LCOE Reduction Potential of Parabolic Trough and Solar Tower Technology in G20 Countries until 2030

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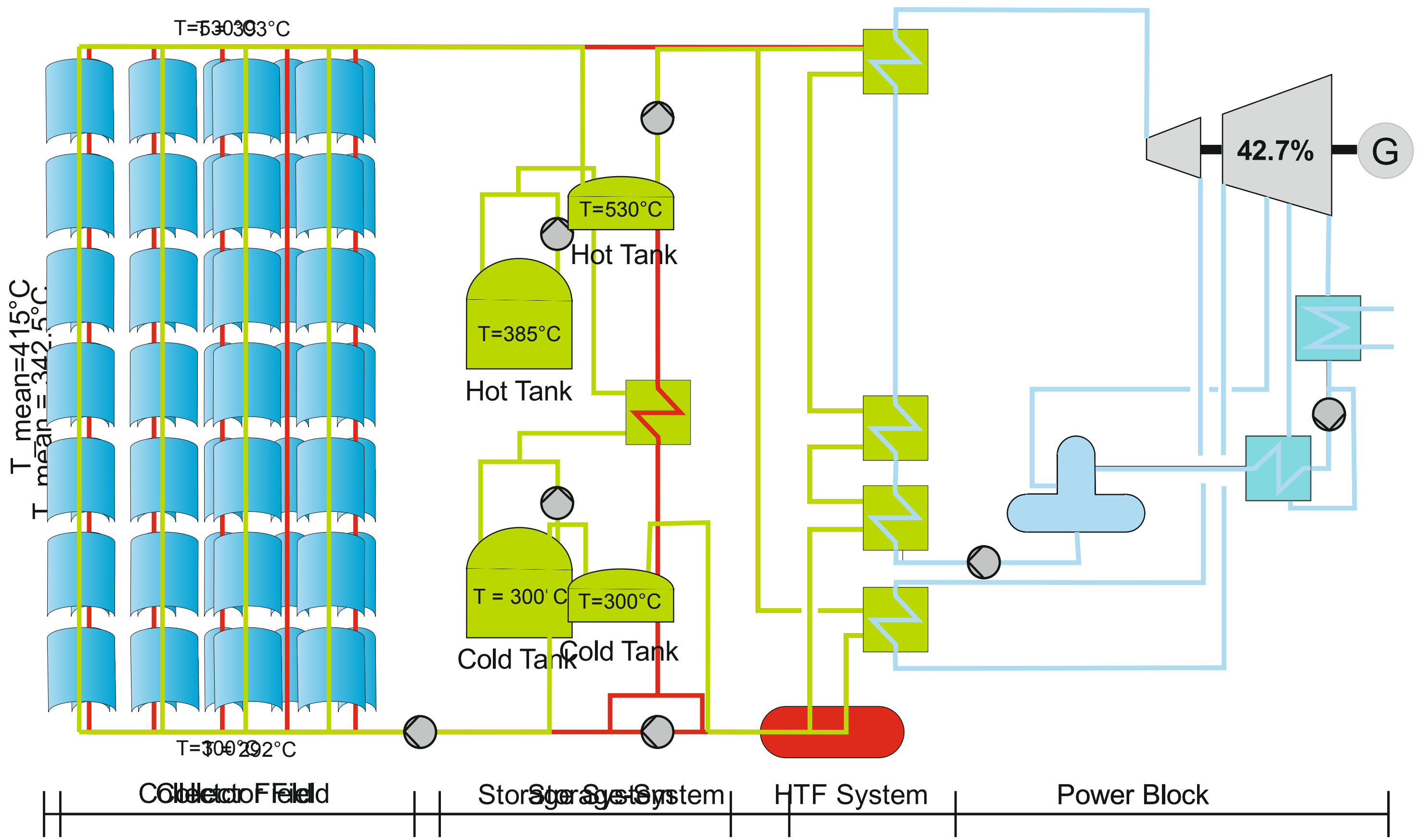
Introduction

