Global renewable energy cost trends

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About IRENA

MANDATE

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

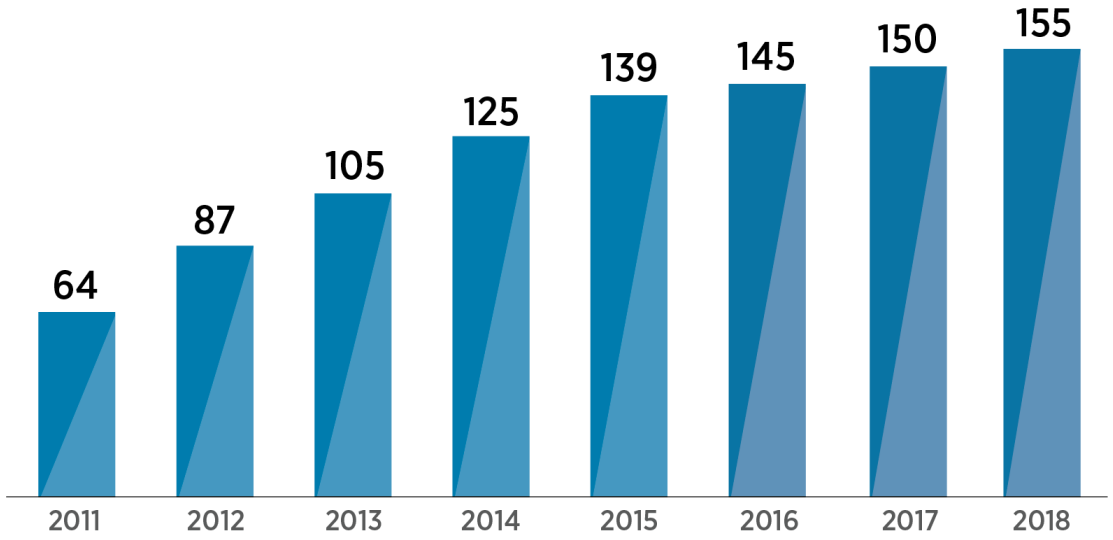
OBJECTIVE

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

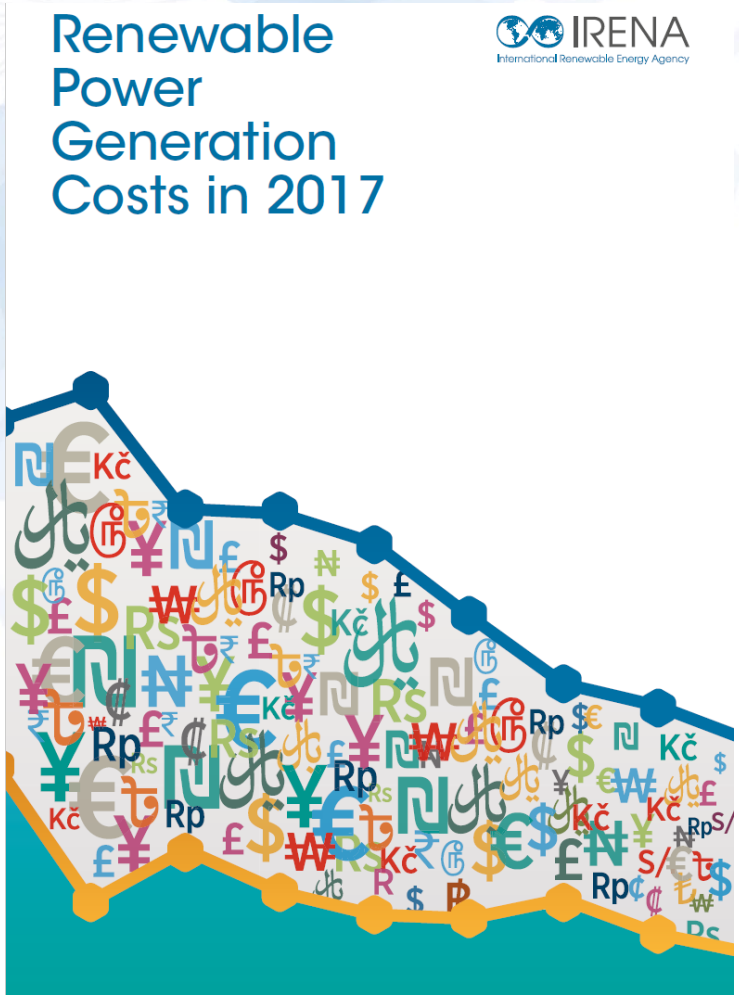
SCOPE

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

Growth in IRENA Membership

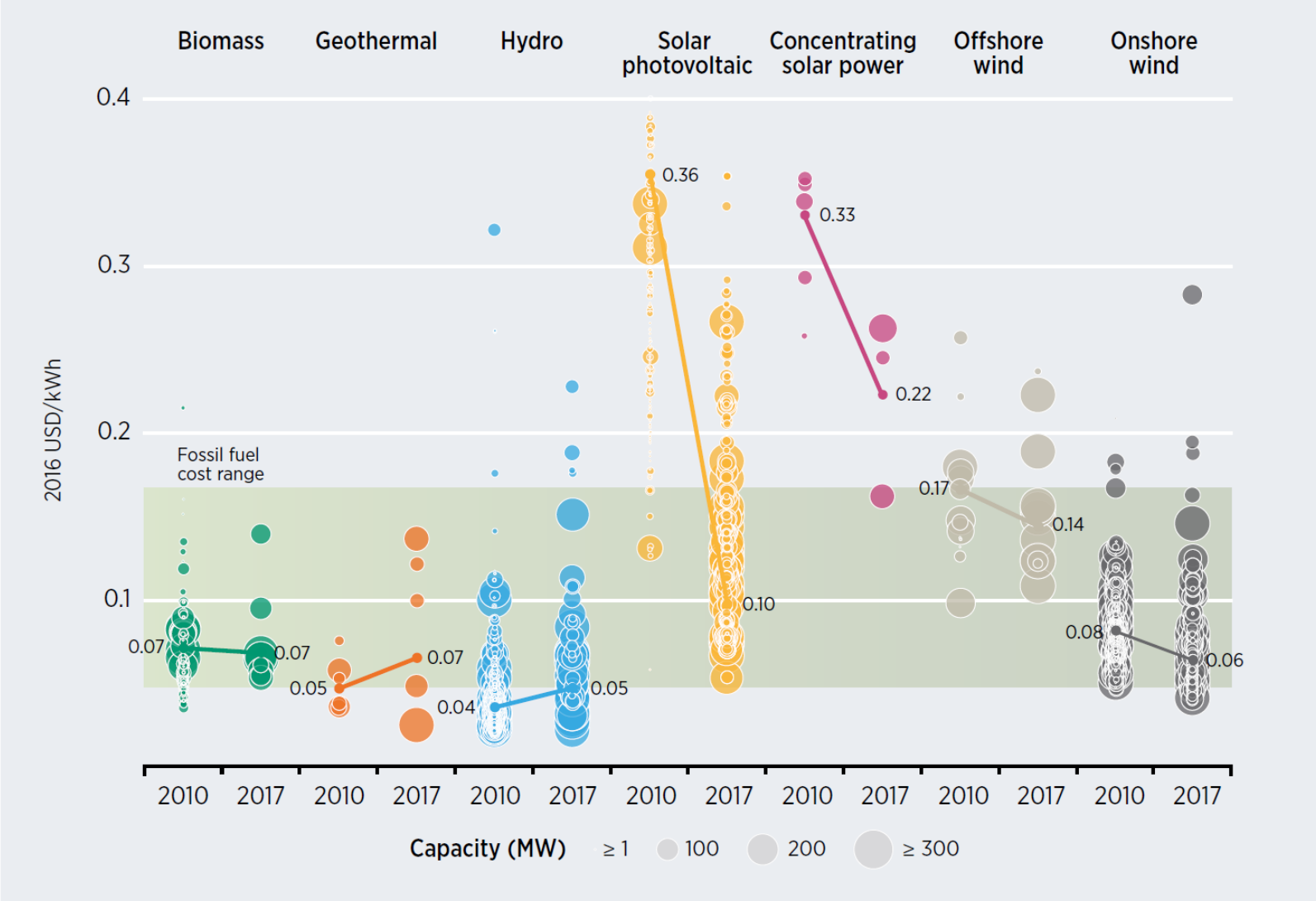


Recent cost evolution



- Latest trends in the cost and performance of renewable power generation technologies
- Global results to 2017, country/regional results to 2016
- Detailed analysis of equipment costs and LCOE drivers
- Integration of project LCOE and Auction results to look at trends to 2020

Recent cost evolution



Source: IRENA Renewable Cost Database.

