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IRENA Insights for Energy Transition

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Structure of the Presentation

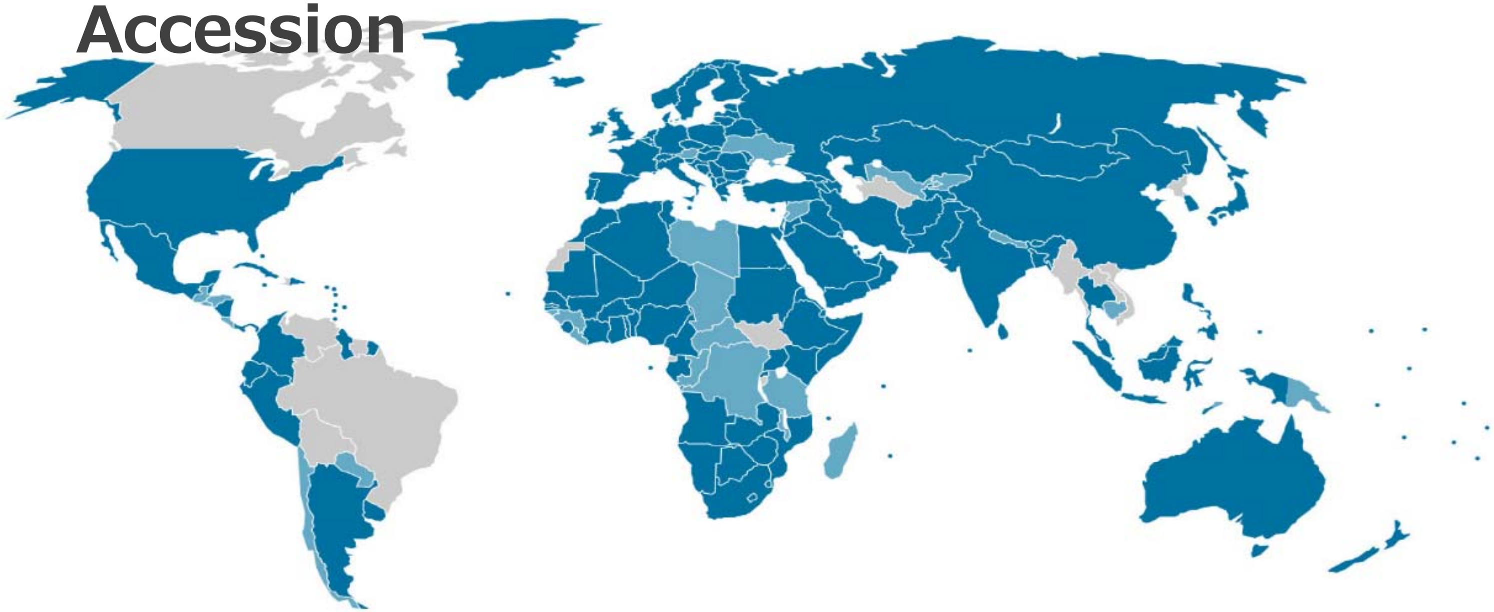
- IRENA overview
- Status and trend for renewable energy
- Costing and high RE cost in Japan
- Grid integration of renewables in the Japanese context
- Renewable energy support schemes

Introduction

- Established in 2011
- Headquartered in Abu Dhabi, UAE
- First global intergovernmental organisation headquartered in Middle East
- IRENA Innovation and Technology Centre in Bonn, Germany
- Permanent Observer to the United Nations – New York
- 

Global Membership

- 152 Members
- 28 States in Accession



Overview

Mandate

To promote the widespread adoption and sustainable use of **all forms of renewable energy** worldwide

Objective

To serve as a **network hub**, an **advisory resource** and an **authoritative, unified, global voice** for renewable energy

Scope

All renewable energy sources produced in a **sustainable manner**

BIOENERGY | GEOTHERMAL ENERGY | HYDROPOWER | OCEAN ENERGY | SOLAR ENERGY | WIND ENERGY

Thematic Areas Work Programme 2016-2017

- I. Planning for the renewable energy transition
  - Global transition roadmap and macroeconomic impact analysis
  - Power sector transformation
  - Technology status and outlook
- II. Enabling investment and growth
  - Project development support, auctions and other policy tools
  - Standards and quality control
  - Marked design and policy
- III. Renewable energy access for sustainable livelihoods
  - IOREC conference, RE for refugee camps
- IV. Regional action agenda
  - Clean Energy Corridors
- V. Islands: lighthouses for renewable energy deployment
  - SIDS Lighthouses
- VI. Gateway to knowledge on renewable energy
  - Energy statistics, costing data

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Close Cooperation with Government of Japan

- Various ministries METI, MAFF, MOFA, MOE

Some recent topics:

- Electricity storage study (released yesterday at ICEF)
- Standards for renewable technologies in harsh environments (ongoing)
- Fukushima related events (next WFES January 2018)
- REmap energy transition roadmaps
- Bioenergy potential assessments, conversion technologies development, environmental impact assessment – Africa, South East Asia
- Pacific Island State workshops, capacity building, training

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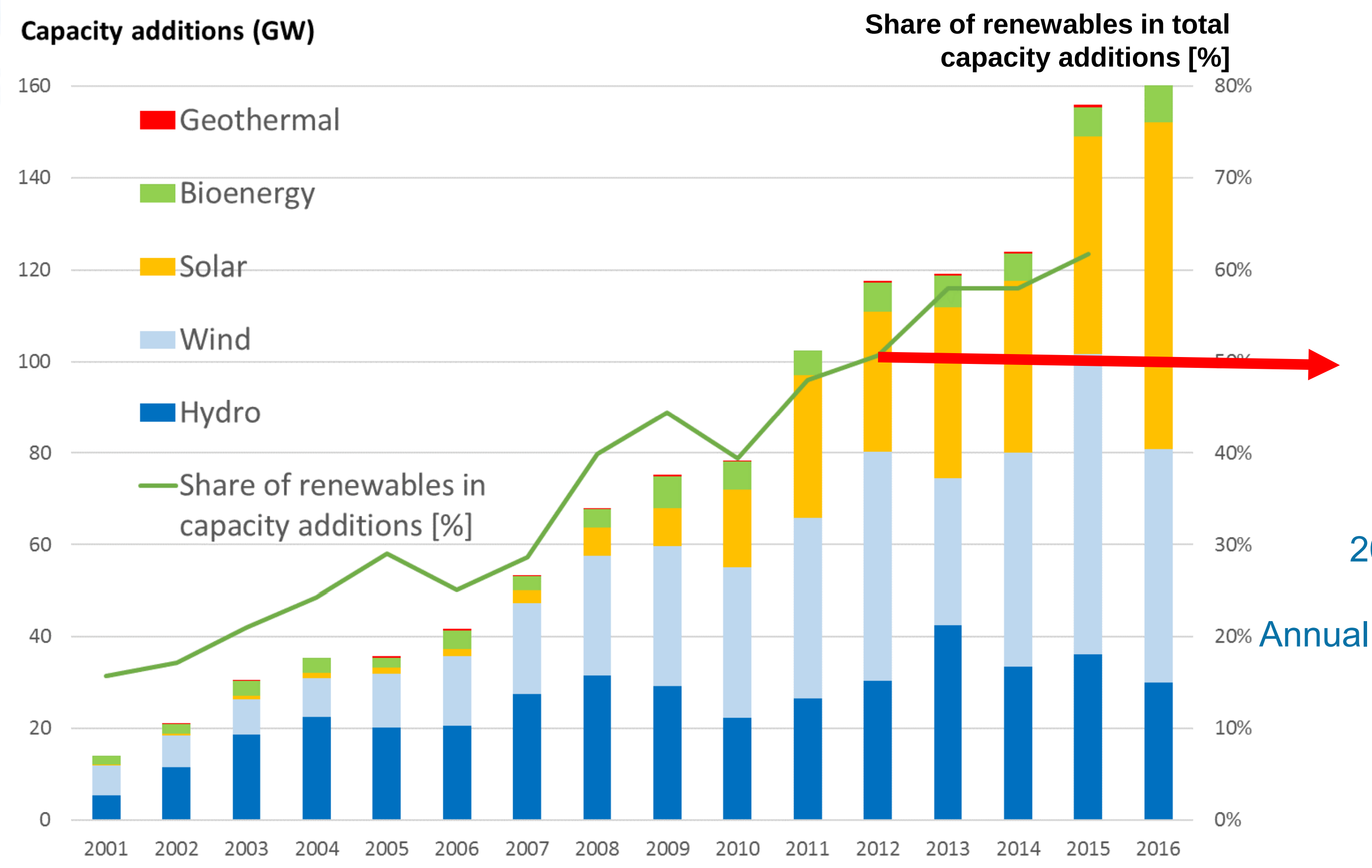
STATUS AND TREND FOR RENEWABLE ENERGY

Ongoing power sector transformation



Since 2012 >50% of total capacity additions

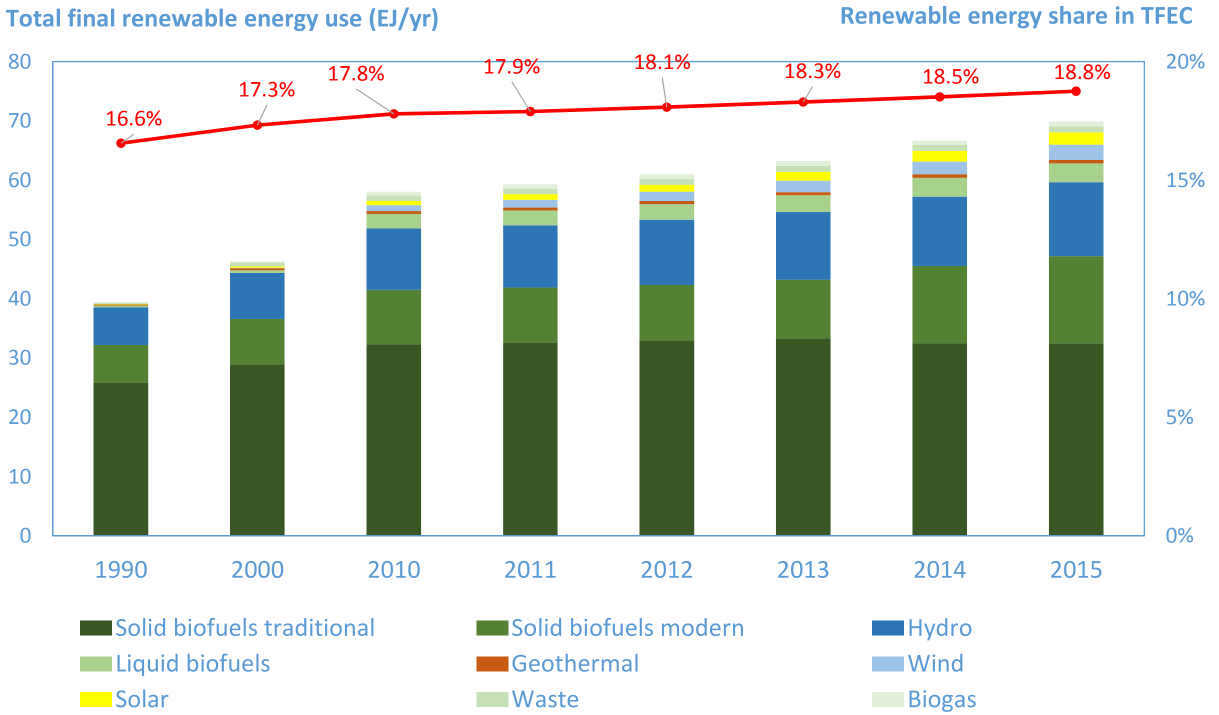
2016

2006 GW RE power generation capacity in place
Annual RE capacity addition 161 GW (+8%/yr)
of which:
71 GW solar
51 GW wind
30 GW hydropower
9 GW biomass

Source: IRENA statistics

- Around **25%** renewable power generation share worldwide
- Growing by **0.7 percentage** per year

Renewable energy in the global energy mix



During 2010-2015, renewable energy share grew from **17.8% to 18.8%** in total final energy consumption – **0.17%/yr** growth.

REmap – Roadmap for Renewable Energy future

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- IRENA's **Global Renewable Energy Roadmap**
- Shows feasible, cost-effective ways to **increase renewable energy deployment** in world's energy mix by 2030 **in line with SDG7**
- **Support the G20** in determining pathways for operationalising Paris Agreement with decarbonisation scenarios analysis to 2050, report released in March 2017
- **Next Update** April 2018

- Identifies concrete **technology options** for countries and sectors
- Assesses policy and investment **implications**
- Outlines **benefits** (economic, social, environmental)
- In cooperation with **70 countries**
- **30 publications to date and datasets**
- **12 individual country reports for major economies – Japan is still missing**

A global view to 2050 – Energy Transition

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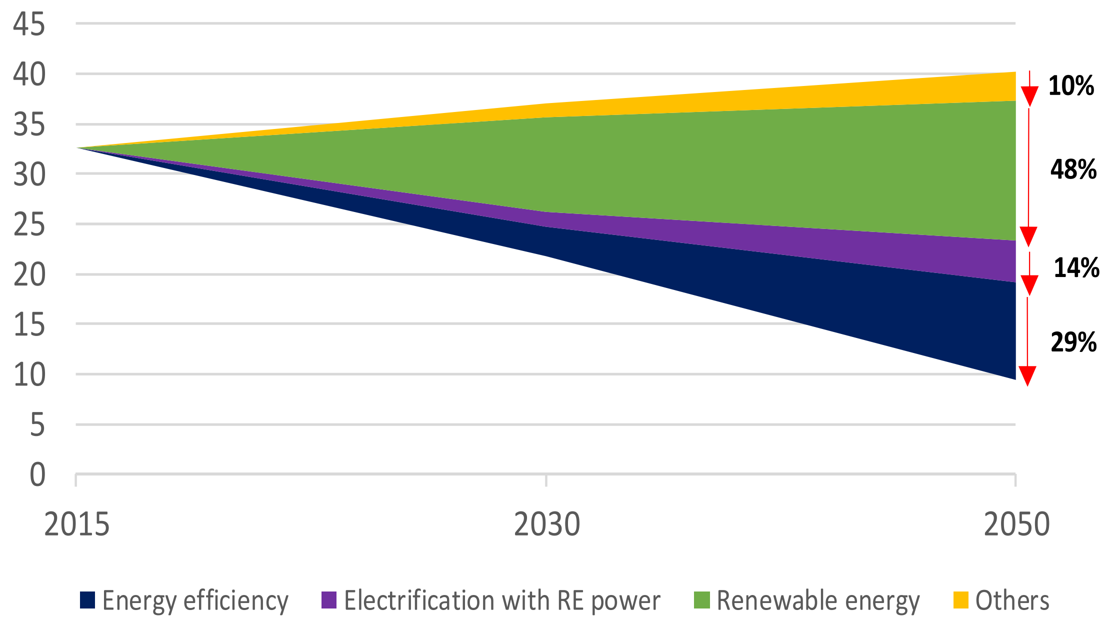
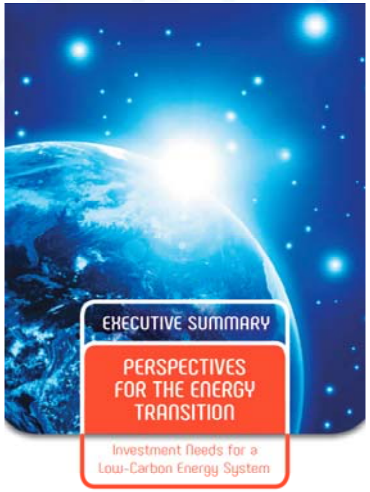
To meet 2 °C climate target set at COP 23 in Paris 2015