- Concentrating solar technology today has the lowest deployment among all commercially available renewable power generation technologies
- Due to the integrated thermal storage technology it has a special role amongst fluctuating renewable power generation systems
- This study was performed to compile a cost database and to estimate future costs mainly based on technological development
- The future cost estimates assuming a further deployment of CSP technology
- This study is a follow up of a comparable study from 2016
- Horizon for cost projections is now 2030
- Individual solar resource and solar field layout for G20 countries plus Morocco and UAE have been considered

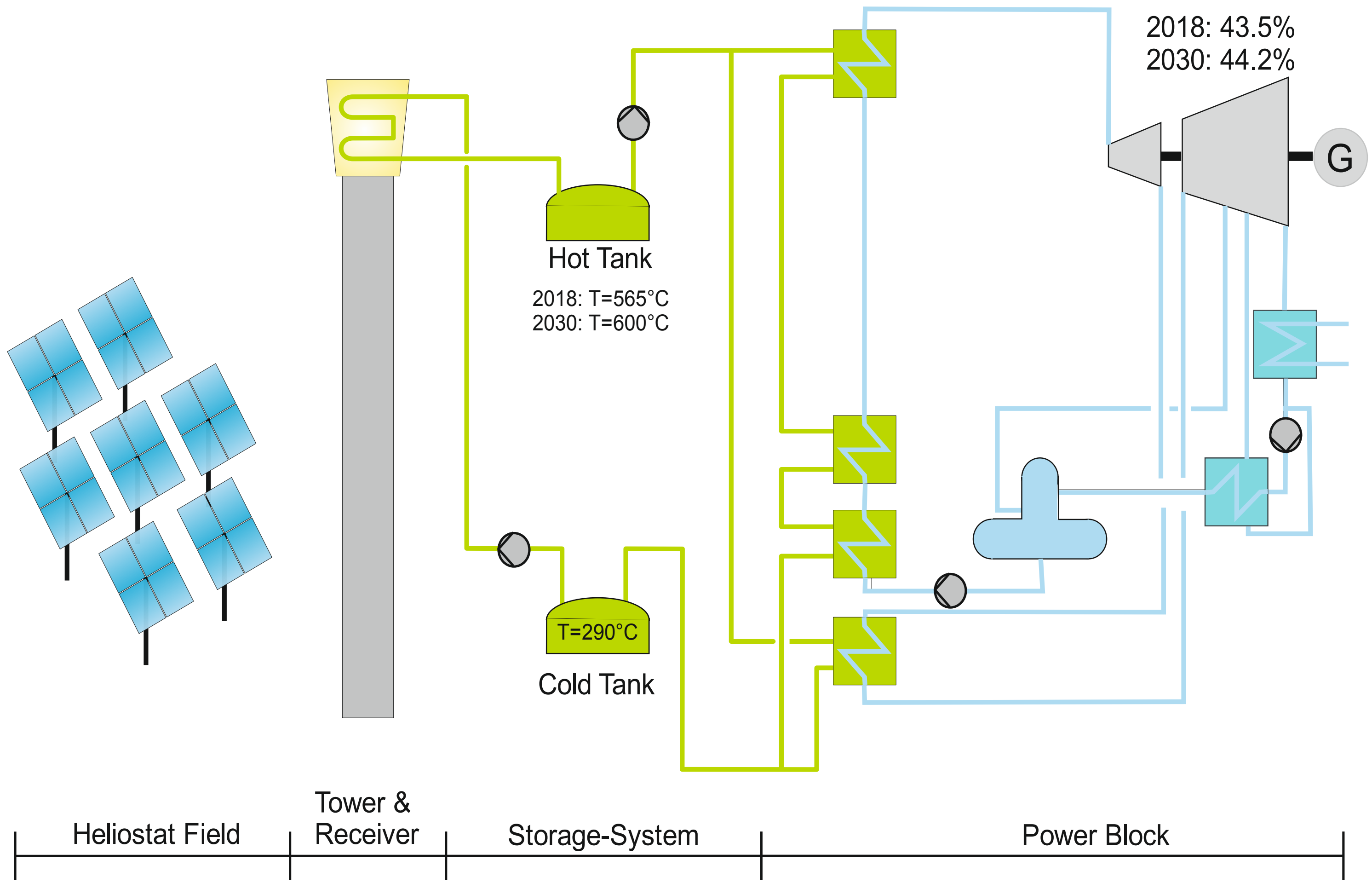
Methodology

- Definition of reference state-of-the-art (2018) systems
- Screening for expected technological development / innovations and definition of future (2030) CSP systems.
- Definition of representative sites for CSP in all G20 countries and determination of meteorological datasets
- Searching for the solar field size leading to the lowest LCOE for each site and technology.
- Definition of current and future component cost benchmarks
- Definition of local content for all costs and calculation of local costs based on a published cost index
- Yield analysis and solar field dimensioning was made with the software greenius
- Calculation of LCOE for 2018 and 2030 for each country using individual costs and individual yield. The same interest rate of 7.5% was used for all countries.

Reference (2018) and future (2030) trough system



Reference (2018) and future (2030) solar tower system



Key dimensioning parameters of the reference and future plants

		Parabolic Trough		Solar Tower	
Design Parameters	Unit	2018	2030	2018	2030
Solar collector / heliostat		Ultimate Trough®	10 m Future Trough	Heliostat based on the Sanlucar 120 type of Abengoa	Advanced future Heliostat
Heat transfer fluid (HTF)		BP/DPO	Ternary Salt[1)]	Solar Salt[2)]	Solar Salt
