IRENA
International Renewable Energy Agency

Corporate Sourcing of Renewables
IRENA Cost Analysis

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All results are **PRELIMINARY** and subject to change

Final report to be released in June 2016

IRENA analysis in support of Corporate Sourcing of Renewables
(CEM7 Campaign)

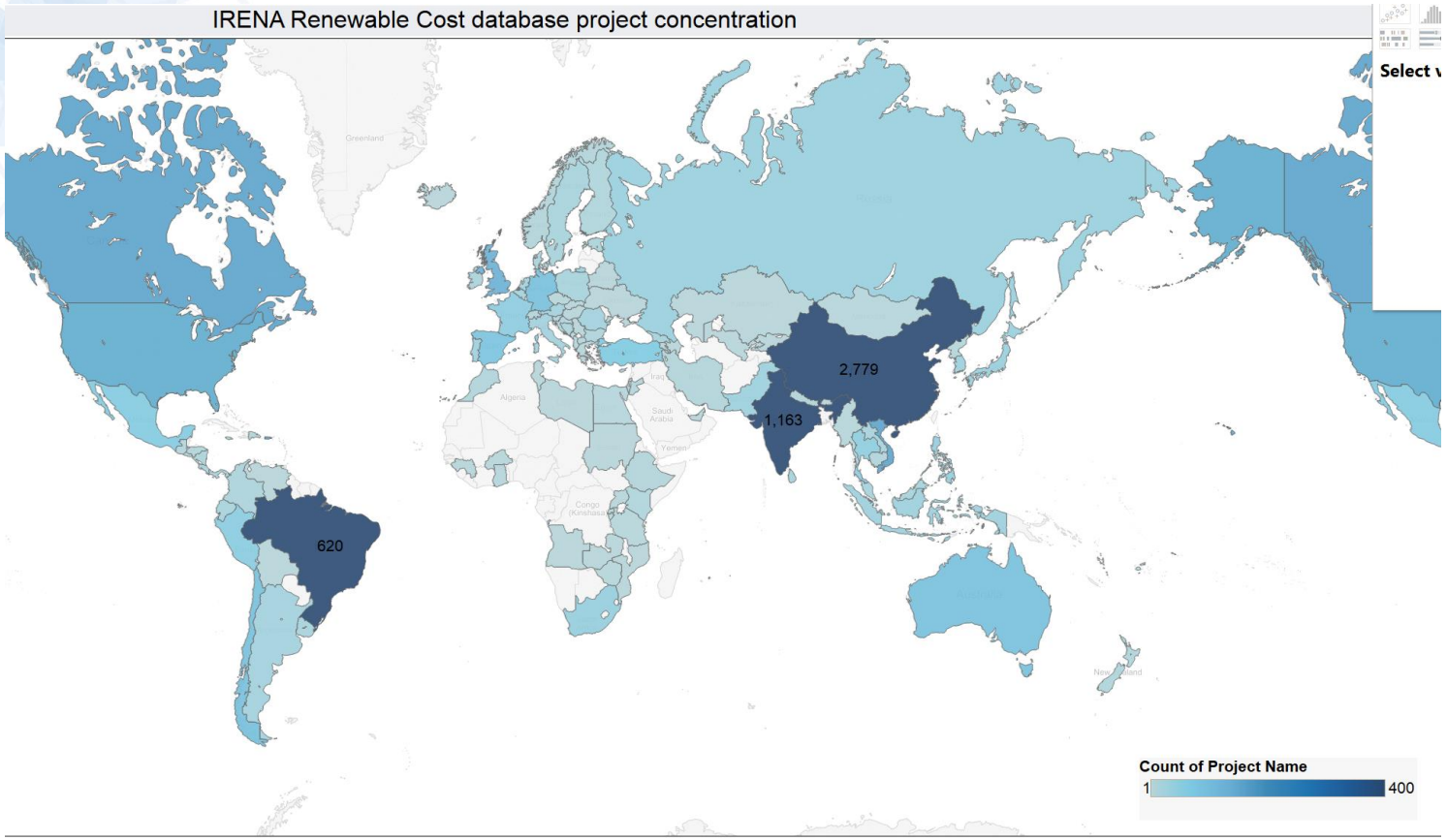
Costs and economics of renewables are central

Ability to scale beyond high margin corporates critical to ambition

Campaign needs to reach SME

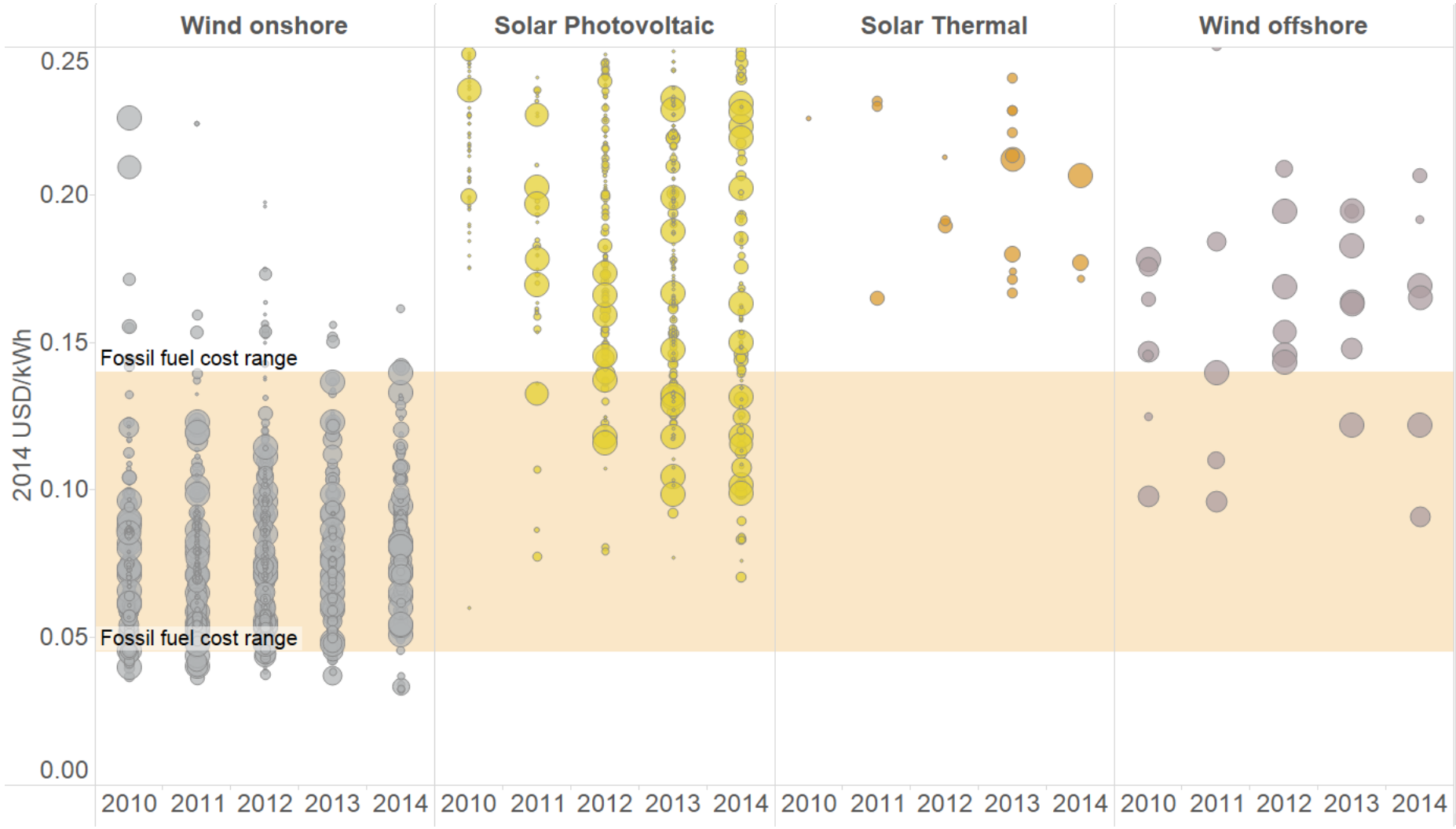
RE business case: Cost data and analysis brings transparency