- Carbon intensity of energy: needs to fall by 85% in 2015-2050
- Energy-emission budget: 790 Gt CO2 from 2015 till 2100





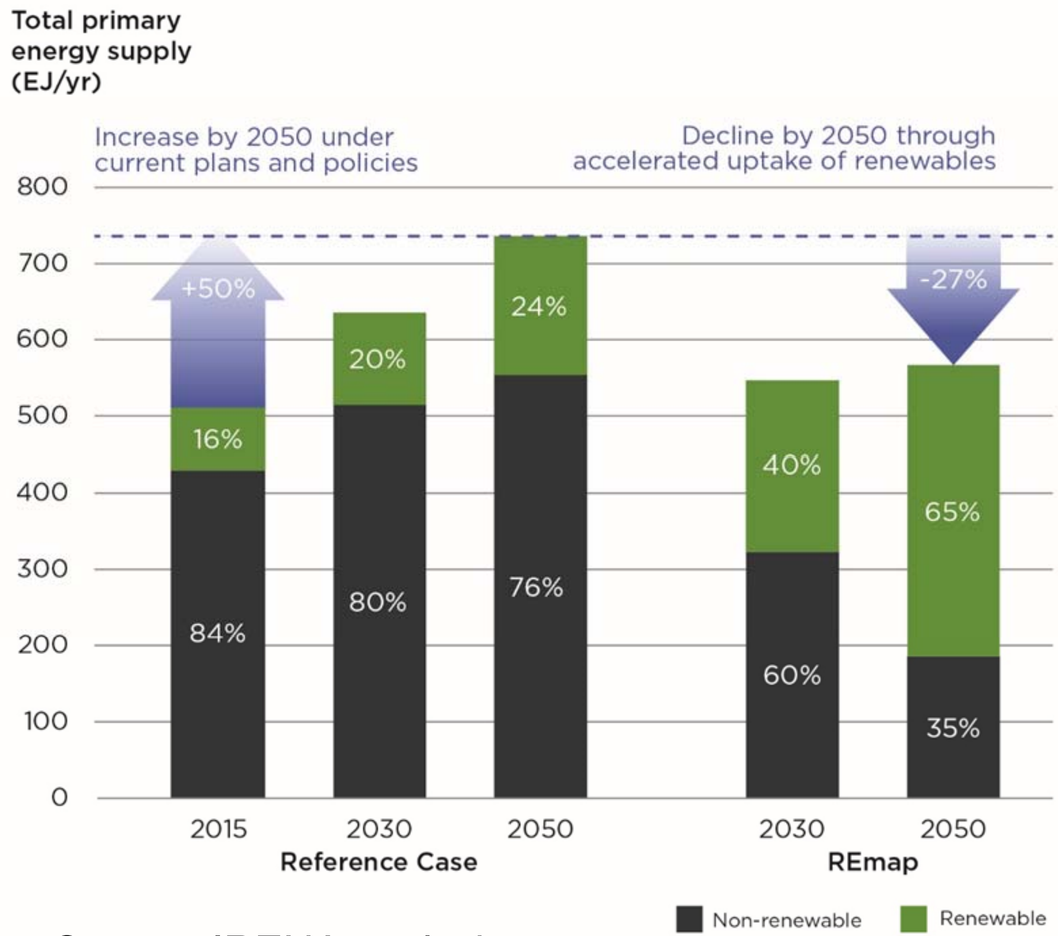
IRENA/IEA, 2017

- G20 has formulated energy and climate action agenda
- Global energy in transition towards decarbonisation

A global view to 2050 – Energy Transition

Renewable energy and energy efficiency can account for more than **90%** of emission mitigation

- Renewables acceleration: needs an 8-fold increase compared to recent years
- Renewables in 2050: represent 2/3 of the energy supply
- Efficiency gains: need to rise to 2.5% per year in 2015-2050 (from 1.8%/yr in 2015)



Source: IRENA analysis

REmap
A Renewable Energy Roadmap

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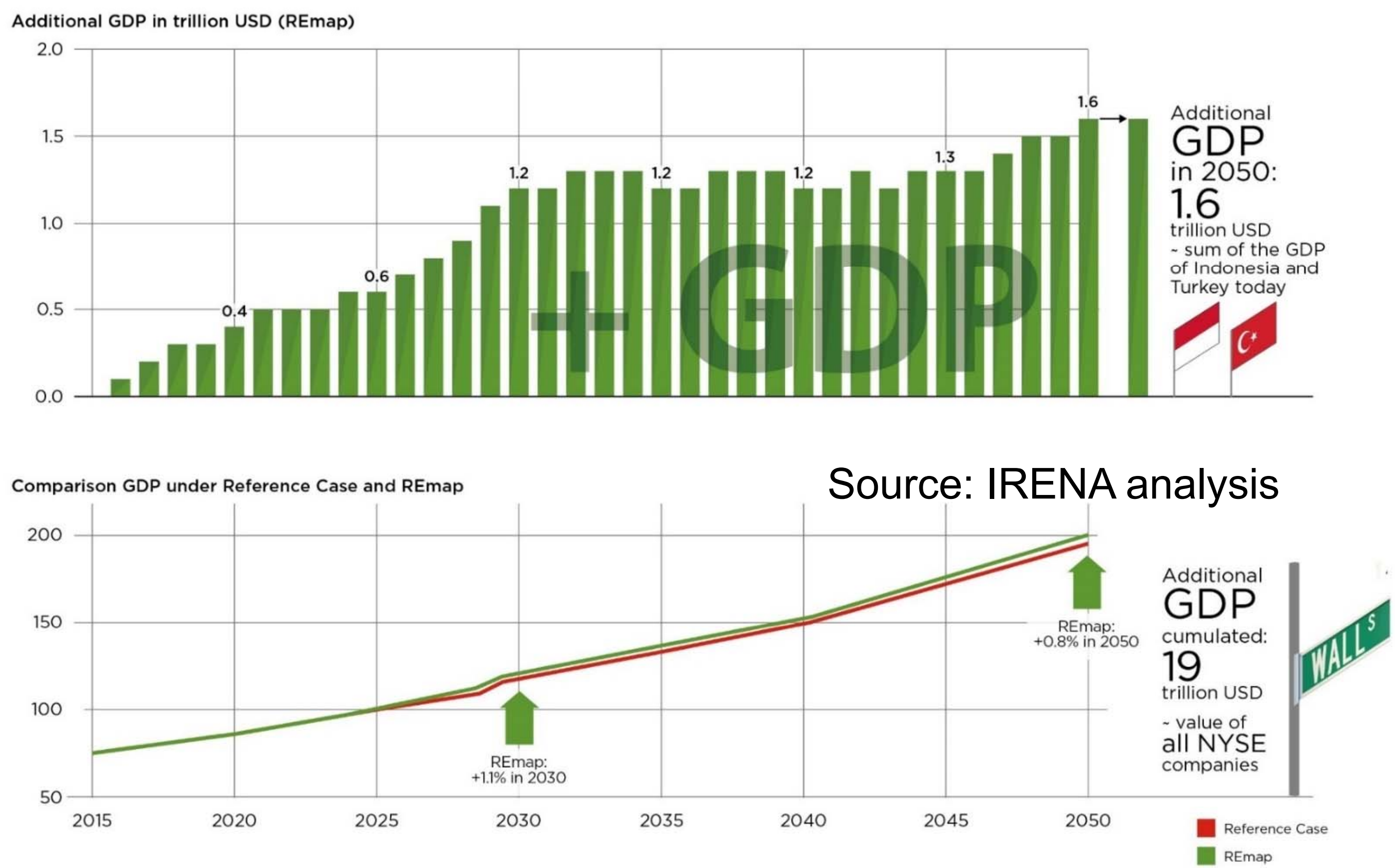
Economic benefits

#REmap



Source: IRENA analysis

- Decarbonising the energy sector in line with REmap increases global GDP by around 0.8% by 2050 compared to the Reference Case
- That is the equivalent of almost 19 trillion USD in increased economic activity between today and 2050.
- Policy benefits exceed the cost by a factor 2-6.

The global energy system is already transitioning with promising benefits

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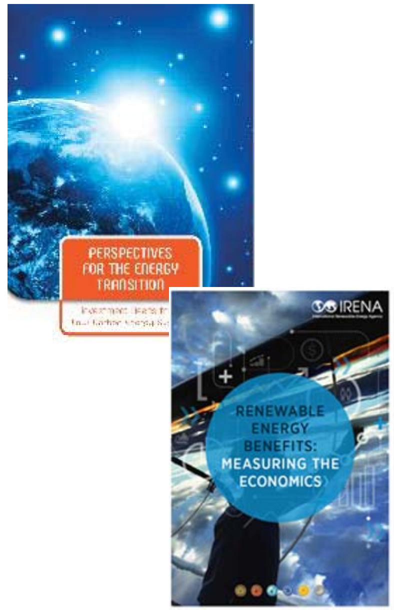
Job creation can potentially increase to 26 million in 2050

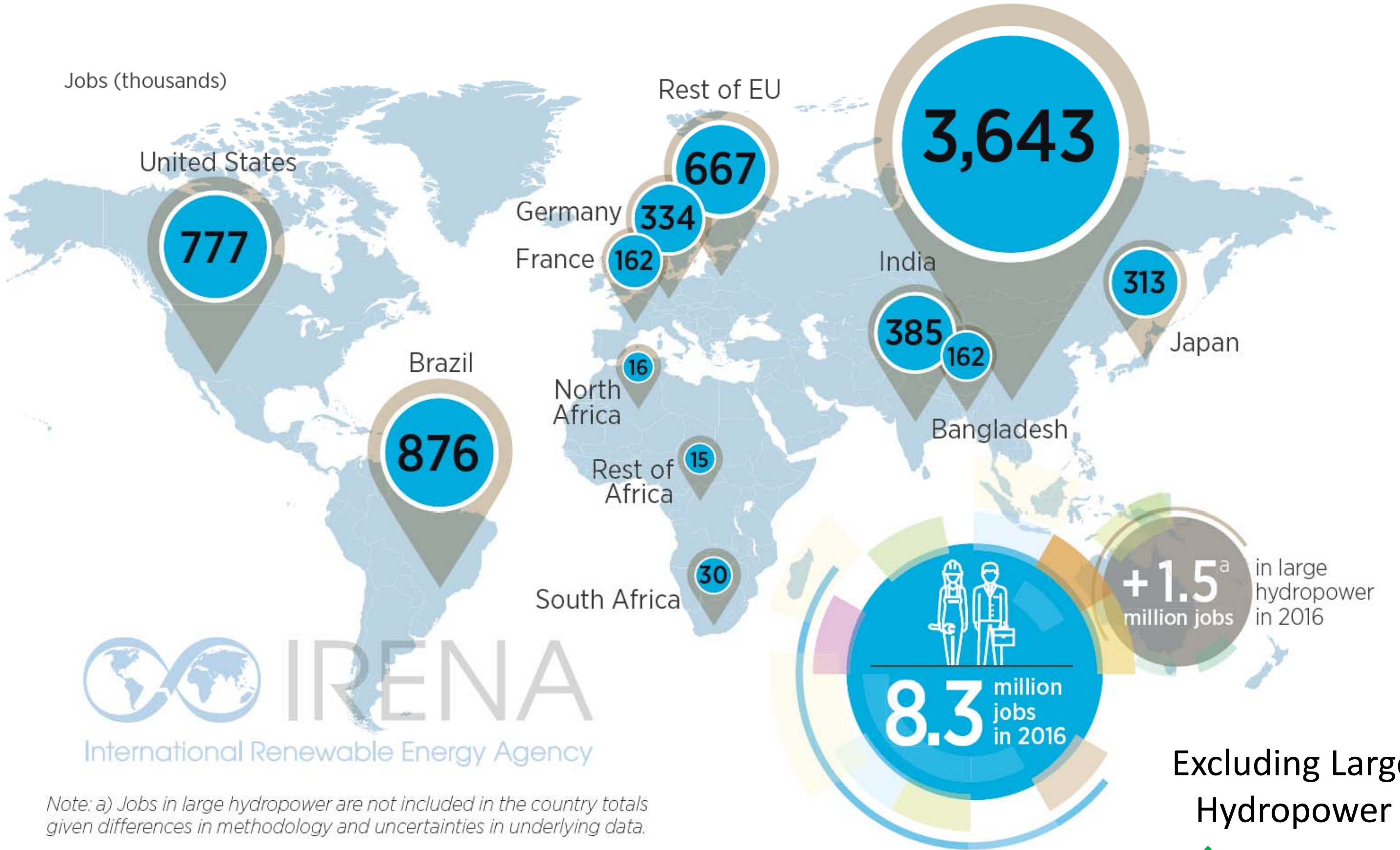
Jobs

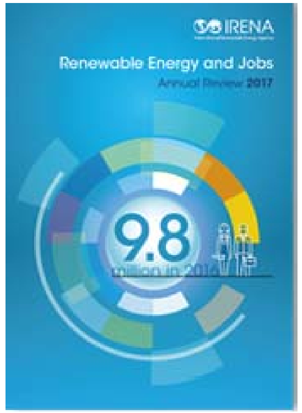


Source: IRENA (2017), Perspectives for the energy transition: investment needs for a low-carbon energy system.