Storage medium		Solar Salt	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

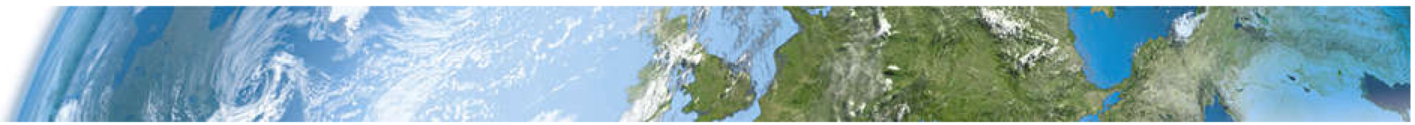
1) Ternary salt mixtures offer the advantage of reduced solidification temperature. One commercial example is Hitec, composed of 7 wt% sodium nitrate ($NaNO_3$), 40 wt% sodium nitrite ($NaNO_2$) and 53 wt% potassium nitrate (KNO_3).

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

Solar resource

Country	Annual sum of DNI from global solar atlas	Region	Latitude	Site	Annual sum of DNI from METEONORM
	kWh/m²			from METEONORM	kWh/m²
Argentinia	1900 - 2100	South west of Buenos Aires	-36.6°N	Santa Rosa Airp.	1815
Australia	2700 - 2900	Central Australia	-23.8°N	Alice Springs	2571
Australia		North Australia	-21.10°N	Whundo	2627
Australia		South Australia	-32.82°N	Whyalla	2295
Brazil	2000 - 2200	Bahia	-13.5°N	Correntina	2004
Canada	1700 - 1900	southern part of Saskatchewan	50.2°N	Regina	1856
China	1800 - 1900	Inner Mongolia	41.6°N	Haliut	2082
France	1800 - 1900	Cote'd Azur	43.1°N	Toulon	1970
Germany	1100 - 1200	South west, Freiburg	47.7°N	Konstanz	1077
India	1800 - 2000	North west, Rajasthan	26.3°N	Jodhpur	1906
Indonesia	1000 - 1300	most regions but up to 2000 in Timor	-10.2°N	Kupang	1541
Italy	1800 - 1900	Sicilia	37.1°N	Gela	1963
Japan	1100 - 1300	Region Tokyo	36.1°N	Tateno	1103
Mexico	2700 - 2800	Chihuahua, close to New Mexico	31.6°N	Ciudad Juarez	2438
Russia	1350 - 1450	Close to Caspian Sea	46.3°N	Astrahan	1487
Saudia Arabia	2600 - 2800	North west, Tabuk	28.4°N	Tabuk	2867
Saudia Arabia		Region Medinah	25.6°N	Chaibar	2529
South Africa	2900 - 3000	North west, Northern Cape	-28.4°N	Upington	2864
South Korea	1200 - 1300	whole country	37.3°N	Wonju	1033
Turkey	1800 - 2100	Southern part, Icel	38.0°N	Konya	2018
United Kingdom	1000 - 1000	Southern Coast	50.8°N	Brighton	1035
United States	2700 - 2900	California	34.9°N	Barstow	2660
European Union	2000 - 2200	Andalucia, Spain	37.2°N	Granada	2039
Morocco	2400 - 2500	Ouarzazate	30.95°N	Ouarzazate	2558
United Arab Emirates	1900 - 2000	Dubai	24.75°N	MBR Solar Park	1759

