CSP Cost Reduction Potential

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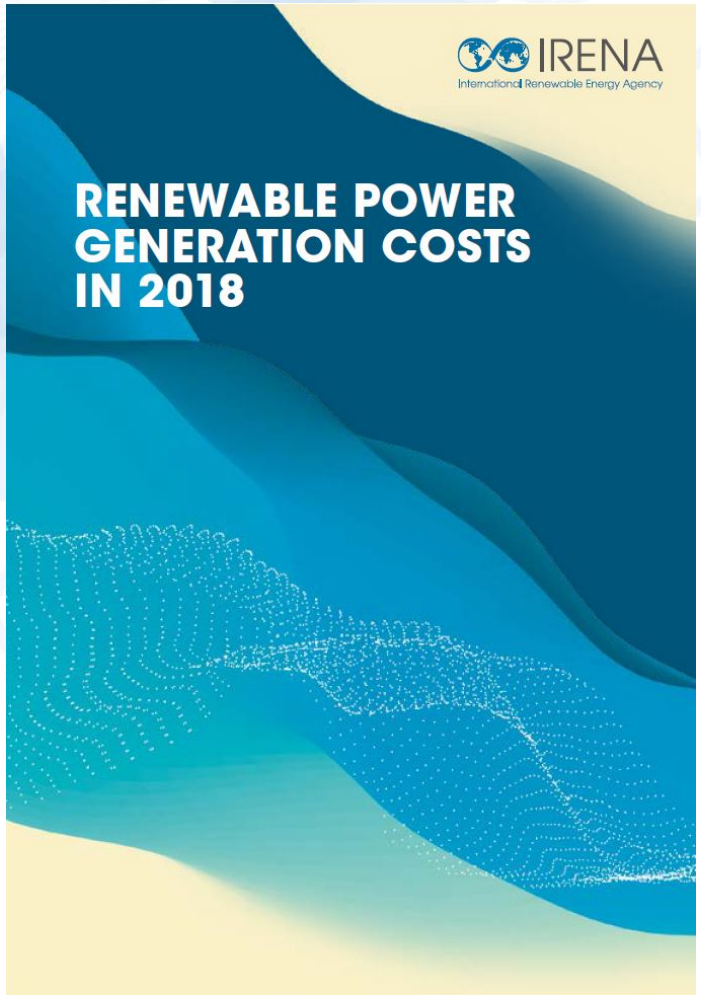
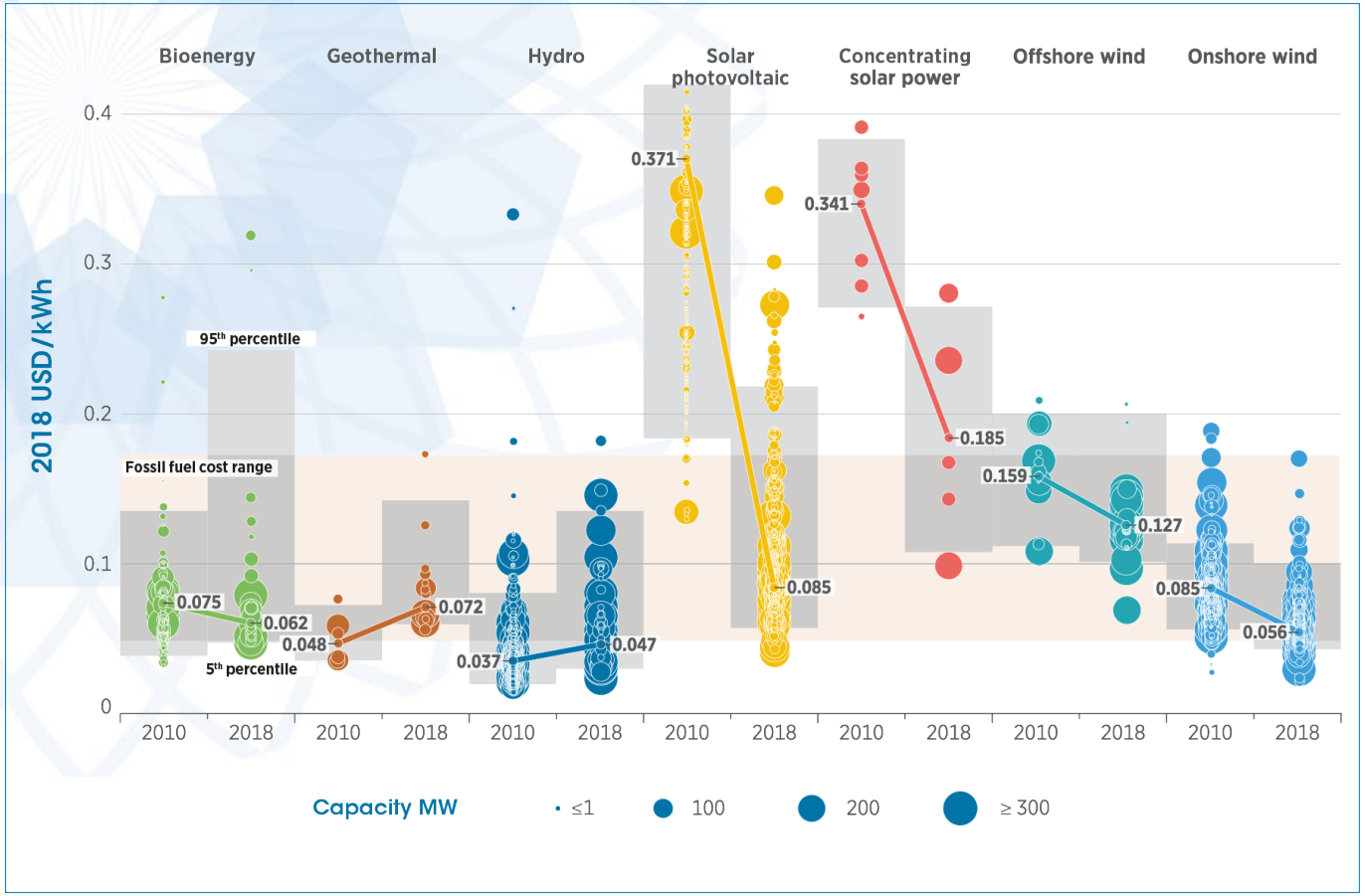
Recent cost evolution



- Latest trends in the cost and performance of renewable power generation technologies
- Global results to 2018
- Detailed analysis of equipment costs and LCOE drivers
- Integration of project LCOE and Auction results to look at trends to 2020-22
- Simple analysis of new competitive metrics

2019 edition to be released in May 2020

Recent cost evolution



Note: This data is for the year of commissioning. The diameter of the circle represents the size of the project, with its centre the value for the cost of each project on the Y axis. The thick lines are the global weighted-average LCOE value for plants commissioned in each year. Real weighted average cost of capital (WACC) is 7.5% for OECD countries and China and 10% for the rest of the world. The single band represents the fossil fuel-fired power generation cost range, while the bands for each technology and year represent the 5th and 95th percentile bands for renewable projects.

- Average LCOE of all renewable power generation technologies, except CSP fall in fossil fuel cost range
- Bioenergy, geothermal, hydro and onshore wind all at lower end of fossil cost range
- Solar PV rapidly falling towards lower end.
- Offshore wind and CSP have much lower deployment. Data suggests costs will continue to fall.

