Renewable Power Generation Costs in 2020: Cost Declines and Record Capacity Additions
Renewable Power Generation Costs in 2020

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2017

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2018

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2019

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Associate Professional, Renewable Cost Status and Outlook

2020
Power generation and PPA/tender databases

Project cost database
~20k projects
1982 GW

PPA/Auction database
~13k projects
583 GW
What’s new in the 2020 report

New WACC assumptions

Solar thermal heat for commercial/industrial use

Some new cost/performance metrics for power gen

Behind-the-meter battery storage costs

Hybrid solar PV/storage pricing vs CSP

Snapshot: Low-cost renewable hydrogen today?
In most parts of the world, RE is the least-cost source of new electricity:

- 62% of utility-scale capacity added in 2020 cost less than the cheapest new coal option.

Will increasingly undercut even operating costs of existing coal.

Low-cost renewable electricity to be the backbone of the electricity system:

- But is also the key to decarbonising the wider energy system.
Recent cost evolution

Source: IRENA Renewable Cost Database

Note: The comparison for CSP is the annual compound percentage reduction for 2018-2020, given that the 2019 value was something of an anomaly. Comparing against 2019 would see the year-on-year reduction rise to 49%.
Recent cost evolution

- Average LCOE of all renewable power generation technologies fall in fossil fuel cost range in 2020.

- Bioenergy, geothermal, hydro, solar PV and onshore wind all at lower end or undercutting. CSP midway

Source: IRENA Renewable Cost Database

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 values for plants commissioned in each year. Real WACC was 7.5% in 2010 and 5% in 2020 for OECD countries and China, and 10% in 2010 and 7.5% in 2020 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.
Recent cost evolution

- The PPA data available to IRENA is becoming smaller proportion of total installed capacity
- Useful insights particularly for identifying where market is heading and what is possible in best possible conditions

Source: IRENA Renewable Cost and Auction and PPA Databases
Today’s strong business case for renewable power: Levelised Cost of Electricity Declines

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>2018 - 2020</th>
<th>2010 - 2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar PV</td>
<td>-7%</td>
<td>-85%</td>
</tr>
<tr>
<td>CSP*</td>
<td>-16%</td>
<td>-68%</td>
</tr>
<tr>
<td>Offshore wind</td>
<td>-9%</td>
<td>-48%</td>
</tr>
<tr>
<td>Onshore wind</td>
<td>-13%</td>
<td>-56%</td>
</tr>
</tbody>
</table>

Source: IRENA. Note CSP LCOE in 2019 excludes projects in Israel.
Learning rates

Quite remarkable rates of deflation for wind and, in particular, solar power technologies.

Source: IRENA Renewable Cost Database
Learning rates

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Table ES2 Learning rates for solar PV, CSP, onshore and offshore wind, 2010-2020 and 2010 to 2021/3

<table>
<thead>
<tr>
<th></th>
<th>Learning rates</th>
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<tbody>
<tr>
<td></td>
<td>Total installed cost</td>
</tr>
<tr>
<td></td>
<td>2010-2020 (%)</td>
</tr>
<tr>
<td>Utility-scale solar PV</td>
<td>34</td>
</tr>
<tr>
<td>CSP</td>
<td>22</td>
</tr>
<tr>
<td>Onshore wind</td>
<td>17</td>
</tr>
<tr>
<td>Offshore</td>
<td>9</td>
</tr>
</tbody>
</table>

6 The learning rate is the percentage reduction in the price/cost for every doubling of cumulative installed capacity.
NOT JUST FALLING COSTS, BUT ABSOLUTELY LOW COSTS
Competitive costs

New renewable capacity added with costs lower than cheapest fossil fuel option

- 644 GW over 10 years has costs lower than cheapest fossil fuel option.
- 534 GW in emerging economies likely to save USD 32 billion this year….
- 62% of capacity (~160 GW) added in 2020 was lower-cost than new fossil fuel option

Source: IRENA Renewable Cost Database
Falling costs increase stranded asset risks

- Falling capacity factors, high fixed costs and CO2 prices spell trouble for Europe's coal generators

- Cost ≠ Capture price/value

But: Gap is looking very large in Europe
Falling costs increase stranded asset risks

- US and India have lower coal operating costs, but...

- But same challenge, as very competitive RE costs...and...

- falling capacity factors and high fixed costs

- Cost ≠ Capture price/value

But: Gap is looking very large particularly in US, even with dual-firing
Solar thermal heat: Commercial & Industrial sectors

- In total: ~1750 projects ~935 MWth
  Data for 24 countries

- Denmark has competitive market and falling costs

- District heating installed cost learning rate is 17-19% in Denmark

- RPGC in 2020 also includes data for Austria, Germany and Mexico

- Larger report to come Q3

Figure 9.1 Total installed costs and LCOHEAT for solar thermal district heating plants in Denmark, 2010-2019

Note: Data is for 50 projects commissioned between 2010 and 2019 ranging in size from 1.8 MWth to 26 MWth.
Battery storage cost trends

• US utility-scale battery costs fell 71% between 2015 and 2018, to USD 635/kWh

Behind-the-meter

• Battery storage system prices fell 71% between 2014 and 2020

• Australia somewhat more competitive, Italy and France more expensive

Source: IRENA and EUPD Research GmbH, 2021; and Solar Choice, 2021
Beyond 4 hours storage....

