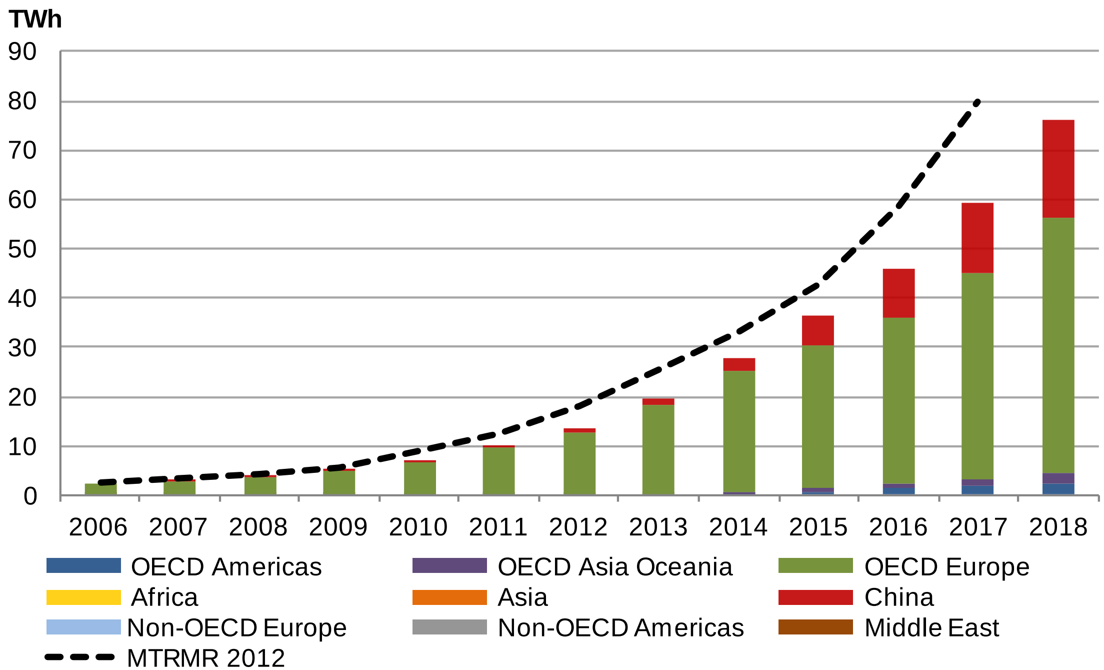
Onshore wind annual capacity additions by region (GW)



Offshore deployment faces challenges

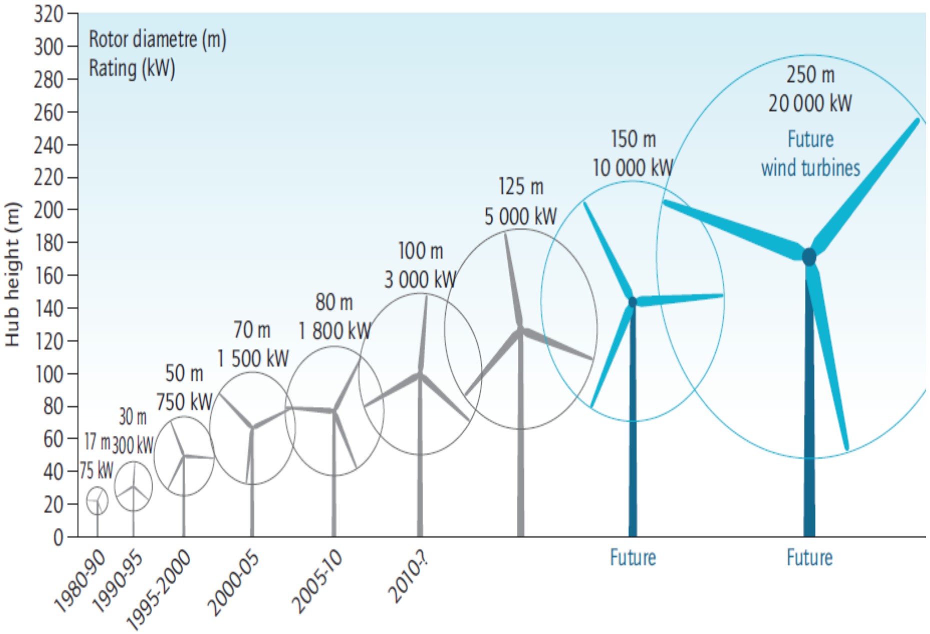
- **Offshore wind outlook revised down significantly versus *MTRMR 2012* due to policy uncertainties, connection delays, financing and supply chain bottlenecks**
- **Europe to represent around 2/3 of total offshore generation**
- **China's offshore capacity to grow with few additions coming from OECD Asia Oceania and OECD Americas**

Offshore wind generation and projection by region

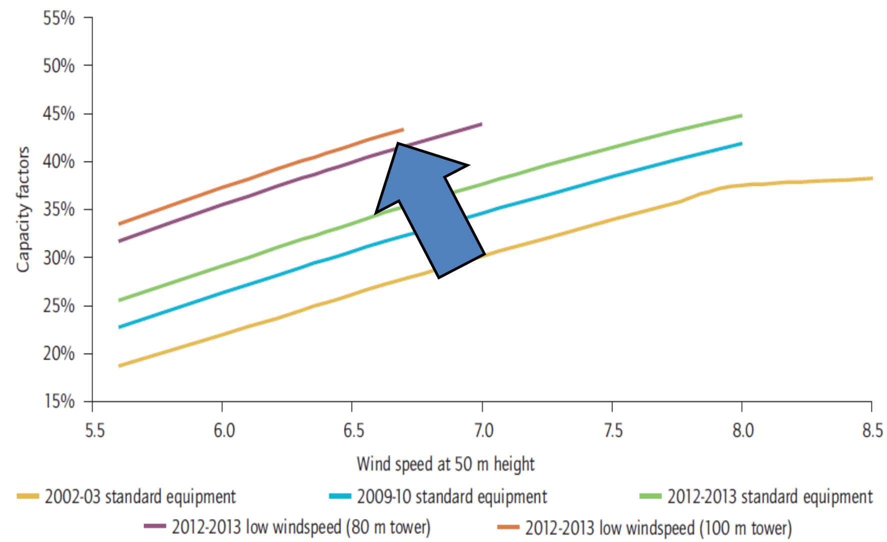


Technology evolution

Turbine size



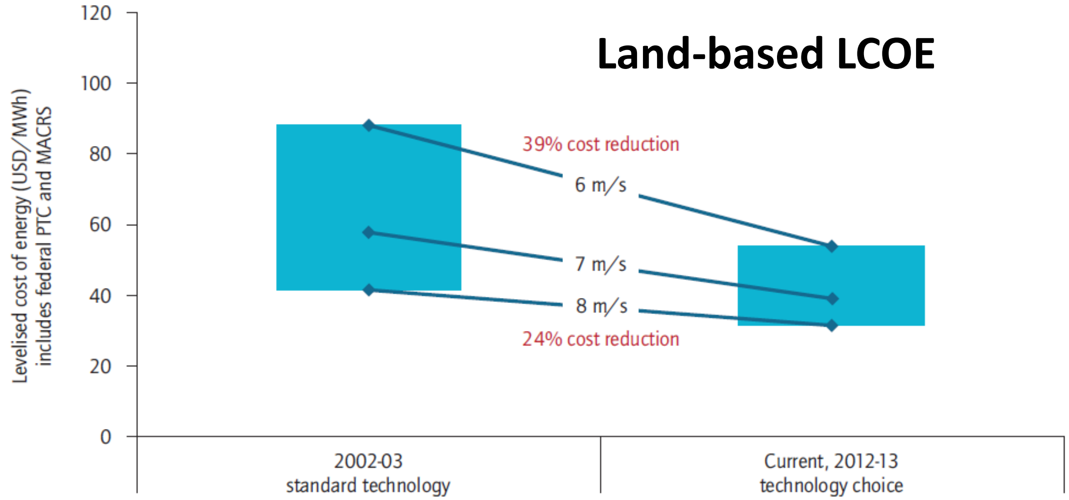
Capacity Factors



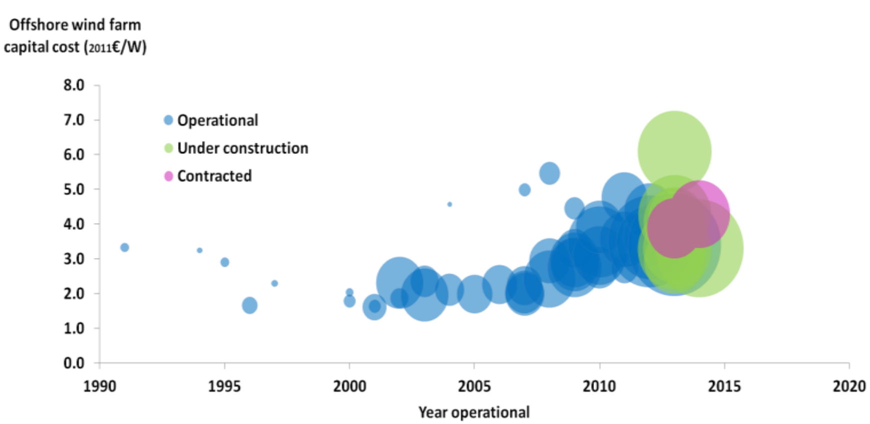
- Growth in size, height and capacity
  - Greater capacity factors,
  - Exploiting sites with lower-speed winds,
  - More power system-friendly making grid integration easier