- The Global Solar Atlas was used to find the region within each country providing the highest annual DNI
- METEONORM software was used to get TMY data sets with hourly resolution for a site within this region.
- For Australia and Saudi Arabia alternative sites closer to the major consumer centres were added



Example of the cost breakdown for a parabolic trough plant (2018)

Parabolic Trough Field	Material + Labour [$/m²]	Share Material [%]	Share Labour [%]	Local content Material [%]	Local content Labour [%]	Local Cost [$/m²]	Inter-national Cost [$/m²]
SF - Site Preparation	25	40%	60%	90%	90%	22,41	2,49
SF - Collector Structure	58	50%	50%	80%	80%	46,40	11,60
SF - Pylons & Foundations	19	40%	60%	90%	80%	15,96	3,04
SF - Mirrors	15	100%	0%	0%		0,00	15,00
SF - Receivers	25	100%	0%	0%		0,00	25,00
SF - Drives	6	100%	0%	0%		0,00	6,00
SF - Electrical	4	90%	10%	80%	80%	3,32	0,83
SF - HTF (only Fluid)	21	100%	0%	0%		0,00	20,50
SF - HTF System (Rest)	31	75%	25%	30%	80%	13,18	17,83
Total PT Field	203,6					101,27	102,29
						49,7%	50,3%

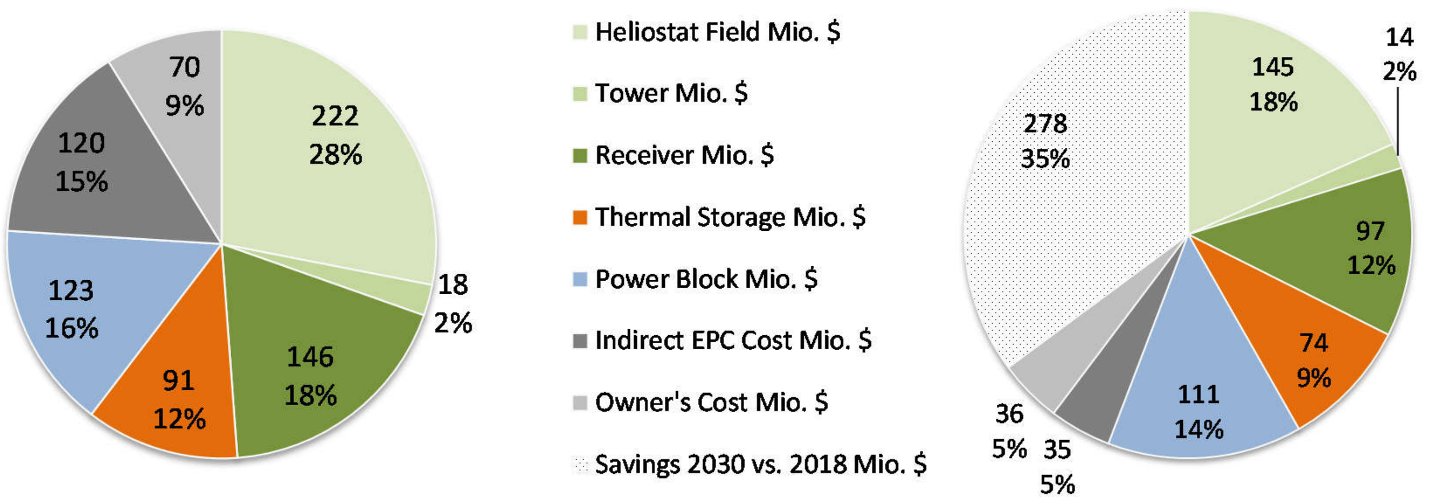
CAPEX structure in 2018 and 2030 for 150 MW plants