Costs continuing to fall for solar and wind power technologies

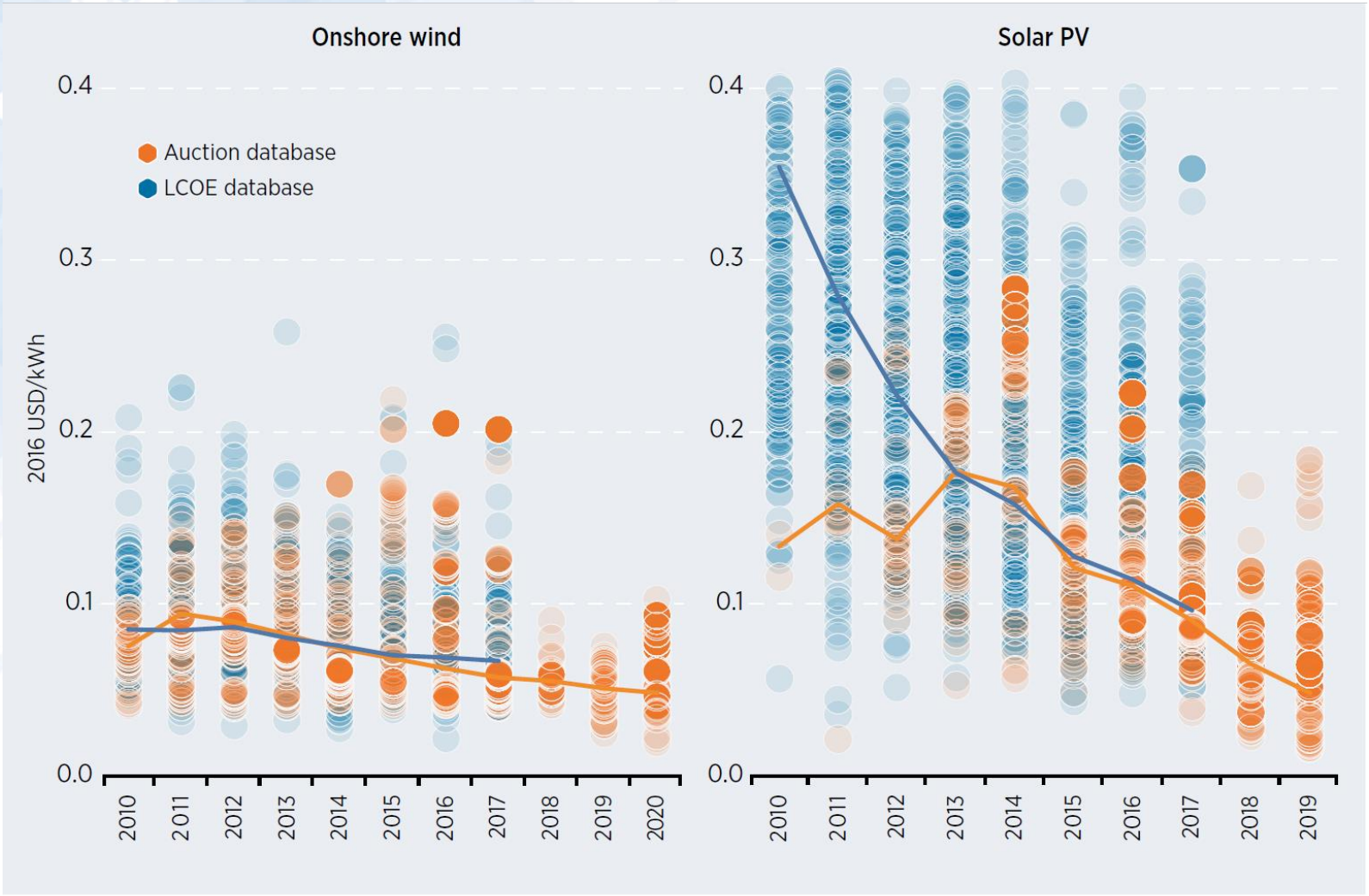
All technologies falling into competitive range

Remarkable rate of cost deflation for solar & wind

All commercial RE power to be competitive by 2020/22

Drivers: Technology, Competitive Procurement, Exp. Developers

Onshore wind and solar PV: LCOE/Auction trends

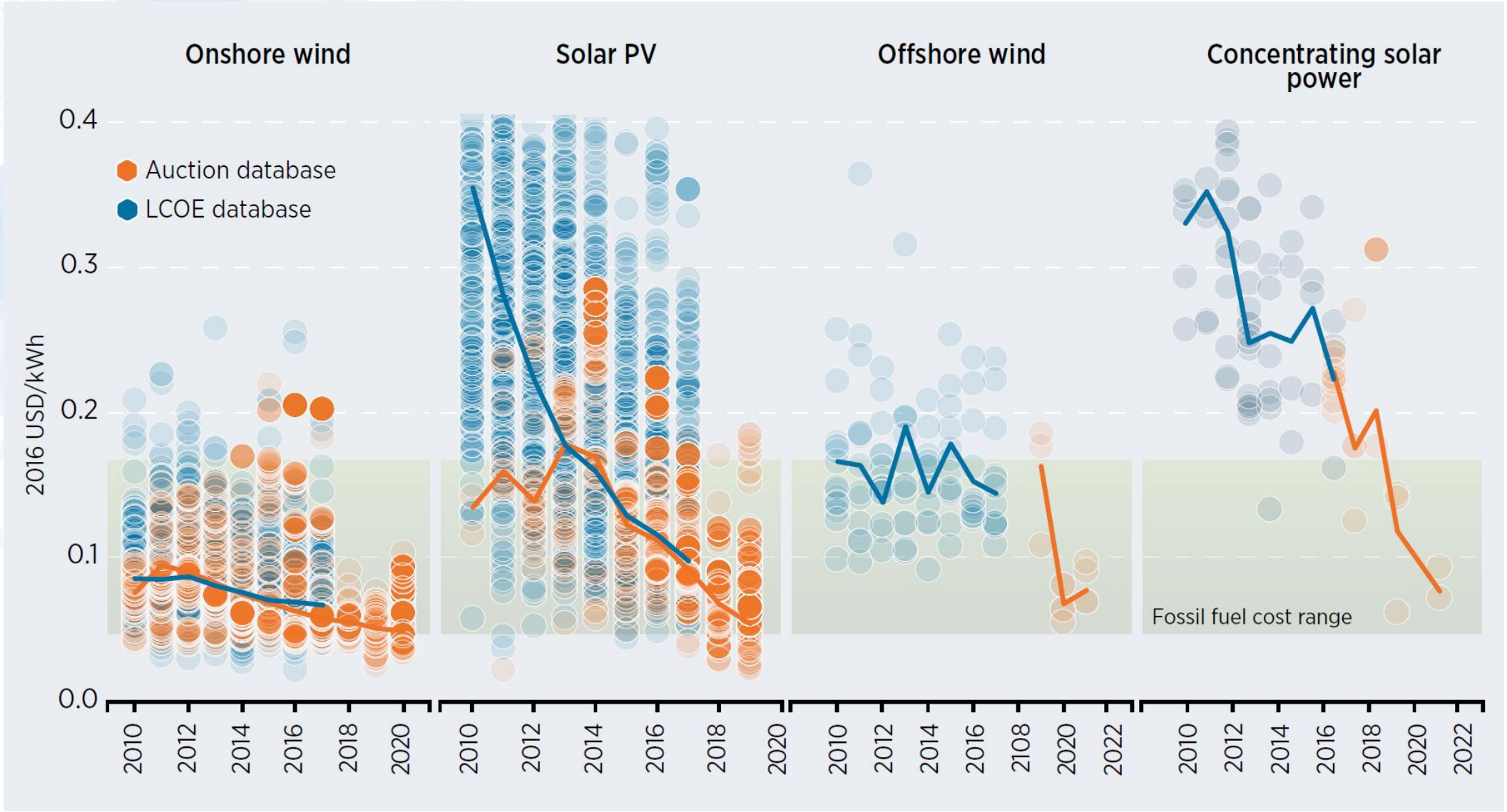


By 2019, LCOE of best onshore wind and solar PV projects at USD 0.03/kWh (or less!)

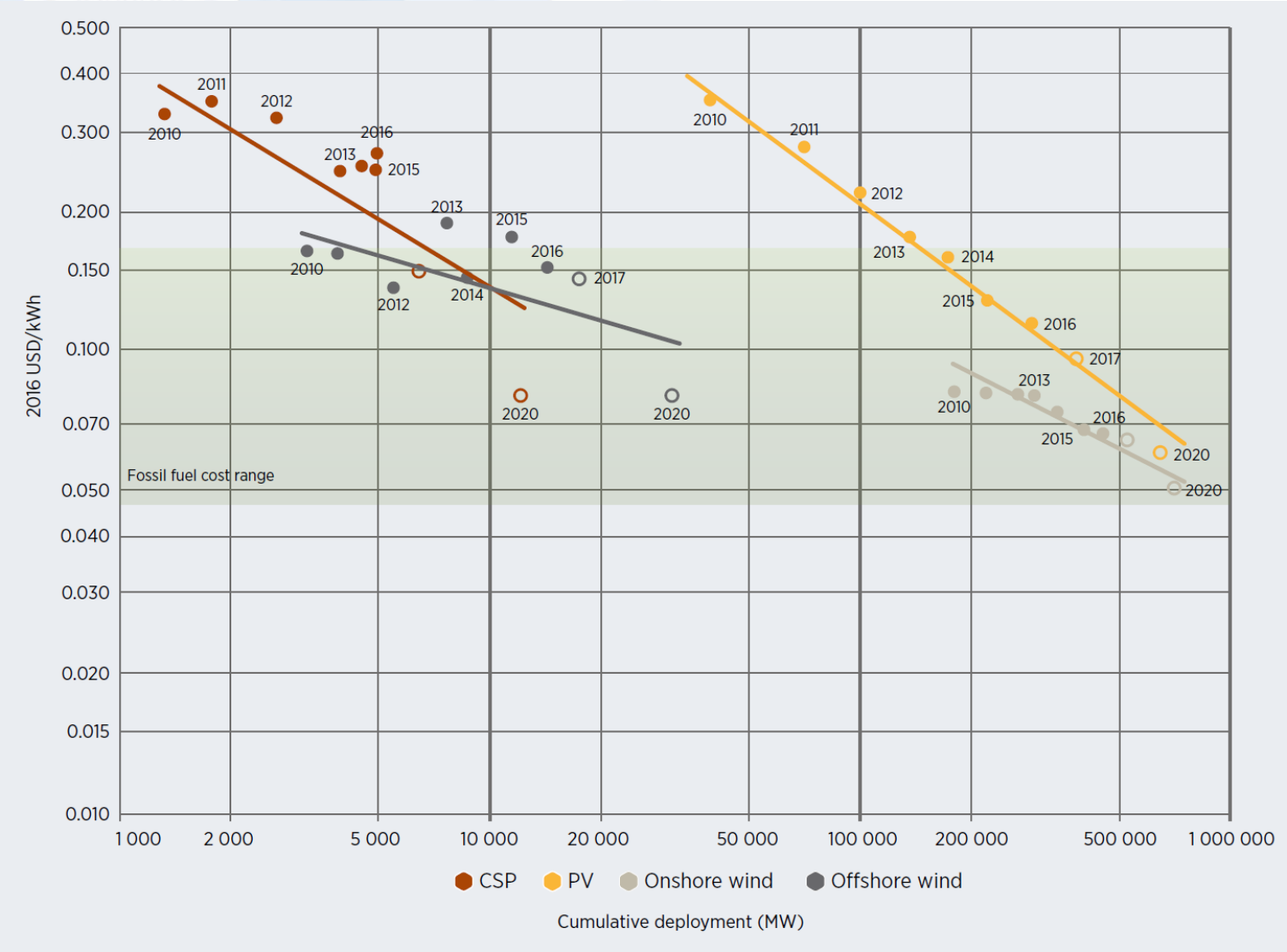
Source: IRENA Renewable Cost Database and Auctions Database.