Power generation database



15000 utility-scale projects, 9000 with LCOE data

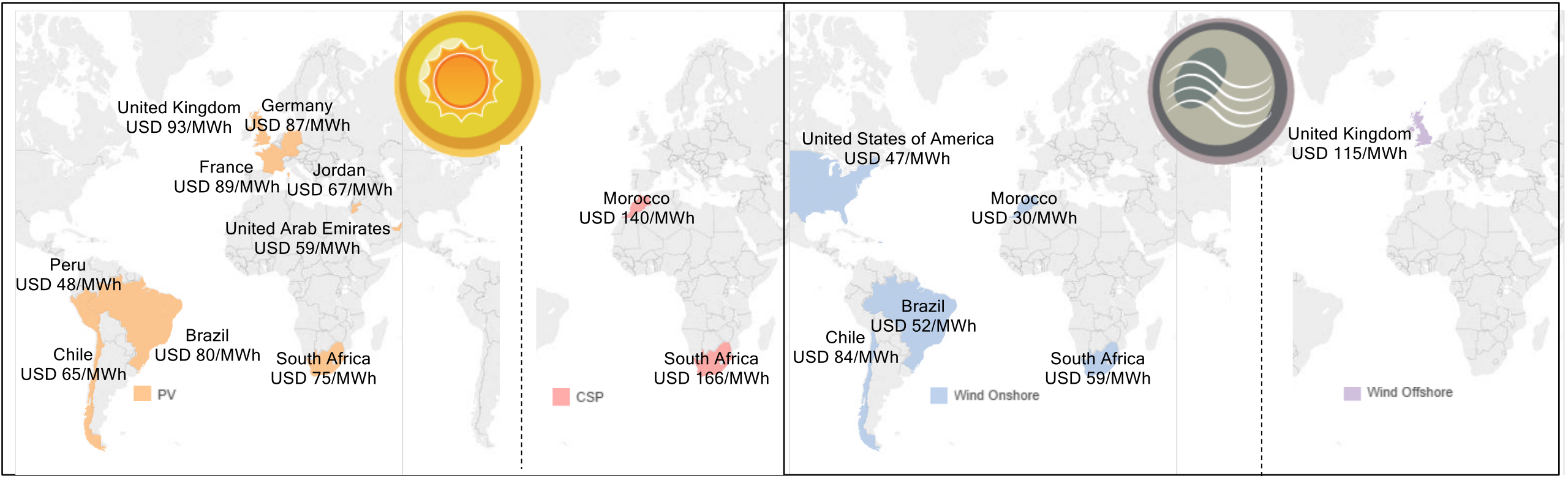
New renewable power technologies: Rapidly maturing



Note: each circle represents a utility-scale project, centre of circle is LCOE value and diameter of circle the project size