Renewable energy jobs globally today

Employment by Country





Including Large Hydropower

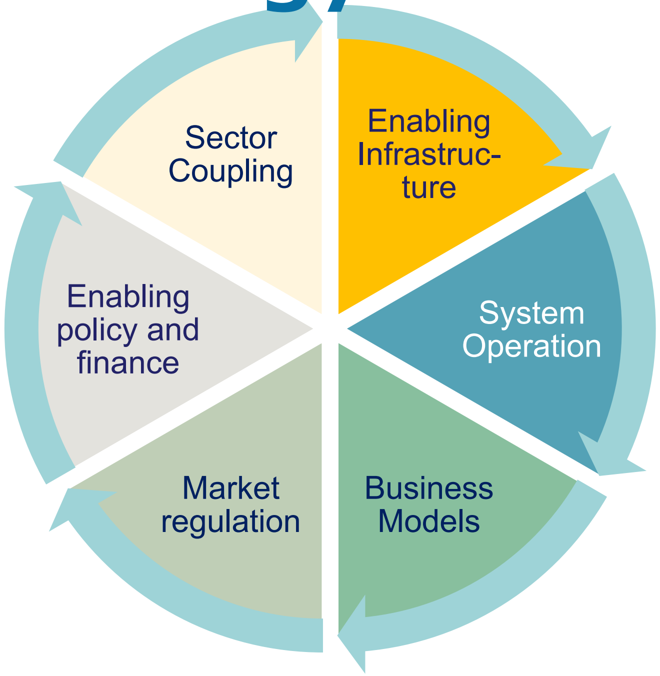
↑1.1%

Excluding Large Hydropower

↑2.8%

Source: IRENA (2017), Renewable Energy and Jobs – Annual Review 2017

A different approach for climate change: Systemic innovation in renewable energy



- **IRENA Innovation Week**
  2nd edition Q2 2018

- **Innovation Landscape Report – Q1 2018**

- **Innovation Outlook** Series
- Forthcoming studies in
  Electric Vehicles & Thermal Storage

- **Technology Briefs:** Over 25 studies
  on RE technologies and its functionalities
  In cooperation with others such as IEA-ETSAP

Climate change action: Unlocking financing for RE projects

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COSTING AND HIGH RE COST IN JAPAN

IRENA's project cost information database: Scope and coverage

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Power: 15 000 utility-scale projects,
¾ million small-scale solar PV
7000 utility-scale PPAs
Smaller dataset on biofuels/EVs

Stationary applications being added

Power: database concentrated in non-OECD as more publicly available information (e.g. multi-lateral financing, development projects, etc)

So what does 15000 projects look like?

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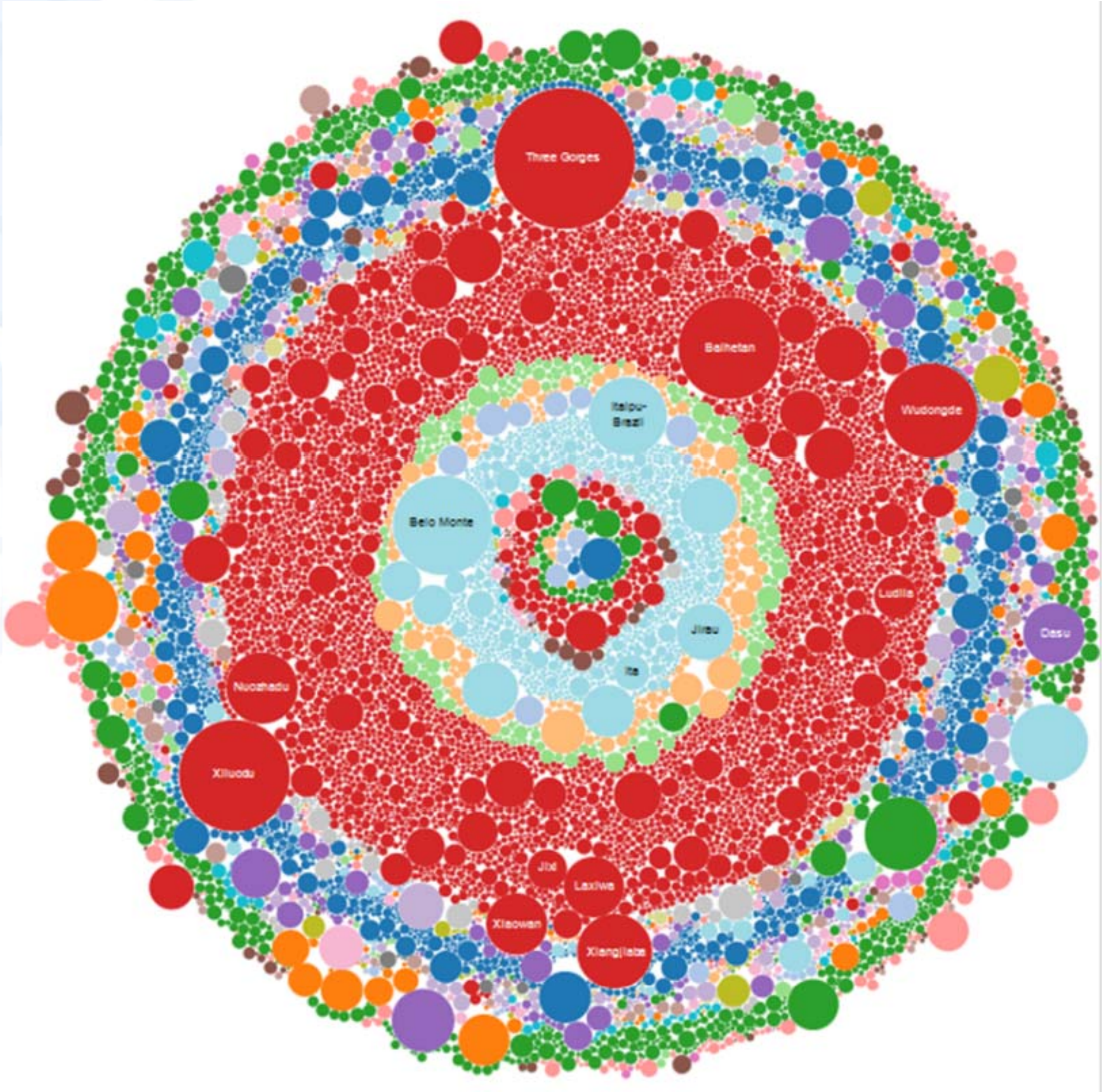
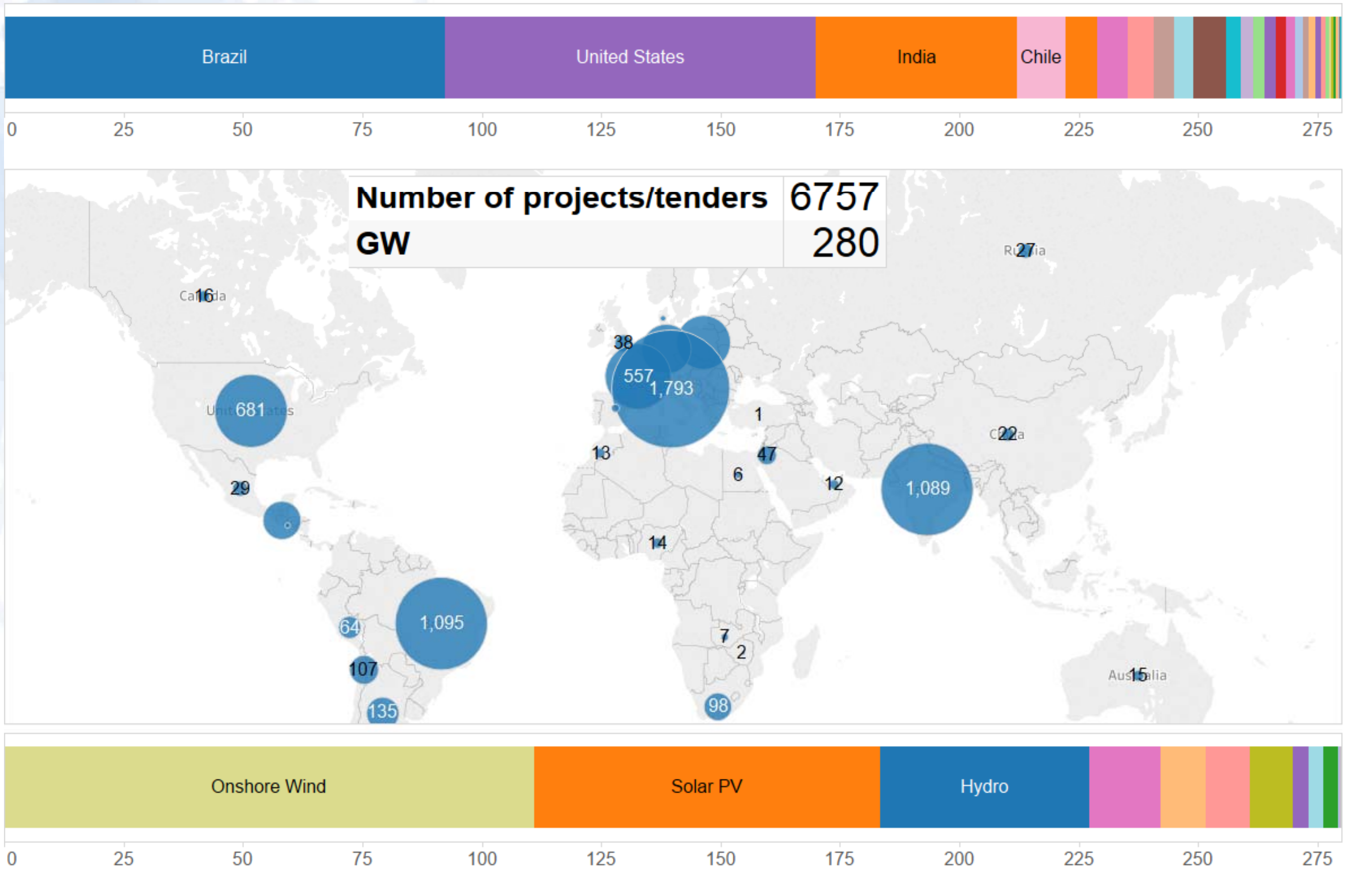


Auction and tender database



LCOE – Global Overview Most remarkable results for solar PV

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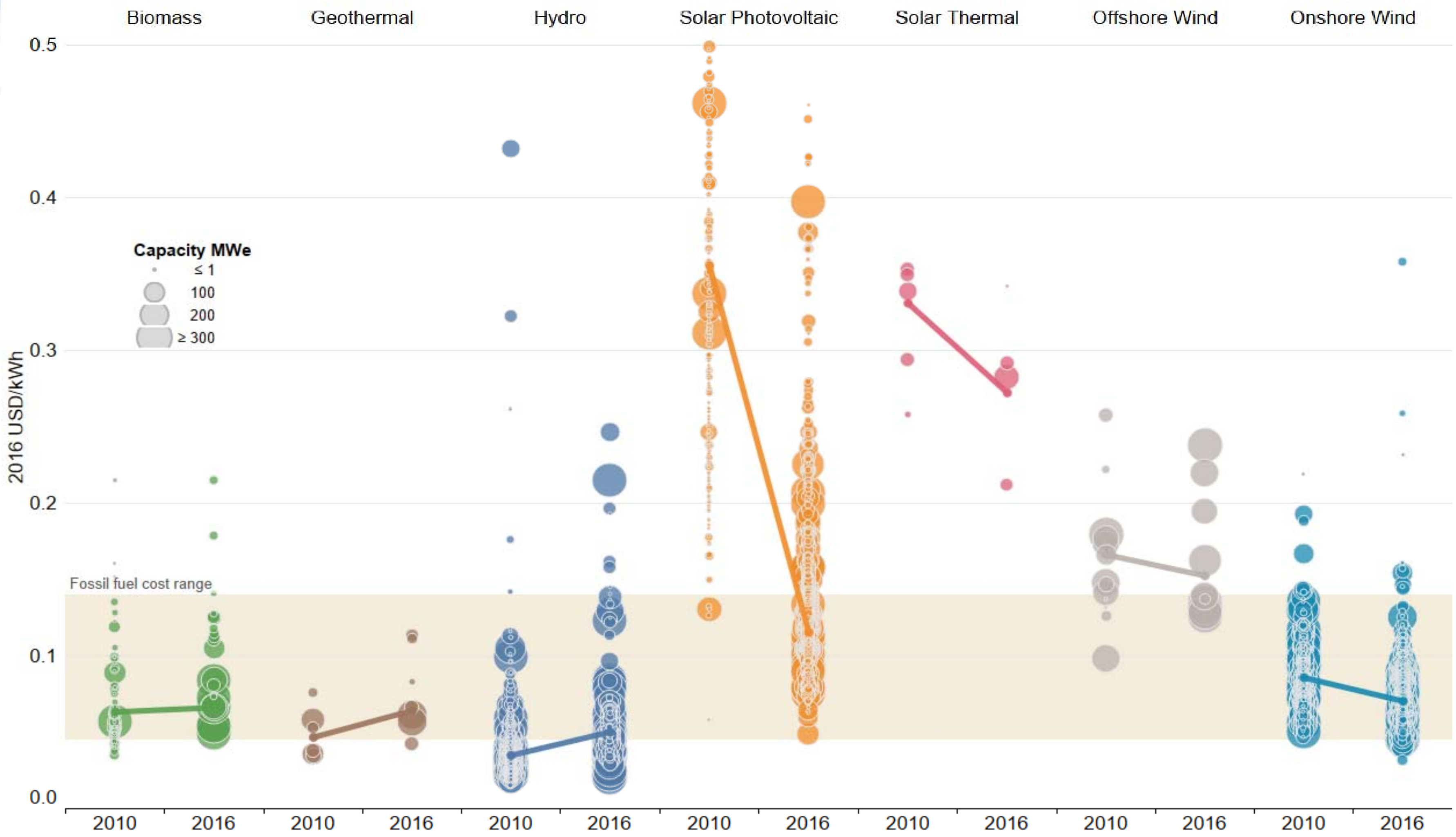