Today's strong business case for renewable power: Levelised Cost of Electricity Declines

	2017 to 2018	2010 to 2018
Solar PV	-13%	-77%
CSP	-26%	-46%
Offshore wind	-1%	-20%
Onshore wind	-13%	-35%

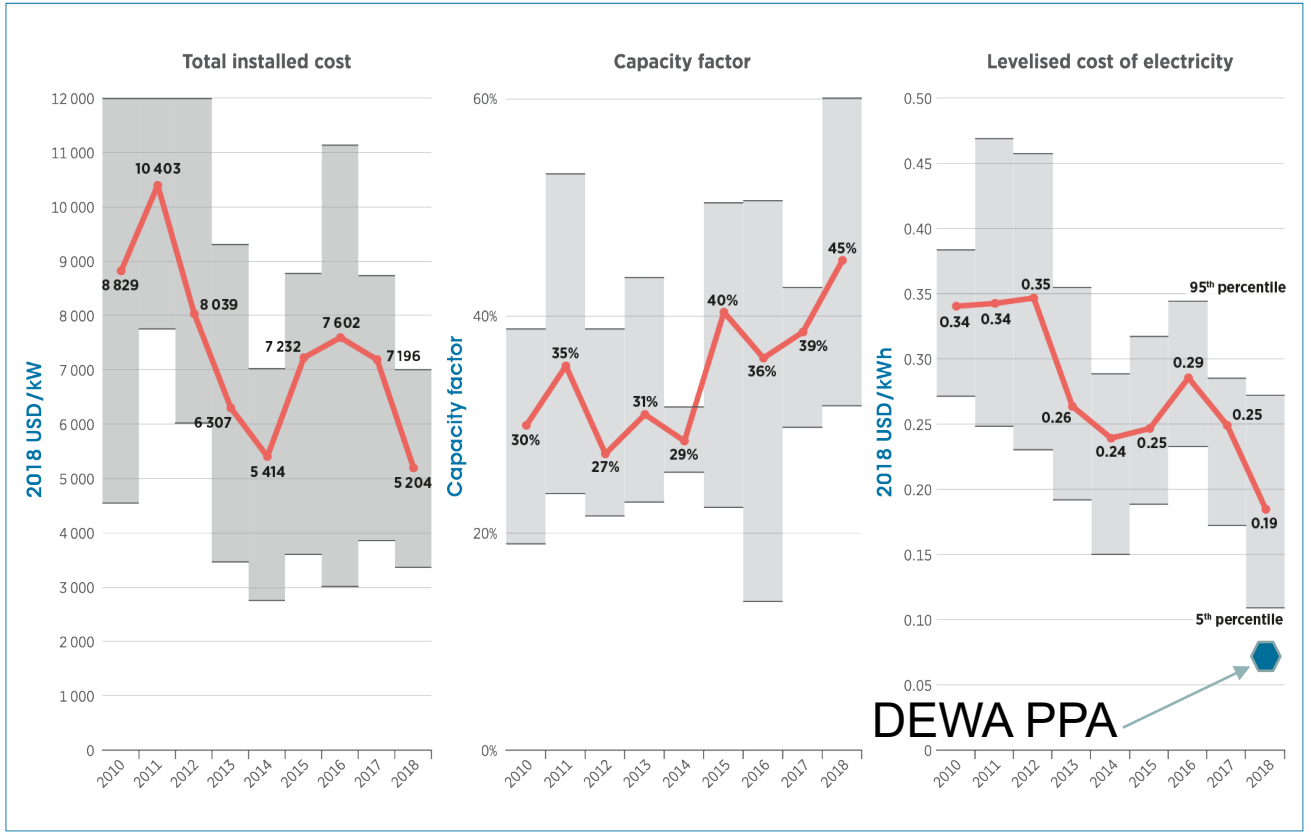
Source: IRENA. End dates: onshore 2020, Solar PV 2019, Offshore wind 2021, CSP 2022

CSP costs and performance

Market is thin, so significant volatility, but downward trend in LCOE is clear

Future cost reductions are coming

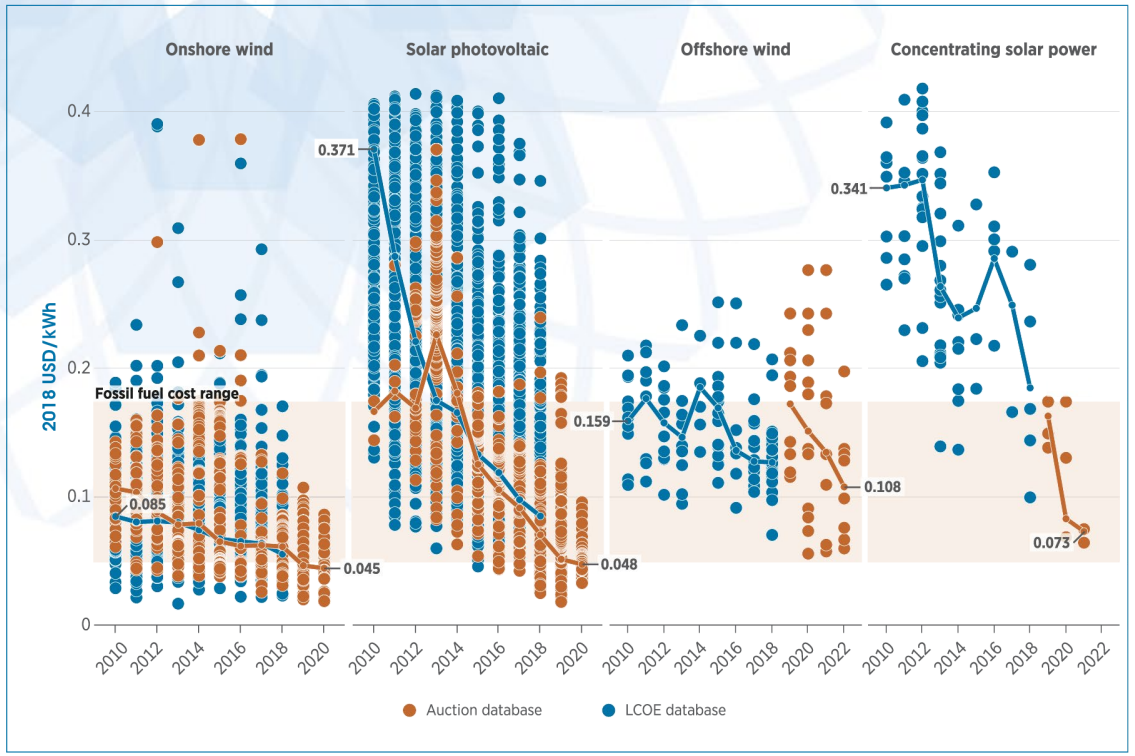
Figure S.7 Global weighted average total installed costs, capacity factors and LCOE for CSP, 2010–2018