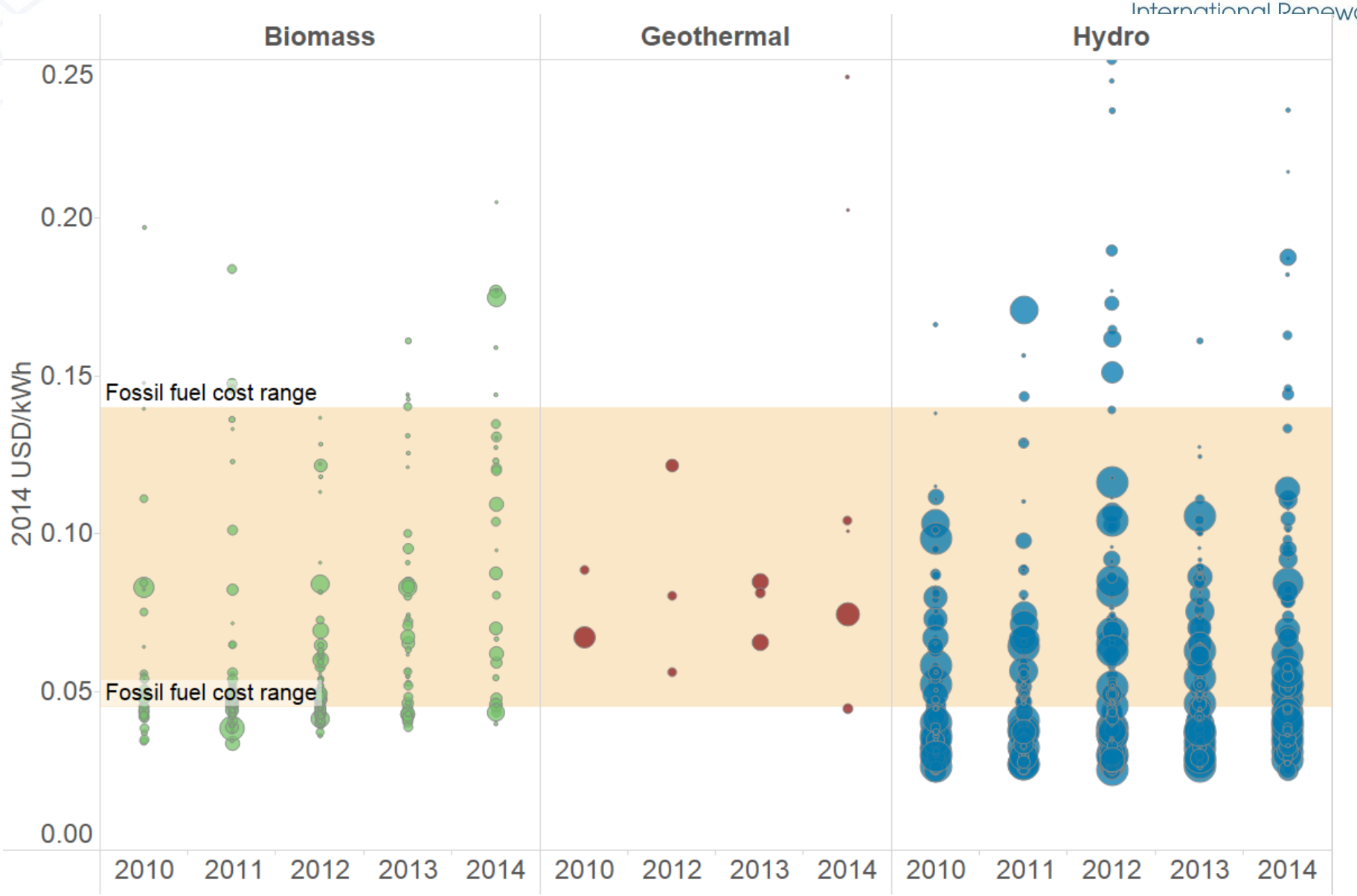
PPAs show costs are decreasing

Projects in a wide range of technologies and locations are being offered at very low long-term contract prices



Today's record low PPA prices are tomorrows average

Renewables: The cost effective solution



Note: each circle represents a utility-scale project, centre of circle is LCOE value and diameter of circle the project size