- Mainland and island Solar+storage is already competitive

- But limited to four hours storage

- CSP is somewhat more expensive, but bridges the gap to daily storage, and with 6 GW deployed, as lots of potential for cost reductions
HYDROPOWER

BIOENERGY

GEOTHERMAL
DEEP DIVE: SOLAR PV
Solar PV cost trends

The LCOE of utility-scale PV has declined 7% YoY in 2019-2020 to USD 0.057/kWh

- Total installed costs w. avg. declined 13% from 2019 and 81% from 2010.
- Record new capacity added: 127 GW
- Cost reduction drivers
  - lower module costs
  - sustained BoS decline
- Capacity factor drop: Shift in share of deployment, but some uncertainty.

Note: costs for PV expressed per kilowatt direct current (DC); capacity factor expressed as an AC-to-DC value.
Solar PV cost trends

Module costs continue its decline, driven by manufacturing optimization and efficiency gains

- Crystalline PV module costs decline around 89-95% (Dec 2009-Dec 2020)

- Costs range in Dec 2020 from USD 0.19/W to USD 0.38-0.40/W

- Recently upward blip due to supply chain tightness

Source: GlobalData (2019); pvXchange (2020); Photon Consulting (2017).
Solar PV cost trends

As balance of system costs fell, so did total installed costs

- Total installed costs fell 77% - 90% by country
- Narrowing of country cost differential, but differences remain

Source: IRENA Renewable Cost Database.
Solar PV cost trends

Country TIC cost in 2020:
- USD 596/kW in India, to
- USD 1,889/kW in Russian Federation

- 61% of global weighted-average TIC decline due to modules. 39% BoS
- The highest cost average was 3x more than the lowest
- Despite convergence of installed costs in major markets in last 5 years, differences persist.

Source: IRENA Renewable Cost Database.
Solar PV cost trends

Source: IRENA Renewable Cost Database.

Country TIC cost in 2020:
- USD 596/kW in India
- USD 1,889/kW in Russian Federation
LCOE cost reduction drivers: Utility-scale solar PV

- Modules and inverters accounted for 55% of the global weighted-average LCOE decline
- BoS costs are also an important contributor

Source: IRENA Renewable Cost Database
Wind turbine cost and performance trends

The more competitive, established markets show larger reductions in total installed costs over longer time periods than newer markets.

Country and site specific requirements influences the wide range in installed costs and O&M cost reductions.

Average capacity factors have increased from improved turbine technology, siting and operations.

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Levelised cost of electricity

Total installed costs

Capacity factors

LCOE
Global LCOE of onshore wind has declined by 87% between 1983-2020:
• USD 0.311/kWh - USD 0.039/kWh
OFFSHORE WIND
Offshore wind cost and performance trends

Between 2010-2020, the global weighted average:

- Total installed cost reduced by **32%** from USD 4,706 to USD 3,185/kW
- Capacity factor increased from **37%** to **40%**
- LCOE reduced by **48%** from USD 0.162/kWh to USD 0.084/kWh
- China accounted for half of new capacity in 2020

Source: IRENA Renewable Cost Database.
Offshore wind - industry trends

Trend towards deployments farther offshore in deeper waters, with larger turbines and installations growing in new and established market.

Total installed costs peaked in 2008 ~USD 5 500/kW but has since fallen to USD 3 185/kW in 2019.

LCOE is now in range USD 0.05-0.10/kWh

Source: IRENA Renewable Cost Database.
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Offshore wind - industry trends

Distance from shore & water depth

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DEEP DIVE: CONCENTRATING SOLAR POWER
Concentrating solar power cost trends

The LCOE of CSP LCOE of CSP plants fell by 68% between 2010 and 2020

- Global w.avg. total installed costs of CSP plants in 2020 at USD 4581/kW – (36% lower than in 2010).
- Capacity factor increased from 30% in 2010 to 45% in 2019
  - Better technology
  - Shift to higher DNI areas
  - Higher storage hours
- Between 2010 and 2019, LCOE cost declined from USD 0.346/kWh to USD 0.182/kWh
Concentrating solar power cost trends

Shift to areas with higher DNI and more storage

- Costs for thermal energy storage have fallen
- Operating temperatures have increased
- This has led to storage capacity (hours) optimal now higher when before when seeking lowest LCOE

Source: IRENA Renewable Cost Database.
Concentrating solar power cost trends

PPA announcements point to a declining trend in costs of electricity

- LCOE fell 68% between 2010 and 2020.
- CSP can play an important role in the energy transition
  - Low-cost
  - Long-duration thermal energy storage
  - Ability to be dispatched

Source: IRENA Renewable Cost Database.
VERY LOW COST RENEWABLE ELECTRICITY
Solar PV below 2 U.S. cent per kWh?

If everything is at its ‘best’ it may actually be possible....

- In Saudi Arabia in 2022 there will be low-cost PV and onshore wind
- How realistic is it?
- Surprisingly, it looks possible
- USD 450/kW, 30 year life, low O&M costs and 1.9% real WACC. Bifacial single-axis tracking CF = 28%

Figure B3.3 Scenarios for utility-scale solar PV LCOE under different input assumptions in Saudi Arabia

Source: IRENA Renewable Cost Database
Is low-cost renewable hydrogen possible today?

Very low-cost electricity makes a lot of things possible....

- In Saudi Arabia in 2022 there will be low-cost PV and onshore wind
- USD 750/kW for alkaline electrolyser, 15 year or 80k hours stack life, 3% OPEX and same WACC as the PV
- USD ~1.62-1.74/kg H2 in 2022
Renewables are increasingly competitive

The winners are customers, the environment and our future

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