Global levelised cost of electricity

by project and global weighted-average

2010 to 2020/22



Solar PV **-87%**

CSP **-79%**

Offshore wind **-47%**

Onshore wind **-32%**

What's going on?
Trends in CSP projects

Shift to better resource quality locations from 2012

Lower cost of capital

Experienced project developers

Competitive procurement

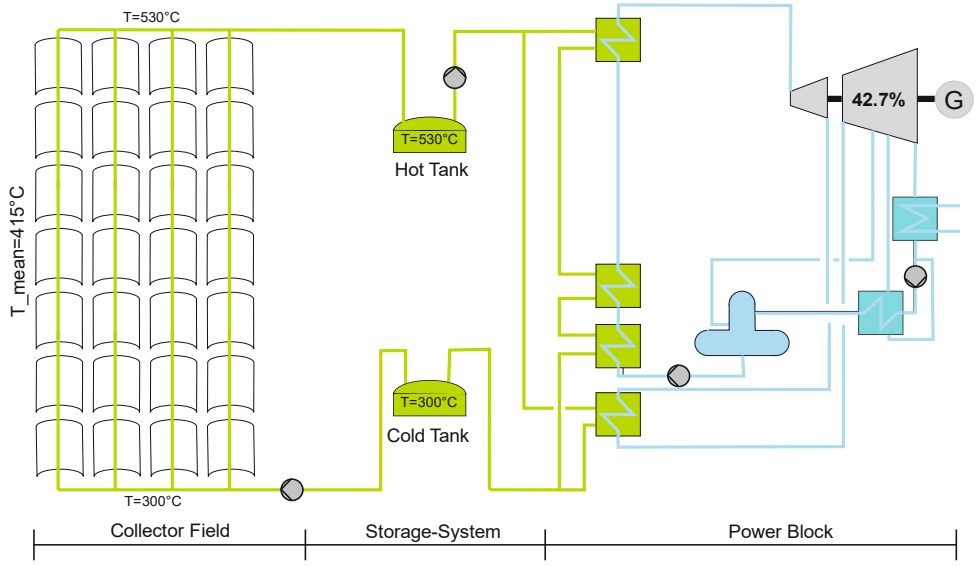
More competitive supply chains

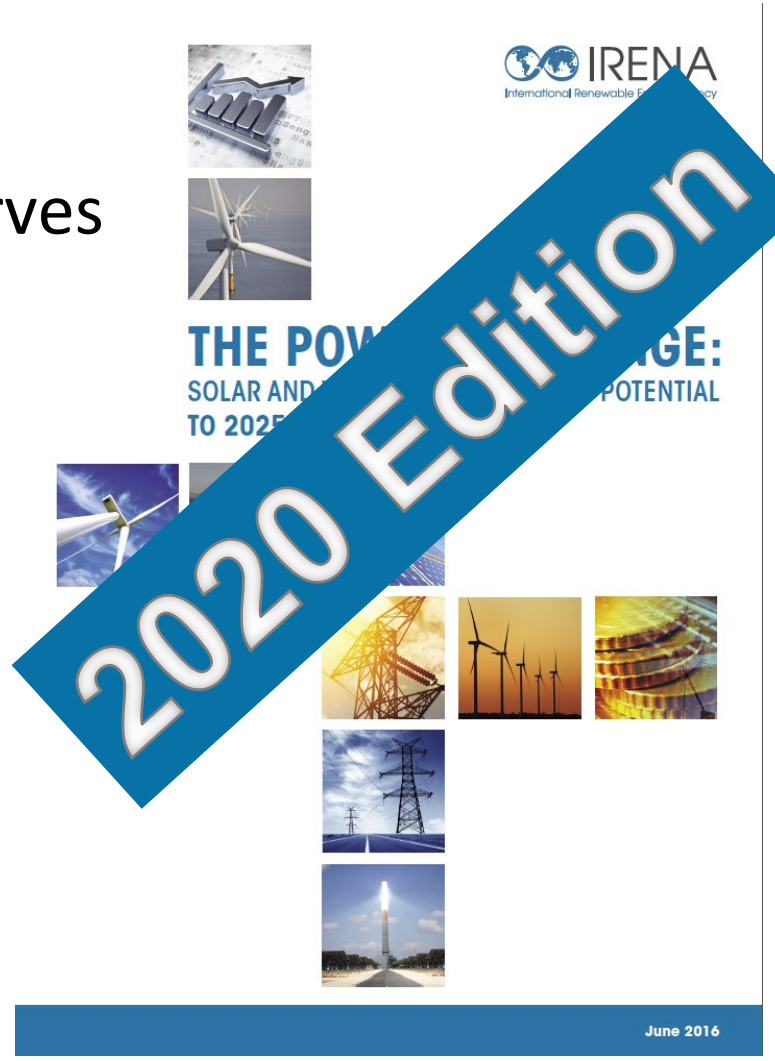
Technology improvements

CSP COST REDUCTION POTENTIAL TO 2030

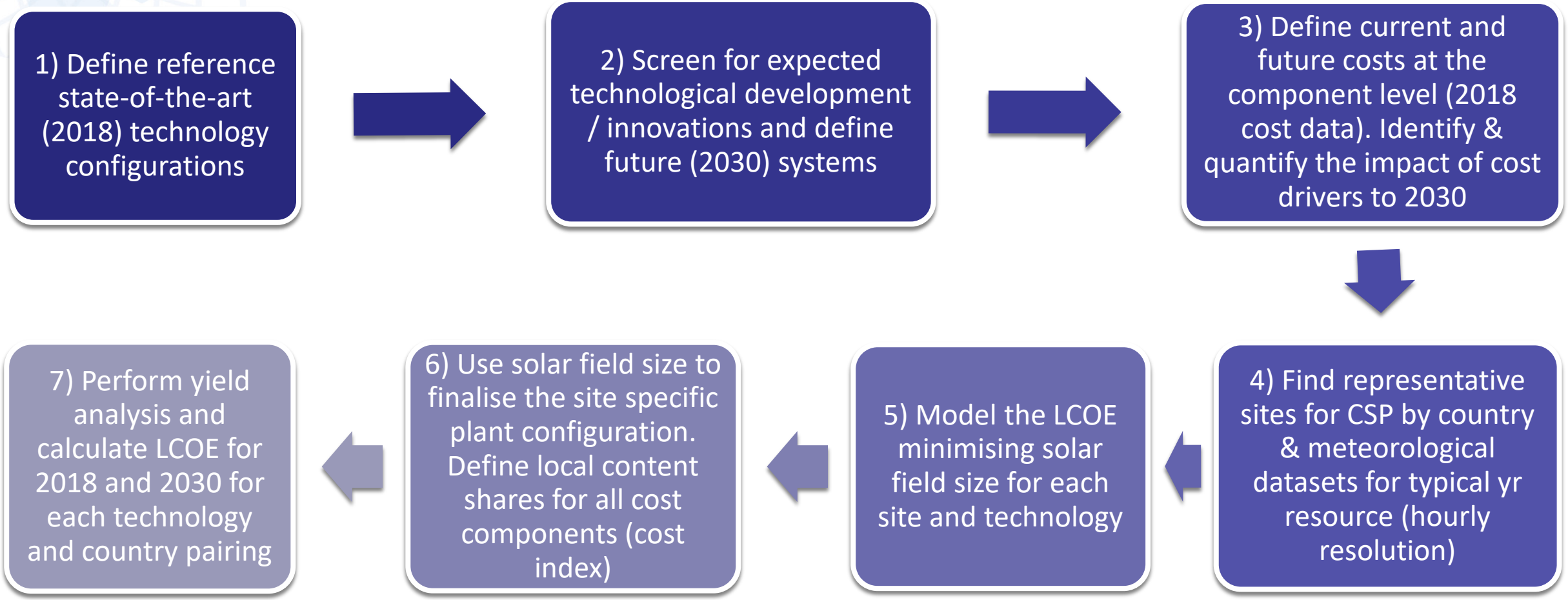
Upcoming work on CSP

Update of “Power to Change” report, expanded to:
-G20 countries
-Mix of techno-economical analysis and learning curves
-More country level insights