Costs will continue to fall for solar and wind power technologies to 2025

Large cost differentials

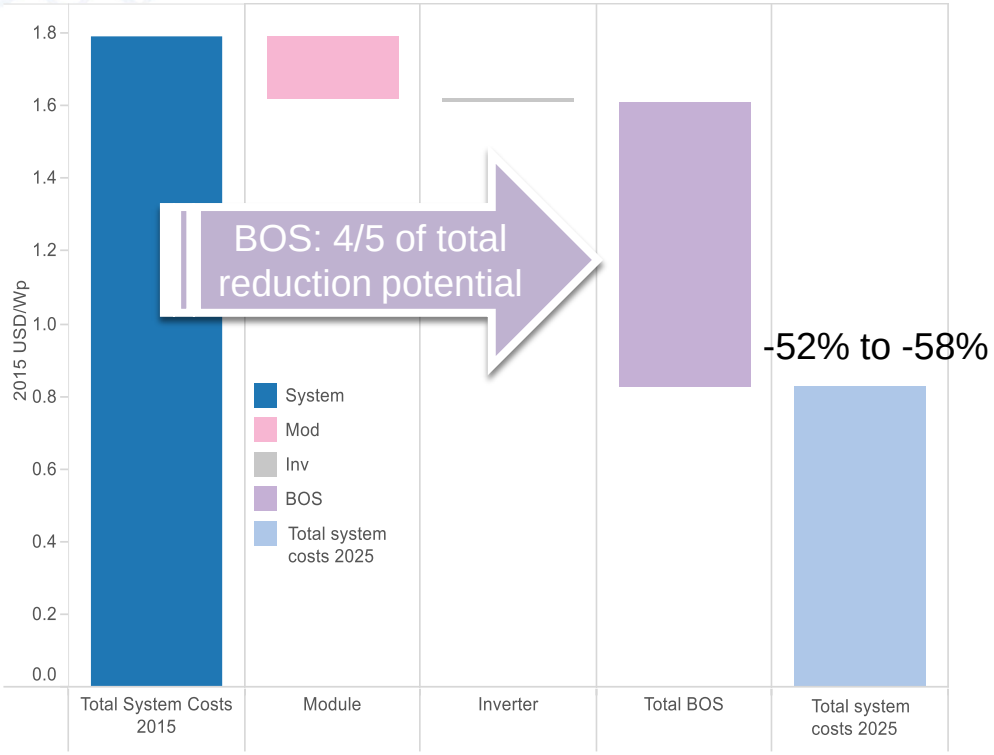
Continued technology innovation

Growing scale of markets

Policy framework critical to unlocking largest savings

SOLAR PHOTOVOLTAICS

Solar PV:
Total installed system costs to 2025



Utility scale PV total system costs and expected cost reductions by 2025

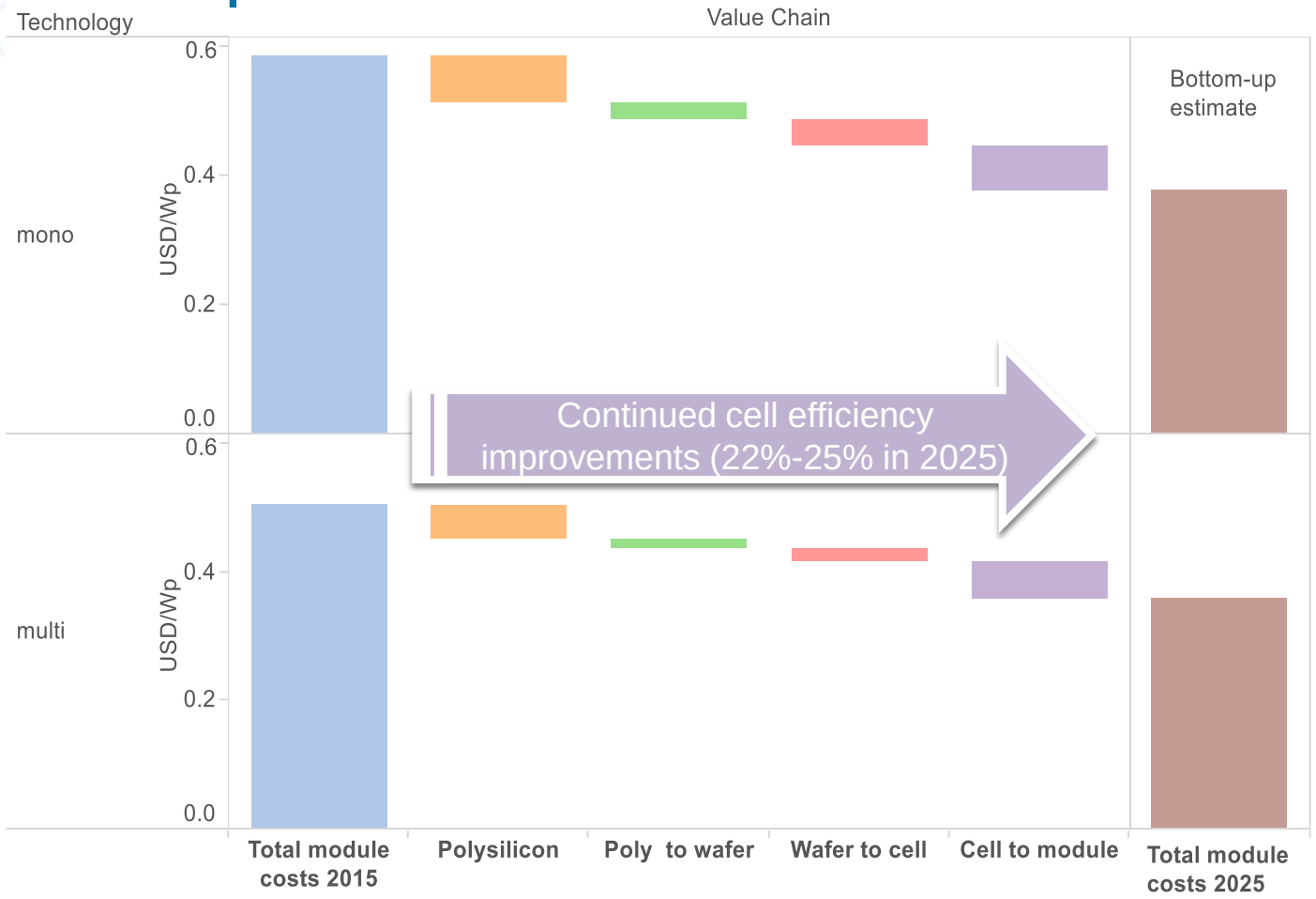
Large average cost reduction potential

BoS dominates potential

Not widely appreciated by policy makers

PV Module costs to 2025

Largest cost reductions from polysilicon production and cell-to-module production



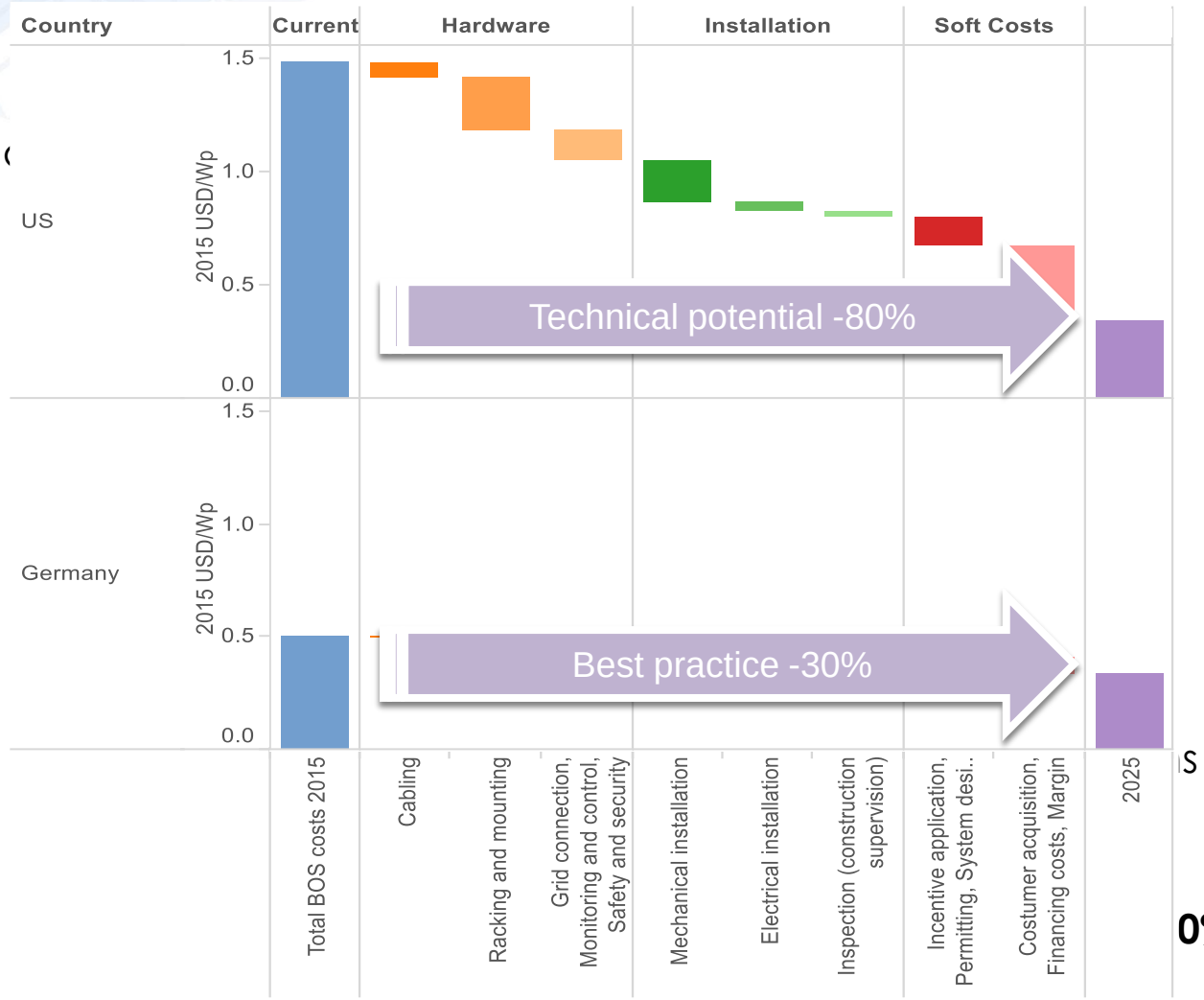
Cheaper Poly-silicon	▪ increased reactor capacity ▪ reduced electricity consumption ▪ uptake of newer manufacturing processes
Cell-Mod Process	Module cost expected to drop: ▪ one-third for mono-crystalline modules ▪ one-fifth for multi-crystalline
Other	Sawing process, thinner wafers, process control improvements. Silver paste and materials use reductions

Solar PV: BoS costs to 2025

BoS costs for utility-scale solar PV plant could fall by between 65% and 71% between 2015 and 2025.

Why?	market and supply chain increased maturity Lower perceived risks => lower margins
Soft costs	Expected to contribute between 43%-46%
Hard-ware	BOS hardware costs decrease expected to contribute another 30-32% to the potential

Policies key to BoS cost reductions



Factor 3 difference between average BoS utility-scale costs in most competitive to least competitive market!

ONSHORE WIND

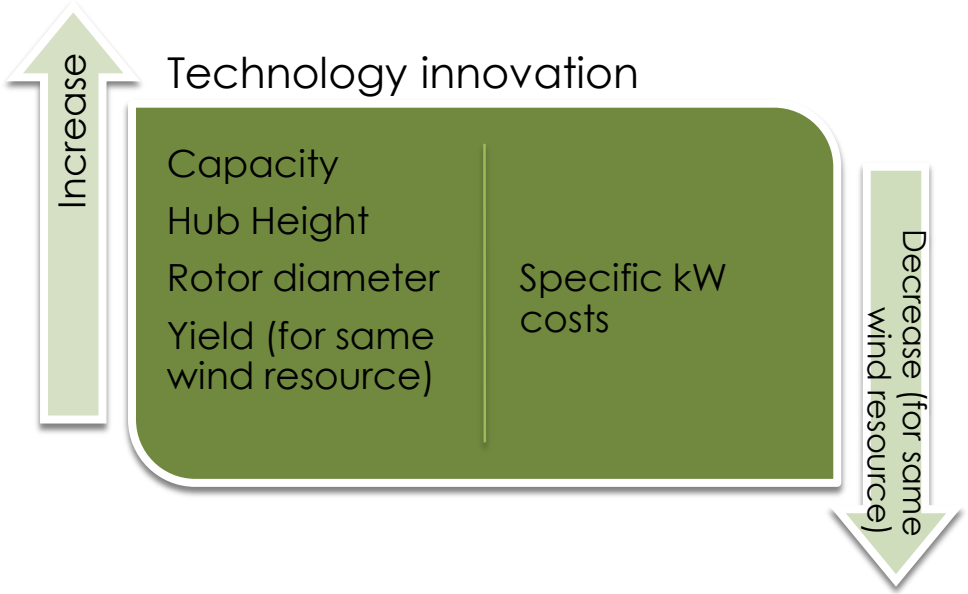
Onshore wind

The cost of onshore wind farms will continue to fall

Historically every doubling of global capacity has meant:

6% declined in investment costs

9% decline in LCOE

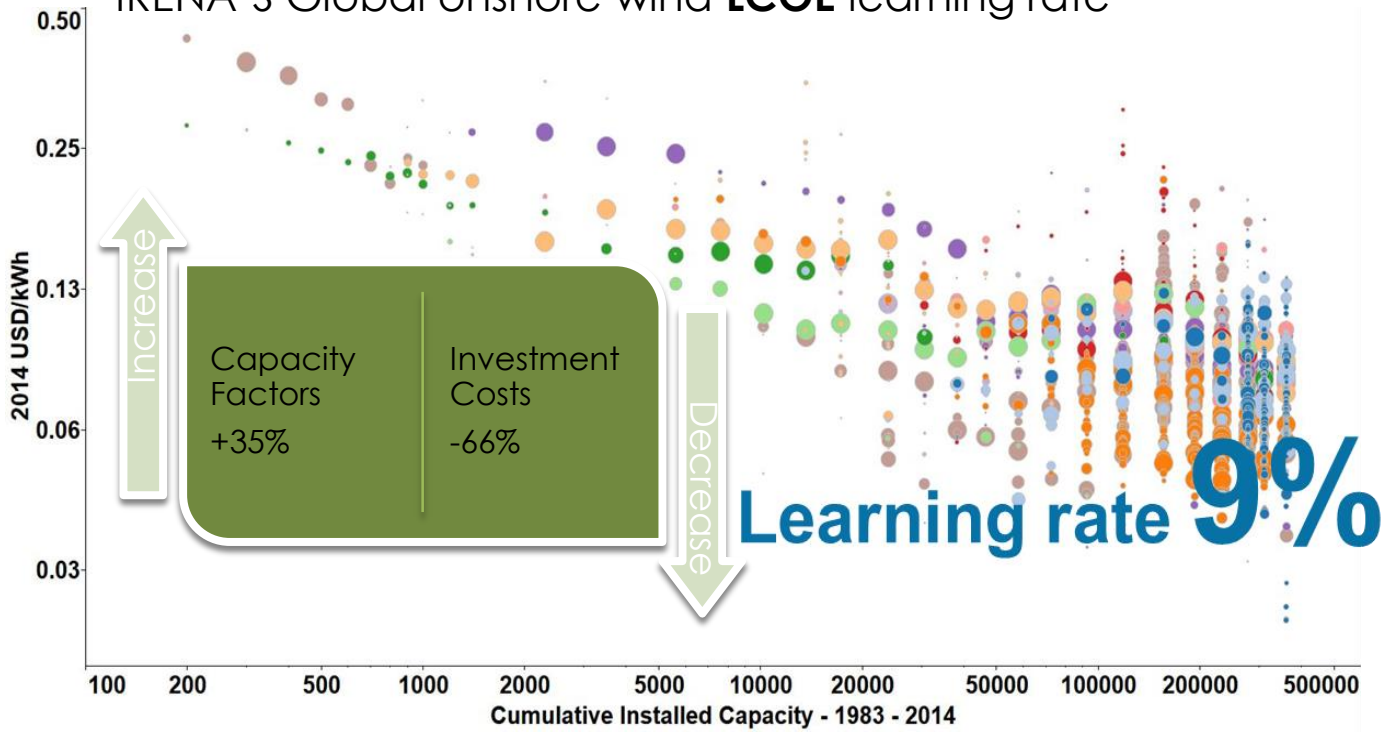


1983-2014	Global weighted average investment cots declined by two thirds: ▪ USD 4766/kW to USD 1623/kW
Drivers	Increased economies of scale ▪ Broader market (100+ countries) ▪ Greater competition in VC ▪ Technology innovation
US 1998-2014	▪ Avg. turbine capacity:+ 170% ▪ Avg. Hub height: +48% ▪ Avg. rotor diam.: +108%

Onshore wind: LCOE

Capacity factors have doubled due to technology improvements and have caused the LCOE to fall faster than installed costs

IRENA'S Global onshore wind **LCOE** learning rate



1983-2014	LCOE: ▪ USD 0.38/kWh to USD 0.07/kWh (-81% fall)
Key Drivers	▪ Technological improvements: have been rapid and are still ongoing
Other	▪ lower O&M costs also have been driving LCOE down

Onshore wind: LCOE

LCOE reductions are ongoing and new technology improvements are continuously deployed

Capacity Factor

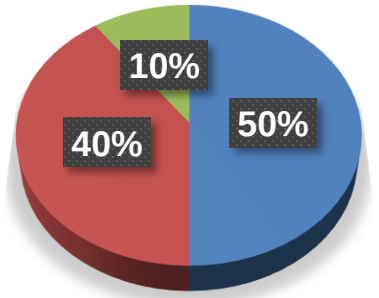
Improved blade design	Larger capacity turbines
Pitch and yaw control	Higher hubs
Taller towers	Larger rotor diameters

Investment cost USD/kW

LCOE (wider adoption of technology improvements)