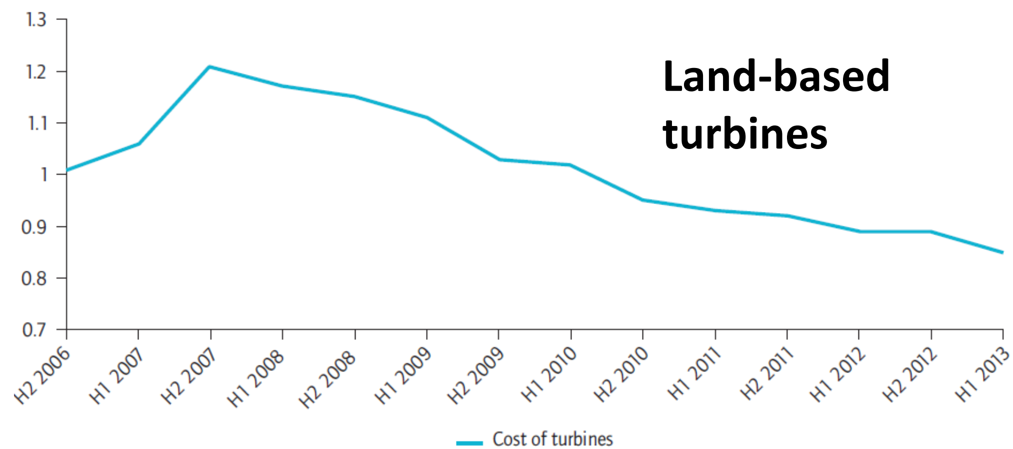
Wind costs decreasing on land

- Land-based wind getting cheaper
- But not offshore

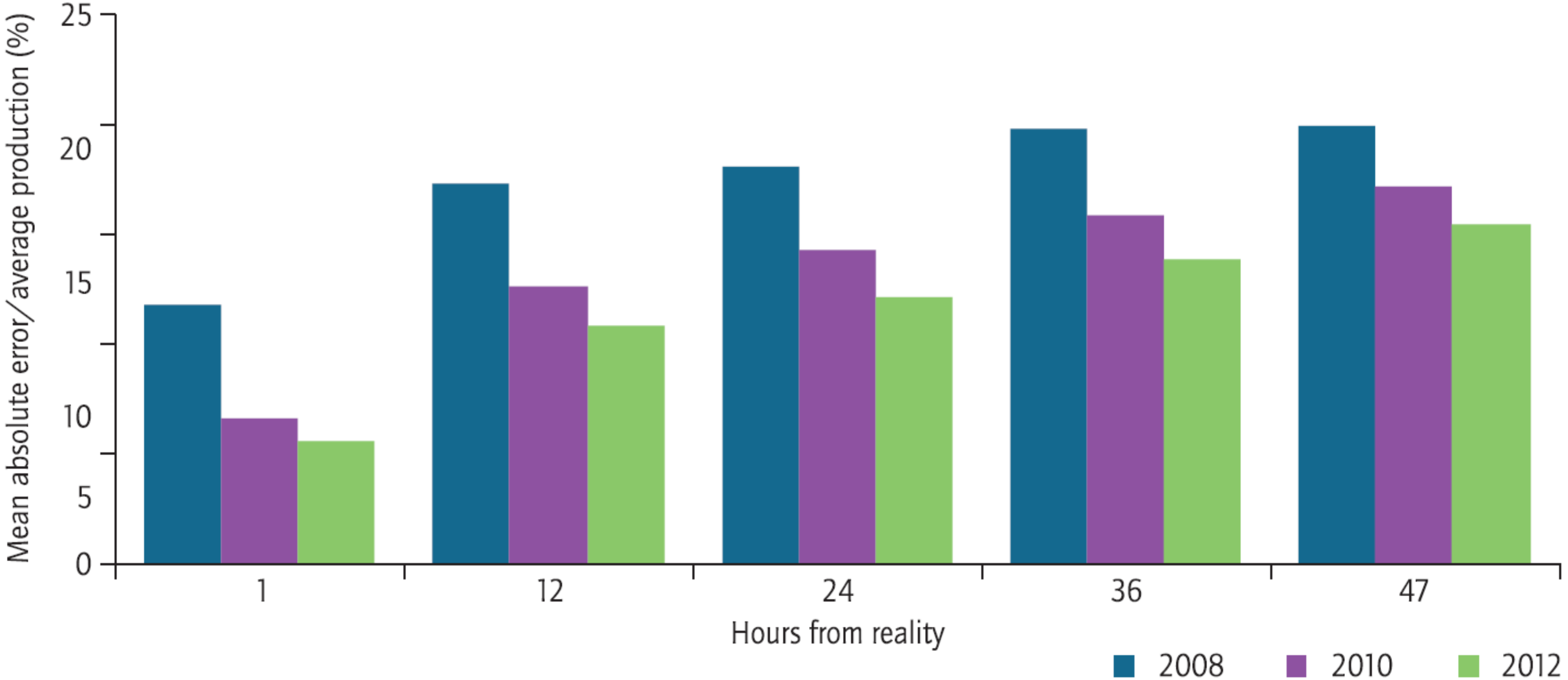


EU offshore parks



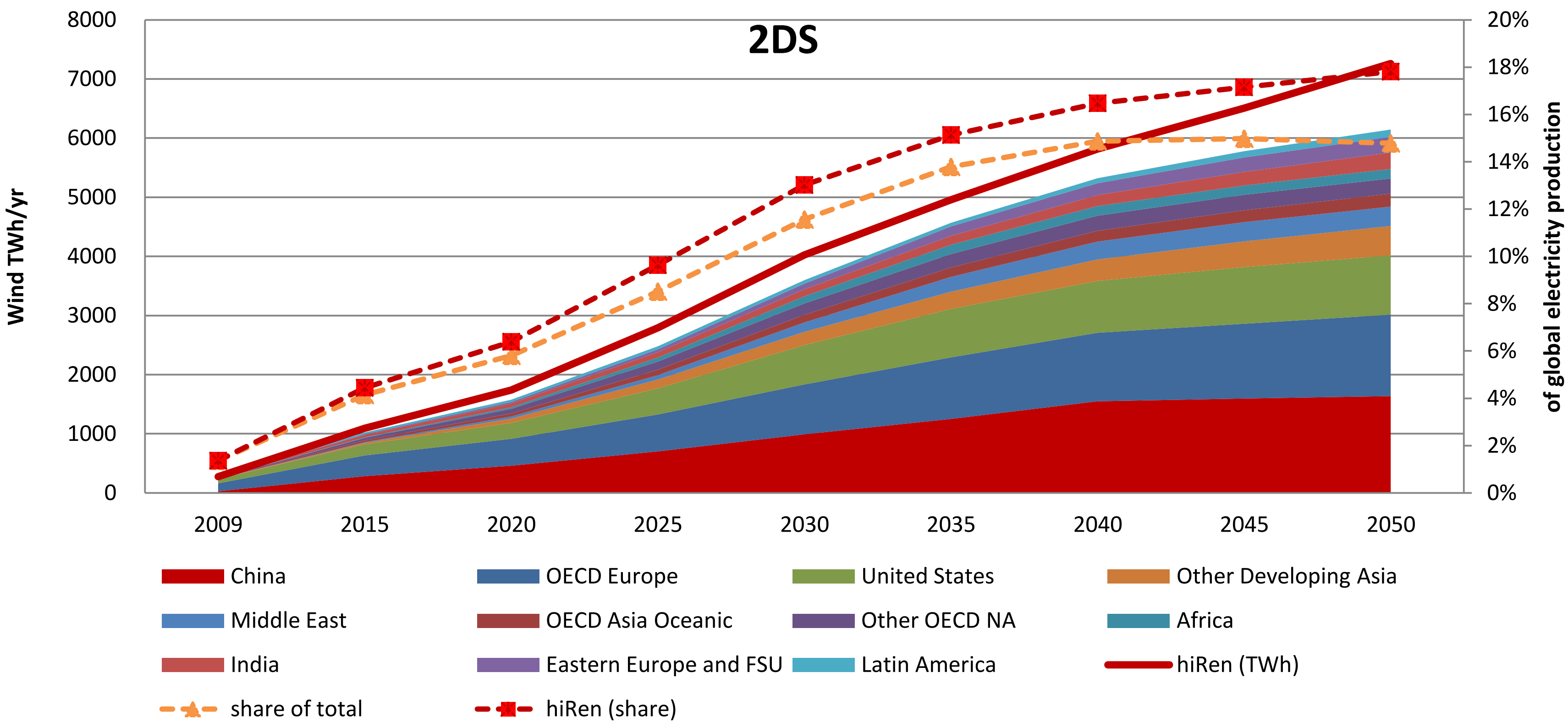


Evolution of forecasting errors



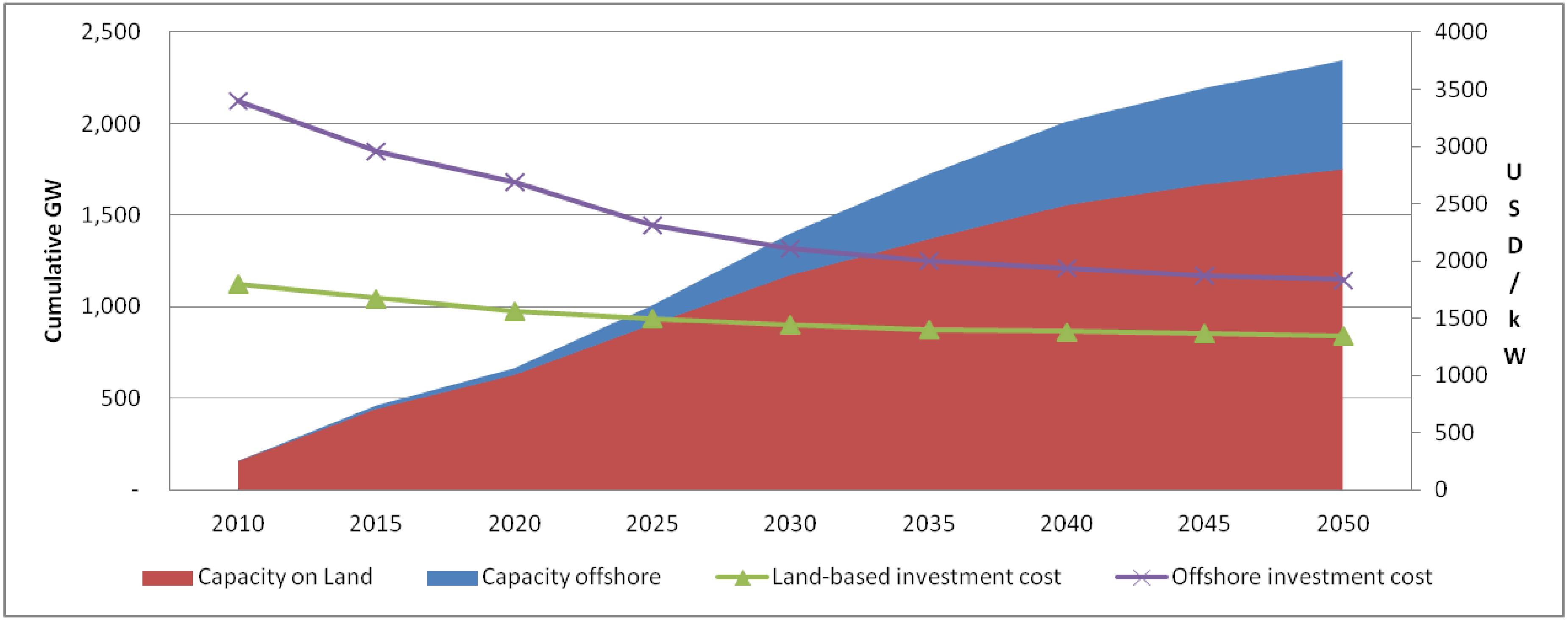
Source: Red Electrica, 2013.