Parabolic Trough

2018

2030

Solar Tower



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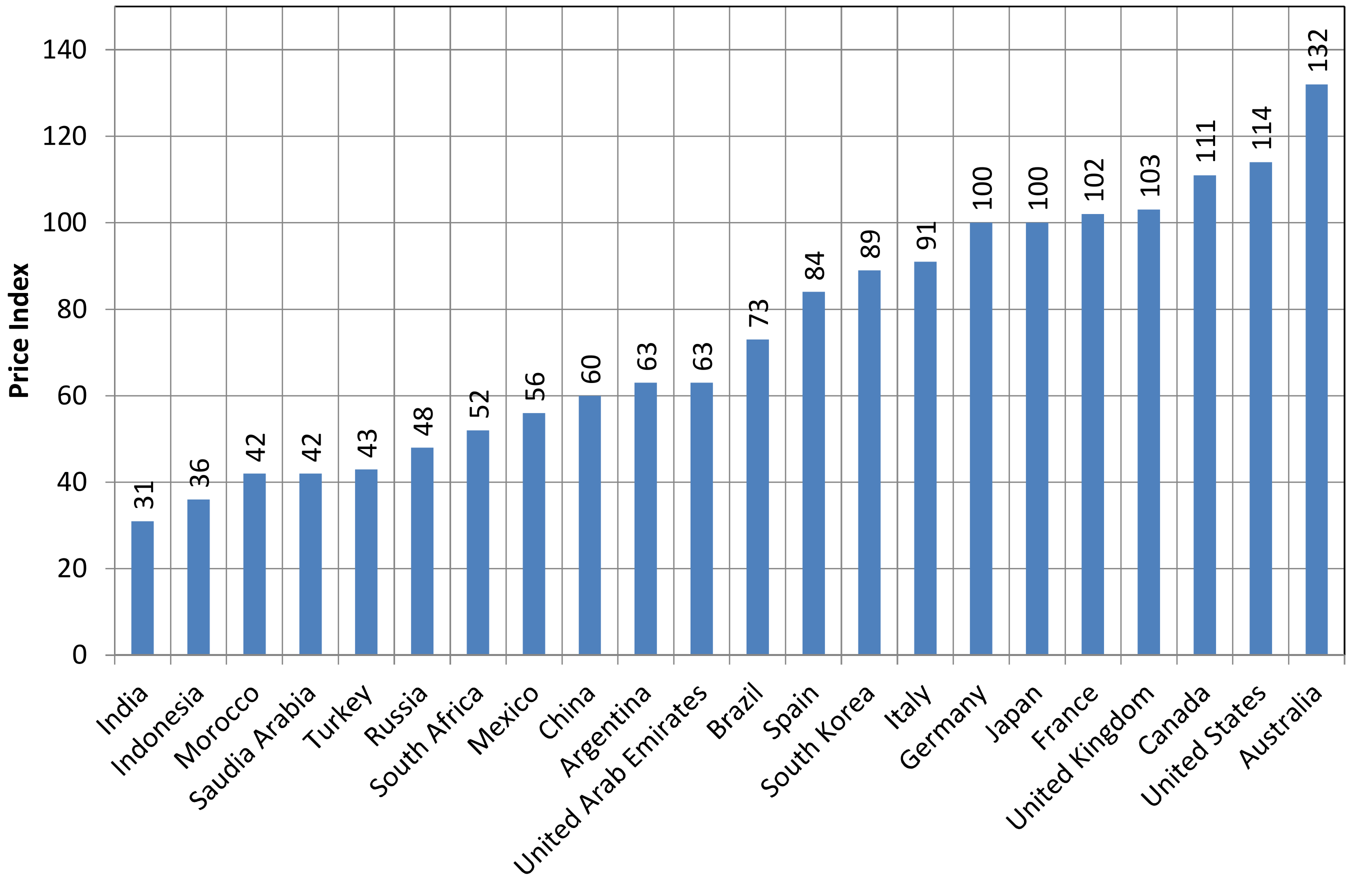
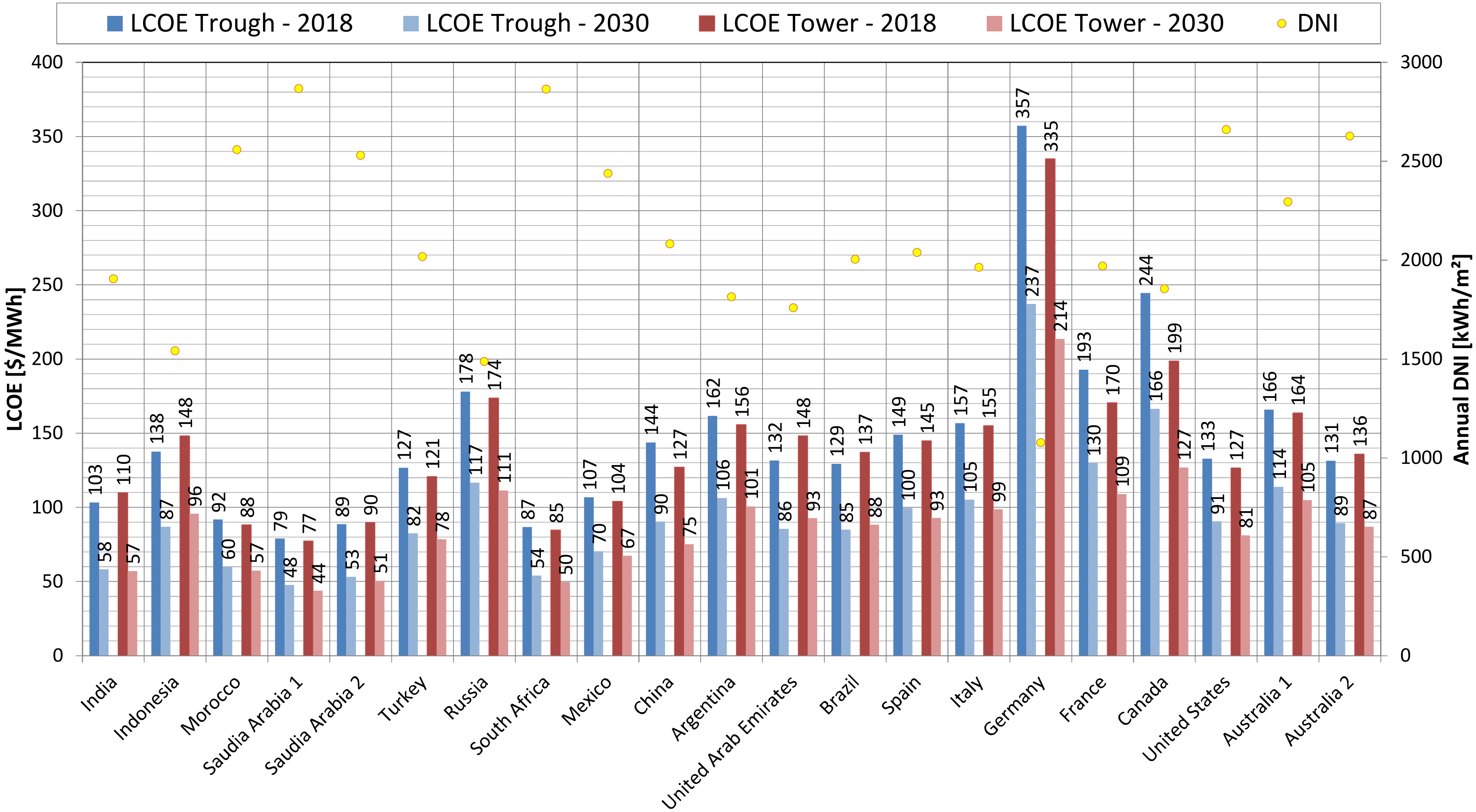
Price index = 100, system configurations for Morocco