decline by **20-30%** by 2025

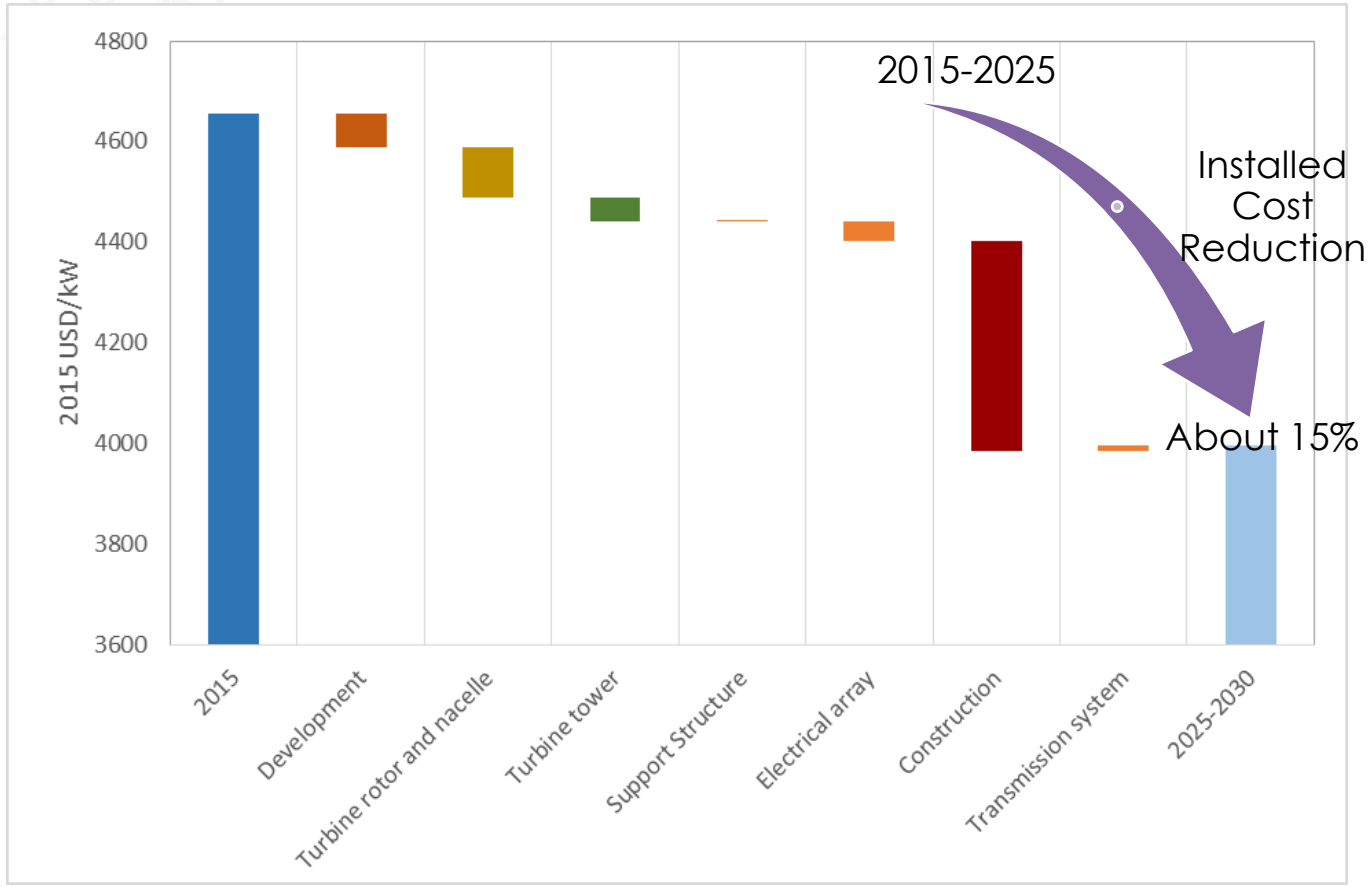
Contribution to LCOE reduction potential to 2025



OFFSHORE WIND

Offshore wind: Installed costs

There are incremental opportunities to reduce capital costs by 2025 across the entire wind farm, from interconnection to project development



Projected installed cost reductions for offshore wind, 2015 to 2025

Inst. costs

Reduction driven by:

- construction and installation (about 60% of total cost reduction potential)