Wind power deployment to 2050 in the Roadmap Vision



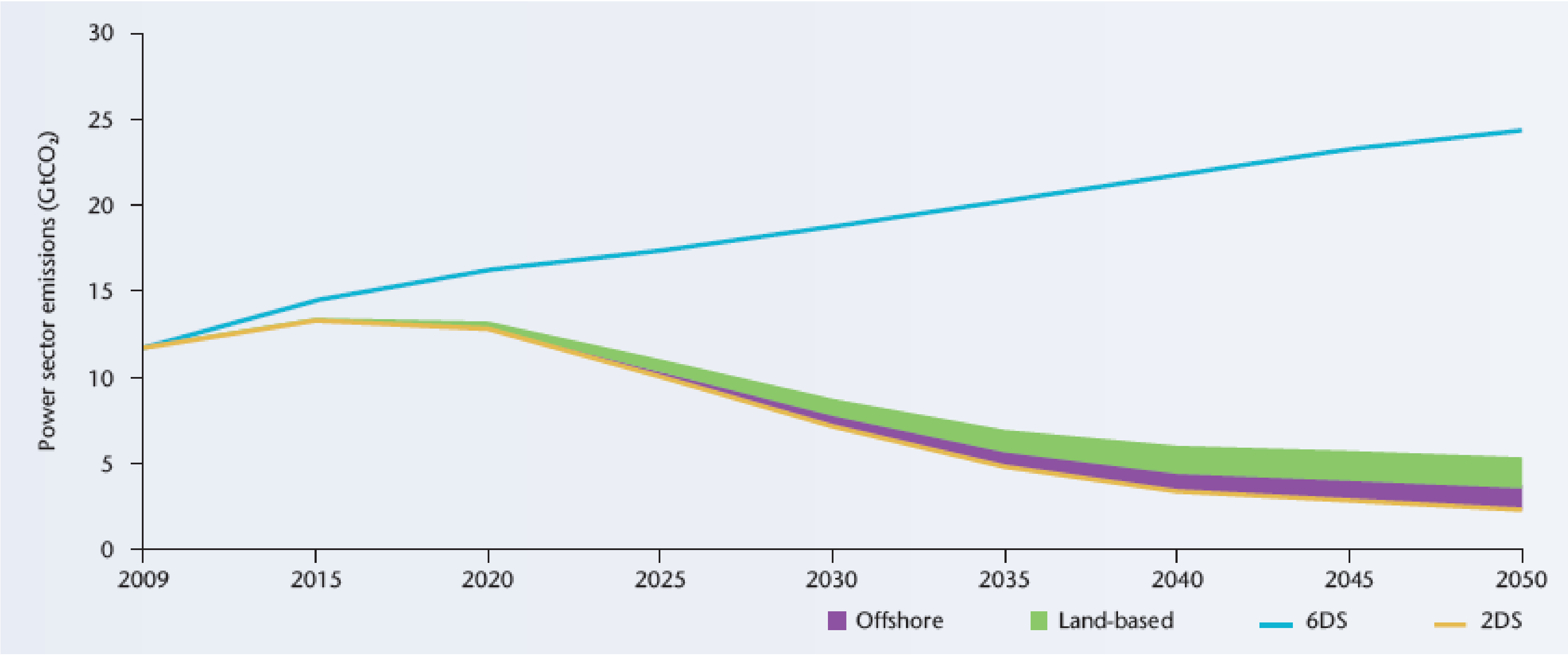
- Wind power to provide 15% to 18% of global electricity
- China, Europe and the USA together account for two thirds

Land-based and offshore deployment and costs



- By 2050, 25% of total global wind capacity to be located at sea, up from 6% in 2020
- Investment costs for wind power to decrease by 25% on land and 45% off shore by 2050

Contribution to CO_2 reductions



- *in 2050, power sector CO_2 emissions rise to 24.4 $GtCO_2$/yr in the 6DS and fall to 2.4 $GtCO_2$/yr in the 2DS.*
- *Wind power provides 3 $GtCO_2$/yr (13%) of the difference, 1.3 $GtCO_2$ of which is from offshore*

Variable RE will need more flexibility

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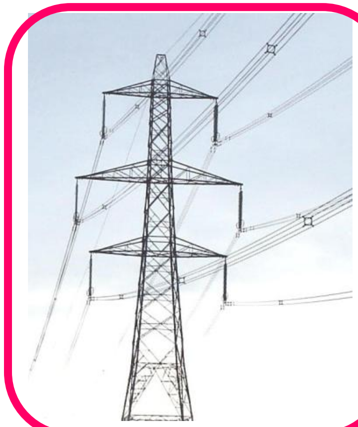
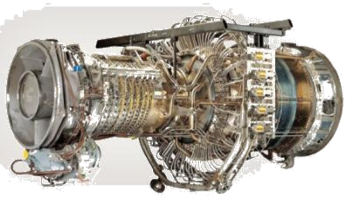


Grid infrastructure



Dispatchable generation

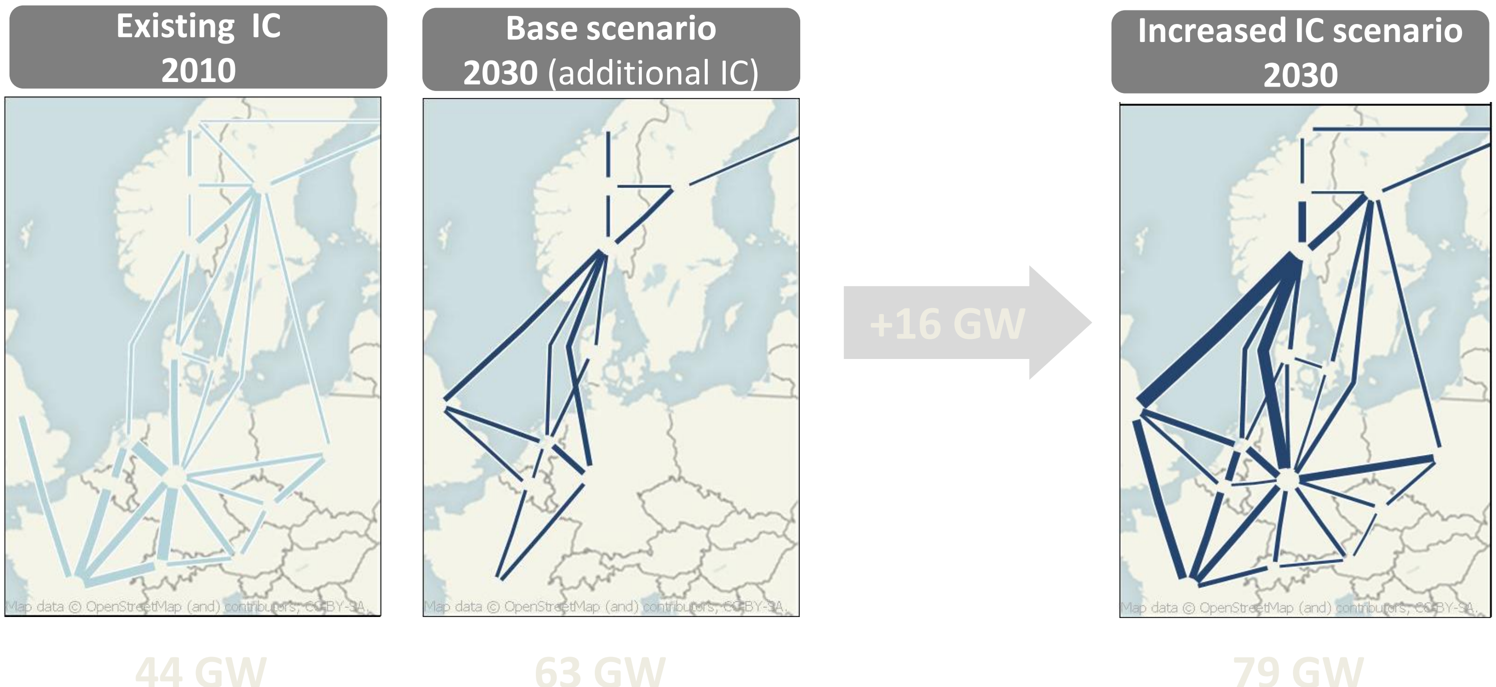
Storage

Demand side integration

- Value of flexibility has to be reflected in the market
- Need for a suite of different flexibility options
- Study “*The Power of Transformation* “published

Transmission and integration key to long-term continued growth

Present and future interconnections in NW-Europe



Source: Pöyry for IEA, 2013

- **Ensuring integration may become more important than lowering wind generation costs**
- **Importance of transmission corridors**

Roadmap actions and time frames

AREAS	TOPICS
TECHNOLOGY	System design
	Advanced components
	O&M reliability and testing
	Resource assessment
	Manufacturing and supply chains
SYSTEM INTEGRATION	Transmission planning and development
	Electricity markets
	Power system flexibility
POLICY and FINANCE	Incentivising investment
	Public engagement and the environment
	Planning and permitting
	RD&D Funding
	International collaboration

INTERNATIONAL LOW-CARBON ENERGY TECHNOLOGY PLATFORM

How2Guide for Wind Energy

CESC Webinar – 22 May 2014

Simone Landolina, IEA

International Energy Agency

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International Low-Carbon Energy Technology Platform

The Technology Platform is the IEA vehicle for:

- Engaging with Partner countries and organisations on low-carbon energy technologies
- Adapting IEA global analysis to regional and local contexts

Key information

- Created in 2010 upon mandate of the IEA Ministers to foster international collaboration on low-carbon energy technologies
- Three types of activities:
  1. *How2Guide* manuals for roadmap development at the national and regional levels
  2. Dialogue workshops and partnership building (engagement)
  3. Selected thematic analysis (cross-cutting)

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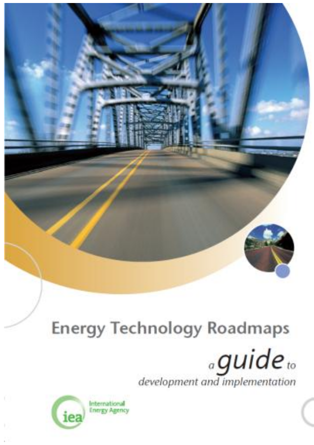
How2Guides: concept

- Building on the IEA global series of technology roadmaps (20+ publications) and IEA established roadmap methodology (updated 2014)

- Growing request for assistance from Partner Countries *IEA-China Wind Roadmap* (2012); *IEA-India Cement Roadmap* (2013); *IEA-South Africa Solar Roadmap* (forthcoming)

- *How2Guides* are a response to this context:

Manuals for policy and decision makers to develop technology roadmaps tailored to national / regional frameworks



How2Guides

Why are we doing this?