Rapidly falling cost
Global purchasing power agreement overview

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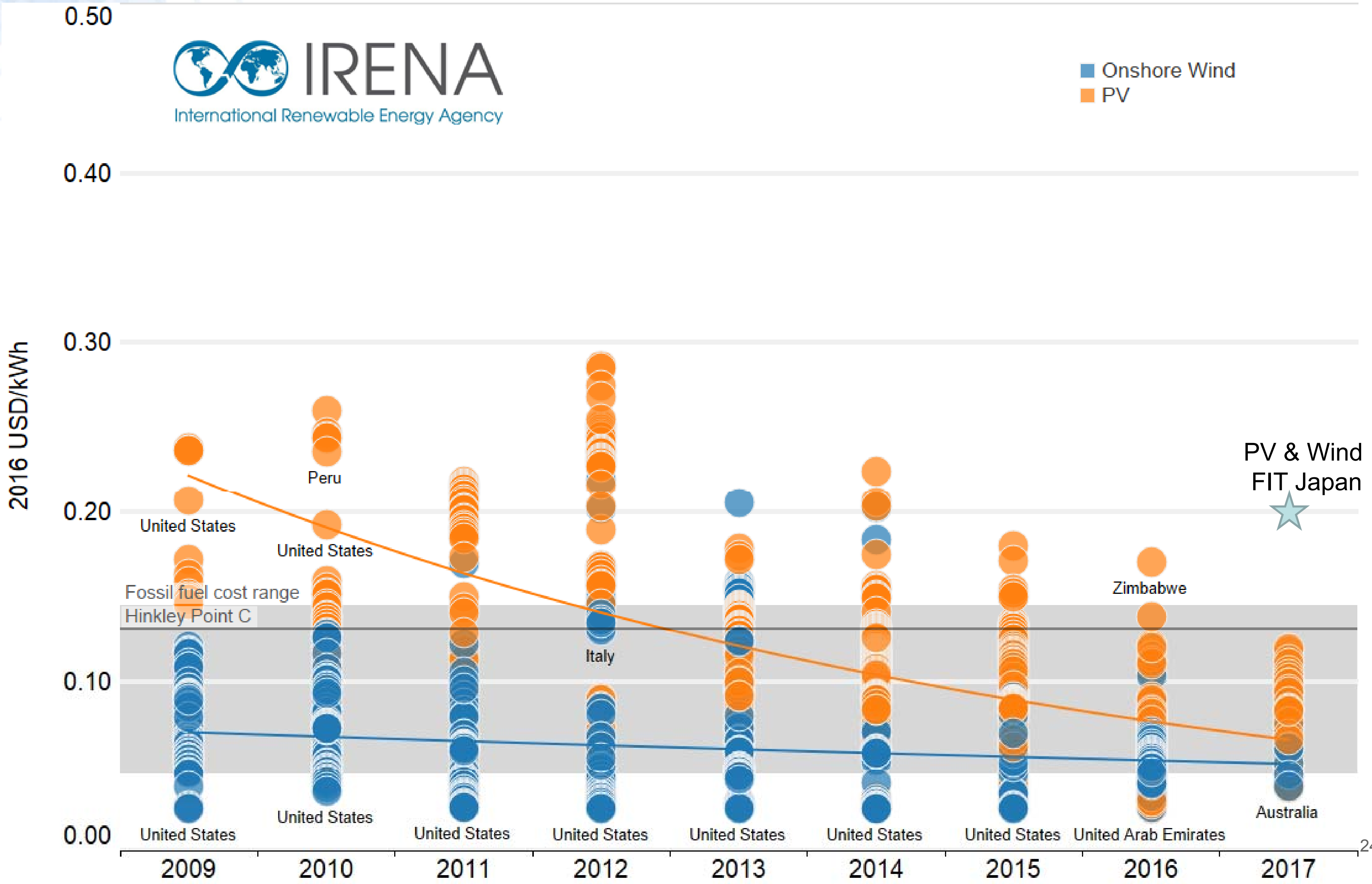


Wind power costs are falling….

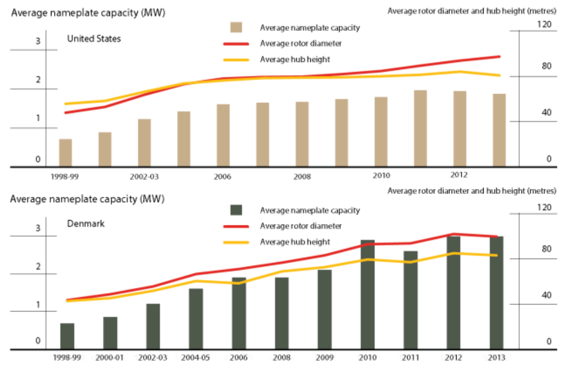
Higher capacity factors from improved technology

\+

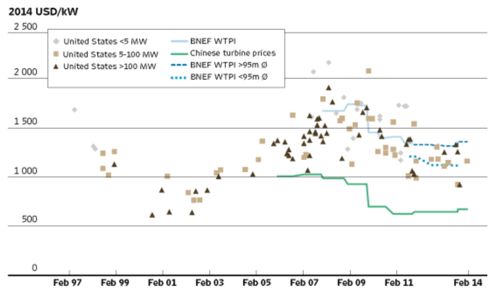
Wind turbine cost reductions

=

LCOEs are falling

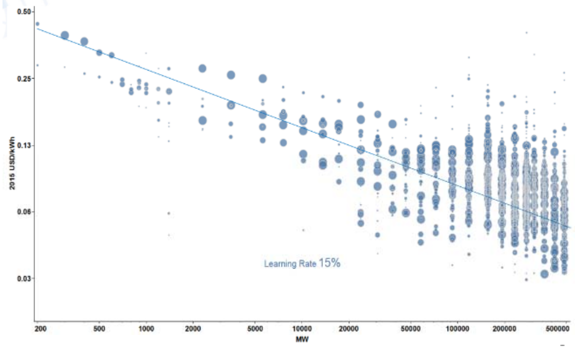


Sources: Wiser and Bollinger, 2014; Danish Energy Agency, 2014; and GlobalData, 2014



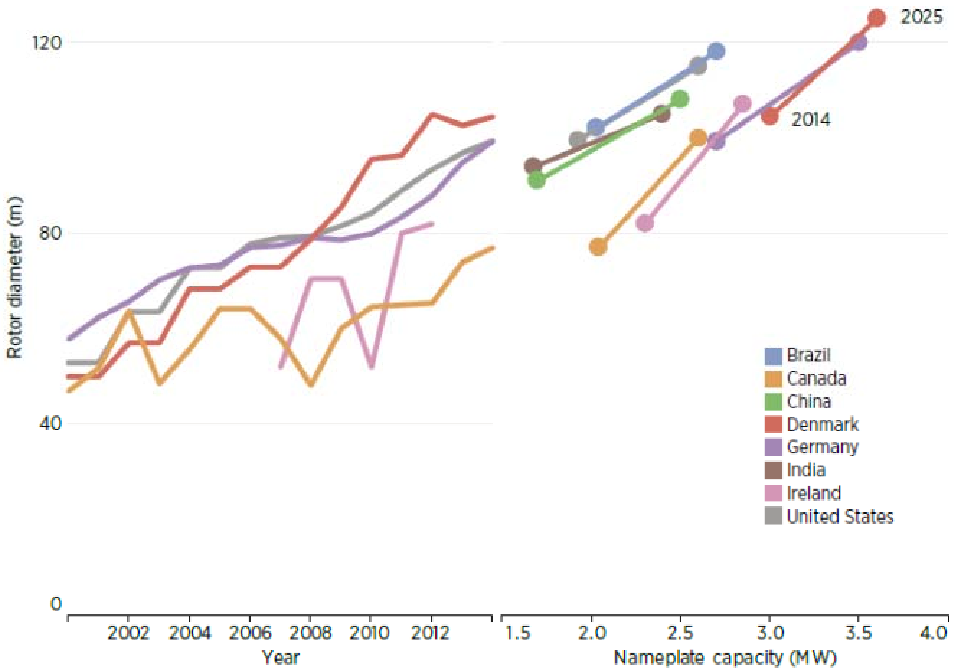
Sources: Wiser and Bollinger, 2014; CWEA, 2013; BNEF, 2014c; and Global Data, 2014

Note: BNEF WTPI represents the half-year average for non-Asian markets, while the United States data are for the specific month of a particular turbine contract and the Chinese data are annual averages.



Onshore Wind: Rotor Diameters & Nameplate Capacity

Rotor Diameters & Nameplate Capacity in Key Markets



Rotor diameters have increased markedly between 2000 and 2014 while nameplate capacity is expected to increase further in key markets up to 2025

Onshore Wind: Capacity Factors

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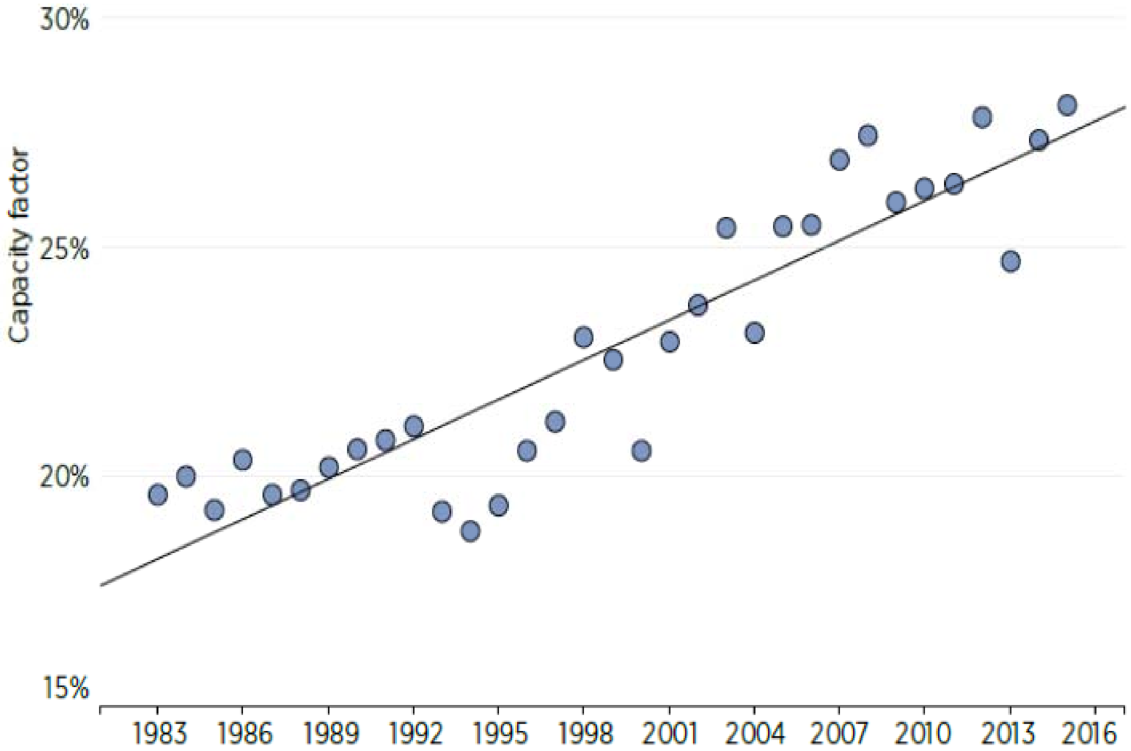
Global Weighted Average Capacity Factors – 1983 - 2015



Global average capacity factors grew by 35% between 1983 and 2014, rising from an estimated 20% in 1983 to 27% in 2014 (a 35% increase)

Global Onshore Wind Learning Curve
Levelised cost of electricity
1983-2016

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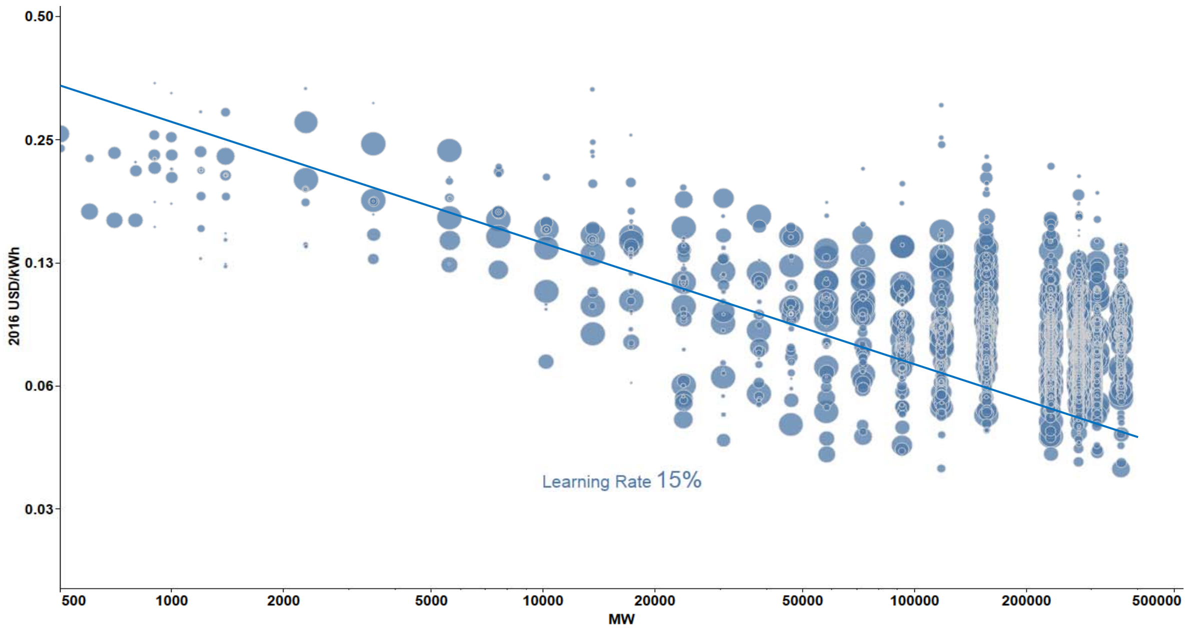

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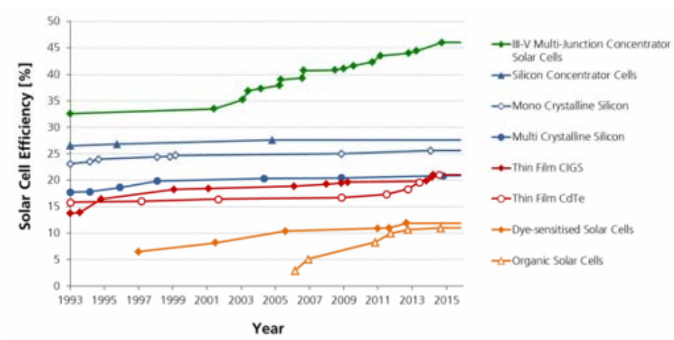
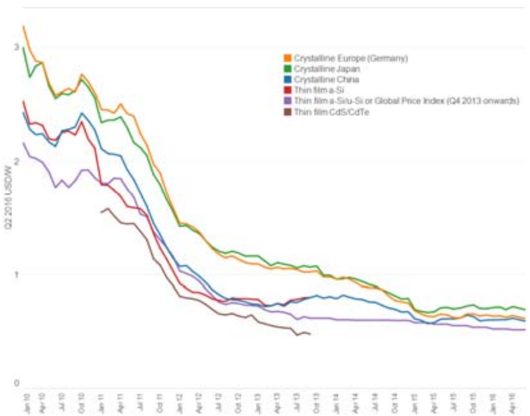
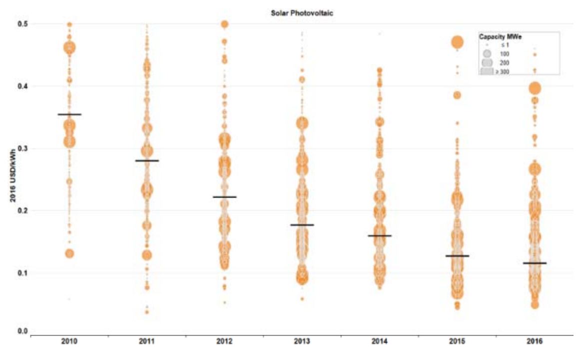
Solar PV costs are falling….