Note: Each circle represents an individual project or auction result, while the solid line is the capacity-weighted average from

Solar & Wind: LCOE/Auction Price Evolution Overview



Learning Rates: Remarkable Deflation in Costs



14%: Offshore wind

21%: Onshore wind

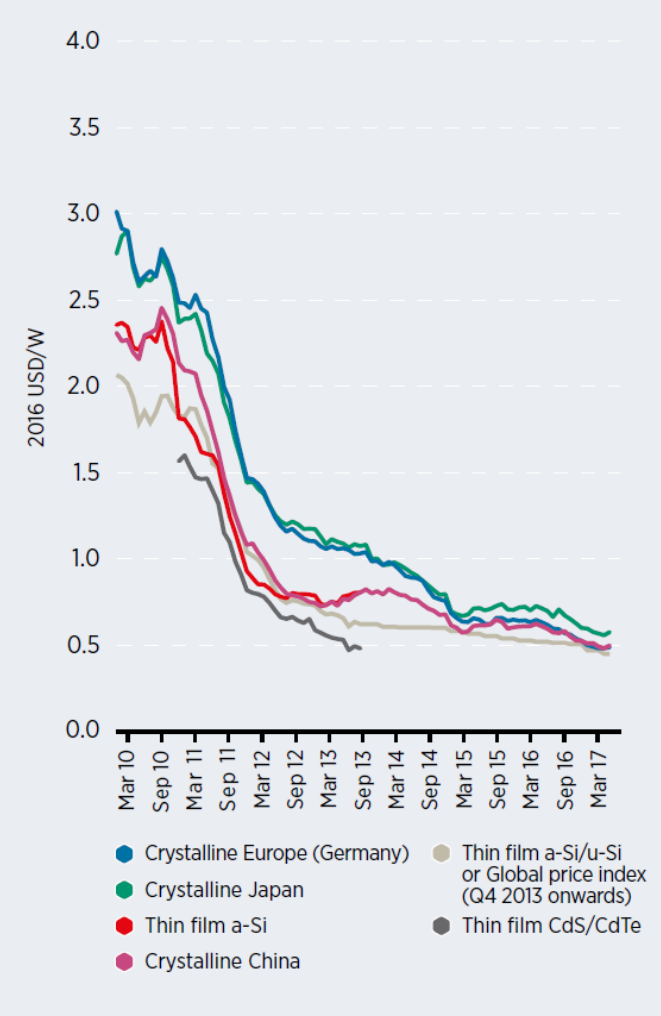
30%: CSP

35%: Solar PV

A CLOSER LOOK AT PV

Solar PV module price trends

Module prices in Europe decreased by 83% from the end of Q1 2010 to the end of Q1 2017



Module costs declined 80% between end of 2010 and end of 2016.

During this period, 87% of the cumulative global PV capacity installed at the end of 2016 occurred.

Source: GlobalData, 2017; pvXchange, 2017; Photon Consulting, 2017.

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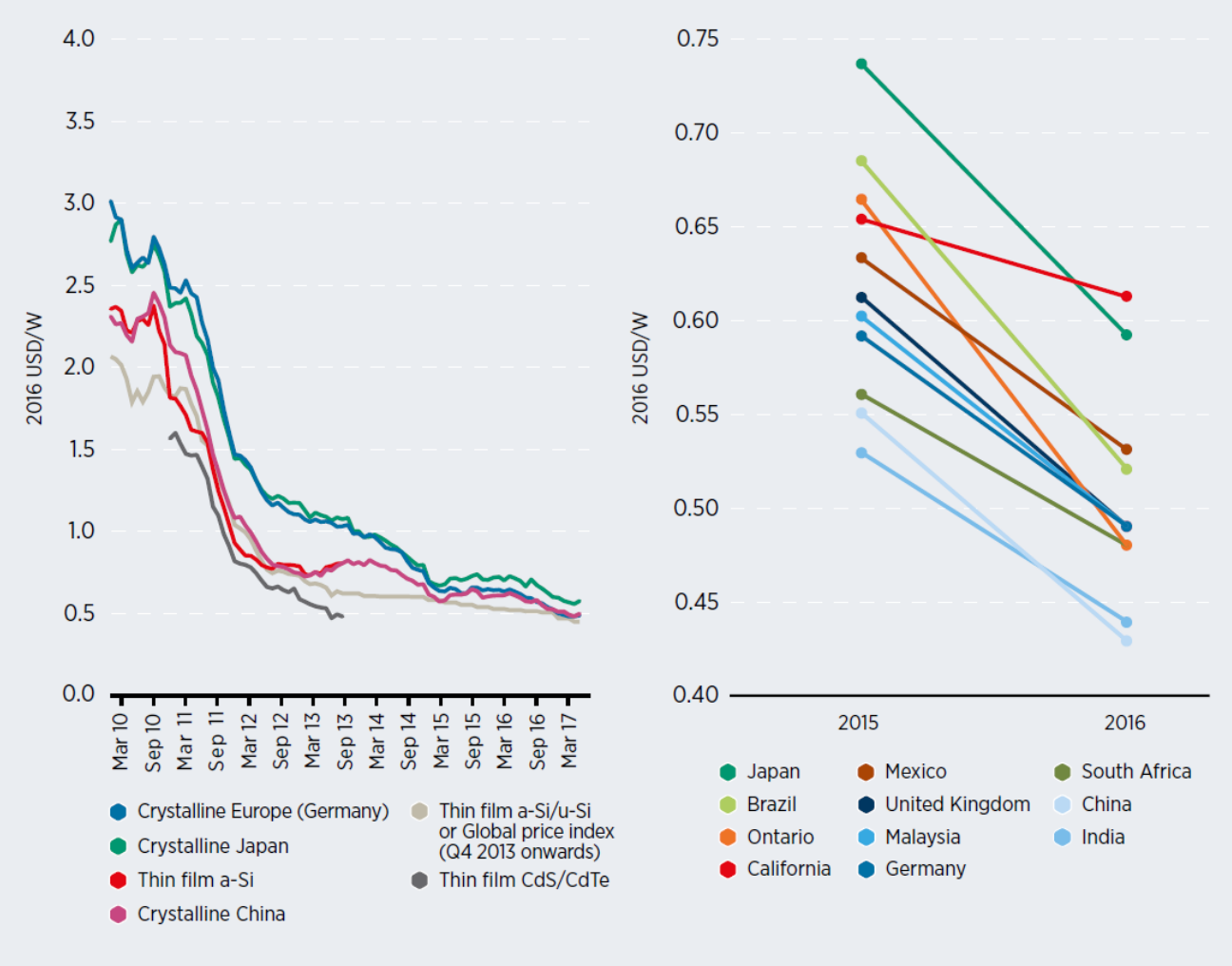
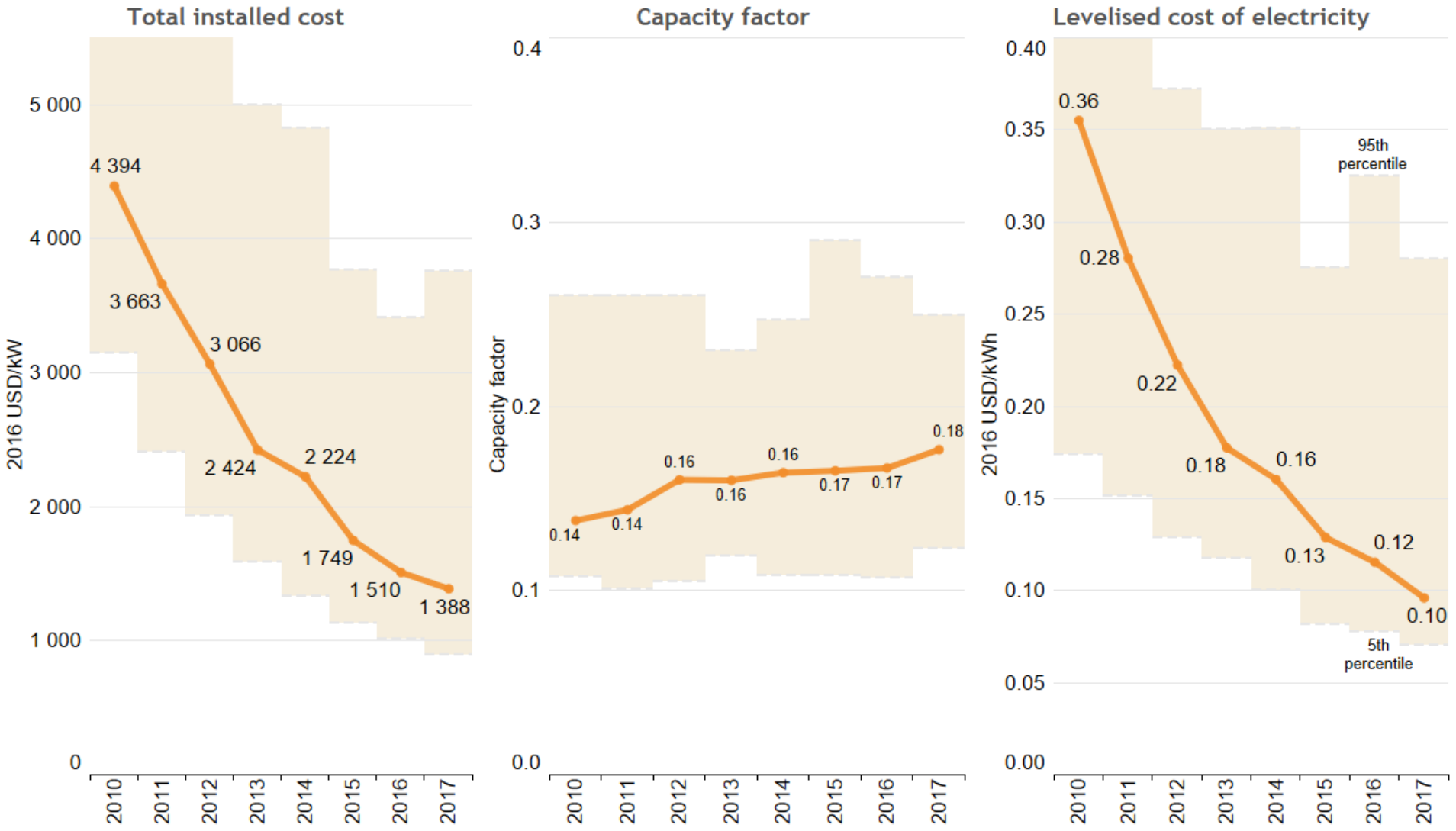


Import treatment, market preferences => wide range of module prices (Range here from USD 0.43 to 0.61/W in 2016).