- To scale-up IEA capabilities to provide support to countries for national roadmap development
- To enhance the impact of the IEA's technology roadmap programme

Is this only for IEA Members?

- Not at all – developing countries and emerging economies are a key audience for this initiative
- Countries which already have technology roadmaps can use it as a tool for internal revision, aiming at improvements in the energy mix

Outputs

- ***How2Guide for Wind Energy*** (released on **10 March 2014**)
- *How2Guide for Bioenergy* (expected Q1 2015)
- *How2Guide for Smart Grids* (expected in 2015)

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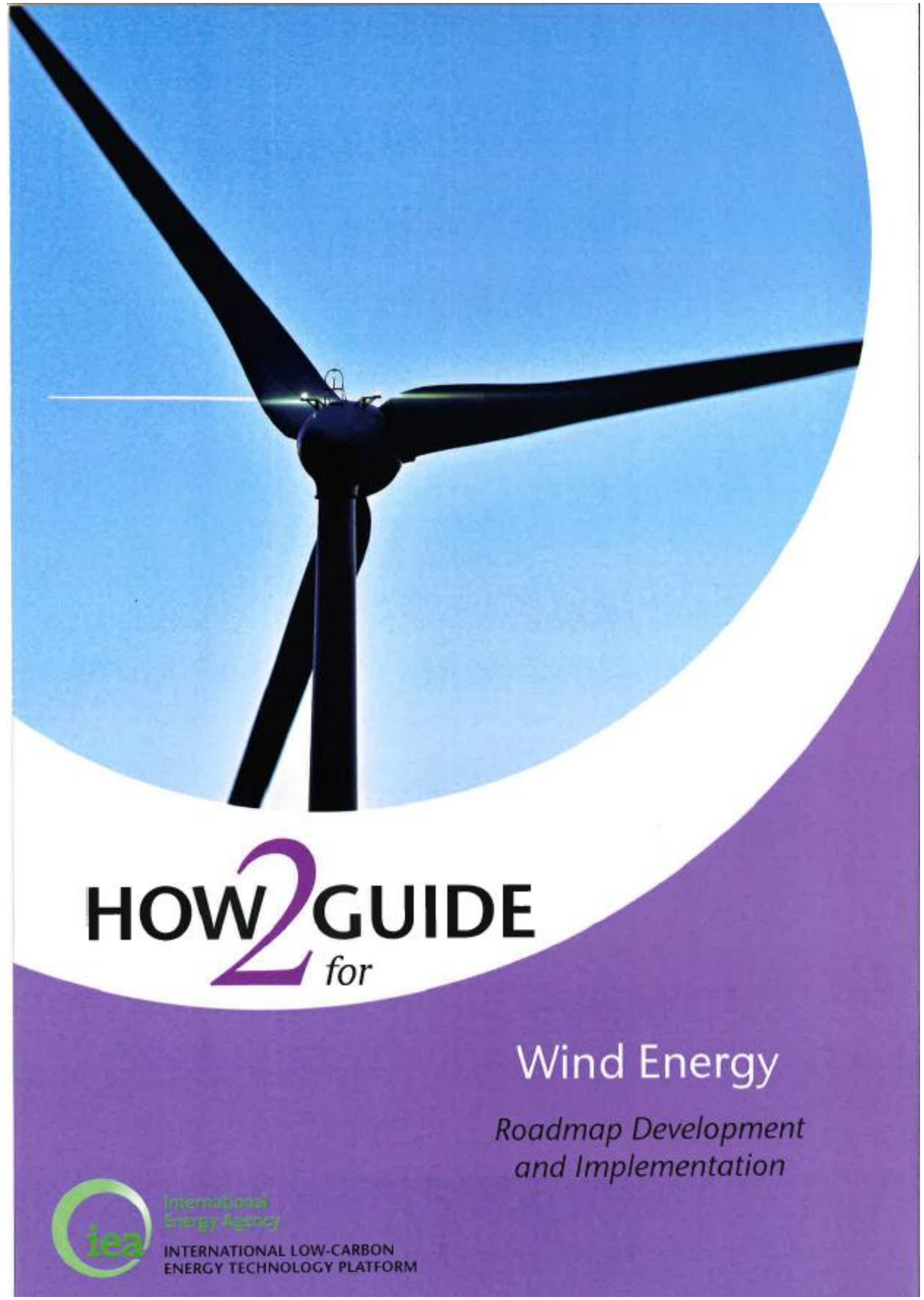

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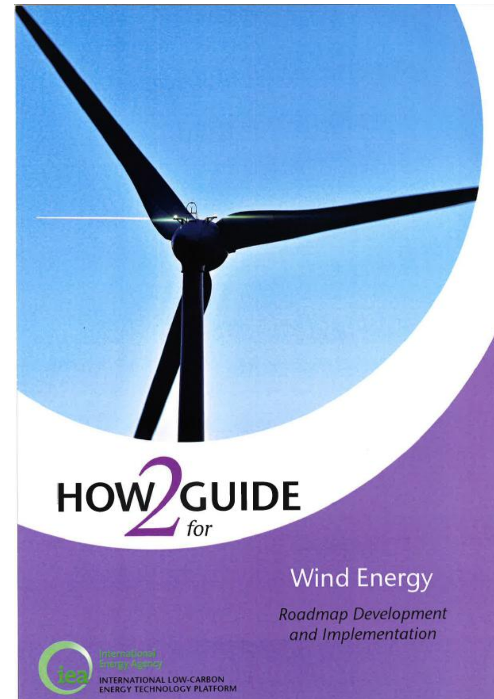
How2Guide for Wind Energy

Key elements:



- **Defines the process of developing and implementing a wind energy roadmap**
- Roadmap methodology guidance through **four steps**, illustrated by case studies
- **Case studies** from IEA Member and Partner countries (China, US, Brazil and South Africa)
- Focus on **utility-scale wind energy** installations (multi-MW WPPs)

How2Guide for Wind Energy

- Sharing lessons learned across regions

- Essential data and information collected during **regional expert workshops**:
  - Oct 2012, The Philippines, with the Asian Development Bank (ADB)
  - Feb 2013, South Africa, with the South African National Energy Development Institute (SANEDI)

IEA-ADB H2G workshops for wind and smart grids, Oct 2012, Manila, The Philippines

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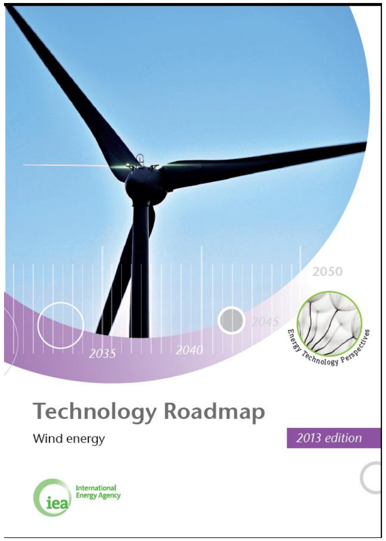
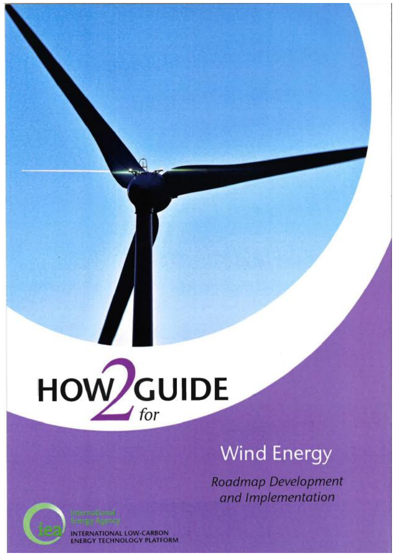
Technology Roadmap vs How2Guide (1)

- Market, technology and cost evolution
- Medium-term global outlook
- 2050 “Vision” based on global energy context and CO_2 reduction scenarios
- Actions and time frames

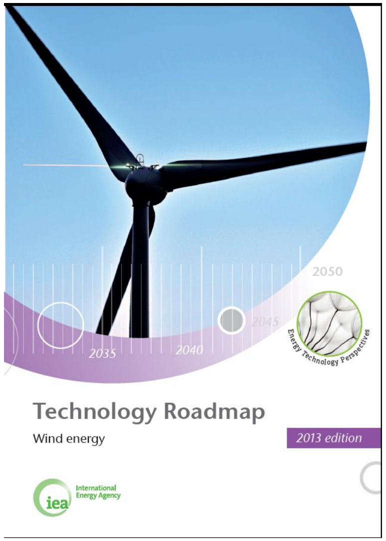


- Short introduction to technology and market
- Process for developing a roadmap
- Step-by-step decision making guidance
- Analysis of drivers, barriers, solutions for wind energy deployment

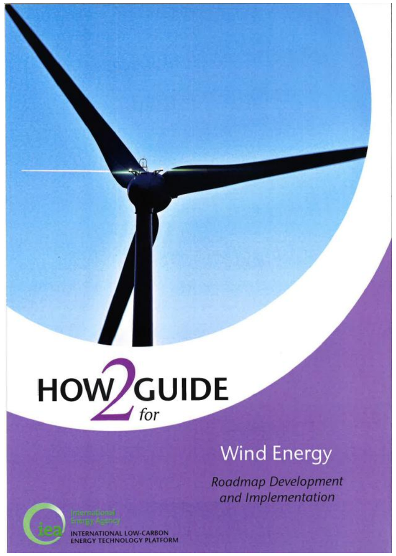


Technology Roadmap vs How2Guide (2)