Higher efficiency modules + Module cost declines = LCOEs are falling



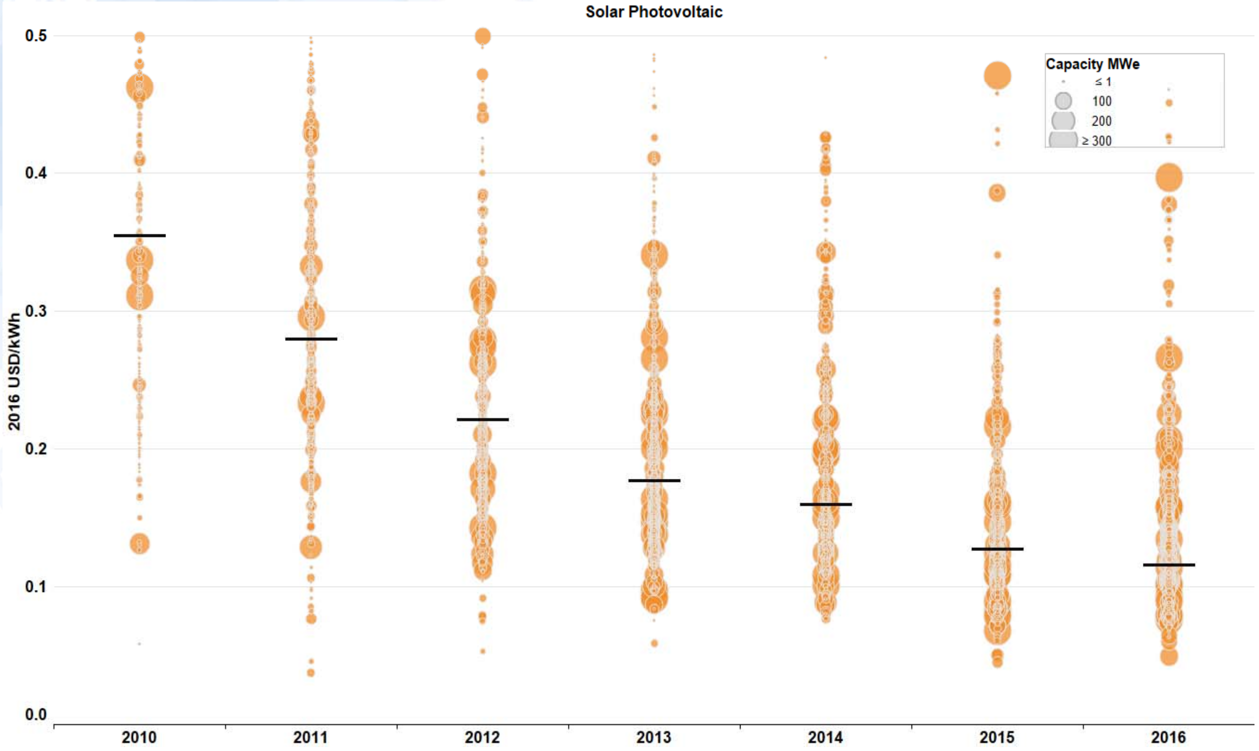
Data: Solar Cell Efficiency Tables (Versions 1-46), Progress in Photovoltaics: Research and Applications, 1993-2015. Graph: Simon Philipps, Fraunhofer ISE 2015





Solar PV utility-scale projects

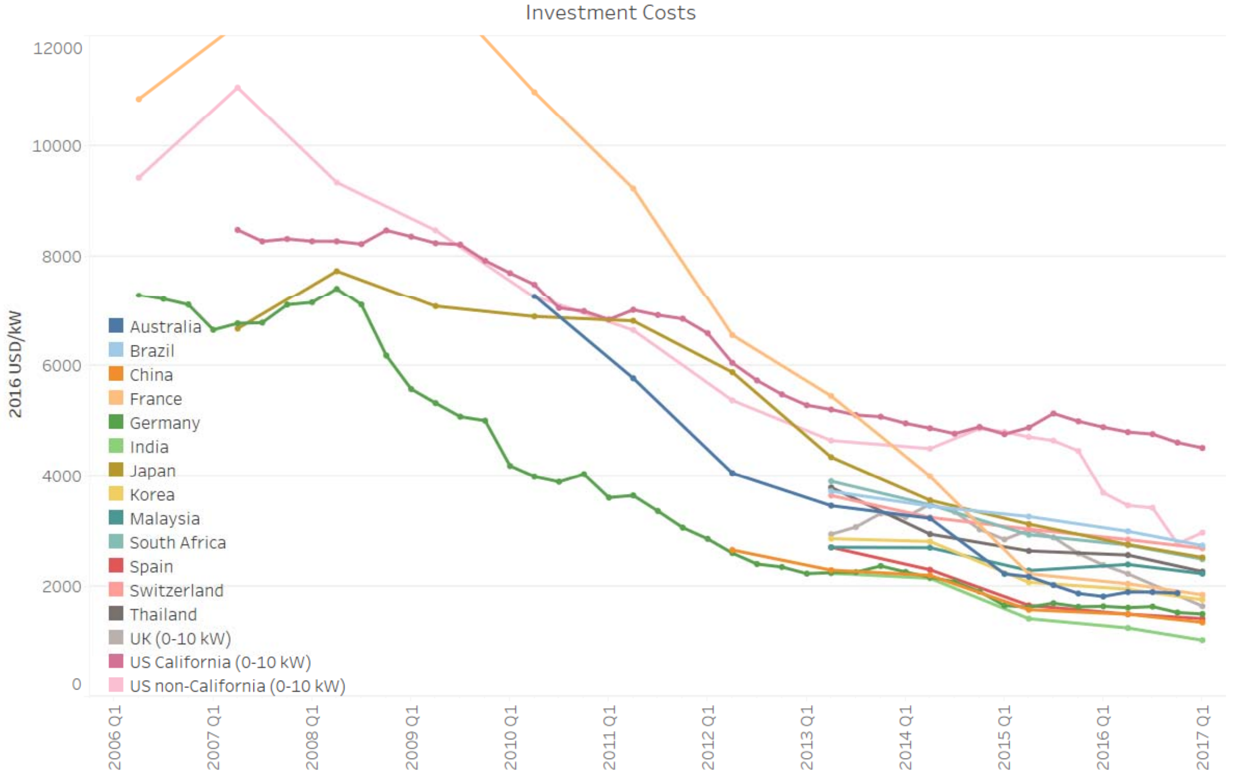
LCOE



Global weighted average
LCOE 2010-16

-68%

Residential solar PV:
Cost differentials persist



Country prices breakdown
Japan at the upper end of the range

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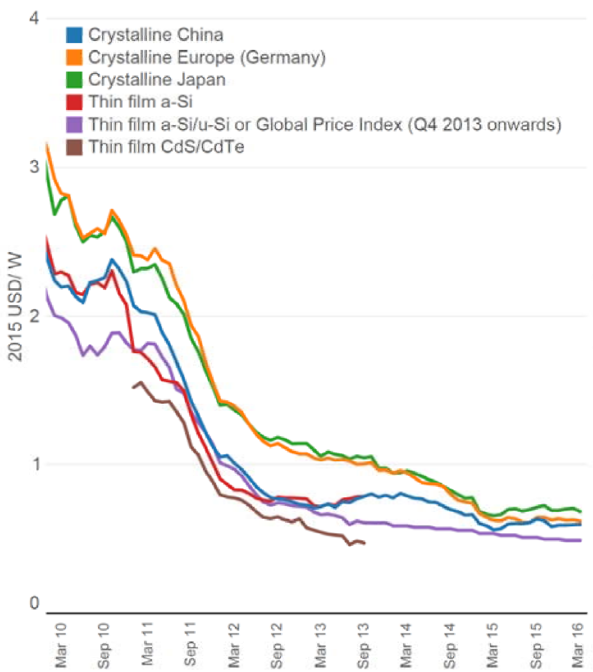
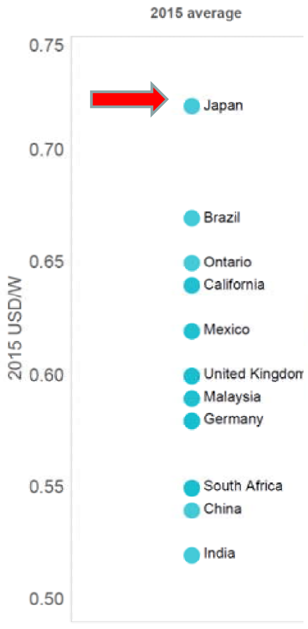
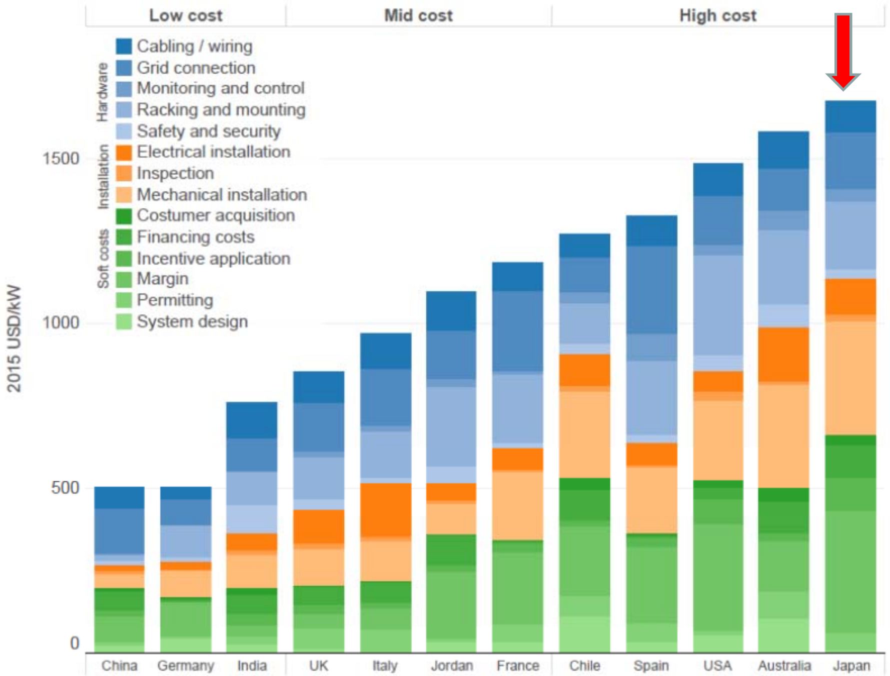
Wholesale module prices 2010-2015