Source: GlobalData, 2017; pvXchange, 2017; Photon Consulting, 2017.

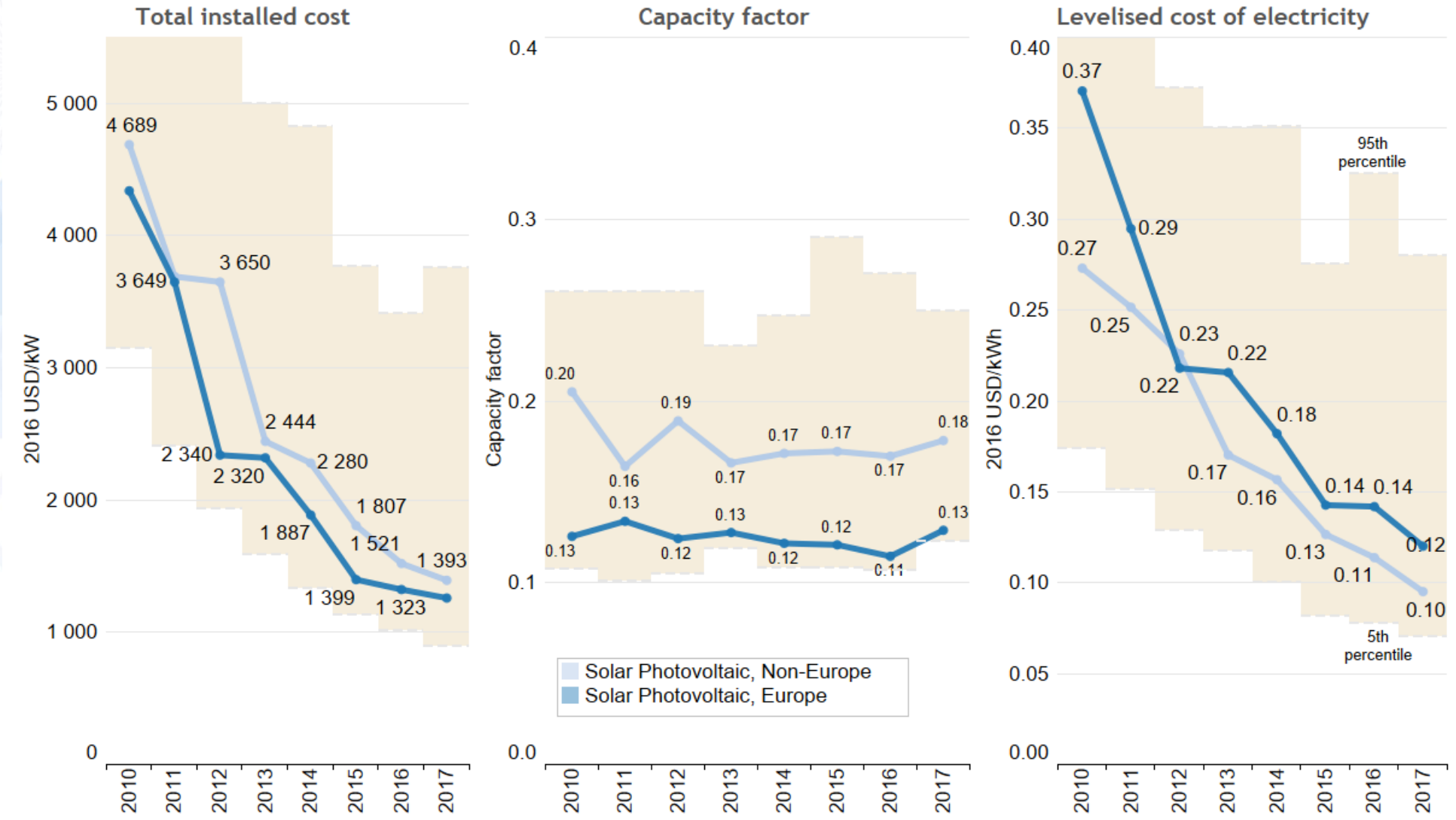
Utility scale PV global trend



- IC: High costs persist in some markets (JPN, US for example)
- CF: 28% relative increase
- Dramatic fall in LCOE

Source: IRENA Renewable Cost Database.

Utility scale PV Europe vs non-Europe trend



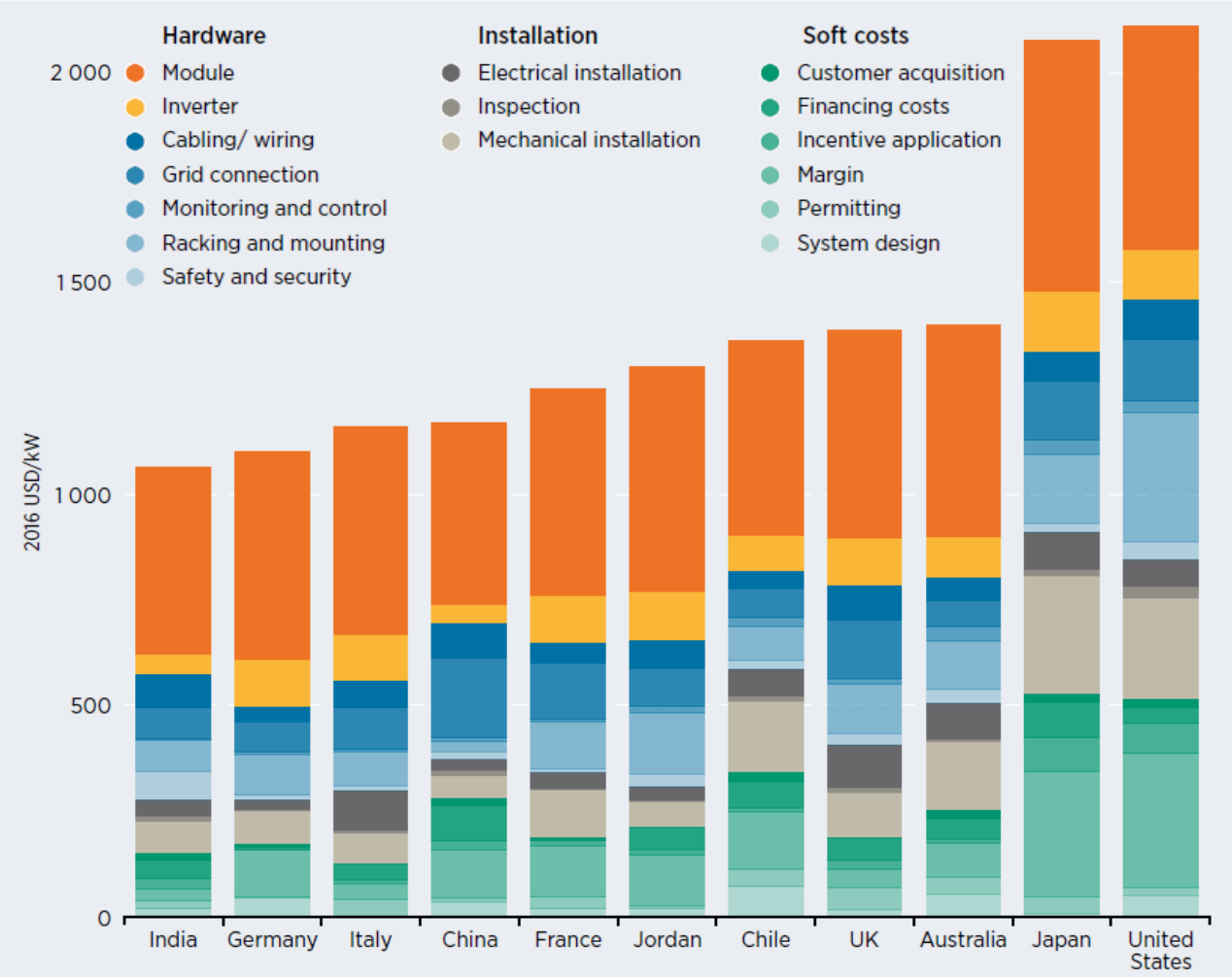
- Non-Europe with consistently higher IC
- CF: significant gap driven by better resources outside Europe
- Consistently lower LCOE's outside Europe

Source: IRENA Renewable Cost Database.