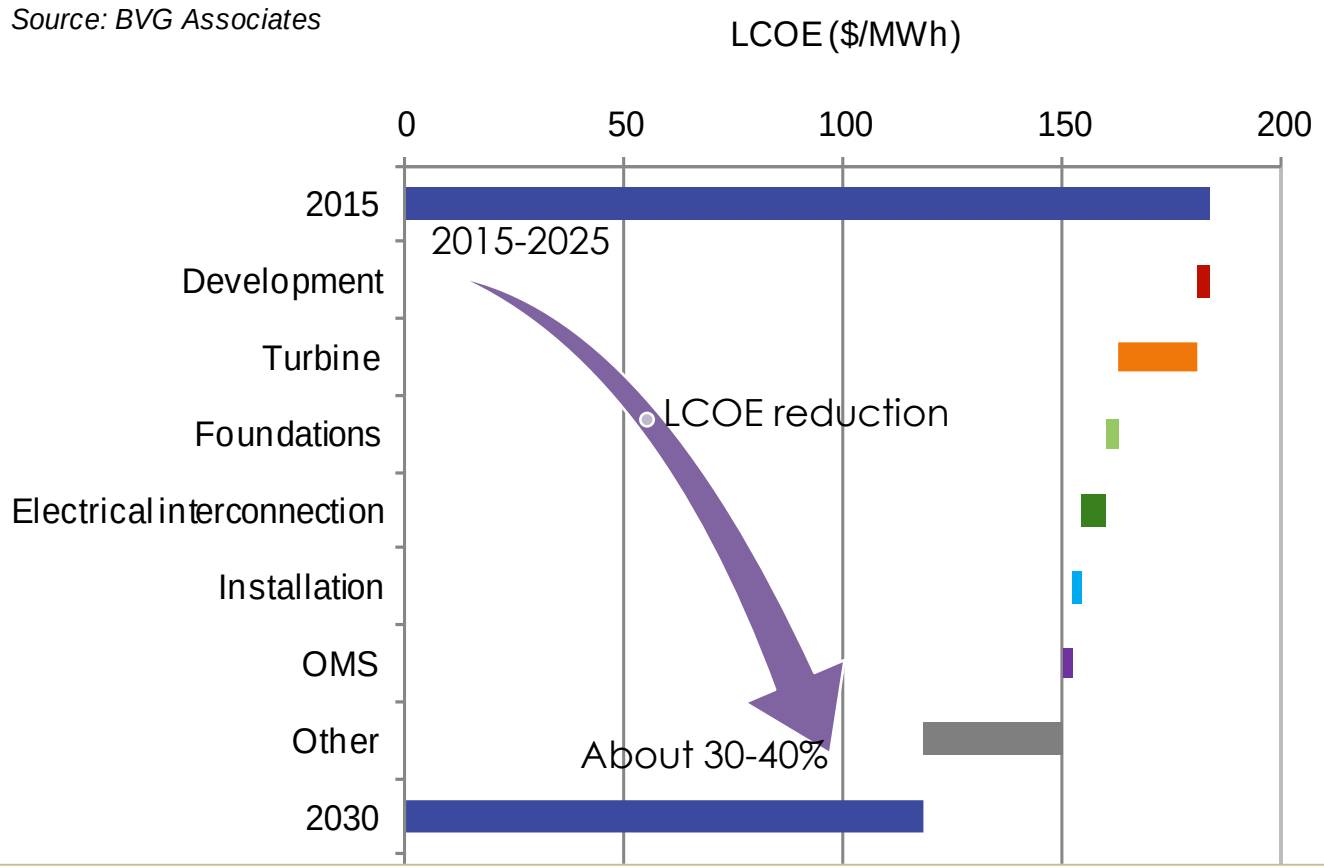
Other

- Incremental cost reductions for turbine rotors and nacelles

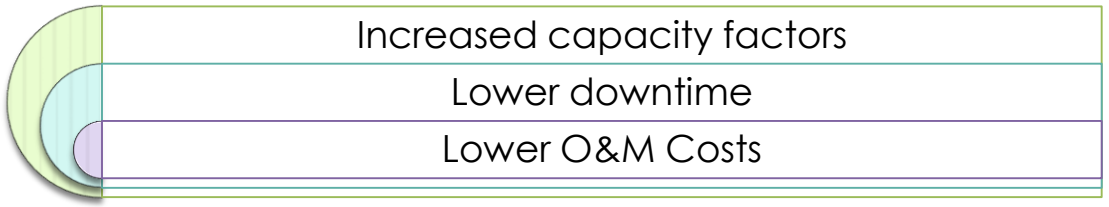
Offshore wind: LCOE

Though the technology is still in its infancy (12GW end 2015), next generation offshore projects could experience LCOE decreases of 30% to 40% by 2025

Source: BVG Associates



2015-2025	LCOE could decrease: ▪ 30% to 40%
Drivers	▪ Reduced cost of capital (larger pool of experienced developers, maturity of local markets, decreased perceived risks.
Larger Turbines	▪ shift from large 6 MW turbines to very large (8 MW+) ▪ blade and drivetrain improvements



CONCENTRATING SOLAR POWER

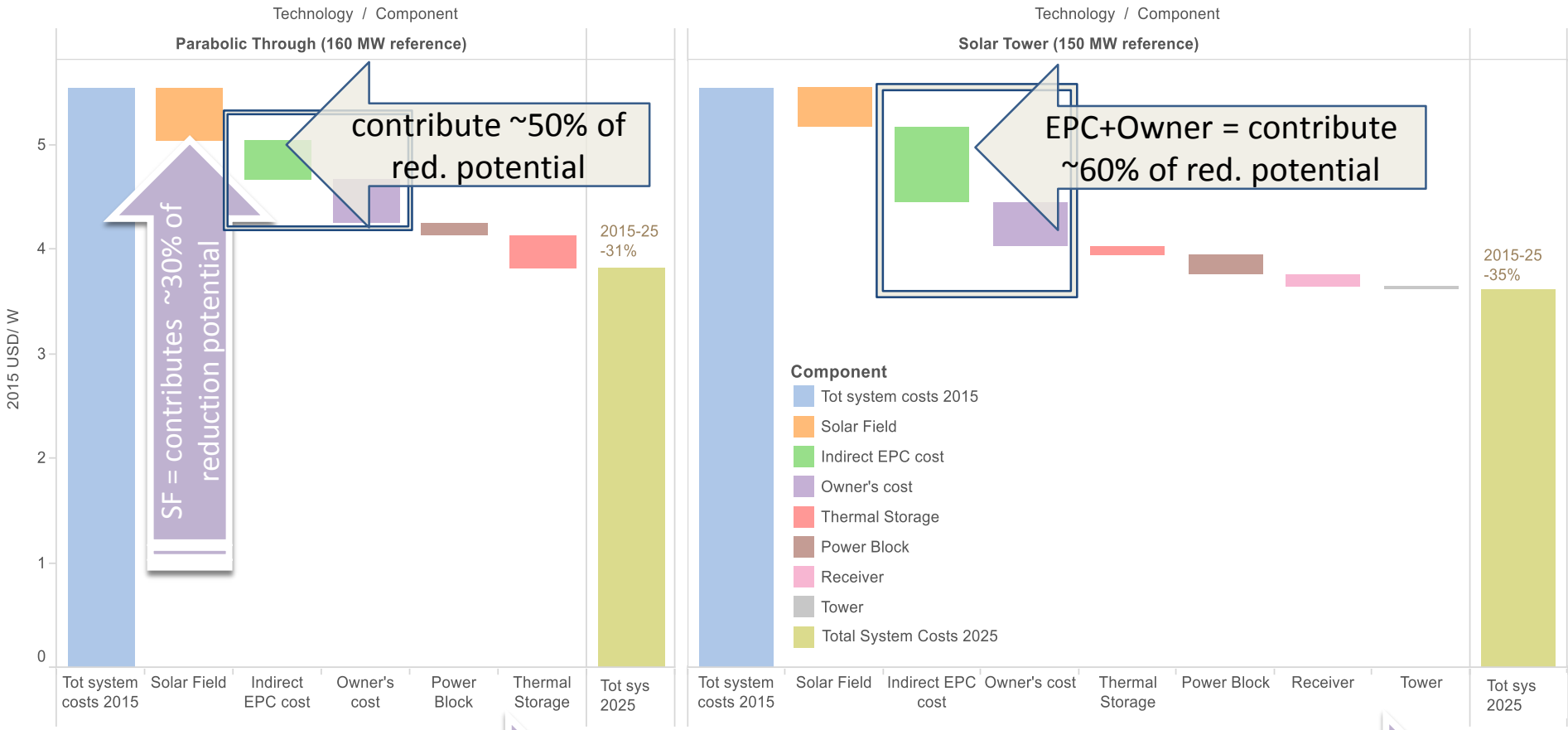
CSP: a set of technologies

- Deployment is in its infancy (~5 GW)
- Cost reduction potential is good. IRENA analysis is focusing on parabolic trough (PT) and solar tower (ST)
- Solar towers have greater cost reduction potential with higher operating temperatures and lower cost thermal energy storage
- Cheap thermal energy storage allows dispatchable power -> potentially more valuable generation (particularly in high RE scenarios)

Concentrating solar power

Deployment in its infancy!

CAPEX could decline by one-third by 2025



Plant Efficiency: 15% currently to 17% by 2025

Plant Efficiency: 15.5% currently to 18% by 2025

PT -31% CAPEX (15-25)