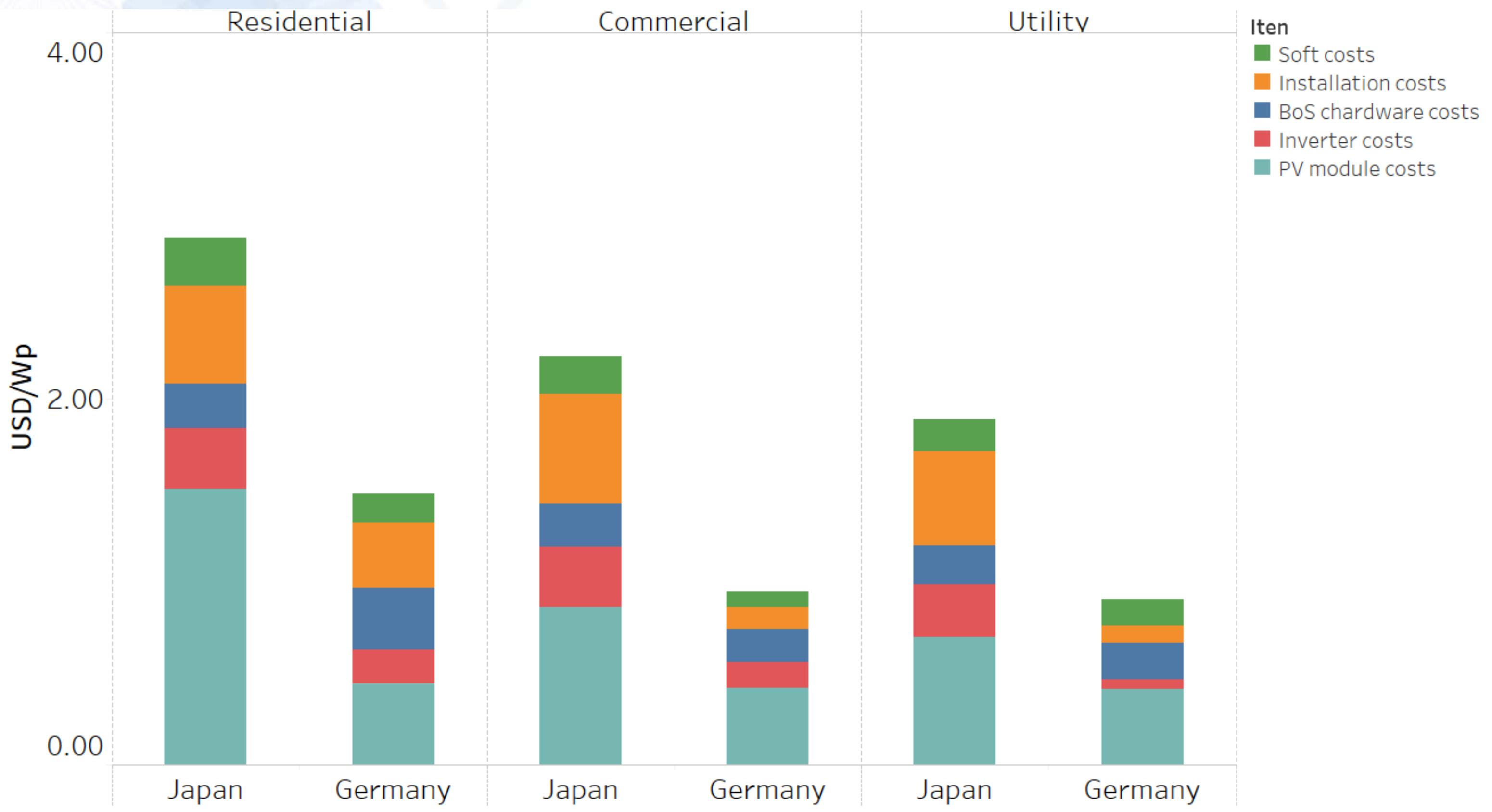




Utility scale
Balance of systems 2015

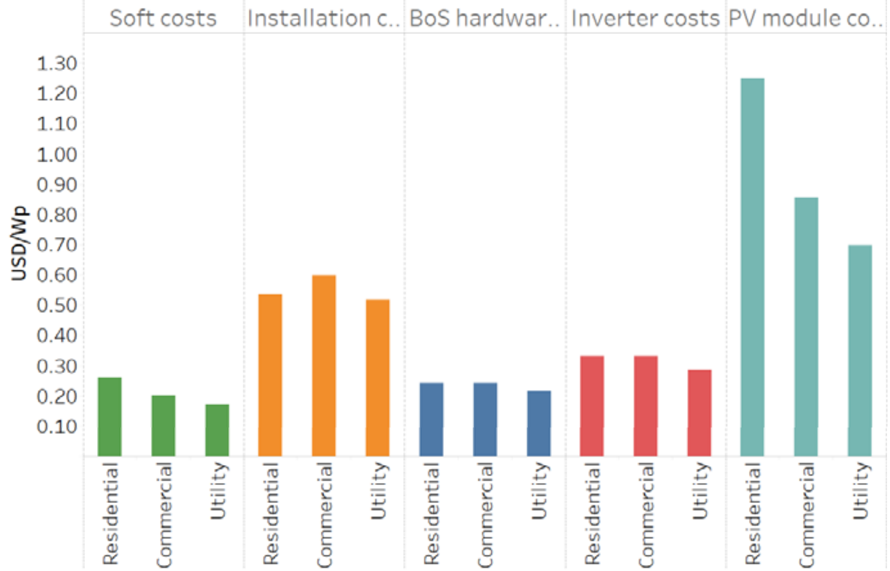


COST BREAKDOWN

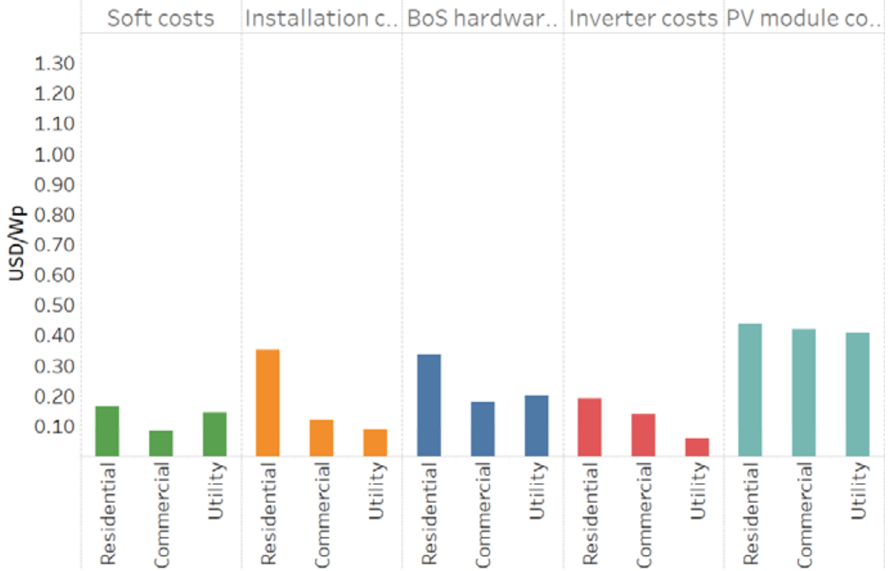


By category and by country

Japan



Germany



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ACTIONS FOR COST REDUCTION

- Optimize installation work
  - Mounting system design
  - Training of installers
  - Reduce installation time (better trained installers, other foundations)
- Lowering cost of Japanese PV manufacturers, which is also important for overseas markets such as Middle East, US, and South America.
- Improve PV system design to reduce cost, and learn from the German experience.
- Utility-scale projects have been the main driver of the Japanese market. The residential market has not grown so much, so there is still room for market growth.
- A change to a market driven system and self-consumption will lower PV system costs.
- Reductions in incentive scheme will result in consolidation and cost reductions.

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RENEWABLE ENERGY SUPPORT SCHEMES

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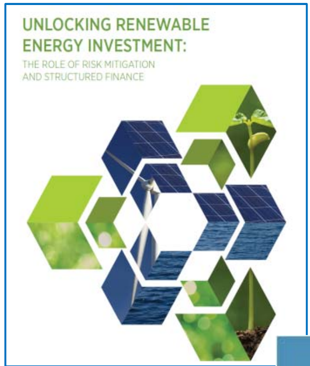
Renewable energy investment requirements and challenges



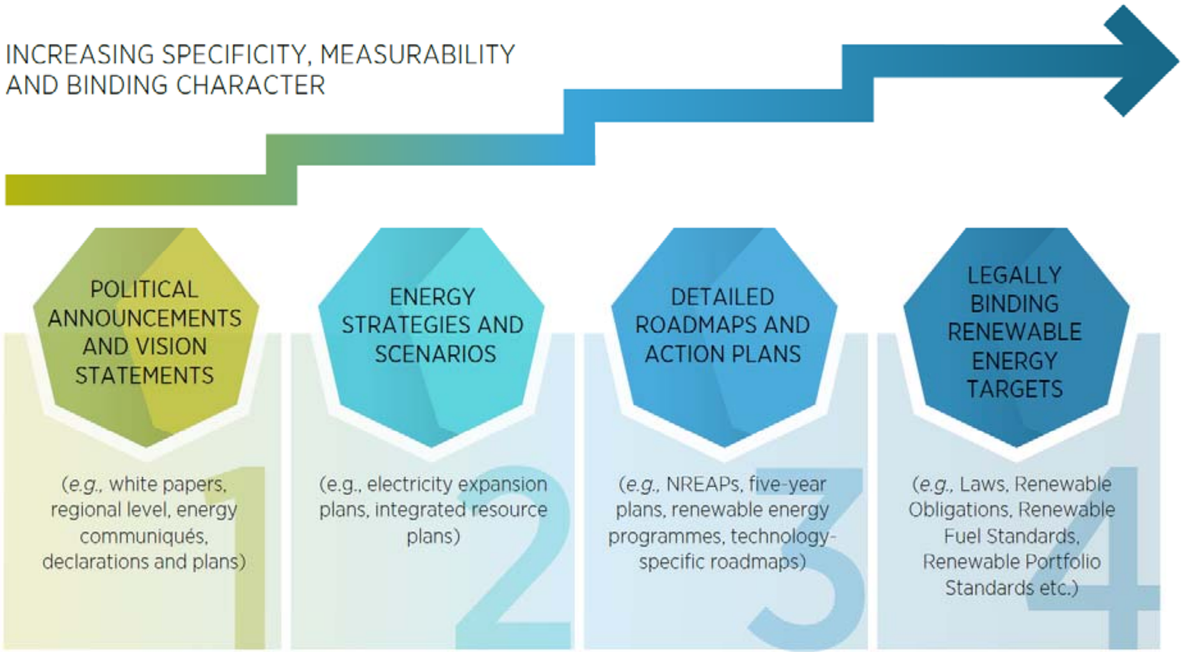
- The energy transition requires scaling up current investments to **500 billion USD per year** up to **2020** and to **USD 900 billion per year** up to **2030**
- Public funding is unlikely to increase above its current level of 15% and private finance will have to supply the lion's share of new investments

Key challenges in unlocking renewable energy investment from the private sector

Project start-up and development	Investment risk management	Scaling-up investment
• Limited experience in the financial sector • Availability of investment-ready projects • Limited access to capital	• Political risk • Policy and regulatory risk • Counterparty risk (power off-taker risk) • Grid interconnection and transmission line risk • Currency risk • Liquidity and refinancing risk • Resource risk • Technology risk	• Insufficient investment size and high transaction costs • Financial regulations restraining illiquid and riskier investments

Targets in the global renewable energy landscape

173 countries have
at least one type of renewable
energy target
– **up from 43** in **2005**



Note: NREAP: National Renewable Energy Actions Plans.

Source: IRENA (2015), Renewable Energy Target Setting.

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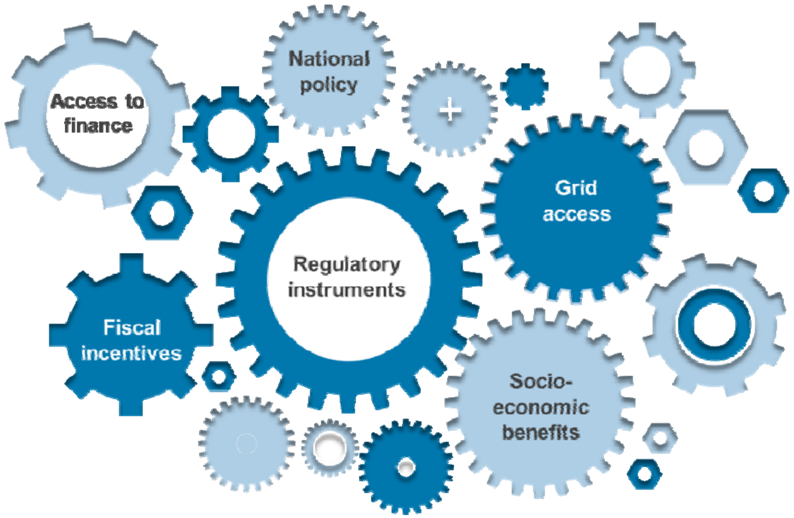
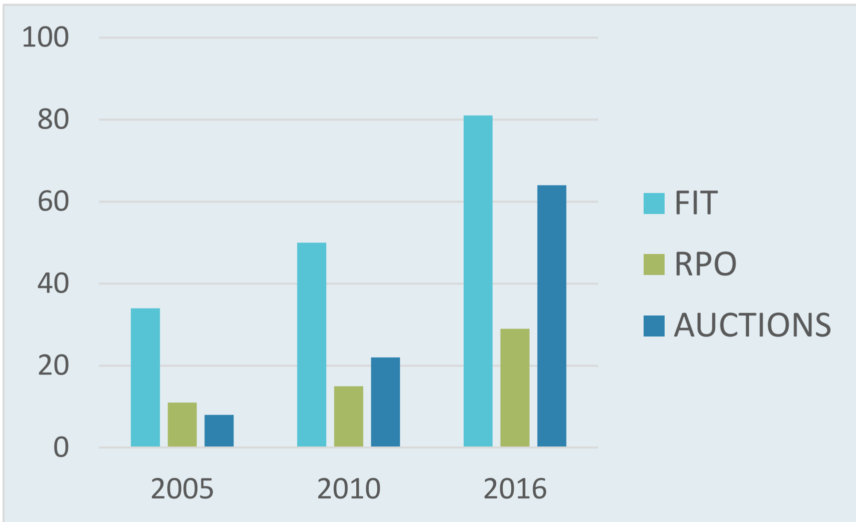
Types of renewable energy policies and measures

NATIONAL POLICY	REGULATORY INSTRUMENTS	FISCAL INCENTIVES	GRID ACCESS	ACCESS TO FINANCE[a]	SOCIO-ECONOMIC BENEFITS[b]
◆ Renewable energy target ◆ Renewable energy law/ strategy ◆ Technology-specific law/ programme	◆ Feed-in tariff ◆ Feed-in premium ◆ Auction ◆ Quota ◆ Certificate system ◆ Net metering ◆ Mandate (*e.g.*, blending mandate) ◆ Registry	◆ VAT/ fuel tax/ income tax exemption ◆ Import/export fiscal benefit ◆ National exemption of local taxes ◆ Carbon tax ◆ Accelerated depreciation ◆ Other fiscal benefits	◆ Transmission discount/ exemption ◆ Priority/ dedicated transmission ◆ Grid access ◆ Preferential dispatch ◆ Other grid benefits	◆ Currency hedging ◆ Dedicated fund ◆ Eligible fund ◆ Guarantees ◆ Pre-investment support ◆ Direct funding	◆ Renewable energy in rural access/cook stove programmes ◆ Local content requirements ◆ Special environmental regulations ◆ Food and water nexus policy ◆ Social requirements

Trends in renewable energy support policies



Number of countries with renewable energy policies, by type



Implemented auctions and a feed-in tariff simultaneously

Used feed-in tariffs to set price cap for auctions

Used auctions to set feed-in tariffs

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Auctions Strengths and weaknesses - Keeping pace with rapidly decreasing costs

Auctions

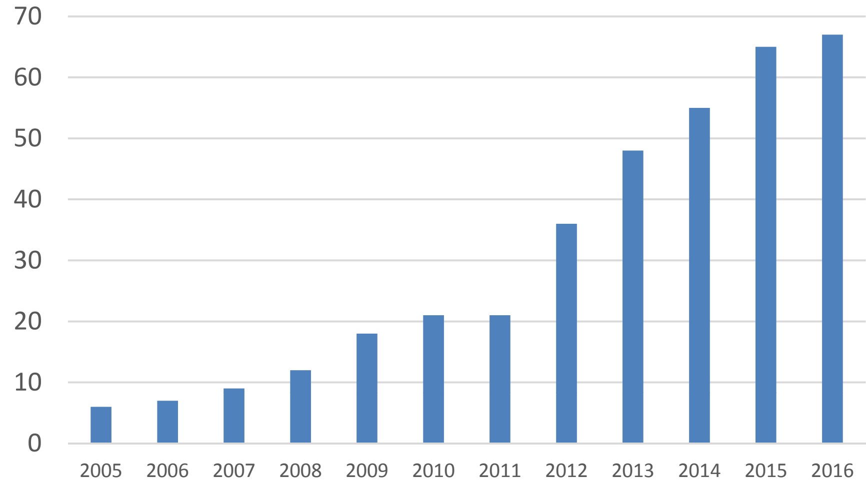
Strengths

- Flexibility in the design according to conditions and objectives
- Permit real price discovery
- Provide greater certainty regarding prices and quantities
- Enable commitments and transparency

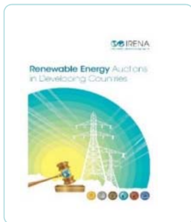
Weaknesses

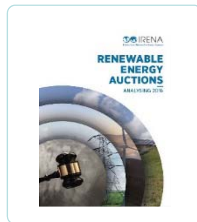
- Are associated with relatively high transaction costs for both developer and auctioneer
- Risk of underbuilding and delays

Number of countries that have adopted auctions



Based on REN21 Global Status Report (2005 to 2016)