- *Land-based wind represents largest RE capacity addition over 2012-2018*
- *Technology evolution: growth in size, height and capacity. Investment costs for wind power to decrease by 25% on land and 45% off shore by 2050*
- *By 2050 wind power to provide 15% to 18% of global electricity. China, Europe and the USA together account for two thirds of installed capacity*



- *Key aspects of baseline research for wind energy roadmap will likely include the following: (…)*
- *Typical wind energy stakeholders and their categorisation (cf. Table 3)*
- *Barriers encountered in the development phase of WPP mainly concern (…) → 15 "action options"*
- *[indicators] Statistics of production failure will be of particular value in the assessment of progress*



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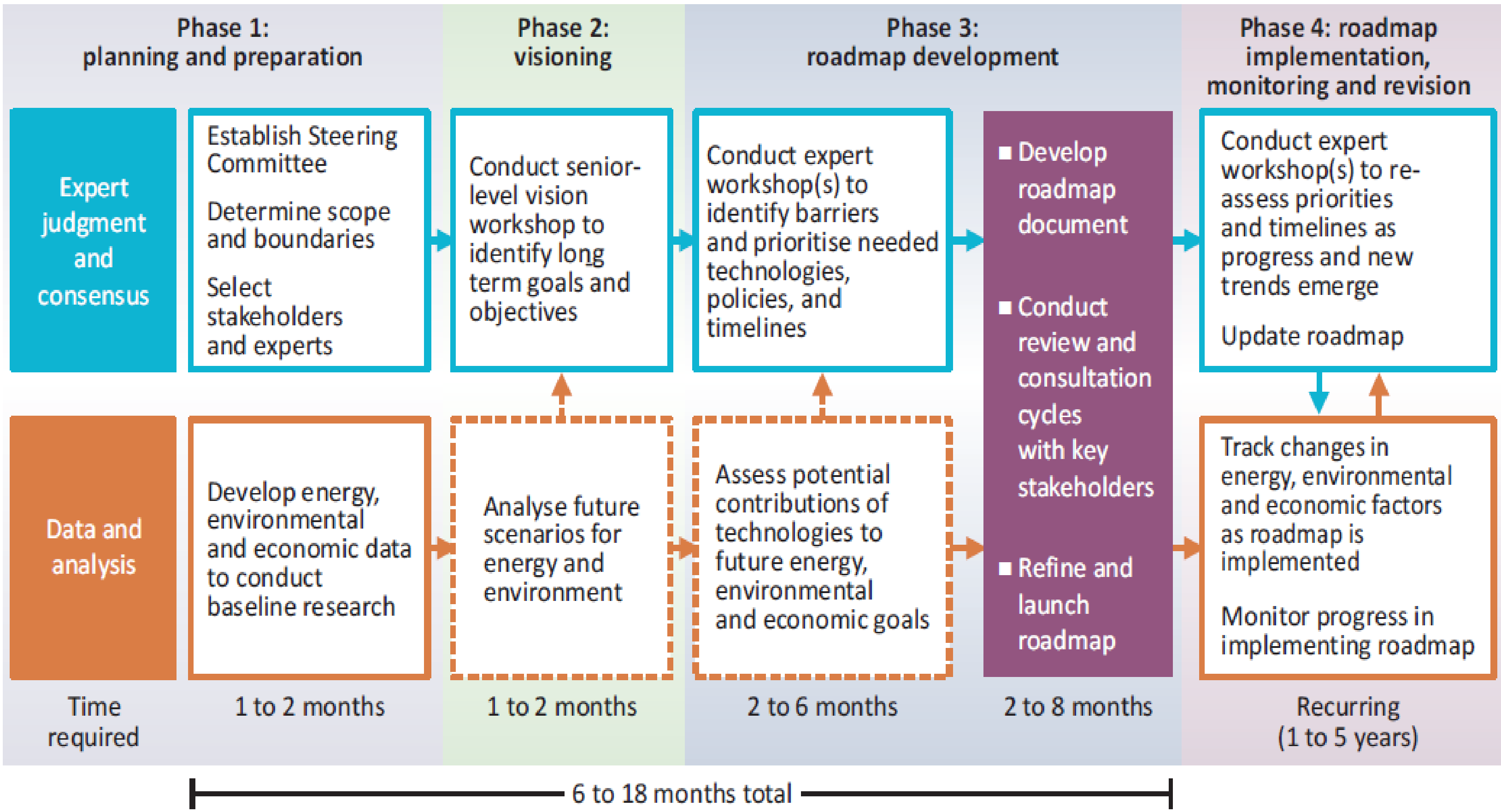
Roadmap process



Adapted from IEA Roadmap Guide (2014). Note: Timescales are indicative.

Dotted lines indicate optional steps, based on analysis capabilities and resources.

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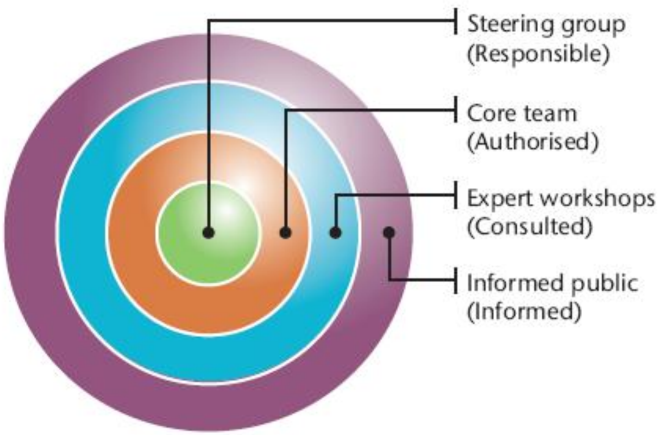
Phase 1: planning and preparation

Identifying wind energy stakeholders



A simple chart can help organise the stakeholders (RACI):

- **R**esponsible (final approval authority, “steering committee”)
- **A**uthorised (team responsible for the roadmap)
- **C**onsulted (stakeholders who attend workshops)
- **I**nformed (but not expected to provide inputs or feedback)

Phase 1: planning and preparation

Establish a steering committee → Determine scope and boundaries → Select stakeholders and experts → Conduct baseline research

Identifying wind energy stakeholders

Stakeholder type	***Corresponding RACI category***
Government (e.g. ministries for environment, energy, treasury, etc.) and other policy makers at national to local levels, as appropriate	Responsible and Authorised and/or Consulted
Industry groups and associations	Consulted or Responsible/Authorised (if roadmap is industry-led)
Project developers	Consulted or Responsible/Authorised (if roadmap is industry-led)
Electricity market regulating body or permit providers	Authorised
Network owners and power system operators (at transmission and distribution levels)	Authorised or Consulted
Land-use and planning decision makers (e.g. local authorities)	Consulted
Aviation authorities (civilian and military)	Consulted
Investors (e.g. development banks, other lenders, venture capitalists, pension funds, etc.)	Consulted
Landowners (public and private)	Consulted or Informed
NGOs, e.g. environmental NGOs, research institutes, universities, etc.	Consulted or Informed
Technology providers	Consulted or Informed
Electricity consumers in the residential sector	Informed
Community groups and local population at large	Informed

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Phase 1: planning and preparation

Key aspects for baseline research on wind energy:

- the wind energy **potential** within the designated geographic area, based on a **resource assessment**
- the extent to which the evolving energy system and market can **manage** wind output **variability** and uncertainty
- the extent to which supply chains and the available specialised workforce can match levels of ambition
- the **role of wind power** in the wider energy portfolio and national power market
- wider energy policy and its impact on competing energy technologies

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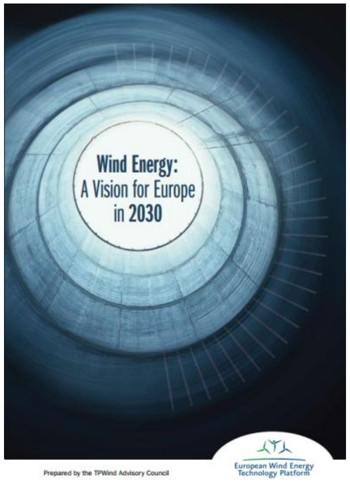
Phase 2: visioning

- A successful roadmap contains a clear statement of the desired outcome, followed by a specific pathway for reaching it.

- Identify main drivers behind development of wind energy (diversify energy mix, CO_2 reduction targets, domestic industry, etc)

- Why are drivers important?
  - They create a **common understanding** of why a higher share of wind is being considered for the energy mix.
  - They are the pillars for defining a **vision** for wind energy.
  - They provide rationale to reject undesirable technologies, project types and outcomes.



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Phase 3: roadmap development

Conduct expert workshop(s) to identify barriers and response actions for wind deployment (technologies, policies, timelines) → Prepare the draft roadmap document (incl. timeline, milestones and responsible actors) → Conduct a review of the draft roadmap, refine and launch the document

Identifying barriers and actions to overcome them:

1. **Planning** relating to developing WPPs (including environment factors)
2. **Development** aspects (including social acceptance factors)
3. **Electricity market** and system aspects
4. **Financial** and economic aspects
5. **Infrastructure** aspects (including availability of specialised professionals).

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Phase 4: implementation and revision

- Consider whether the roadmap itself needs adjustments in light of experiences gained through implementation
- Qualitative and quantitative **indicators** to track and monitor progress in implementing a wind energy roadmap
- The How2Guide for Wind Energy identifies 35 possible indicators, the choice of which one to use is country/region-specific
- For each indicator, identify stakeholders responsible for **monitoring** and reporting

Conclusions

- Wind power can contribute up to 18% of the world's electricity supply by 2050
- Saving 3 to 4.8 $GtCO_2$ emissions per year
- **National and regional roadmaps can play a key role** in supporting wind energy development and implementation, helping countries to identify priorities and pathways which are tailored to local resources and markets.
- Cost-effective penetration of wind energy requires the engagement of a wide range of stakeholders

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Thank you for your attention…

… and many thanks also to the co-authors and contributors!