Total installed cost trends in selected markets

Most cost reductions are happening at the balance of system costs level

Breakdown of utility-scale solar PV costs by country in 2016

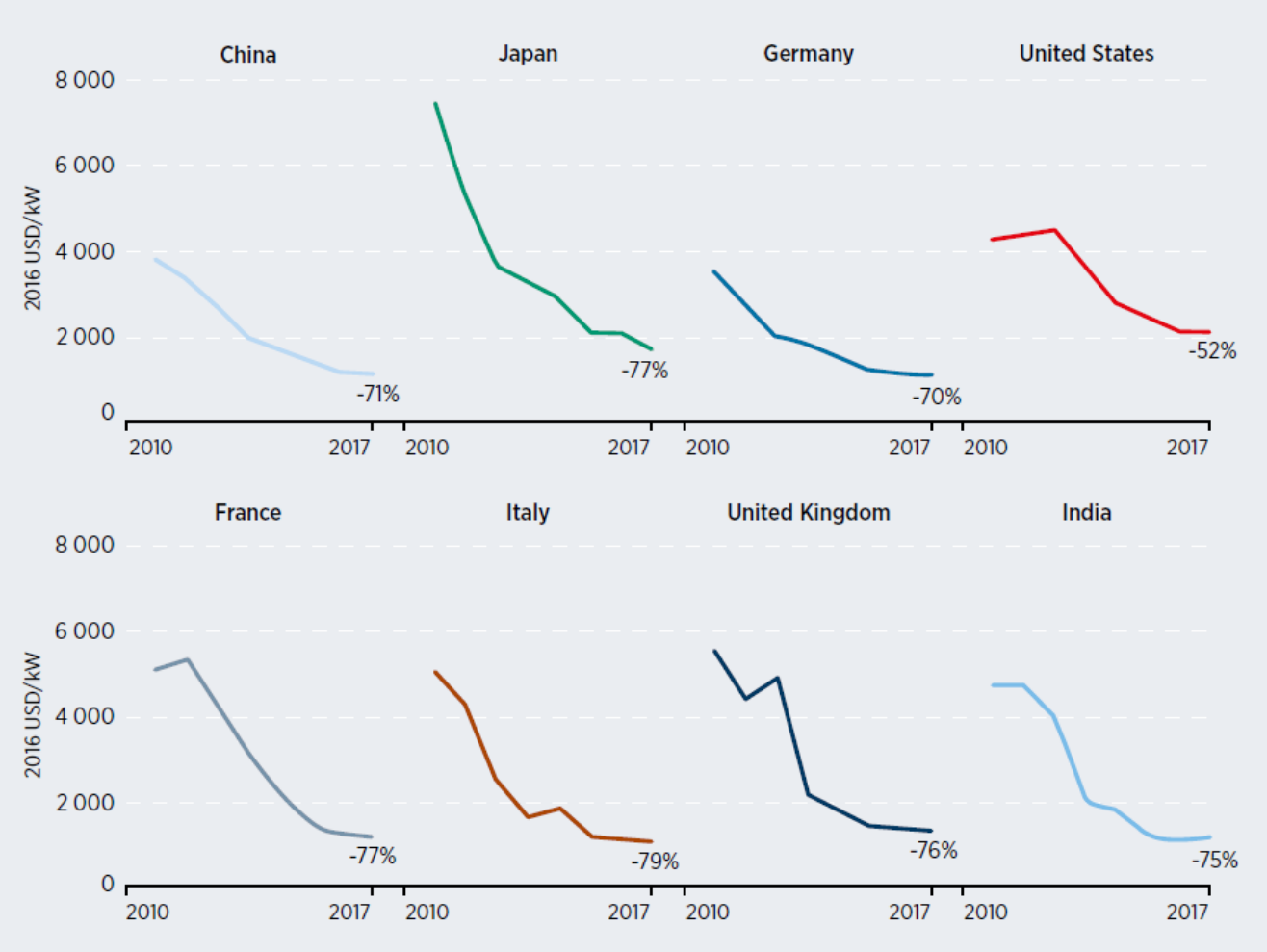


Markets that significantly reduced the differential over Chinese installed costs did so by **driving down BoS costs** towards more competitive levels.

Countries with competitive total installed cost levels have, on average, BoS costs (excluding the inverter) that make up **about half** of the total installed cost.

Total installed costs of solar PV

Between 2010 and 2017 the global weighted average cost of utility-scale PV decreased by 68%



Source: IRENA Renewable Cost Database.

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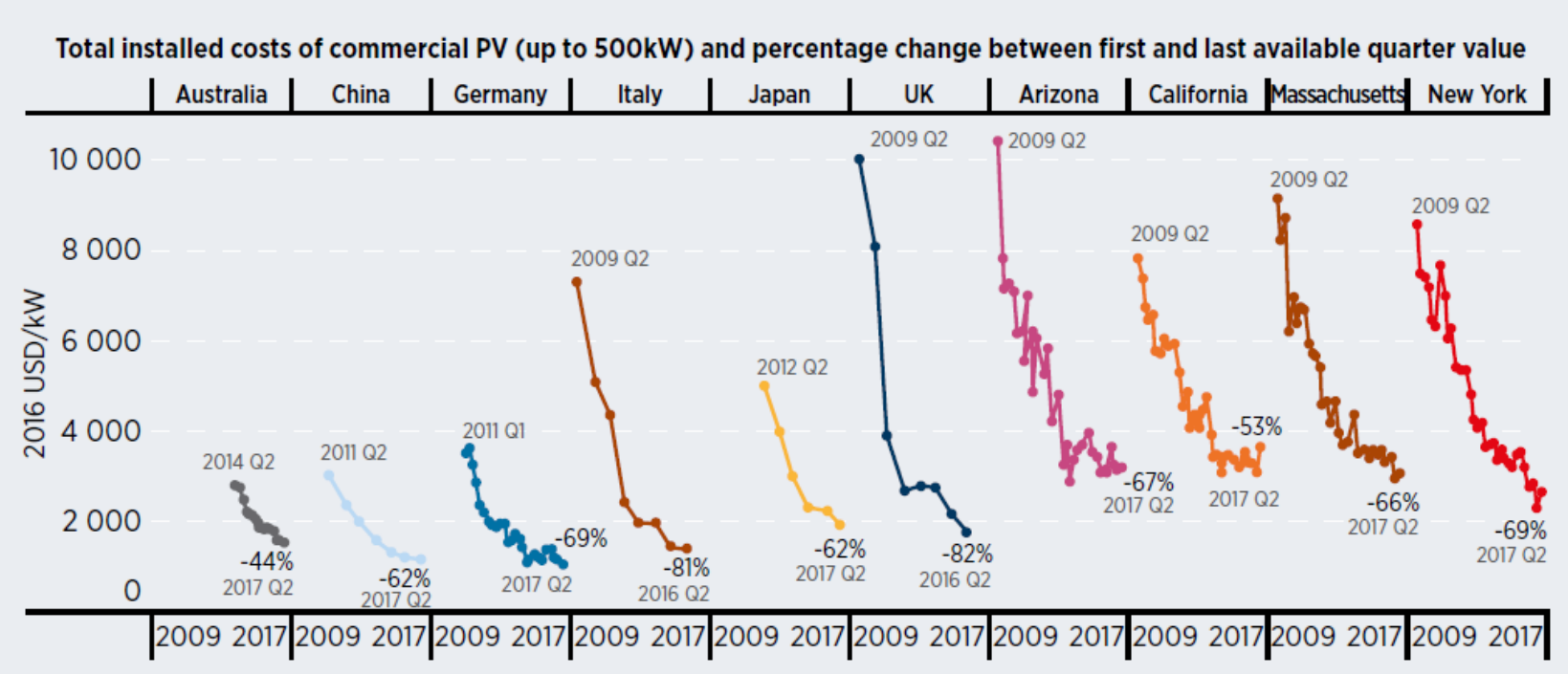
Global capacity weighted average total installed cost of newly commissioned utility-scale PV projects during 2017 at USD 1 388/kW (a 10% decline from 2016).

Chinese, German and Italian projects all close to USD 1 100/kW during 2017.

Cost differentials also declining and increasingly converging to best practice levels

Solar PV cost trends in the commercial sector

Economic opportunities have caused significant growth in the commercial sector in recent years



Total installed costs of commercial sector solar PV (up to 500 kW) similar downward trend than utility-scale segment

Lowest total installed commercial PV costs in Germany and China, at USD 1 100/kW and 1 150/kW, respectively in Q2 2017.

The highest cost market remains California at USD 3 650/kW

Source: IRENA Renewable Cost Database.