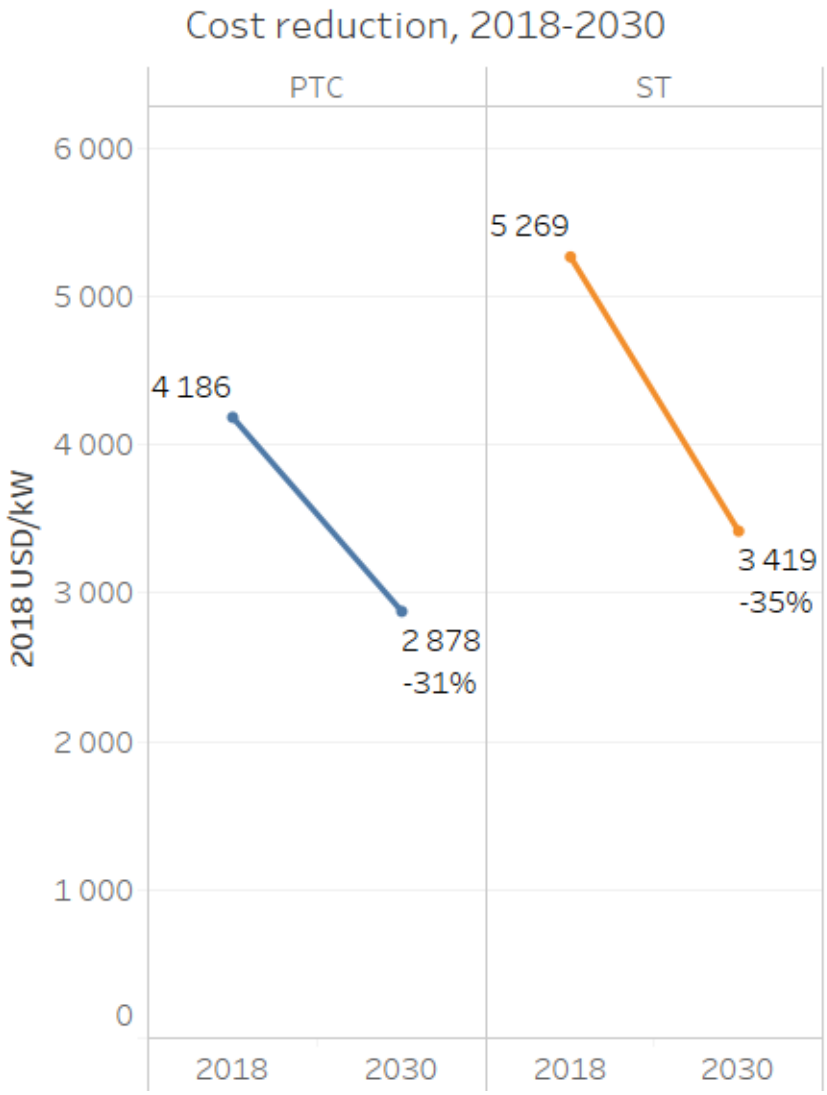


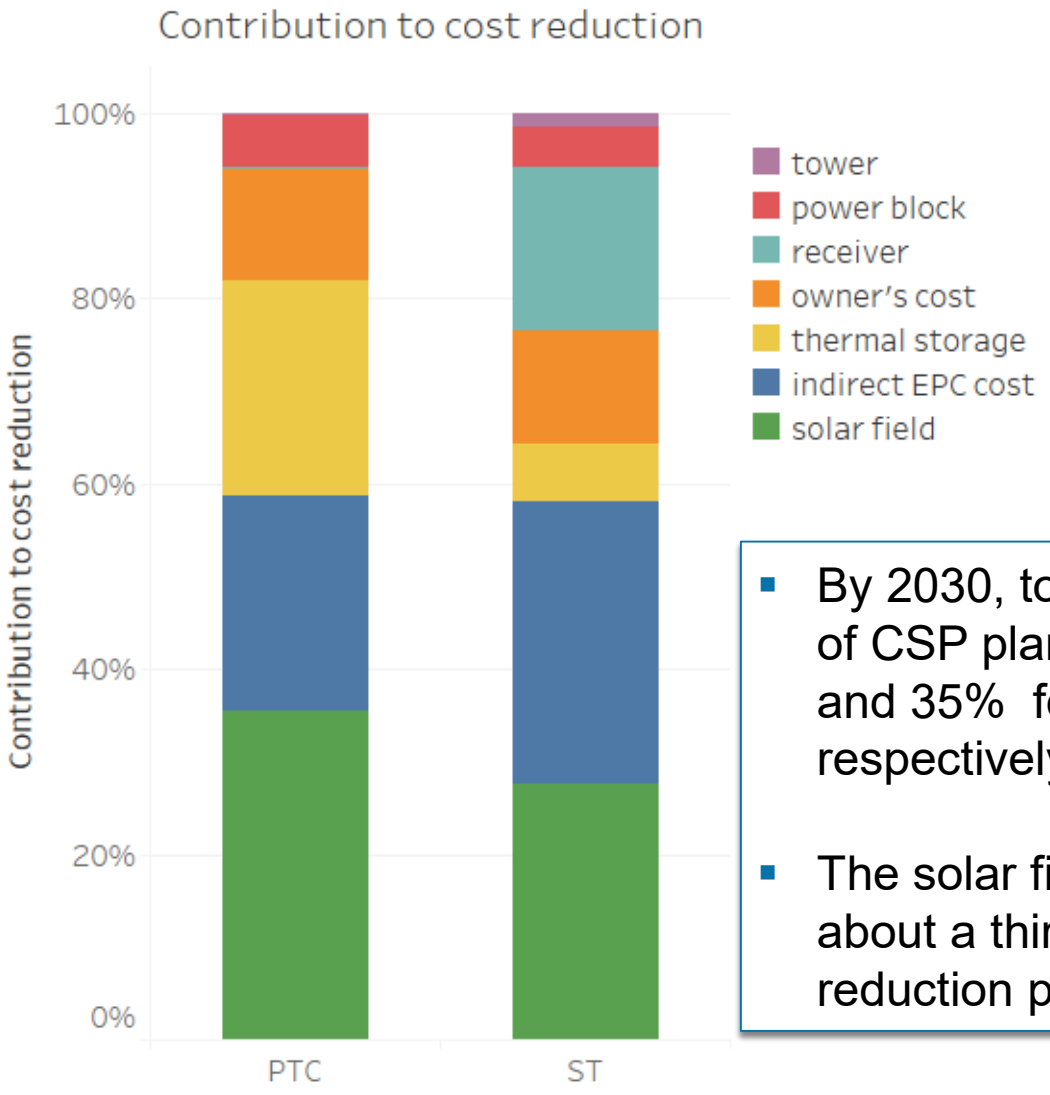


Cost reduction methodology



3) CSP total investment cost for the reference plant





- By 2030, total investment costs of CSP plants to decrease 31% and 35% for PTC and ST respectively.
- The solar field to contribute about a third of the cost reduction potential.

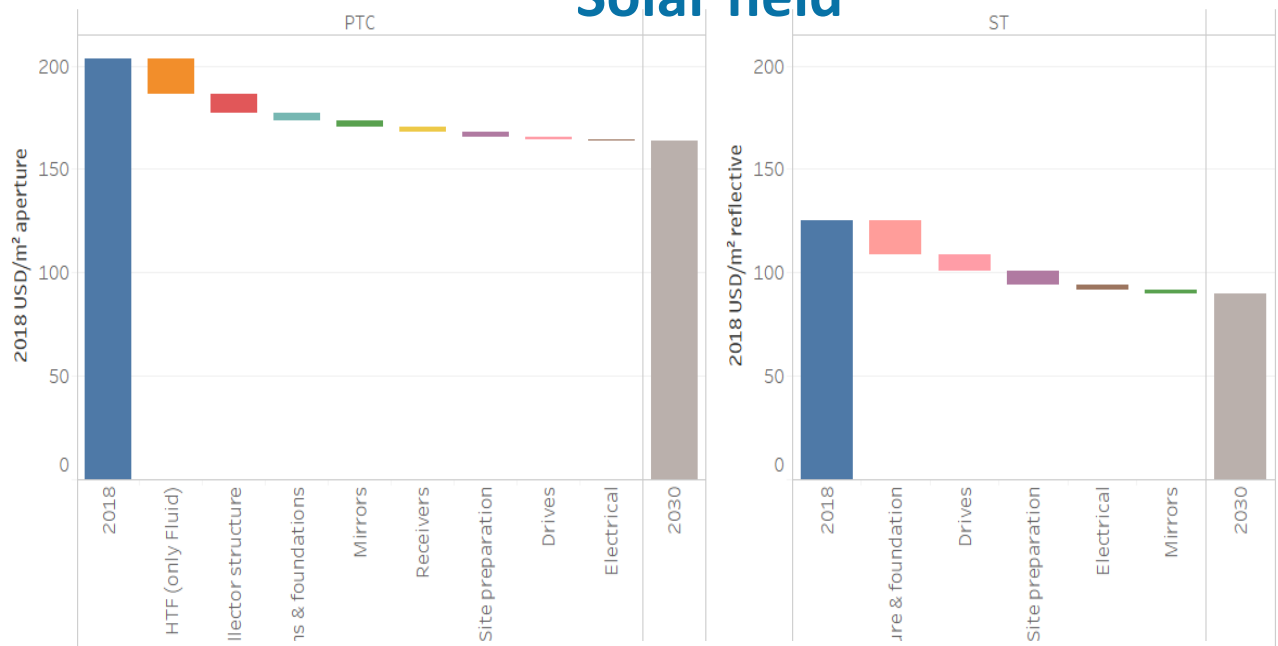
3) CSP costs reduction potential to 2030:

Installed cost by component

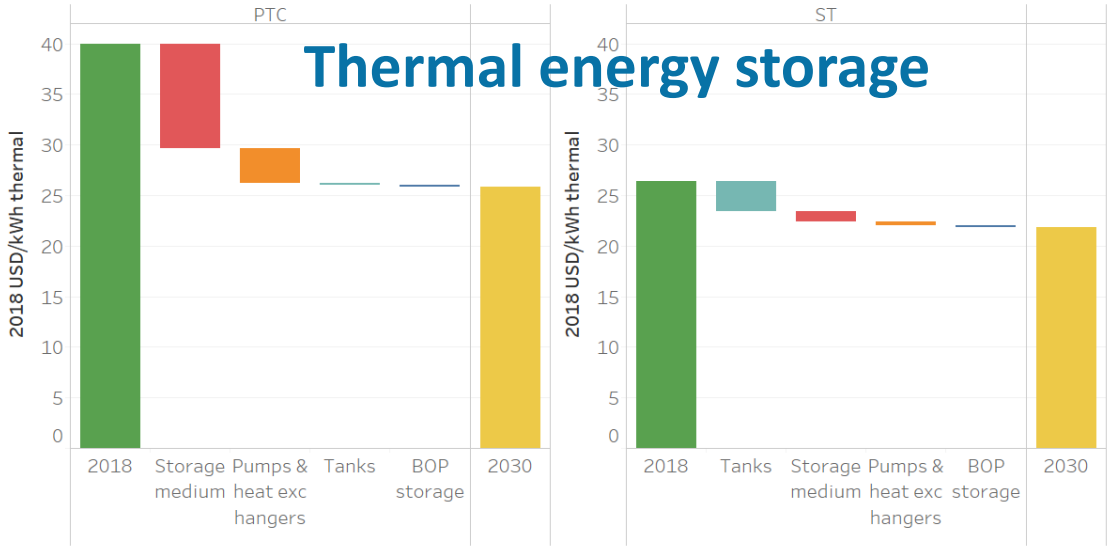
Generic plant configuration for PTC and solar towers to establish cost benchmark