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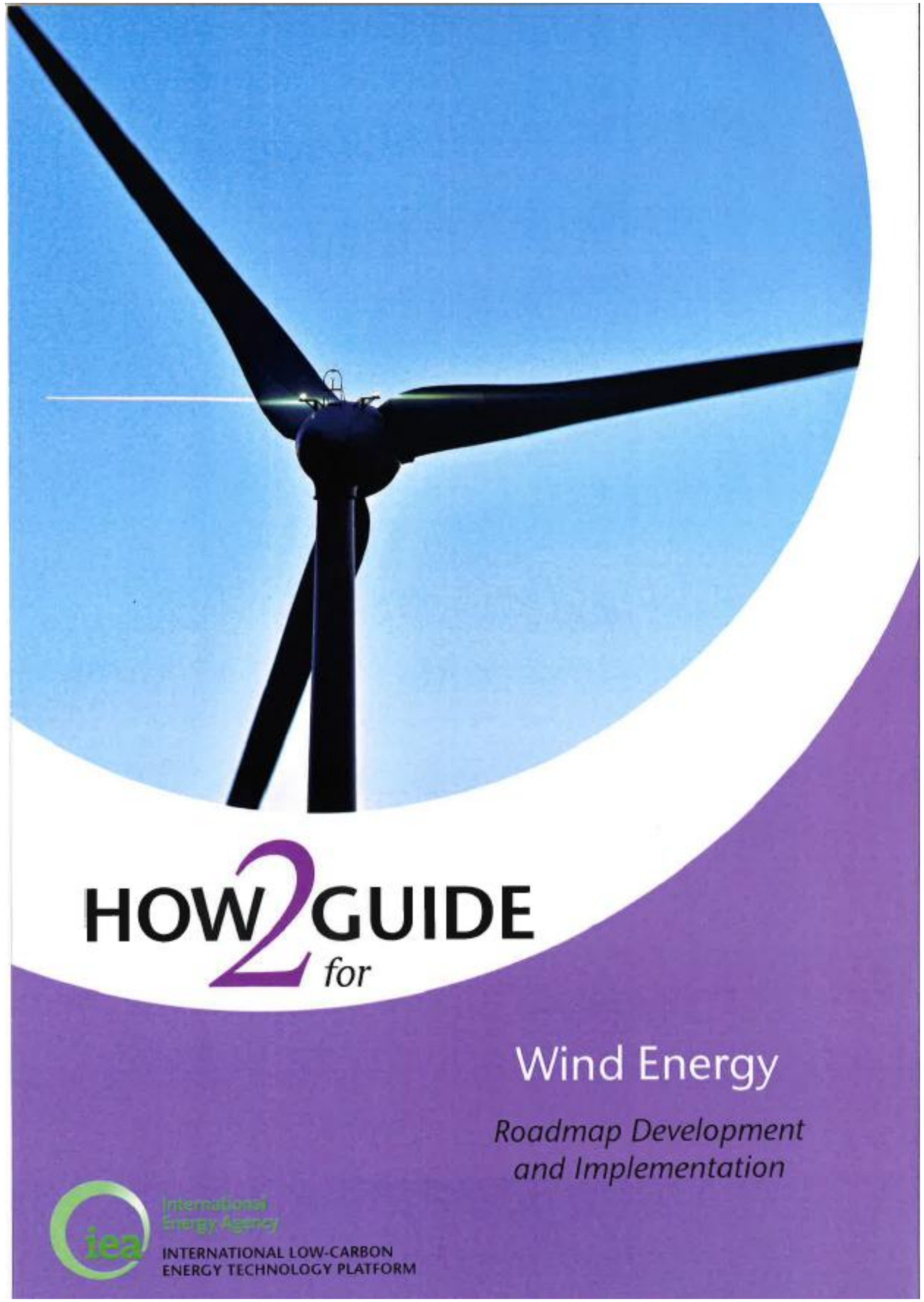


The Power of Transformation

Wind, Sun and the Economics of Flexible Power Systems

Simon Müller

Analyst, System Integration of Renewables

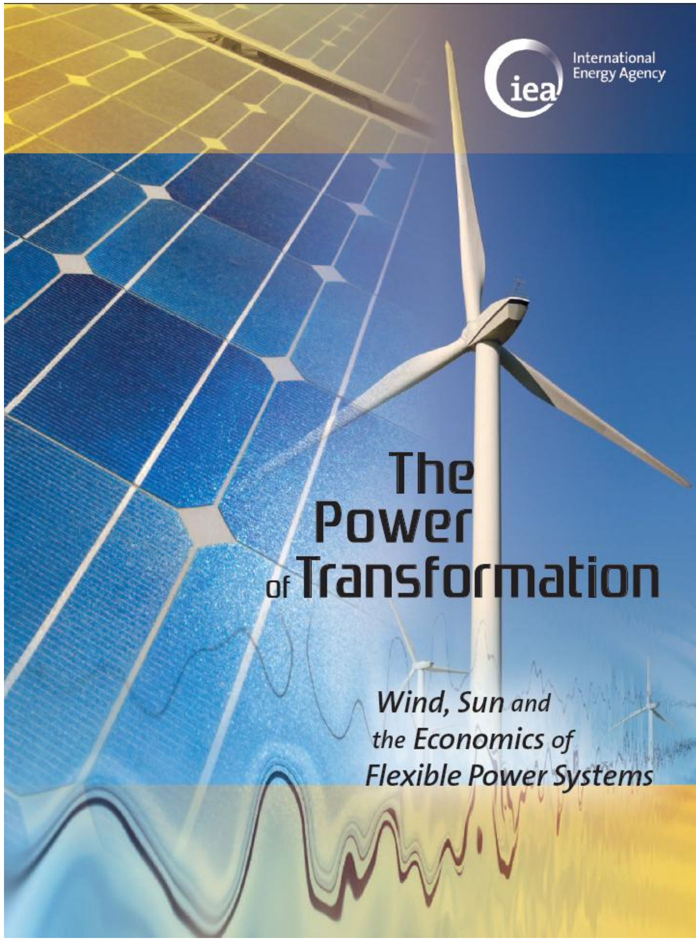
Renewable Energy Division

International Energy Agency

Paris, 22 May 2014

The Grid Integration of Variable Renewables Project - GIVAR

- **Third project phase at a glance**
  - 7 case studies covering 15 countries, >50 in-depth interviews
  - Technical flexibility assessment with revised IEA FAST tool
  - Detailed economic modelling at hourly resolution



Interaction is key

Properties of variable renewable energy (VRE) ⟷ **Flexibility of other power system components**