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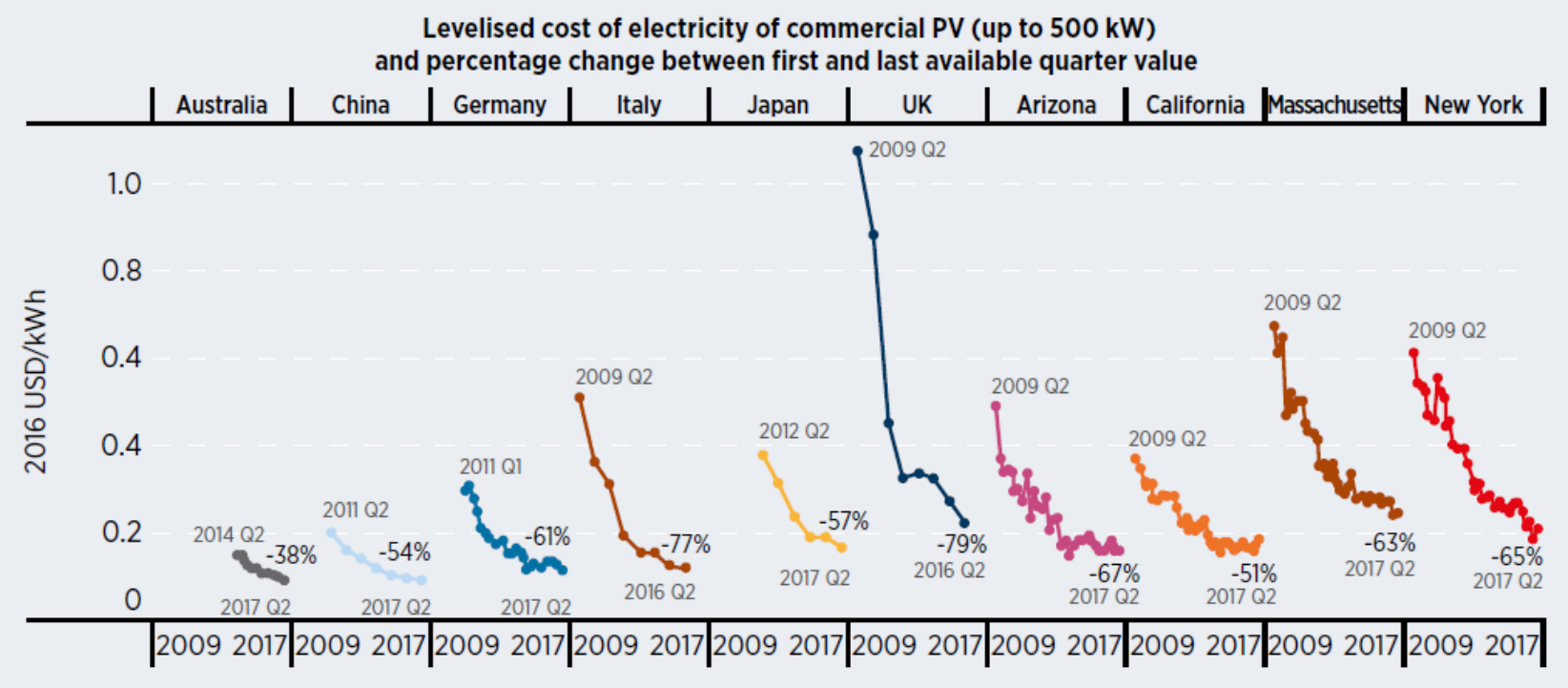


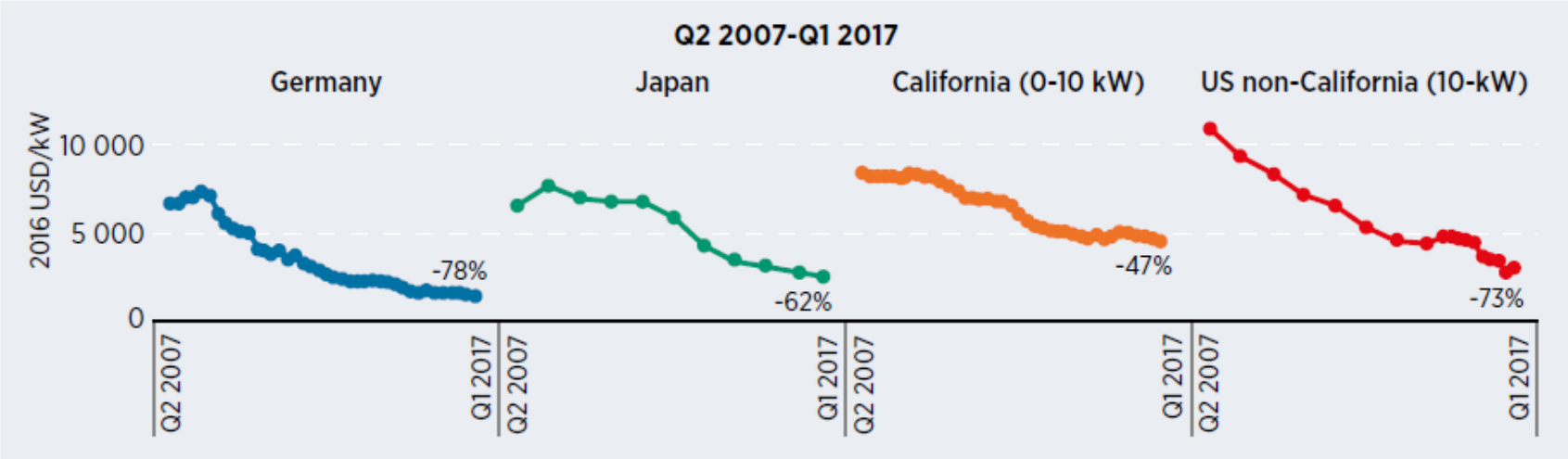
Lowest average LCOE at USD 0.10/kWh in Australia Q2 2017 (38% decrease between Q2 2014 and Q2 2017).

On the high end, LCOE estimates for the UK and some US markets are about twice that level during Q2 2017.

Source: IRENA Renewable Cost Database.

Solar PV cost trends in the residential sector

Total installed costs have also declined sharply in a wide range of countries



The total installed costs range of residential solar (longest historical markets):

USD 6 700 to USD 11 100/kW in Q2 2007 to

USD 1 050 to USD 4 550/kW in Q1 2017

Source: IRENA Renewable Cost Database.

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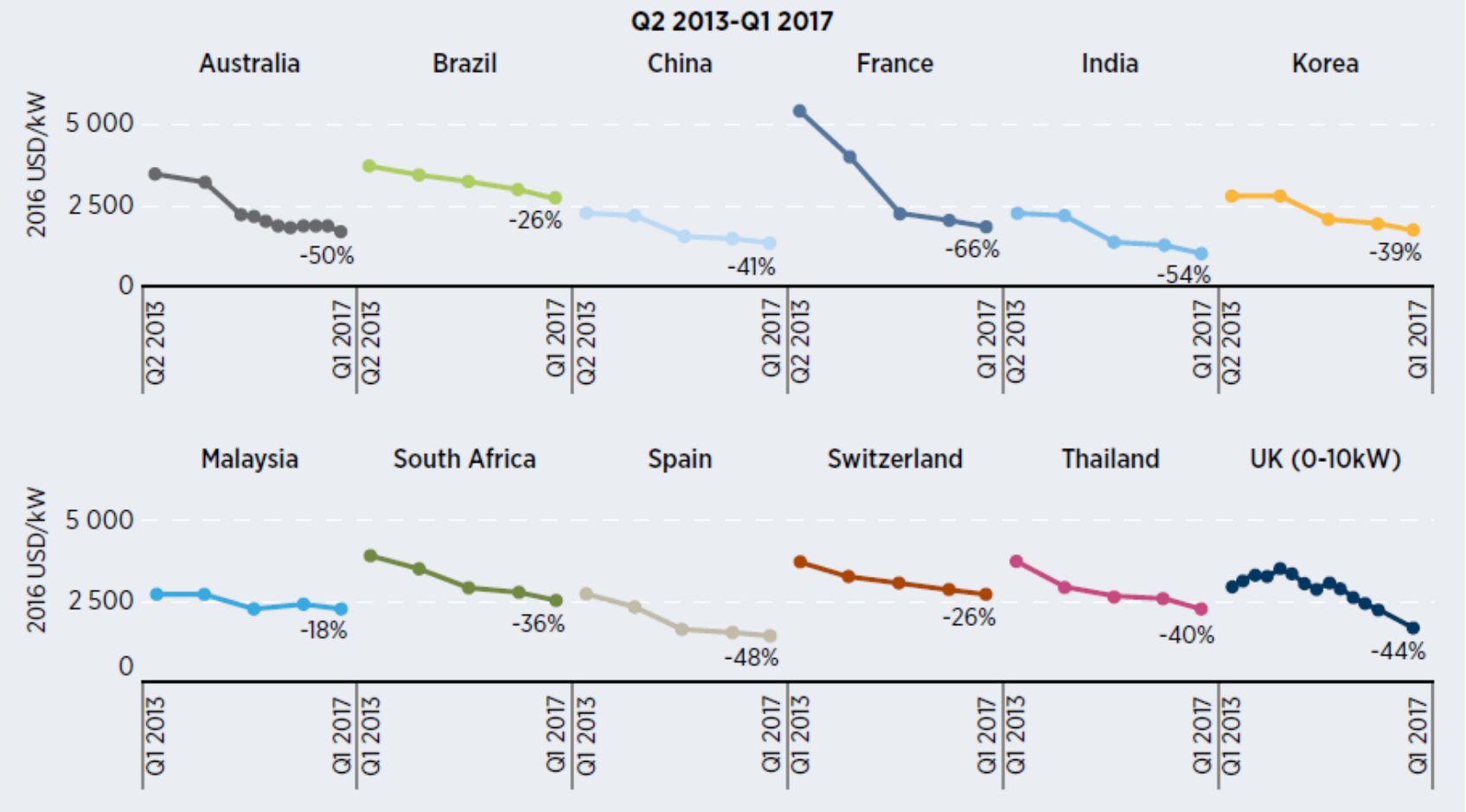


A broadening of the residential PV market since 2013.

Installed costs fell by between 18-66% between Q2 2013 and Q1 2017.