Price index of all countries considered in this study

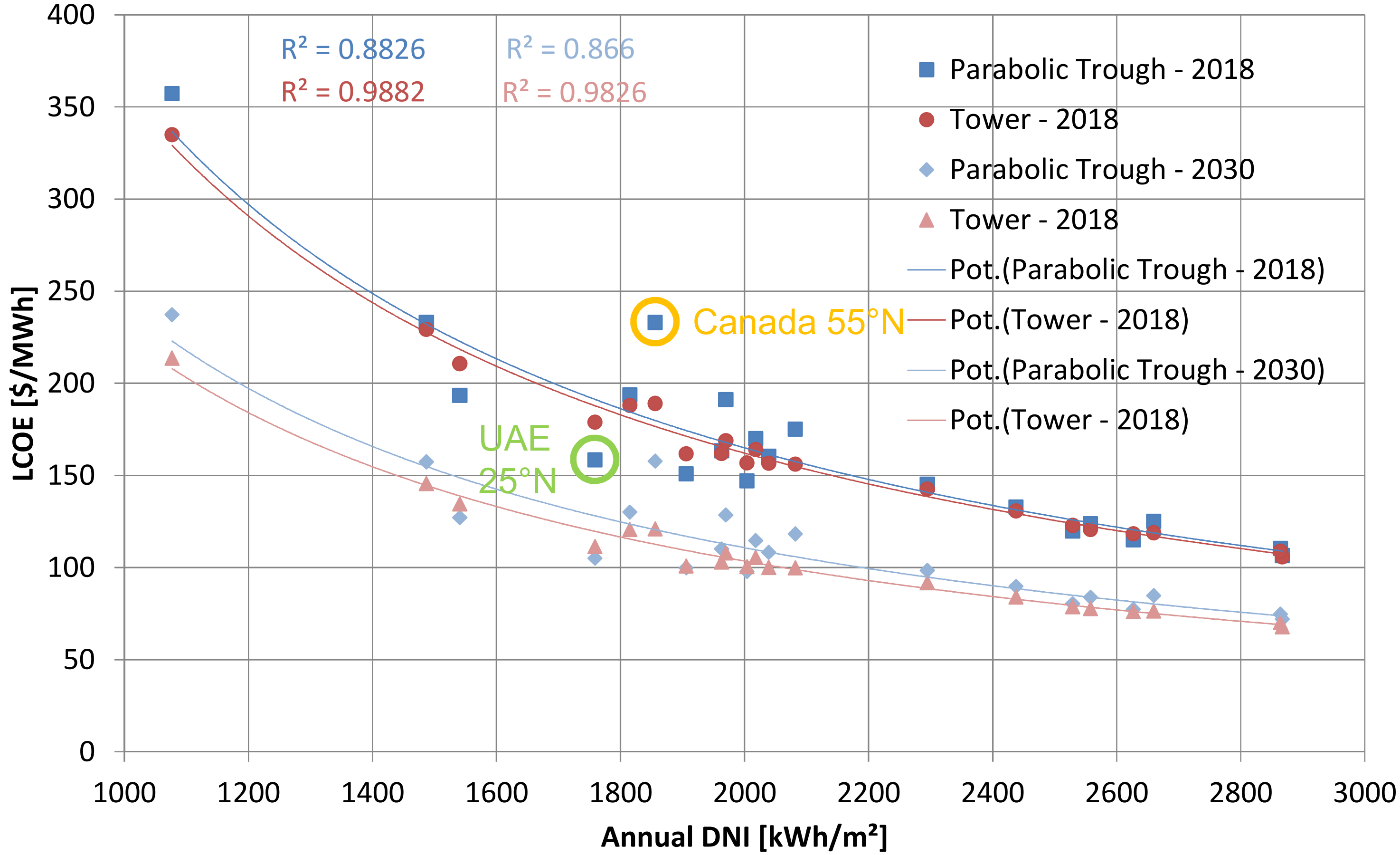


Source: OECD, "Price level indices (indicator)", 2017,
https://data.oecd.org/price/price-level-indices.htm

LCOE and DNI resource for all CSP plants sorted by price index



Impact of DNI resource



LCOE for all sites and plant types with price index set to 100.
Lines represent potential law fit curves with their respective R^2 mentioned in the graph