yrs

sec

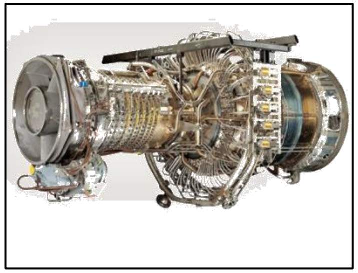
100s km

1 km

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

Grids

Generation



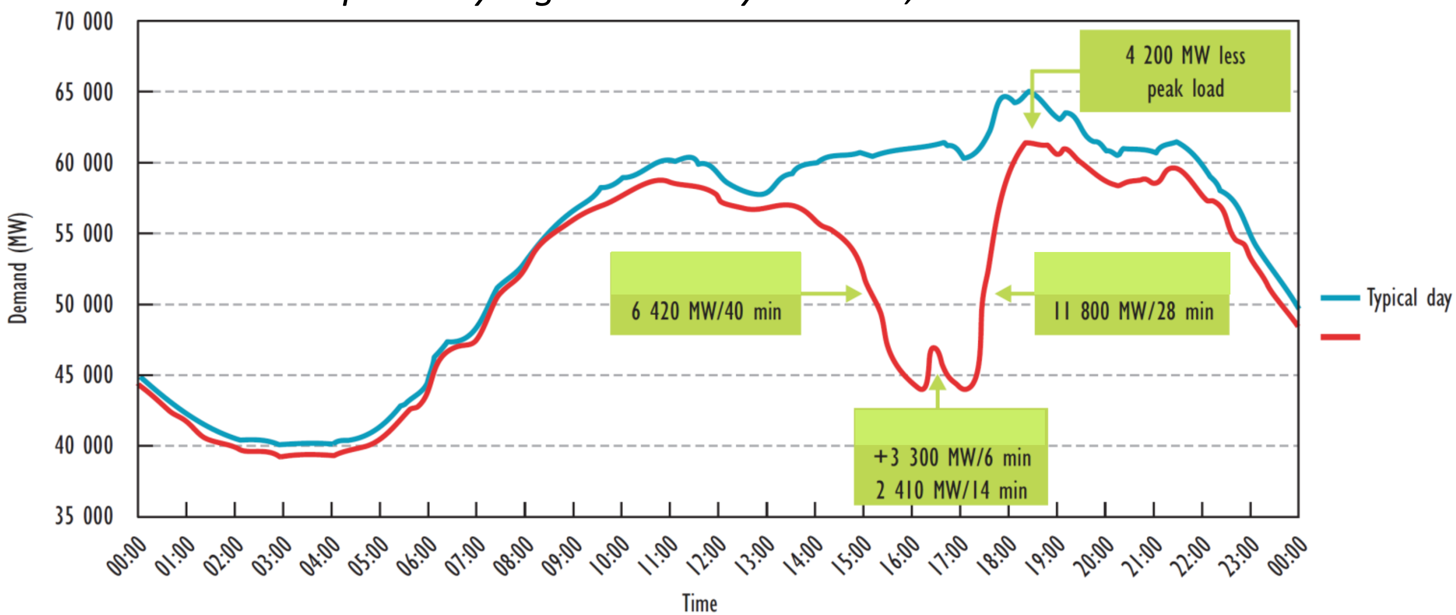
Storage

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**

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>**

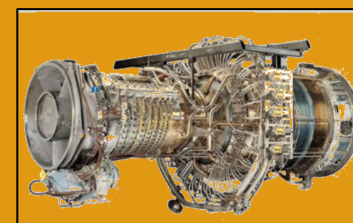
Three pillars of system transformation

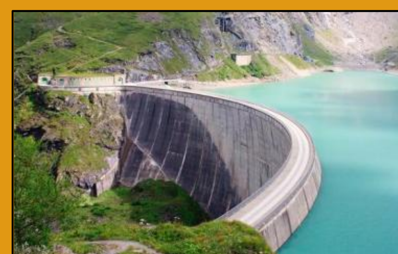
Technology spread

Geographic spread

Design of power plants

System friendly VRE





Investments

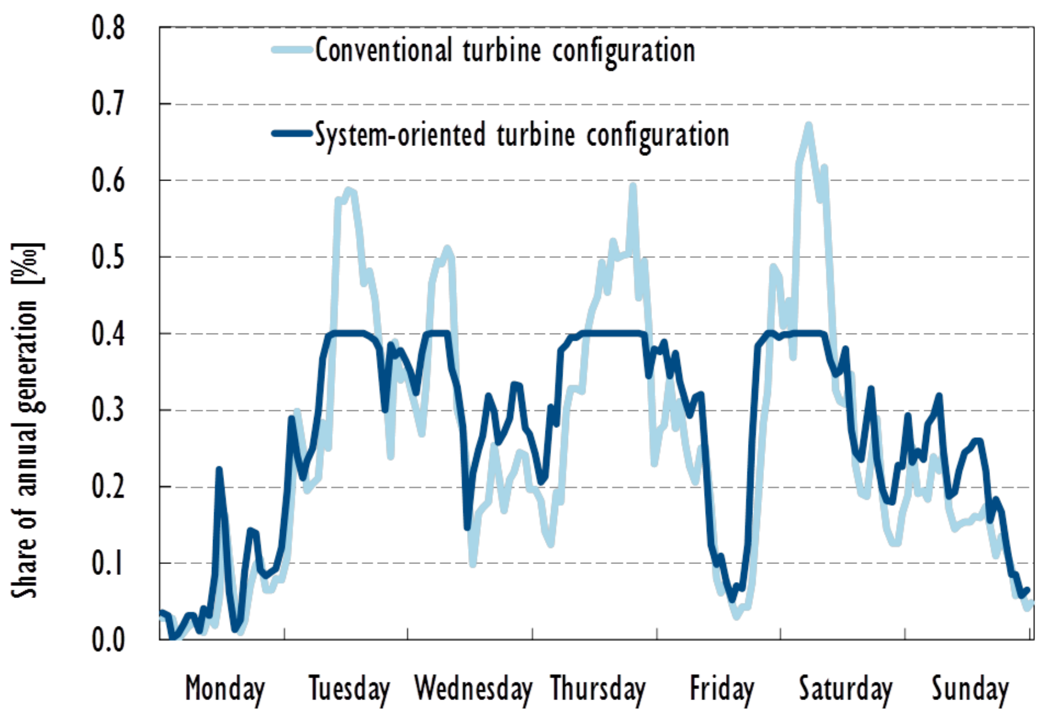
Operations

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!

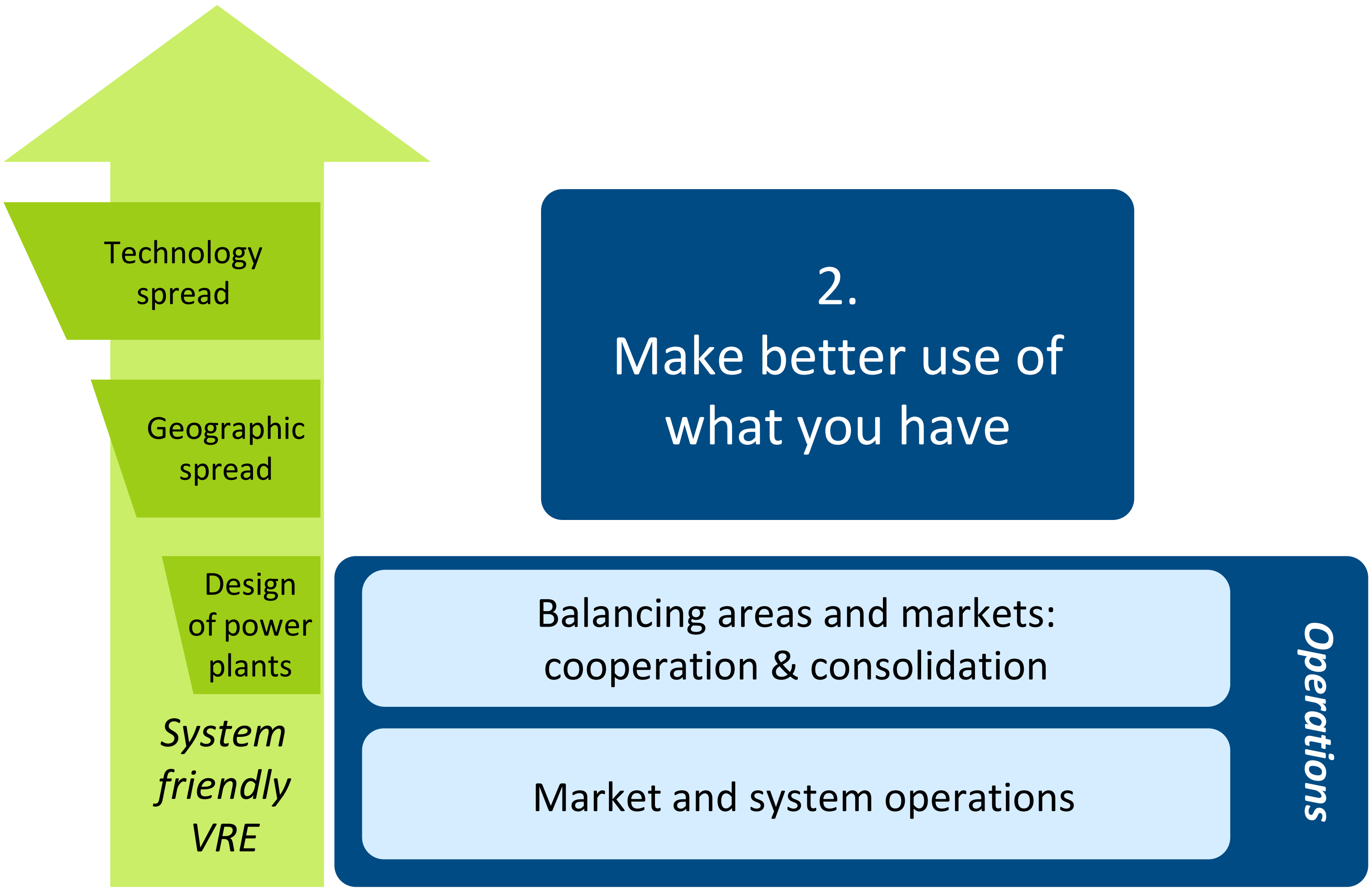
→ Take a system perspective when deploying VRE

Example: System friendly design of wind turbines reduces variability



Source: adapted from Agora, 2013

Three pillars of system transformation



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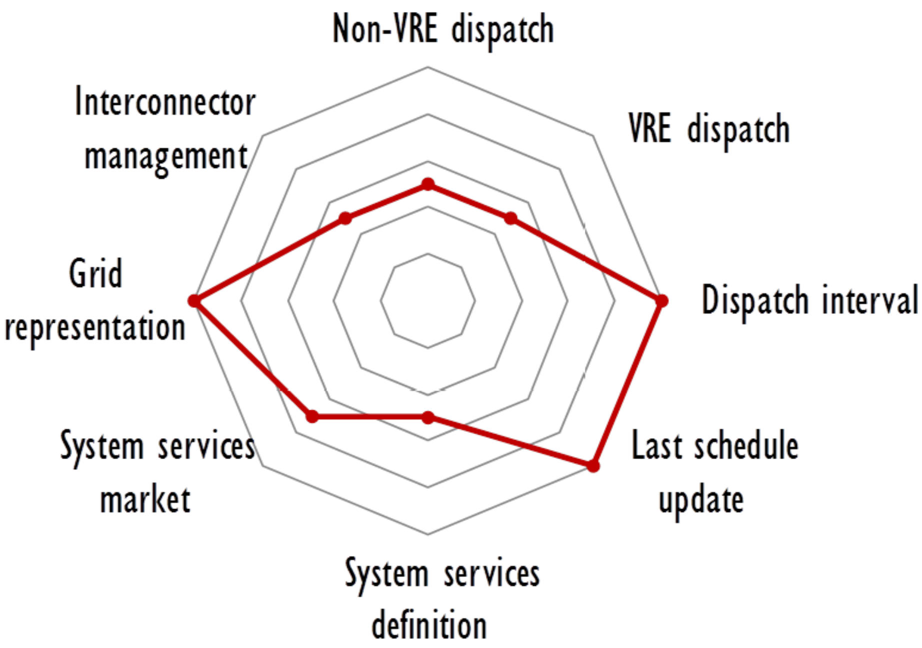
2) Better system & market operation

- VRE forecasting
- Better market operations:
  - Fast trading
    Best practice:
    ERCOT (Texas) – 5 minutes
  - Price depending on location
    Best practice: United States – Locational Marginal Prices
  - Better flexibility markets
    - *Updated product definitions*
    - *Full remuneration of services*
    - *Fully aligned trading of services and wholesale electricity*

Example: ERCOT market design



→ Make better use of what you have already!

Three pillars of system transformation

Technology spread

Geographic spread

Design of power plants

System friendly VRE

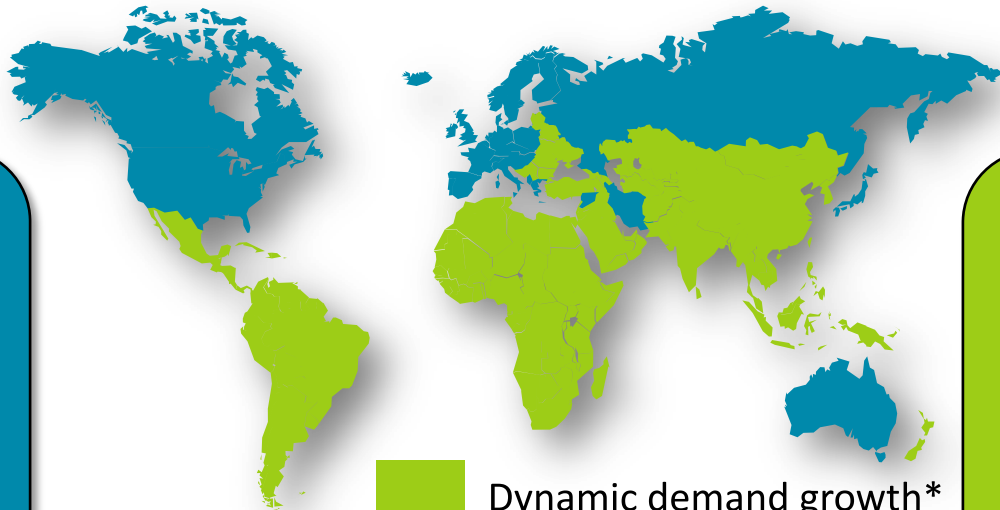
3.
Take a system wide-strategic approach to investments!