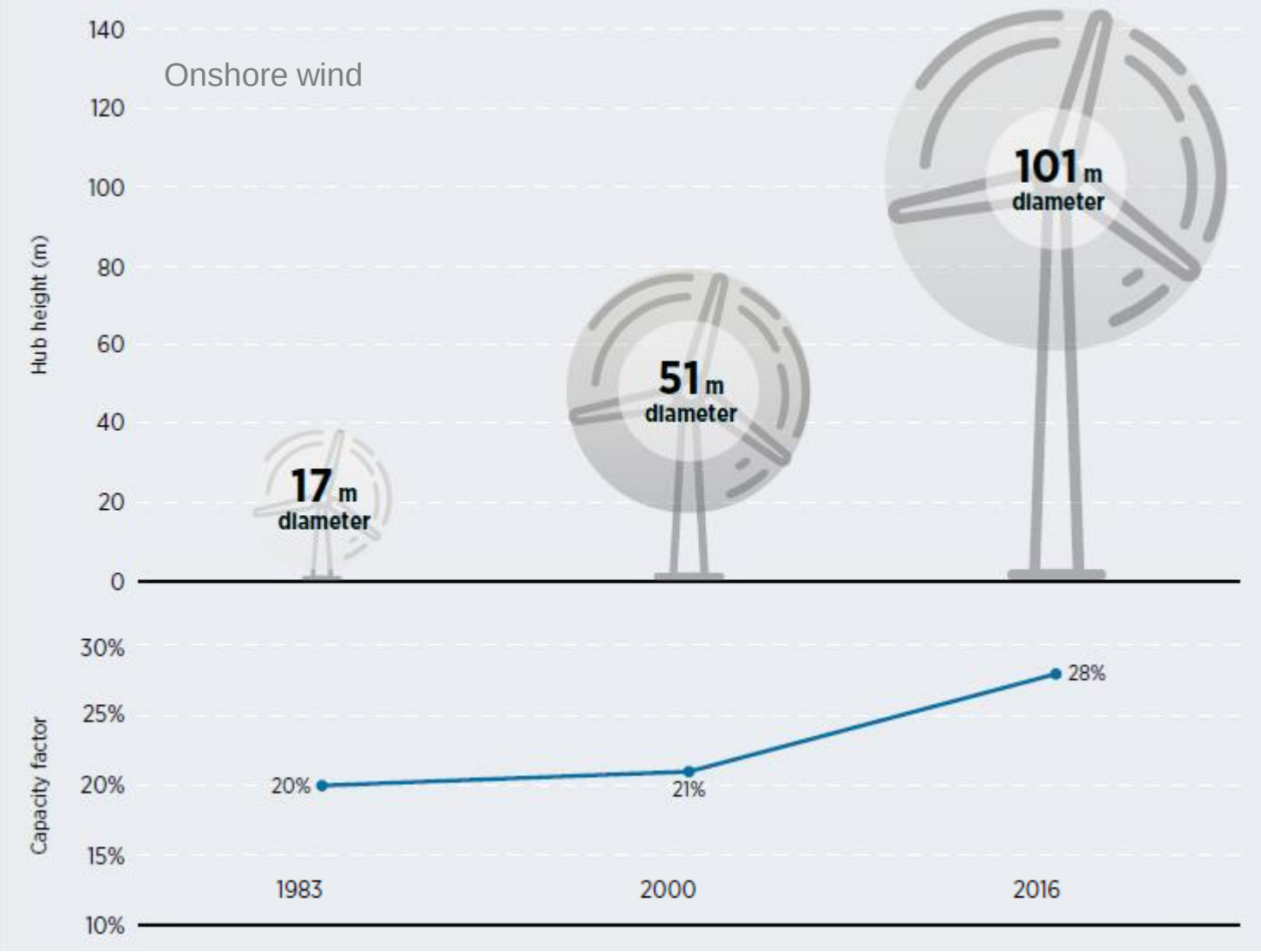
Still a wide span in costs exists (e.g. California ~ 3x India)

Source: IRENA Renewable Cost Database.

A CLOSER LOOK AT WIND

Wind trends

Wind turbine costs have declined while capacity factors have increased

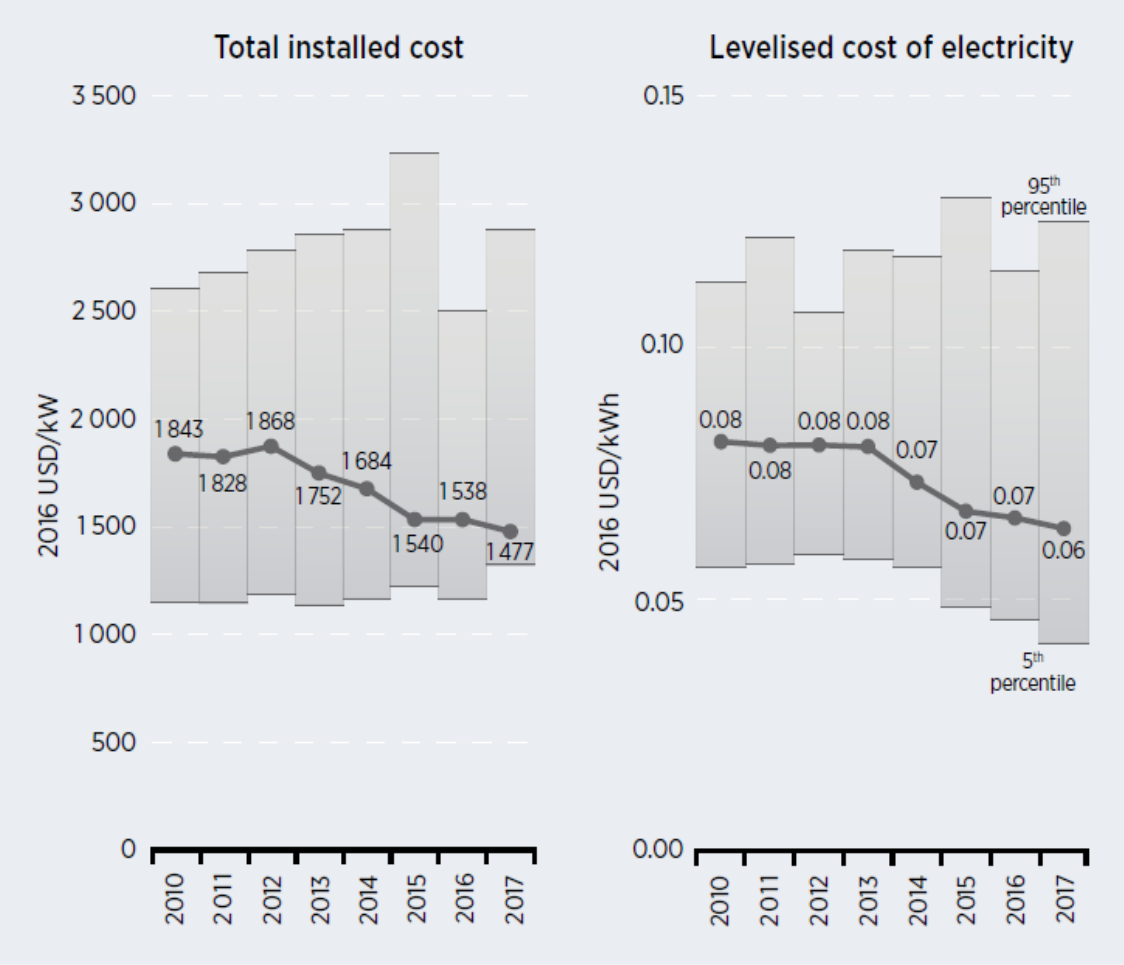


- Rotor diameters and hub heights have doubled from 2000 to 2016
- Capacity factors have increased by a third from 2000 to 2016
- Installed capacity increased by 26 times from 2000 to 2016

Wind trends

Onshore wind, increasingly a source of low-cost electricity

Onshore wind, 2010-2017

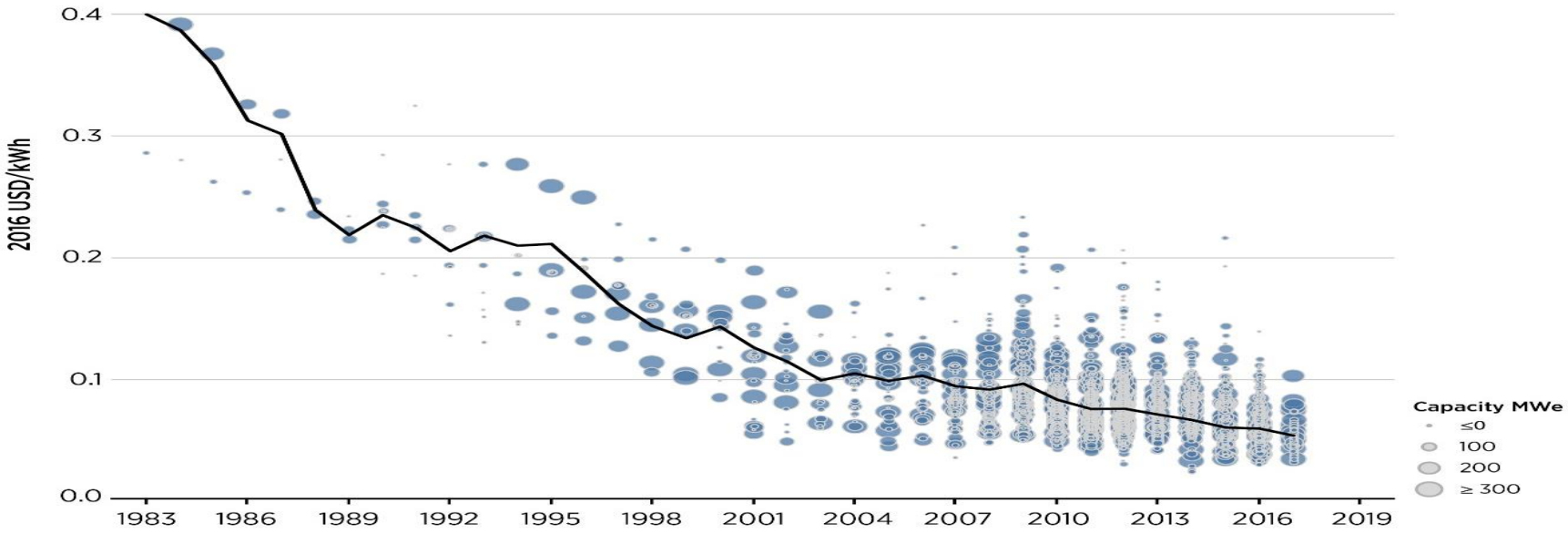


Source: IRENA Renewable Cost Database.