Policy adaptation to reduce the cost of support

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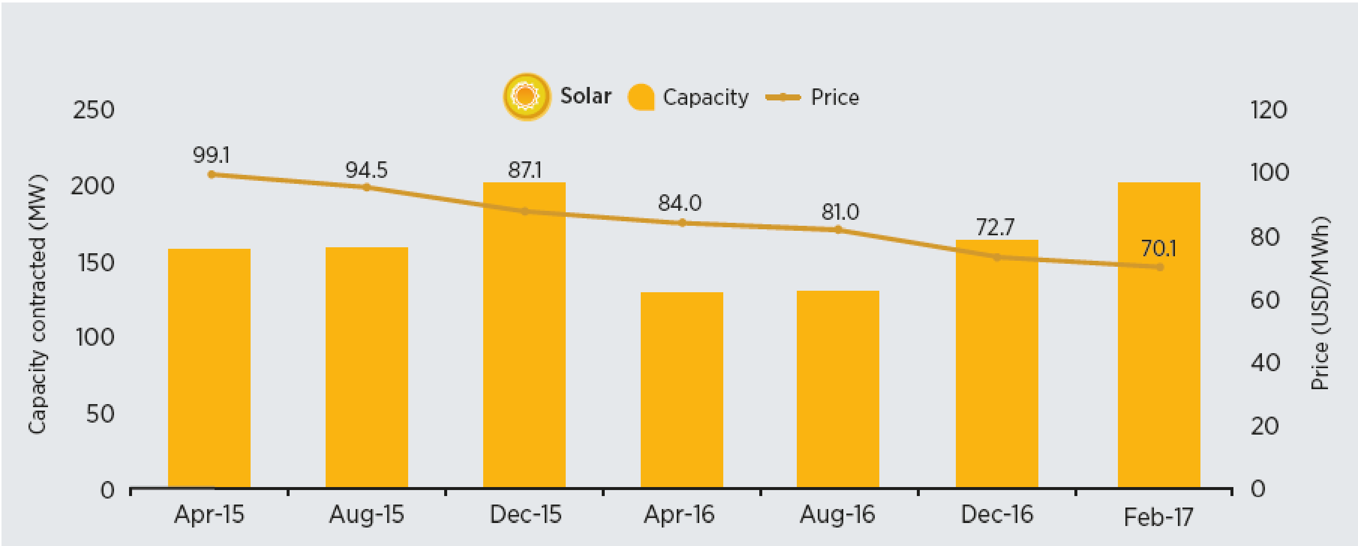
The move from FIT to FIP to Auctions in Germany

- **USD 117.5/MWh** support paid under the FIT in 2014.
- The support level is the sum of the average monthly wholesale price at the energy exchange (EPEX) and a floating premium.
- What is paid to the auction winner is the difference between the monthly average market value of the generated electricity from PV installations and the auction price.



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GRID INTEGRATION OF RENEWABLES

Three VRE integration challenges

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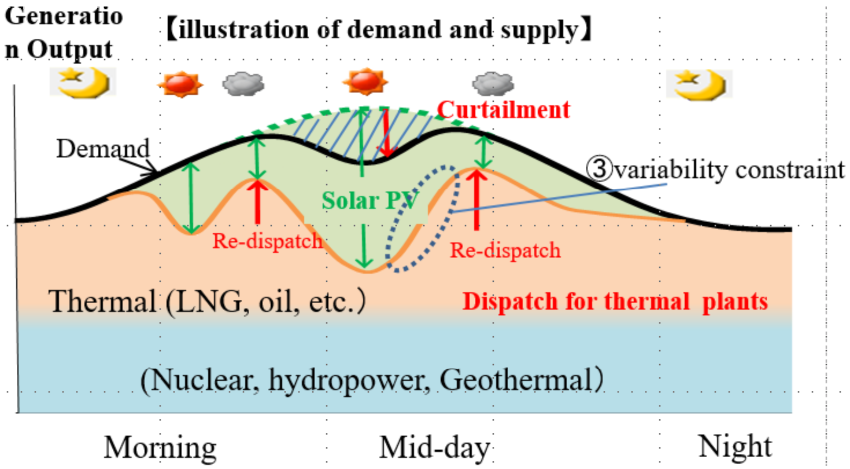
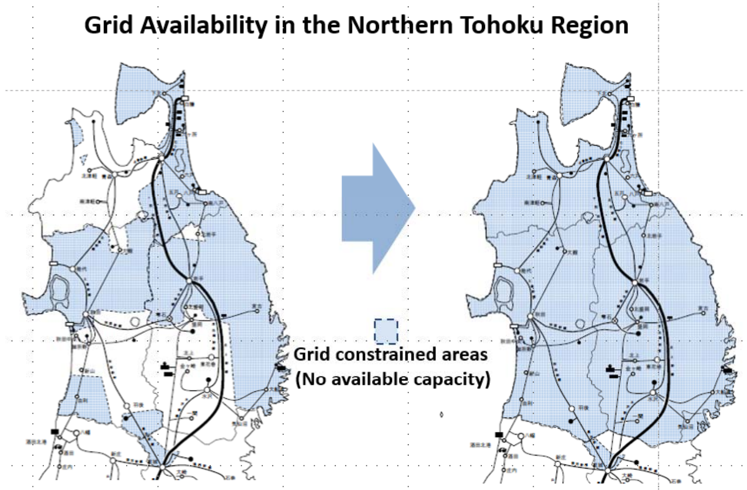
» Surplus VRE generation due to mismatch demand and supply



» Flexibility due to fast change in the VRE output

» Transmission capacity due to rapid increase in the VRE generation and location specificity



Power sector transformation

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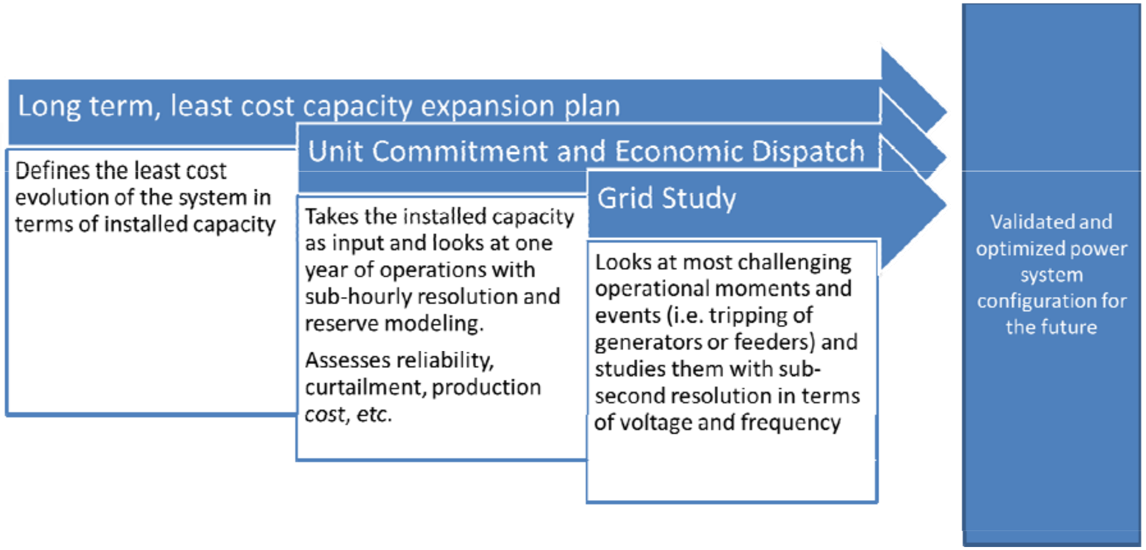
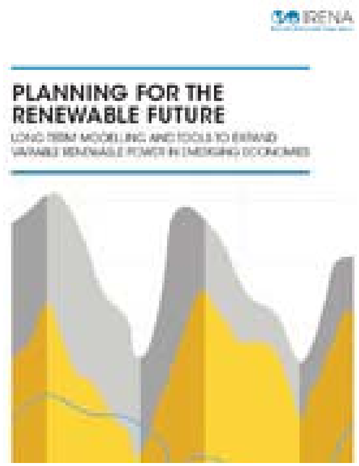


- Planning for the power system of the future: from capacity expansion to operations
- Flexibility toolkit for RE integration
- Electricity storage: technology, market outlook, business case
- The role of electric vehicles and heatpumps in the power sector transformation
- Advisory service and workshops:



Flexibility

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Transmission

Flexible Thermal Generation

Flexible Hydro Generation

Demand Side Management

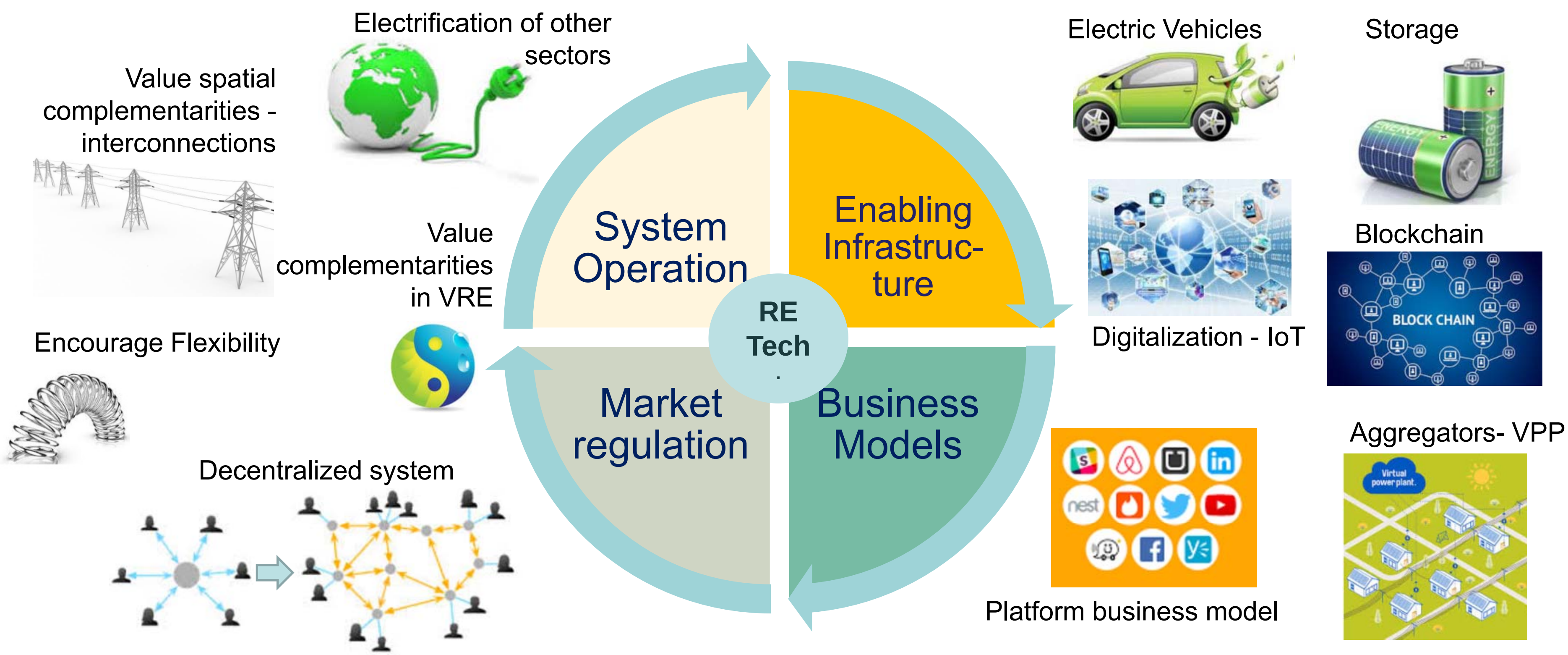
Power2Grid (Heat, gas...)

Energy Storage Systems

System operation practice and market design can activate flexibility potentials

No lack of innovations – but what is relevant for the local context?

We need to map and understand the implications of these innovations for the power sector



Emerging Innovations Power Sector Transformation – E-mobility

Storage and Electric Vehicles Smart Charging (mobile storage)

Provide flexibility to the grid

Grid Services:

- Primary and secondary reserves:
  - Enhanced Frequency Response
  - Frequency Containment Reserve
  - Frequency Restoration Reserve
- Energy Shifting

Behind-the-meter:

- Solar self consumption
- Community Storage
- Increased Power Quality
- Peak shaving

Grid to Vehicle (G2V):

- Load management: peak shifting

Vehicle to Grid (V2G):

- Primary and secondary reserves
- Other ancillary services
- Energy shifting

Vehicle to Home (V2H):

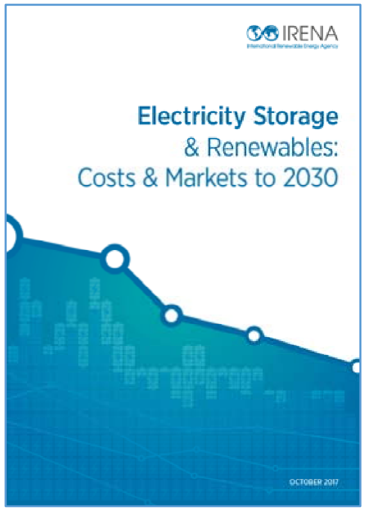
- Solar self consumption
- Increased Power Quality
- Peak shaving

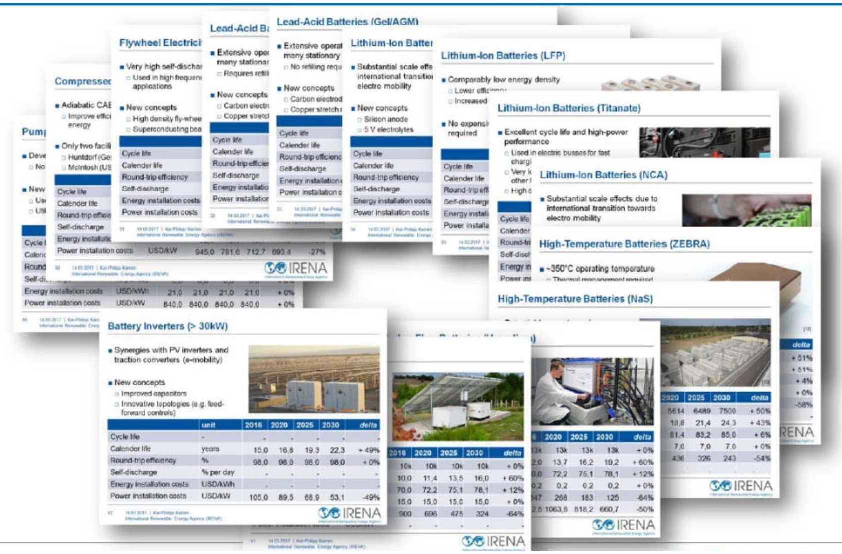
Battery Energy Storage Systems (BESS)