Detailed component level analysis to 2030

Solar field



Thermal energy storage

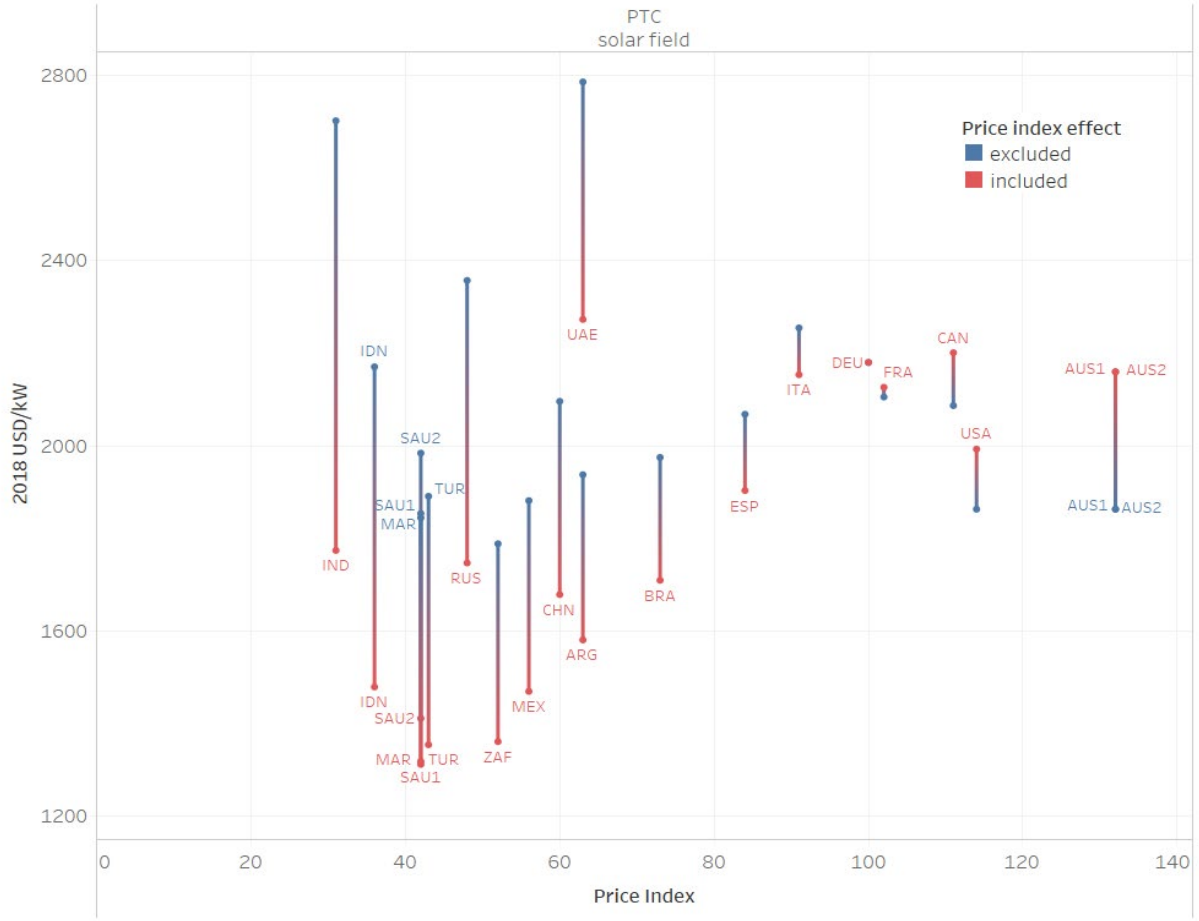


5 & 6)
Determine site specific solar field and costs

Based on locations and storage size, optimal solar field size is simulated

This sets reference plant configuration costs

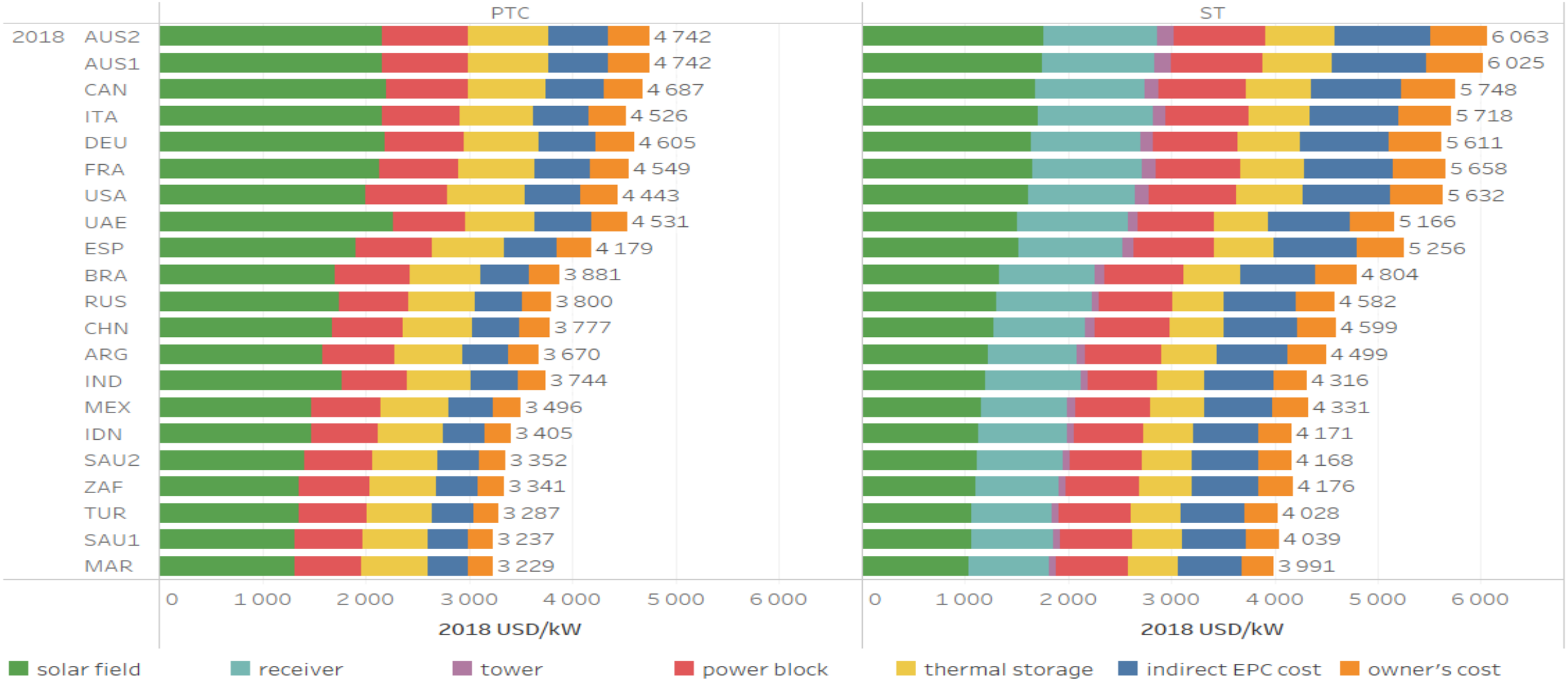
Local content shares and impact then shifts costs up or down relative to benchmark



2018 PTC solar field costs

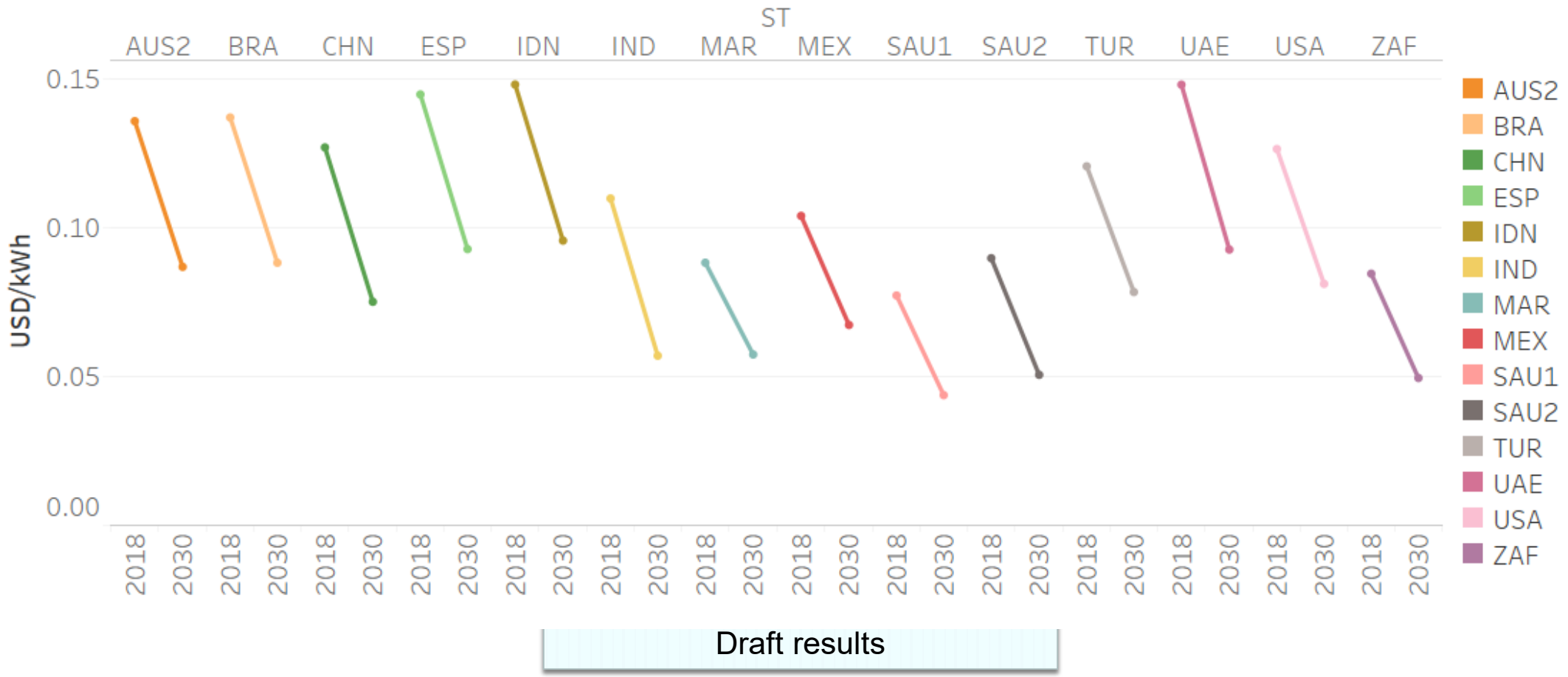
6) Results in significant variation in installed costs

Total installed cost breakdown of country-specific PTC and ST plants, 2018



CSP costs reduction potential to 2030:

7) Levelised cost of electricity

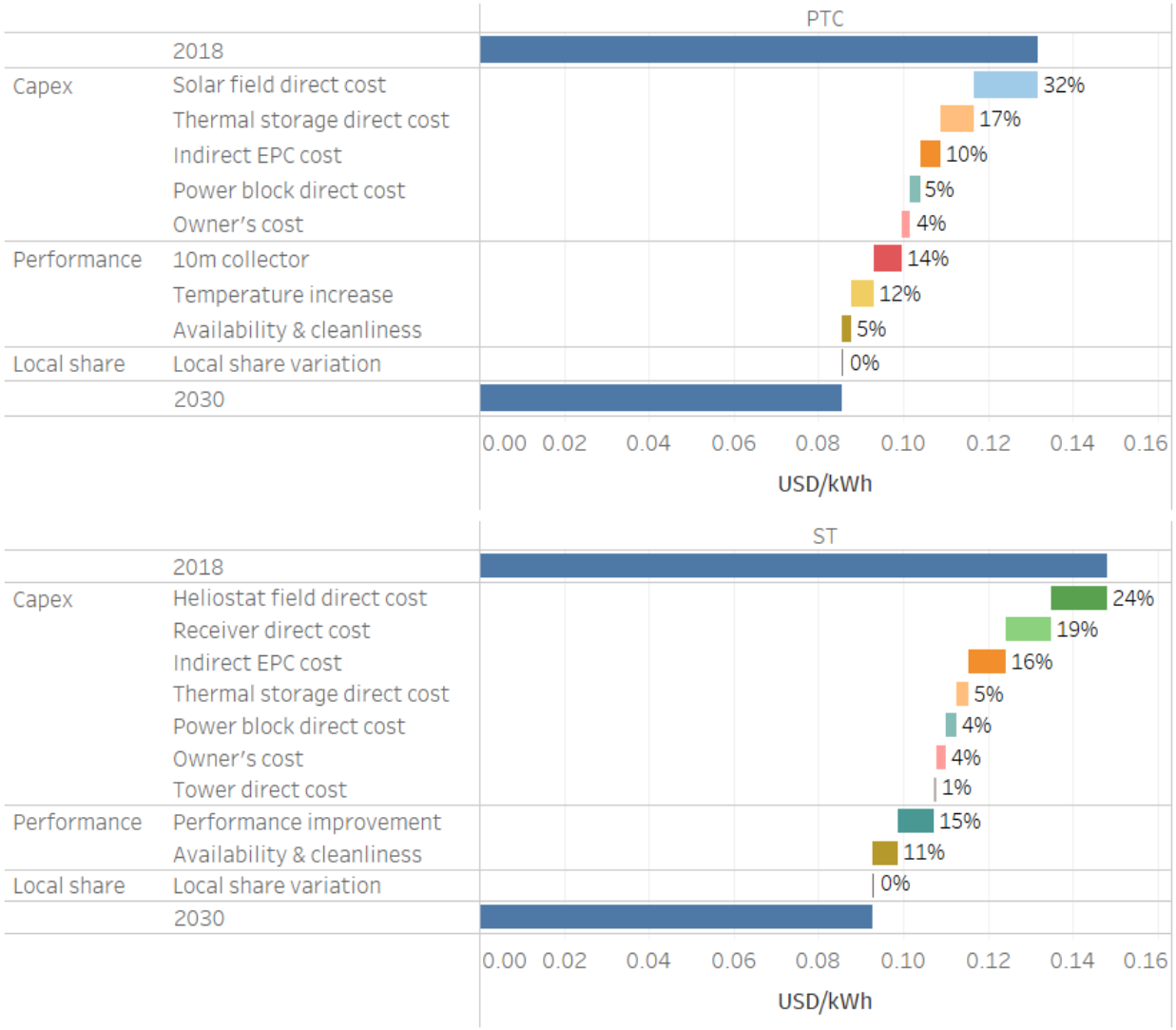


Draft results

Highly competitive dispatchable power by 2030 in high DNI locations

CSP costs reduction potential to 2030:

7) Cost reduction drivers



Both technologies benefit from

-increased competition in supply chain

- technology improvement that reduce costs & improve performance

But some specific differences in both tech drivers and magnitude of contribution to cost reduction

Renewables are increasingly competitive

The winners are customers, the environment and our future

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3. Upcoming work: CSP

Reference plant key design parameters summary

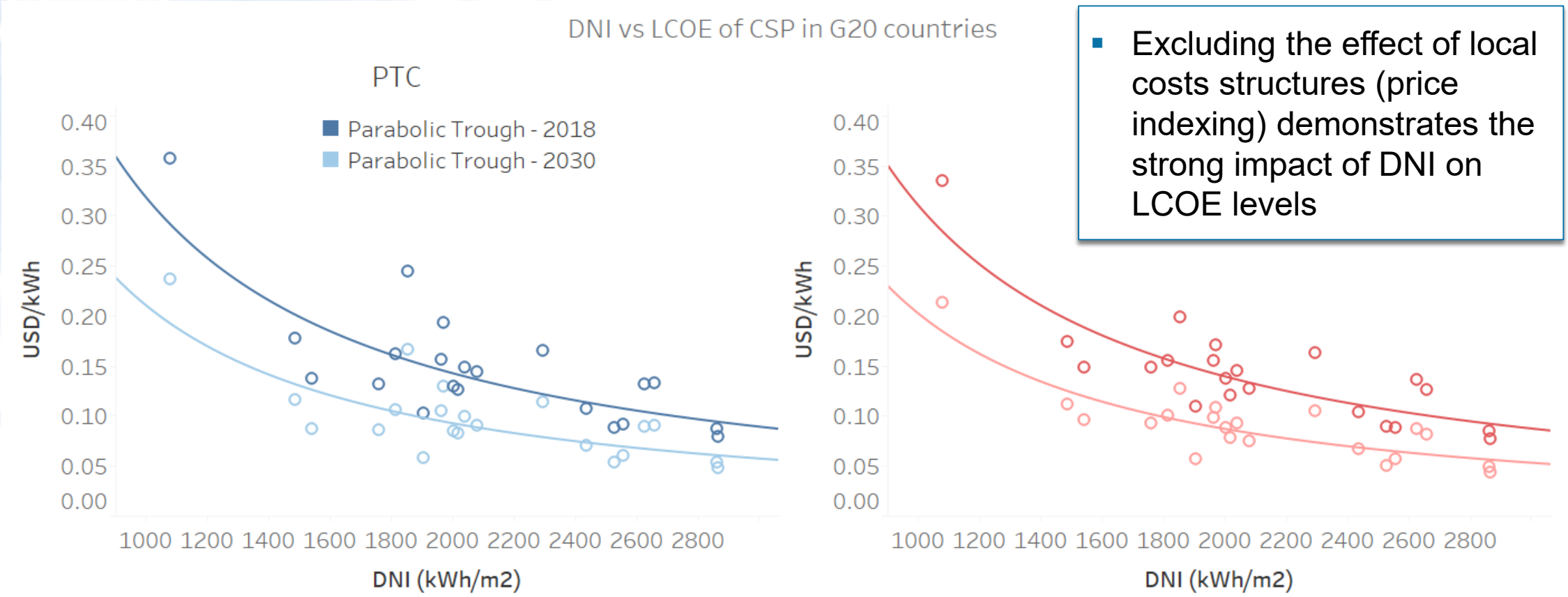
		Parabolic Trough		Solar Tower	
Design Parameters	**Unit**	**2018**	**2030**	**2018**	**2030**
Solar collector / heliostat		Ultimate Trough®	10m Future Trough	Heliostat based on the Sanlucar 120 type of Abengoa	Future Heliostat
Heat transfer fluid (HTF)		BP/DPO	Ternary Salt[1]	Solar Salt	Solar Salt
Storage medium		Solar Salt[2]	Ternary Salt	Solar Salt	Solar Salt
Maximum HTF temperature	[°C]	393	530	565	600
Thermal energy storage capacity (full load hours)	[h]	7	7	10	10
Gross electrical output	[MW]	150	150	150	150

[1] Ternary salt mixtures offer the advantage of reduced solidification temperature. They are composed of three chemical components. One commercial example is Hitec, composed of 7 mol% sodium nitrate (NaNO3), 49 mol% sodium nitrite (NaNO2) and 44 mol% potassium nitrate (KNO3).