- Globally, wind turbine costs have declined by half in 2017 in comparison to 2007–2009
- Total installed costs fell by 20% from 2010 to 2017
- The global w. avg. LCOE of onshore wind fell by 22% from 2010 to 2017

Wind – Global LCOE

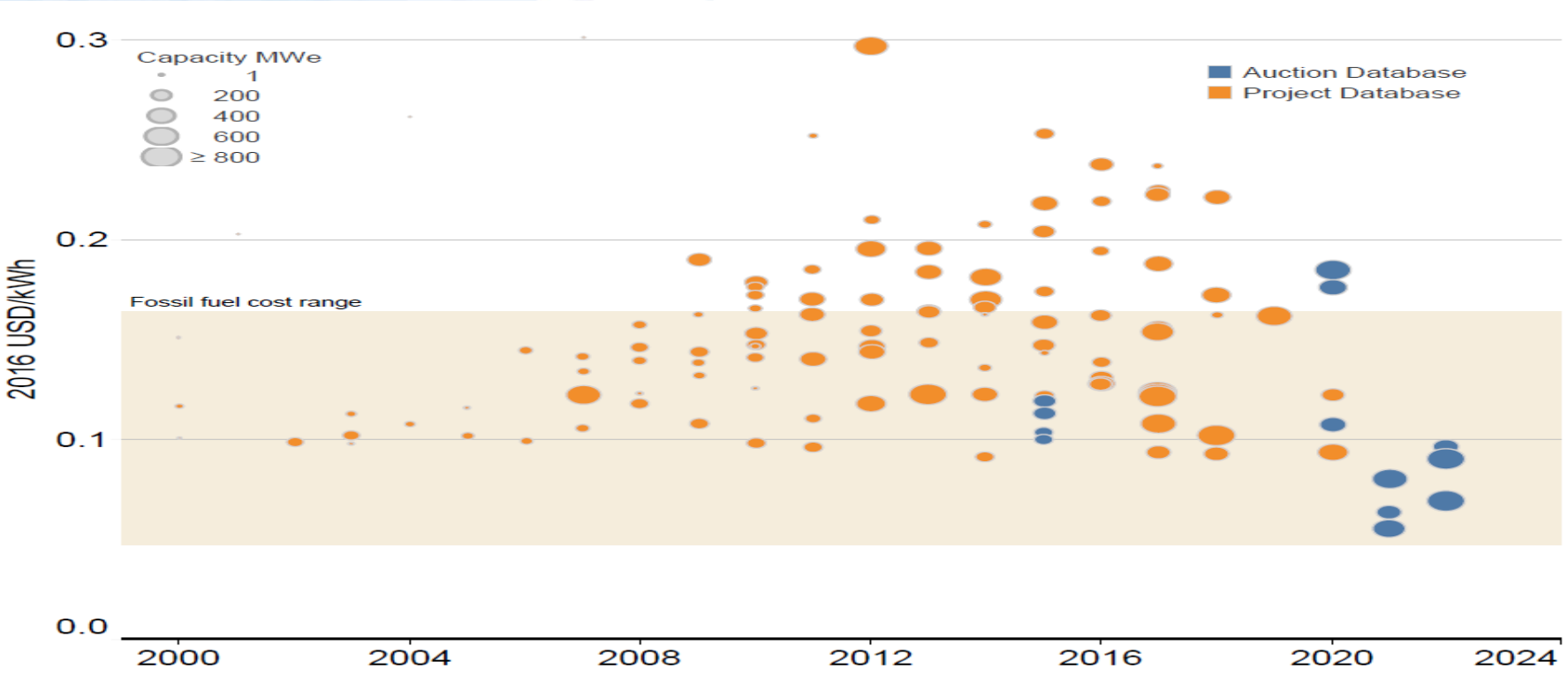
LCOE of onshore at USD 0.06/kWh in 2017, offshore at USD 0.14/kWh



- Globally, the LCOE of onshore wind declined by 85% from 1983 to 2017

Wind – Global LCOE

LCOE of onshore at USD 0.06/kWh in 2017, offshore at USD 0.14/kWh



- Offshore wind auction in 2016 and 2017 will deliver projects in the range of USD 0.06 to USD 0.10/kWh by 2020 to 2022

Other IRENA cost work

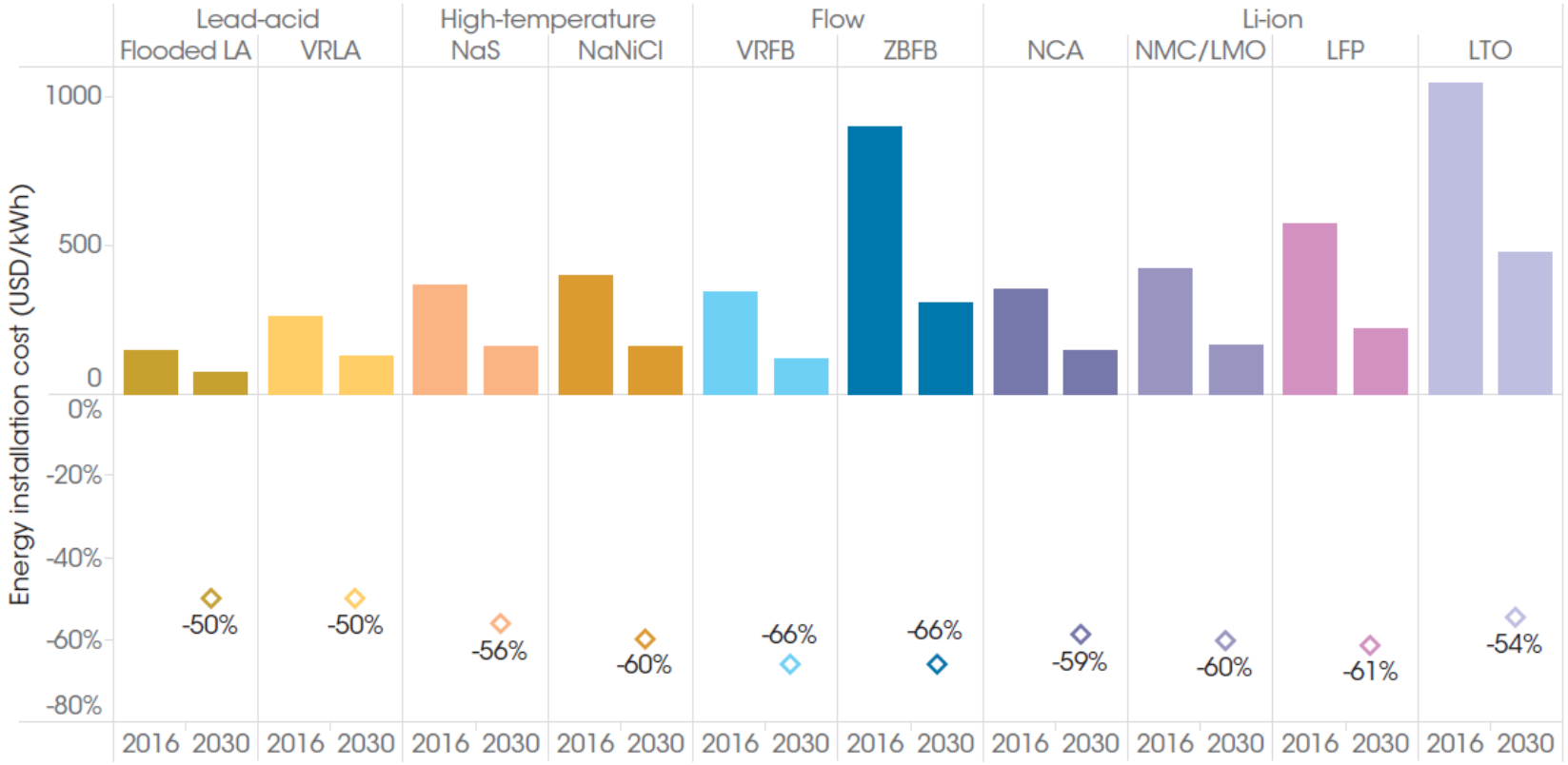
1. PV installed cost trends,

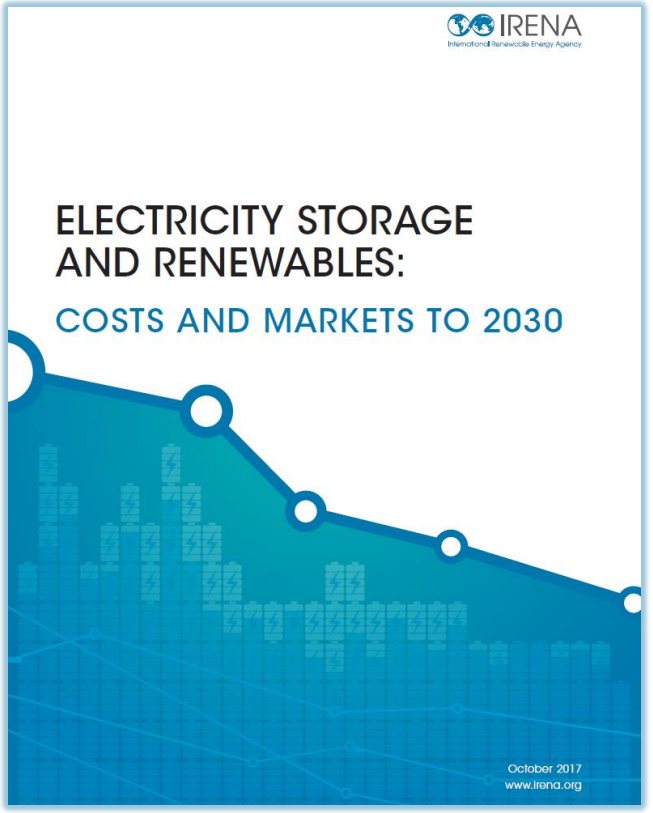
2. Effective electricity rate when the solar PV system is generating, and

3. The location-specific levelised cost of electricity (LCOE) of the PV system

Other IRENA cost work

Installed energy costs to fall 50-66% by 2030





Note: LA = lead-acid; VRLA = valve-regulated lead-acid; NaS = sodium sulphur; NaNiCl = sodium nickel chloride; VRFB = vanadium redox flow battery; ZBFB = zinc bromine flow battery; NCA = nickel cobalt aluminium; NMC/LMO = nickel manganese cobalt oxide/lithium manganese oxide; LFP = lithium iron phosphate; LTO = lithium titanate.

Renewables are increasingly competitive

The winners are customers, the environment and our future

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