- USD 5550/kW to USD 3800/kW 2025

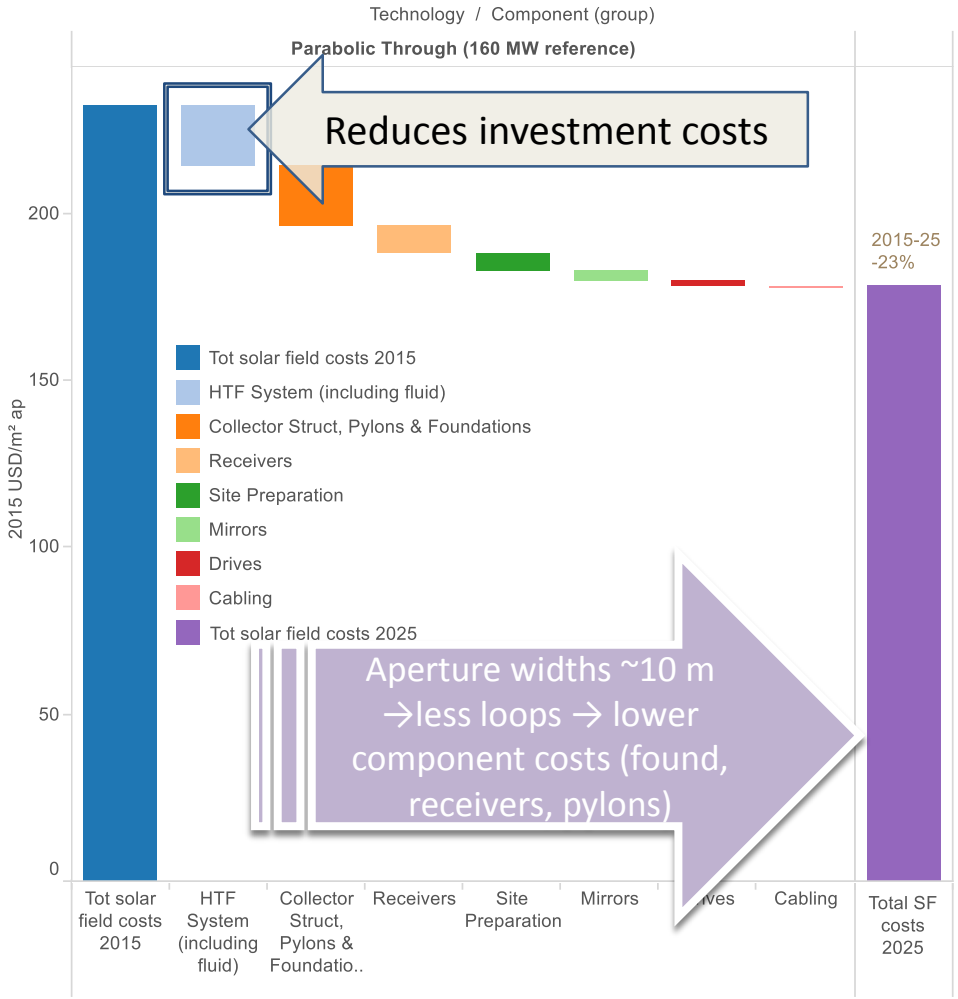
ST -35% CAPEX (15-25)

- USD 5450/kW to USD 3600/kW

Indirect EPC costs + Owner's costs also major contributors to reduction potential

The solar field

By 2025 CAPEX for the solar field could decrease by 23% for parabolic through (PT) and by 27 % solar tower (ST) technologies



PT

-23%

Switch to molten salt as HTF towards 2025

→higher process temperatures

ST

-27%

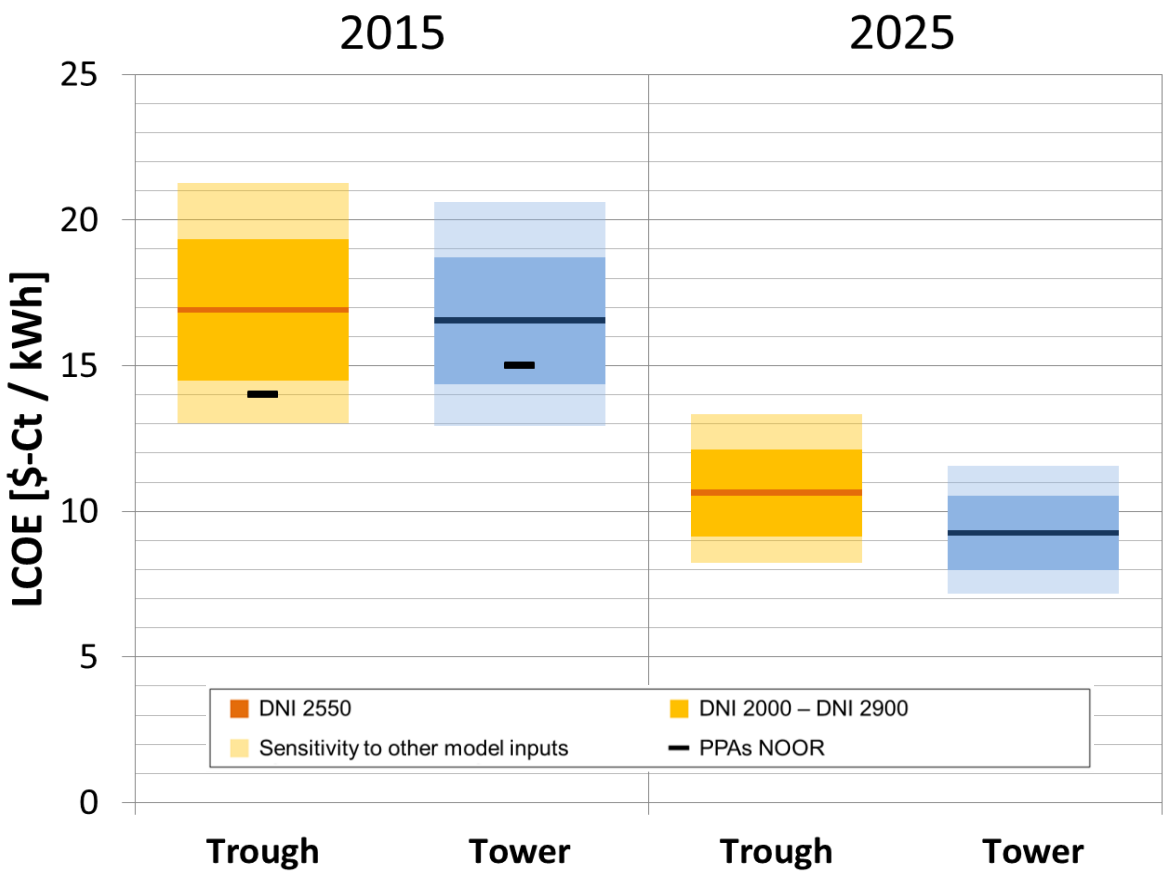
Drives improvements

Structural design

More efficient assembly procedures

Concentrating solar power

By 2025 the LCOE of both parabolic through and solar tower technologies will decrease about 35%



Main driver	Lower capital investment costs
Output 2015-2025	Assuming medium irradiance (DNI = 2550 kWh/m2) PT electricity output: +7.6% ST electricity output: +8.4%
LCOE	2015: USD 15-19/kWh in 2015 2025: USD 0.09/kWh to USD 0.12/kWh for PT USD 0.08/kWh to USD 0.11/kWh for ST

IRENA
International Renewable Energy Agency

Available online

Reports, presentations, events, high-res charts

www.irena.org/costs

LCOE ranges and averages

www.irena.org/resource

Additional functionality and data detail coming 2015 to REsource

Upcoming cost analysis: 2016/17

IRENA PV parity indicators

Global onshore wind learning curve

Cost of RE for stationary applications

RE power cost reduction potentials

RE and financing costs

Solar PV costs in Africa

Historical RE power generation investment

Renewable power generation cost updates 2016 and 2017