Balancing areas and markets: cooperation & consolidation

Market and system operations

Operations

Transformation depends on context



Dynamic demand growth*

Slow demand growth*

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**

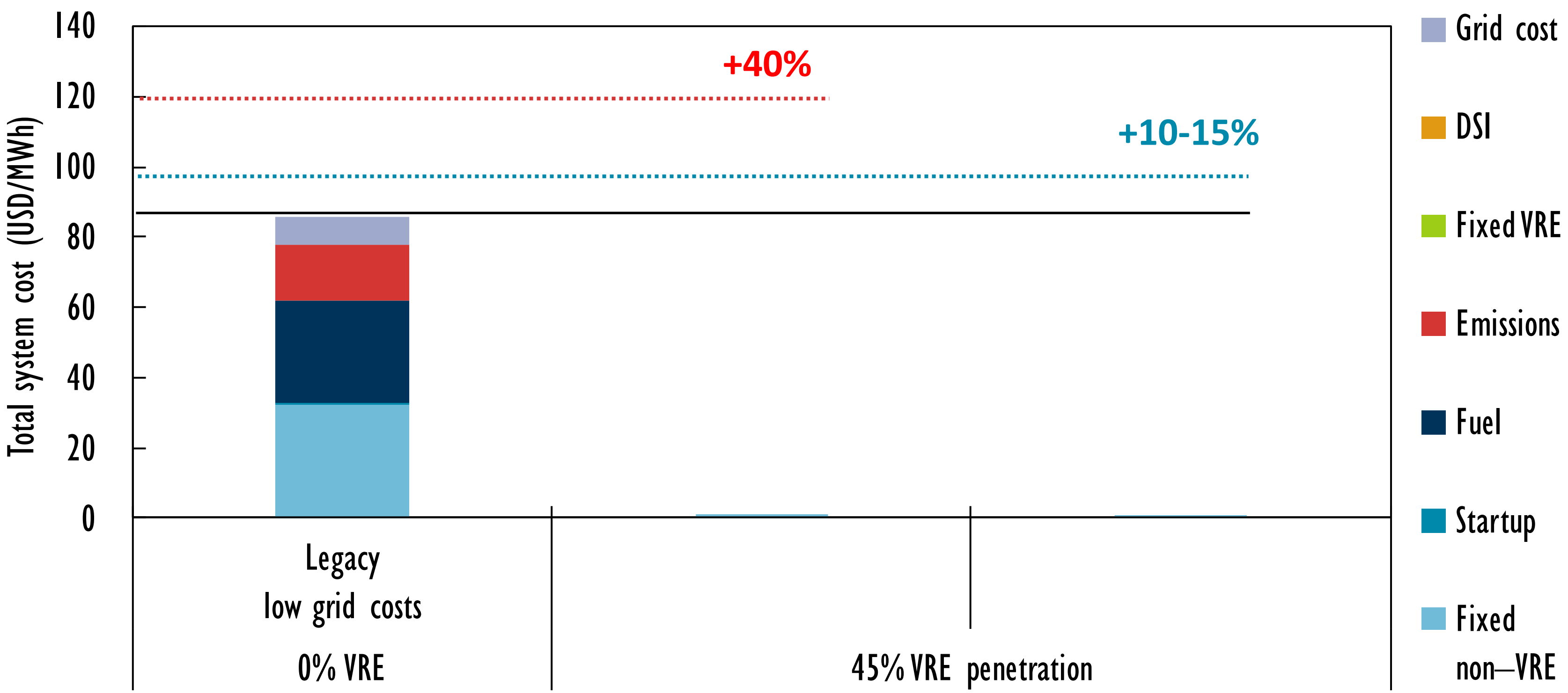
→ **Implement holistic, long-term transformation from onset**

→ **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

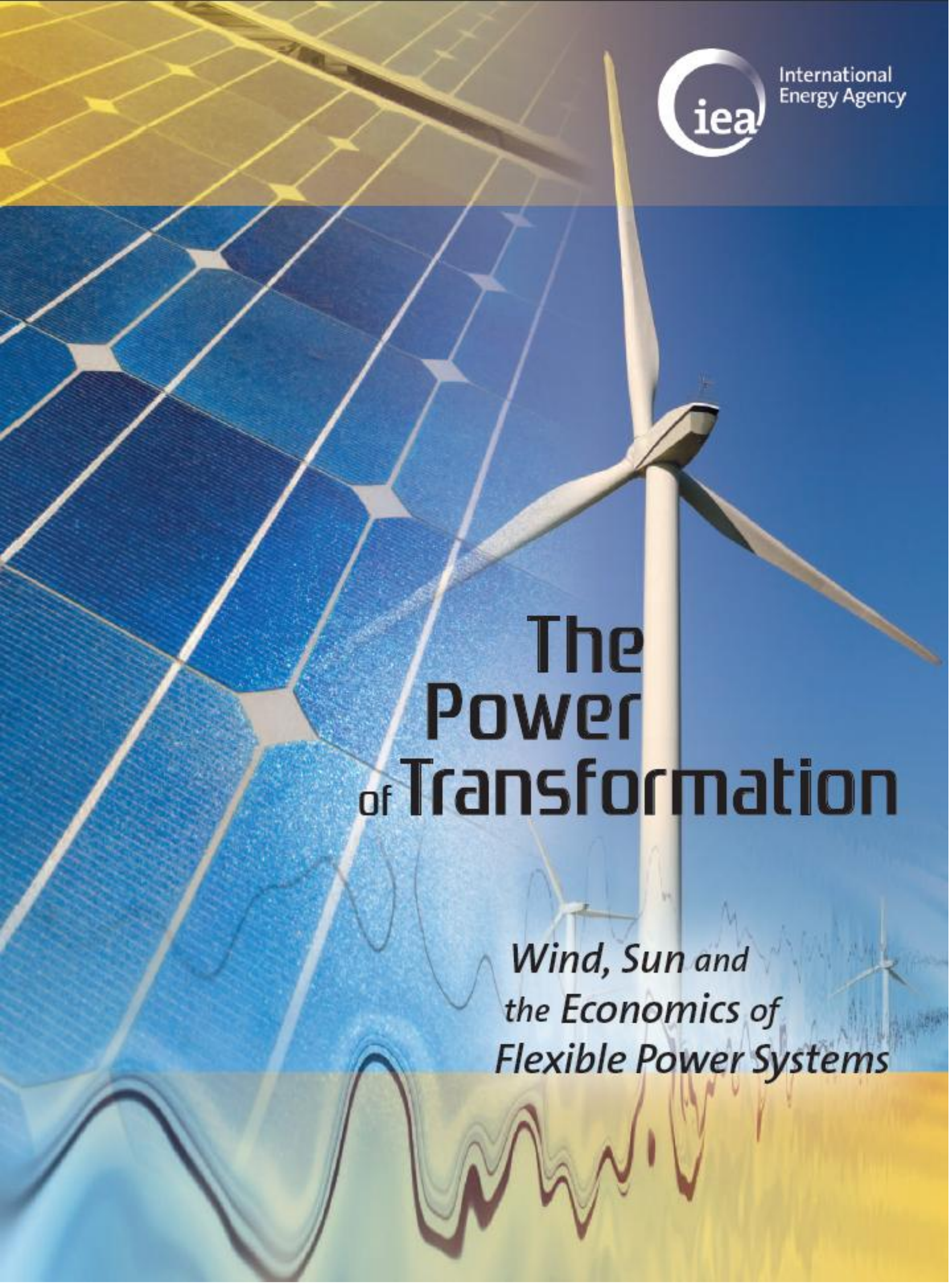
This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

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**



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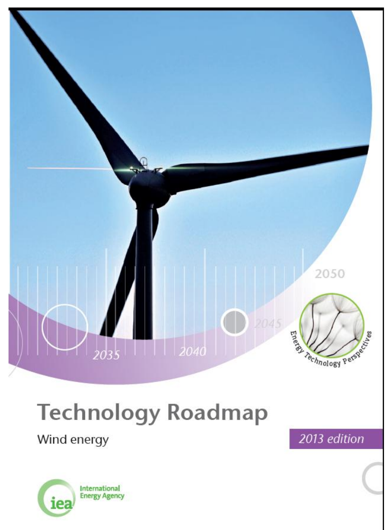
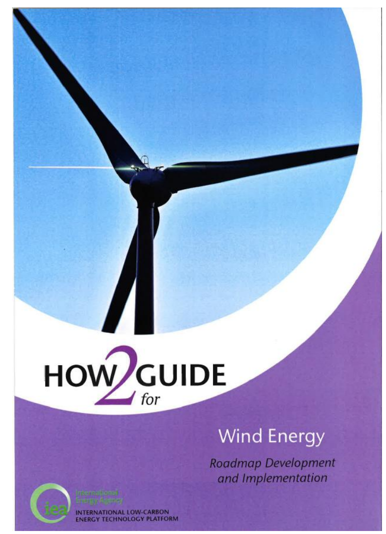
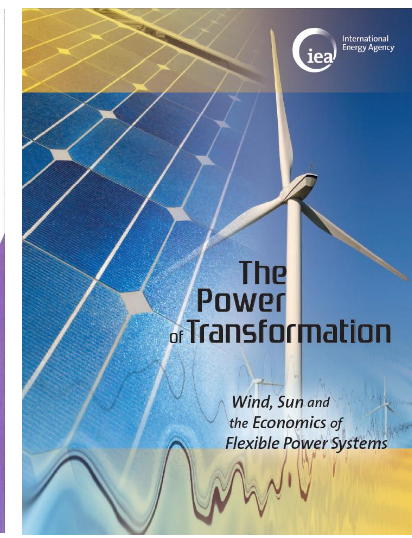
Perspectives for the Deployment of Wind Energy: Overview of Global Trends by 2050 and Guidance to National Roadmapping Efforts

IEA Panelists:

- Ingrid Barnsley
- Cédric Philibert
- Simone Landolina
- Simon Müller







Paris, 22 May 2014