IRENA International Renewable Energy Agency

Battery Electricity Storage Costs and Markets to 2030 – launched yesterday

- Detailed descriptions of 13 storage technologies including their required balance of system
- Strengths and weaknesses of each technology are highlighted, possible development paths including opportunities and threats are discussed
- Comprehensive technology overviews for stationary storage systems available on the market today
- Typical system designs for 12 typical storage applications
- Excel Tool to calculate the Cost of Service of all storage technologies in different applications





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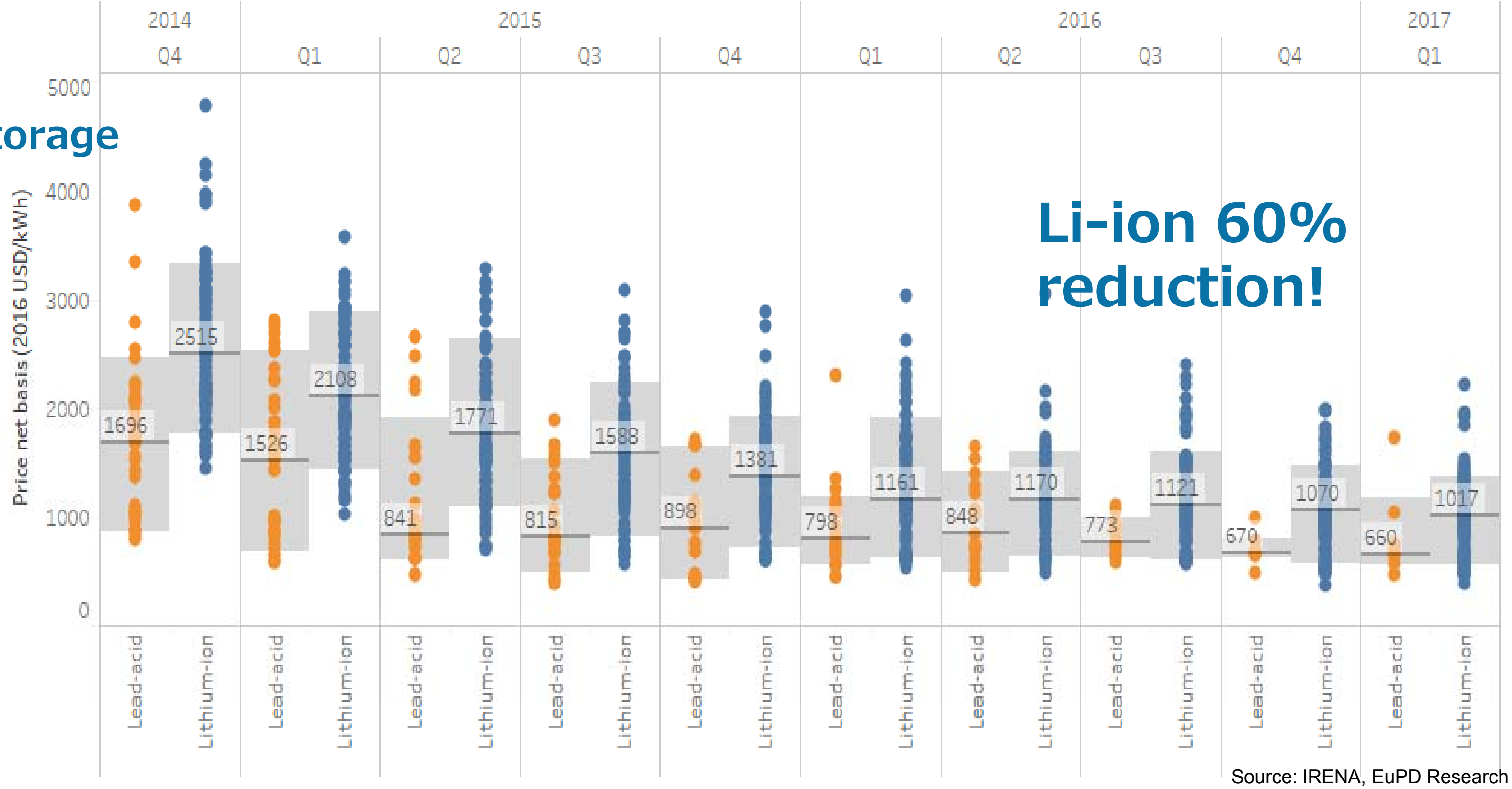
Small-scale: rapidly falling prices

Home storage

Li-ion 60% reduction!



Source: IRENA, EuPD Research

Median prices for lithium-ion based residential storage system offers in **Germany** have declined roughly 60% Q4 2014 to Q1 2017

Note: Horizontal bar shows median offer price, grey range 10th and 90th percentile.

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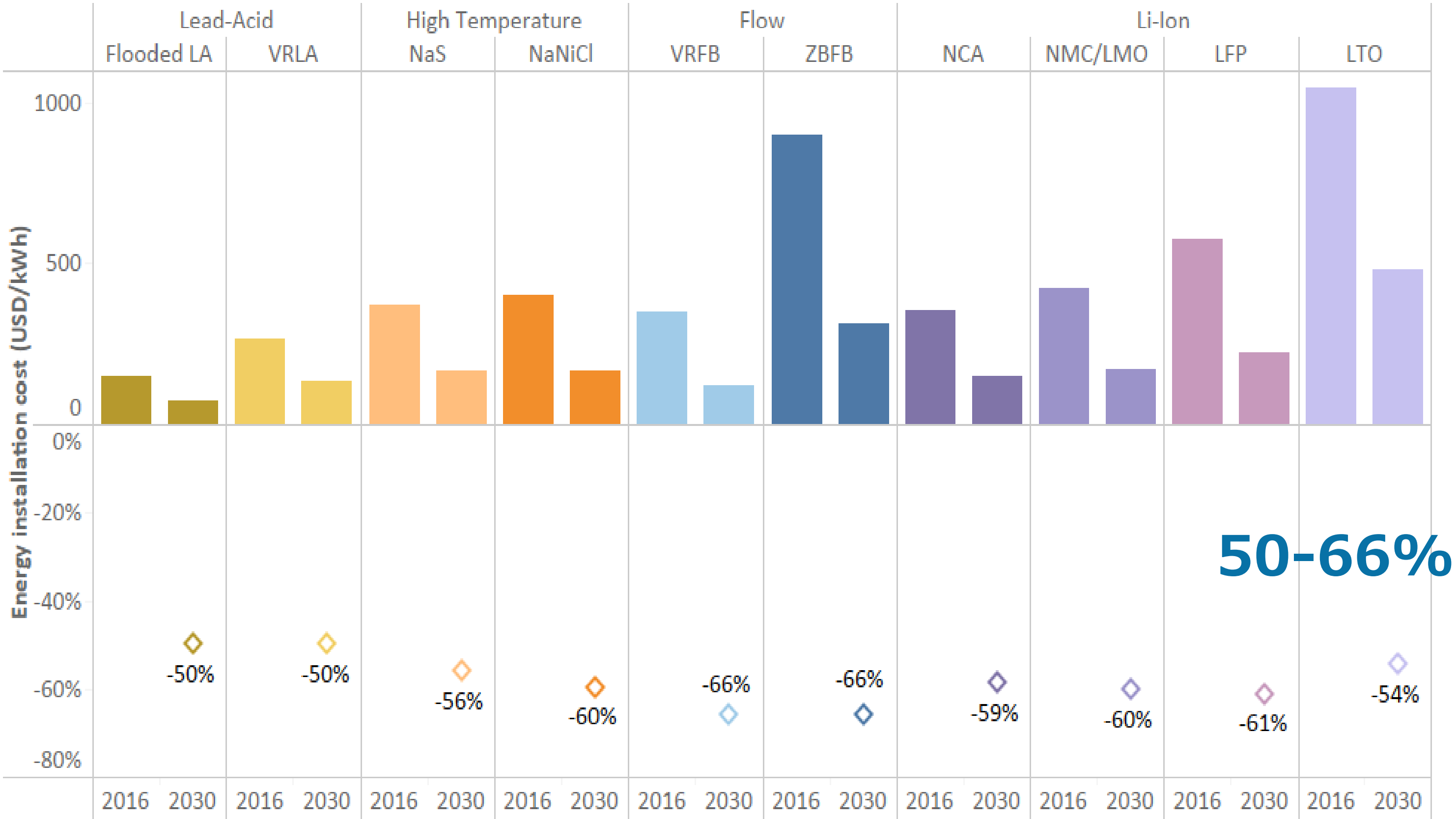
Potential cost evolution



50-66% reduction

Asia Interconnections

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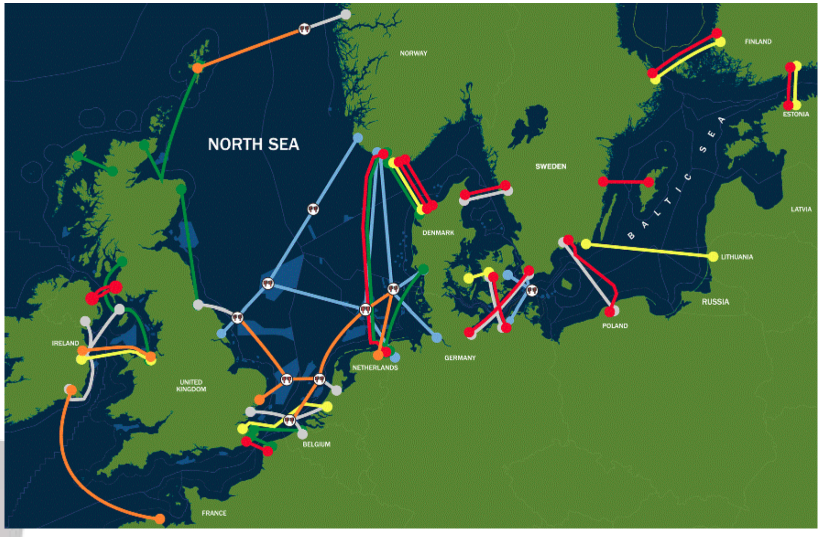
Asia Super Grid - International project to send electricity from wind firms in Mongolia all the way to Japan



Japan – Korea 220 km
Netherlands – Norway 320 km
existing HVDC subsea cable since 1990's
Payback 6 months

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Flexibility of power plants

- Typical positive load gradients
  - Germany: 2-3%/min (hard coal fired PP)
  - Denmark: 3-4%/min (hard coal fired PP)
  - Denmark: 8-10%/min (gas fired PP)

  - CCGT commissioned 2011: 3%/min

- Typical minimum stable generation (minimum load)
  - Germany: 45-55% (hard coal fired PP)
  - Denmark: 10-20% (hard coal fired PPs commissioned between 1985 and 1997)
  - CCGT commissioned 2011: 50-52%

This superior flexibility have been achieved due to ongoing improvements for decades!

Source: Dong Energy

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Thank you!

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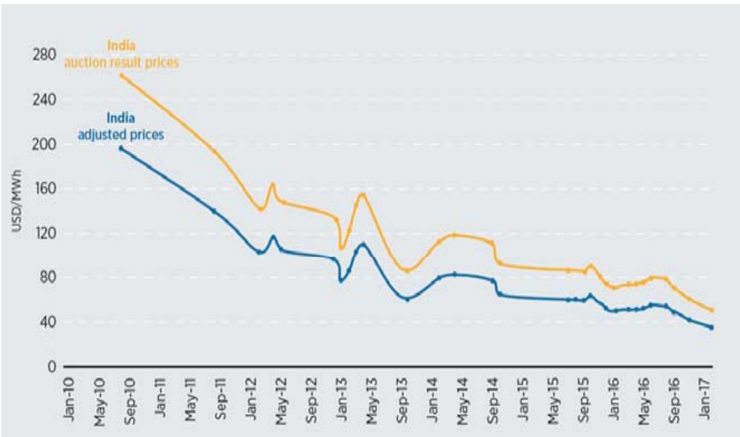
Hybrid policies - The case of India

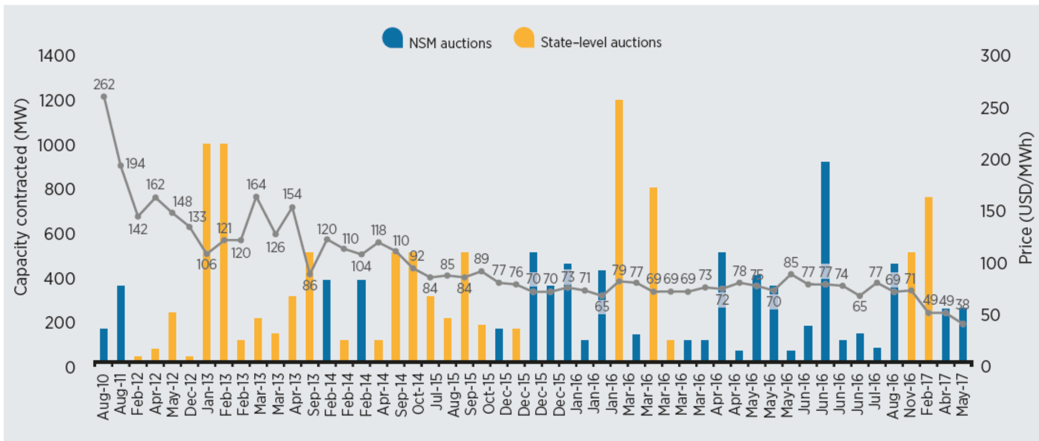
Historically higher prices in India compared with Peru, the United States and South Africa

- **Developers account for inflation risks**
- **Guarantees to hedge against off-taker risks in some states**
- **Increasingly affordable finance**
- **Government fund to hedge against currency exchange risks**
- Domestic content requirements in some state auctions

India's actual and adjusted solar prices



The trends of solar auction prices. 2010-2017



Sources: Based on BNEF (2016); Bridge to India (2017); Elizondo-Azuela et al. (2014); MNRE (2010) and MNRE (2012).

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OBSERVATIONS

- Japan still shows significantly higher installation cost than Germany in all three analysed sectors.
- Installation times are still higher in Japan than Germany
  - Japan mainly uses earth screws, while Germany mainly used pile driven foundations.
- Higher module cost in Japan, because a large percentage of modules is by Japanese Producers.
  - According to REI the cost disparity has shrunk in the last 2-3 years.
- Design standards are higher in Japan than Germany due to differences in the natural environment.
- Japan has higher solar irradiance, which gives lower LCOE despite higher CAPEX of PV systems.

Many flexibility options