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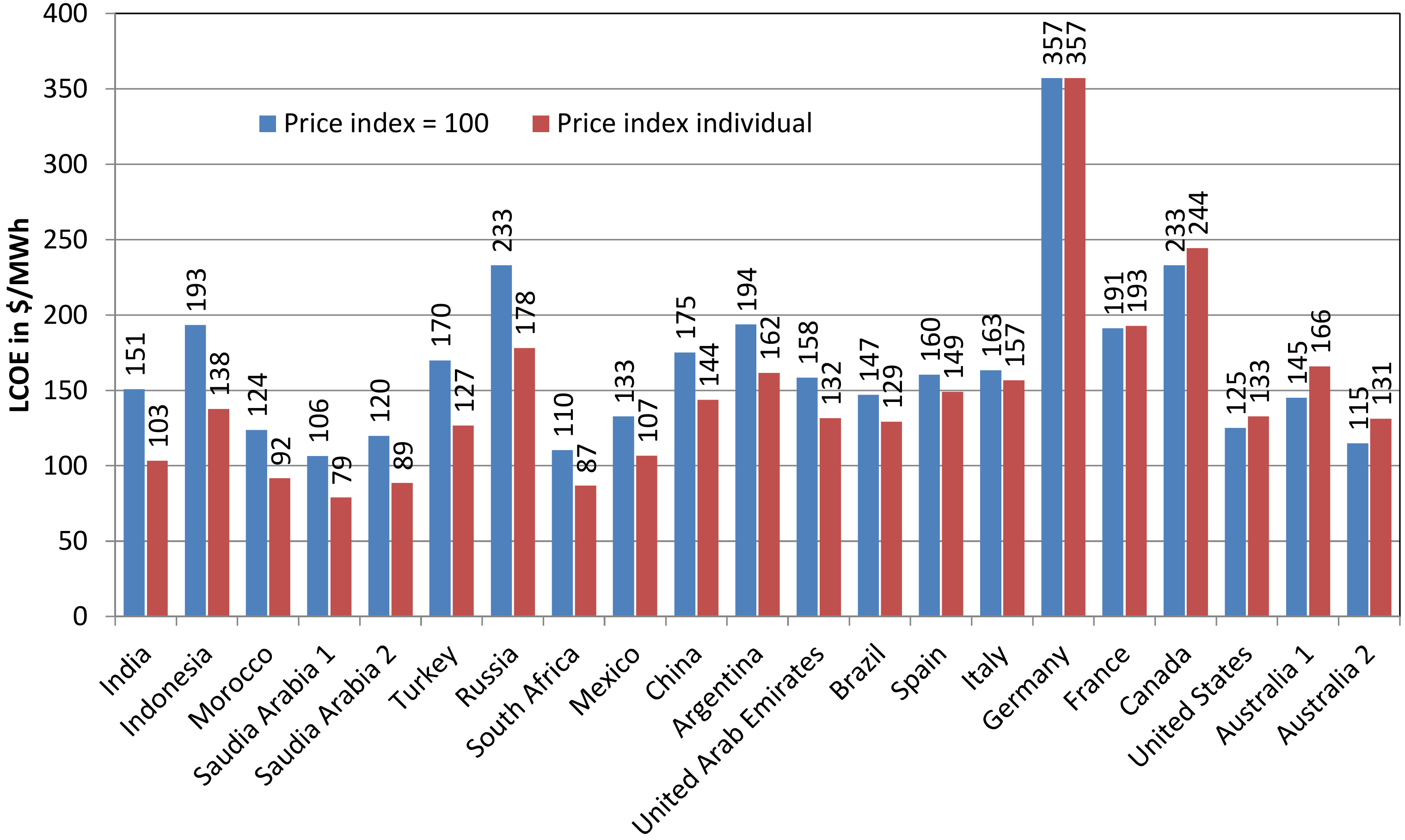
Impact of price index on LCOE
(parabolic trough plants in 2018)



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Conclusions

- The price index for G20 countries varies from 31 (India) to 132 (Australia) and together with a local content of 40-50% this may lead to a factor > 2 in LCOE with all other parameters being the same
- DNI resource is a very important parameter for LCOE
- Site latitude is also relevant, particularly for parabolic trough plants
- Assuming 7.5% WACC and 25 years of lifetime, the LCOE of dispatchable CSP electricity could fall to between USD 44 and USD 100/MWh in the G20 where annual DNI is above 1800 kWh/m²
- These numbers may not directly compared with recently published PPA data since those may be based on different interest rates and lifetimes or sometimes are blended tariffs for CSP/PV plants