[2] Solar Salt: 60wt% sodium nitrate ($NaNO_3$) and 40wt% potassium nitrate (KNO_3)

Cost reduction potential… CSP

Solar resource availability largely determines LCOE limits



- Excluding the effect of local costs structures (price indexing) demonstrates the strong impact of DNI on LCOE levels

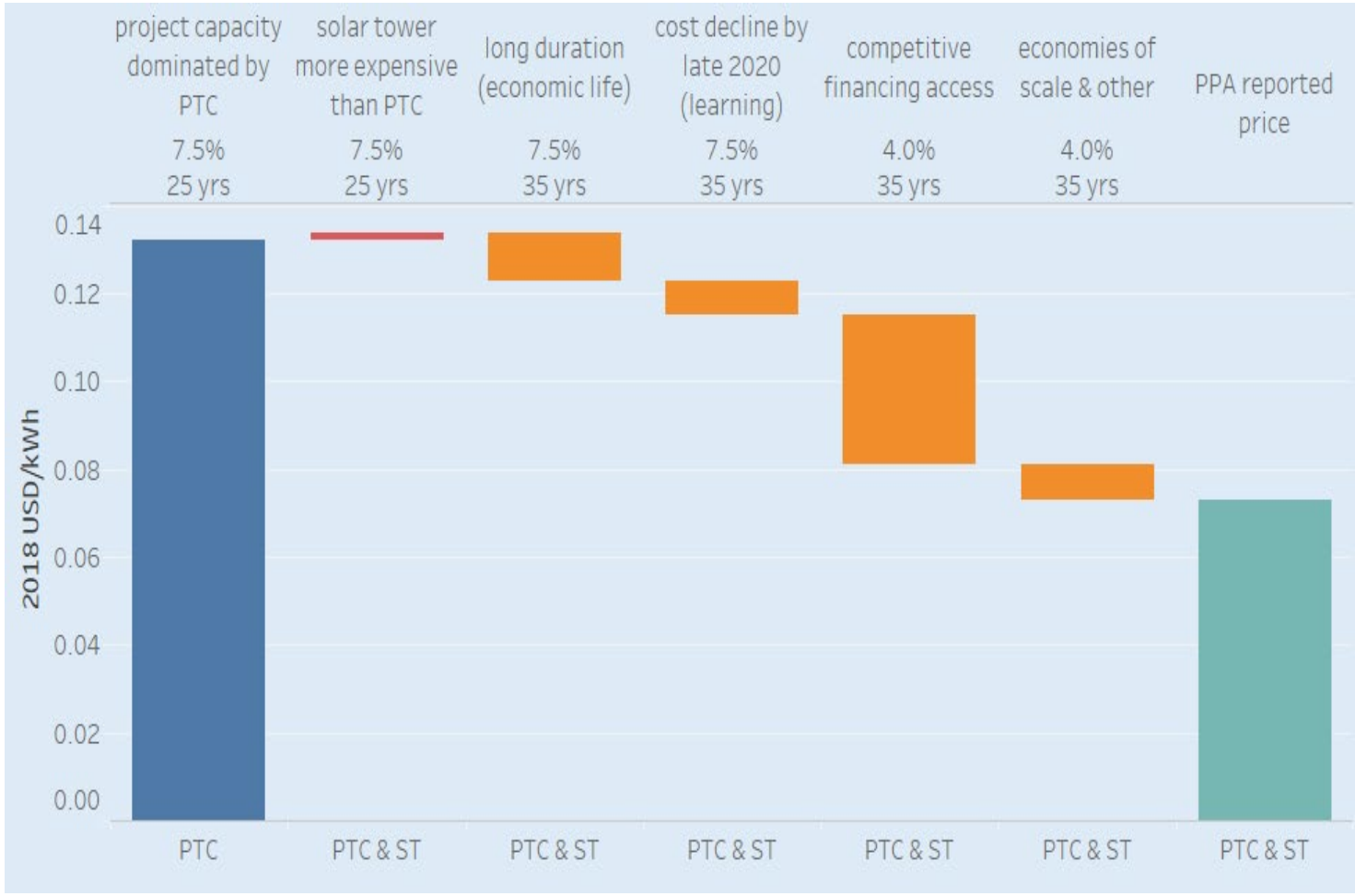
Source: IRENA and DLR

Our data vs DEWA PPA

Complicated analysis given blended project

Key drivers of low cost:

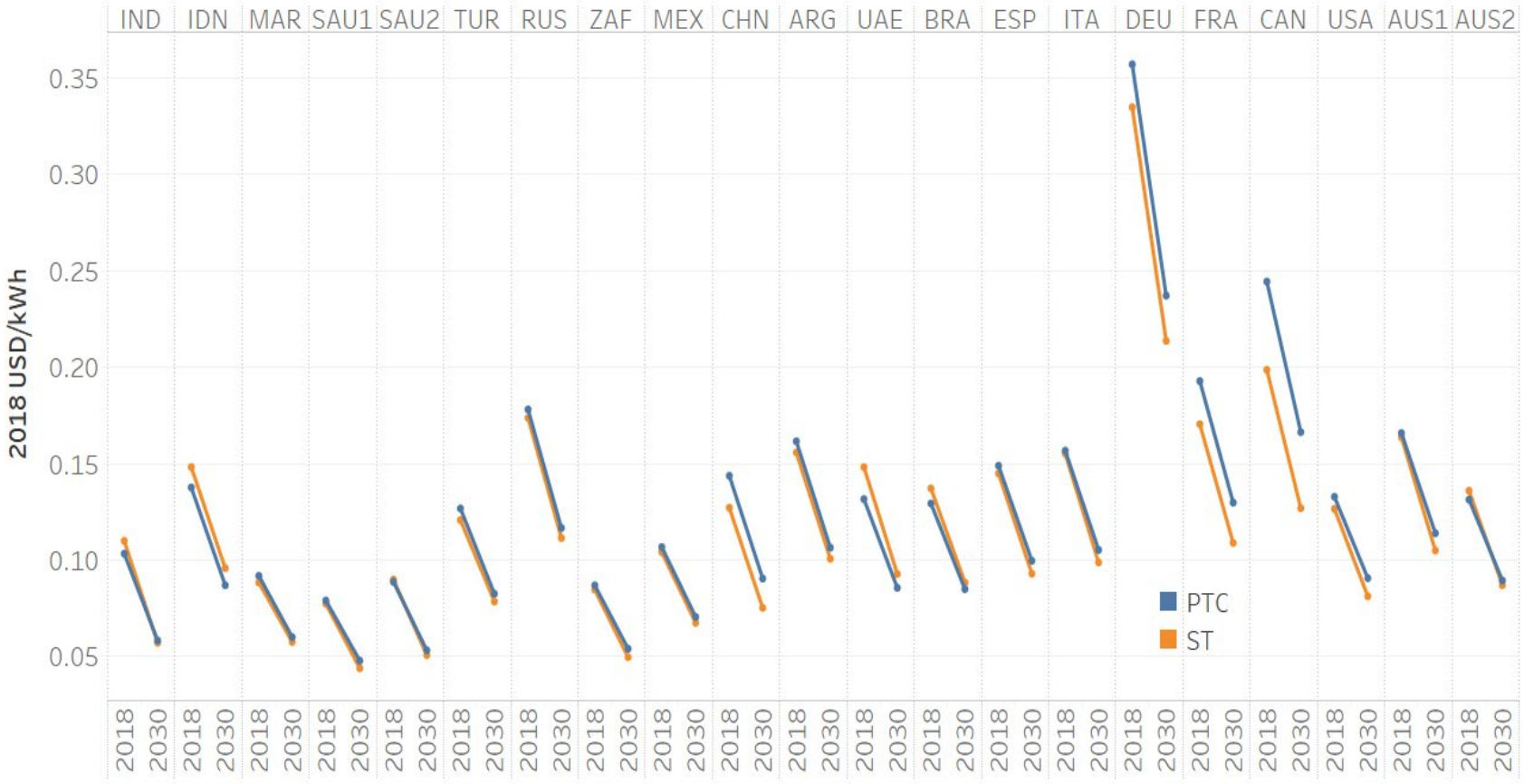
- **Financing**
- **Long-term PPA**
- **Economies of scale**
- **Ongoing cost reductions**



Cost reduction potential… CSP

CSP already very attractive in several countries with high solar resources

- Both analyzed CSP technologies (PTC and ST) expected to decline further increasing competitiveness in even more markets



Source: IRENA and DLR, 2018. Note countries sorted by lowest price index.