Presenters:
Pablo Ralon and Sonia Al-Zoghoul, Renewable Energy Cost Status and Outlook

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Renewable Power Generation Costs in 2021

Michael Taylor, Pablo Ralon and Sonia Al-Zoghoul
In most parts of world RE least-cost source of new electricity

- 73% (163 GW) of new utility-scale capacity in 2021 globally cost less than cheapest fossil option.
- Globally, new renewable capacity added in 2021 could reduce electricity generation costs in 2022 by at least USD 55 billion.

- Costs continued to decline in 2021 despite of supply chain disruptions.
- Renewable received largest ever increase in competitiveness in 2022 in Europe due to fossil fuel price crisis.
Solar PV
Solar PV: Evolution of key metrics

- Over 843 GW installed by the end of 2021 (21-fold growth between 2010-2021)
- Total installed costs w. avg. declined 6% from 2020 and 82% from 2010.
- In 2021, the LCOE YoY reduction was 13% (88 lower than 2010)
Module costs declined driven by manufacturing and efficiency gains

- Between December 2009 and December 2021, crystalline silicon module prices declined by between 88% and 95%.

- Mainstream modules sold for USD 0.26/W during December 2021 (12% lower than Dec 2020).

- Range of costs in Dec 2021 from USD 0.20/W for the lower cost modules to as high as between USD 0.42 and USD 0.44/W.
In 2021, PV module prices climbed due to supply chain disruptions. This has meant higher material costs, or lower availability with 2021 costs 4%-7% higher than in 2020.

- Data for H1 2022, shows mainstream modules increased 8% compared to 2021.
- High efficiency modules are 4% higher in H1 2022 compared to 2021.
- Low cost offerings declined 6% between 2021 and H1 2022, returning to 2020 levels.
Reductions occurred despite supply chain disruptions

Total installed cost reduction of 4% - 11% in historical markets (China, India, Japan, Korea, US and Germany)

Very competitive costs in India led to w. avg. TIC of USD 590/kW in 2021, a value 6% lower than in China.

Competitive cost structures continue to prevail in newer markets: Netherlands (9% decline) and Türkiye (5% decline)
While solar PV has become a mature technology, regional cost variations do persist, though cost convergence continues year by year.

Modules and inverters accounted for 61% of the global weighted average TIC decline between 2010 and 2021.
How has the LCOE of utility solar PV become so low?

Solar PV module costs declined so rapidly that new solar PV markets have emerged, globally. EPC, installation, and development costs, with other soft costs, accounted for 26% of the LCOE decline. Together, cost reductions in inverters, racking and mounting, and other BoS hardware made up 17%.
Concentrating Solar Power
Concentrating solar power: a decade of improvement

CSP from 2010 to 2020

-70% Solar field costs
-50% Total installed costs
-68% Levelised cost of electricity

COSTS

PERFORMANCE

PTC aperture width +24%
Storage duration +218%
Capacity factor +40%
Total installed costs for CSP fell by 50% between 2010 and 2020

- The avg CF of newly-commissioned CSP plants increased from 30% in 2010 to 42% in 2020 globally.

- TIC:
  - 2010-2020: -50%
  - 2019-2020: -6%

- Between 2010 and 2021 the LCOE declined 68% to USD 0.114/kWh

- CSP, now in the mid-cost range of new capacity from fossil fuels.
Total installed costs for CSP fell by 50% between 2010 and 2020

- CSP plants almost exclusively include low-cost and long-duration thermal storage systems

- CSP plants are now routinely being designed to meet evening peaks and overnight demand.

- Larger storage capacity, gives CSP greater flexibility in dispatch and the ability to target output in high-cost periods.
Onshore Wind
Onshore wind cost and performance trends

2010-2021:

- Deployment grew 4-fold to reach 769 GW (72 GW in 2021)

The global weighted average:

- Total installed cost reduced by 35% to USD 1 325/kW
- Capacity factor increased from 27% to 39%
- LCOE reduced by 68% to reach USD 0.033/kWh

Source: IRENA Renewable Cost Database.
Wind turbine characteristics and costs

Average 2021 turbine price:
- In China: USD 425/kW (84% lower than 1998)
- Outside China: USD 780/kW to USD 960/kW (48% to 62% lower than 2009)
- Recent uptick outside China (supply chain disruptions in 2020 and 2021)

Source: BNEF 2022; Wiser, et al., 2020; Vestas Wind Systems, 2005-2022; and the IRENA Renewable Cost Database.
Higher capacity factors driven by technology improvements

Technology improvements have resulted in an almost one-third improvement in the global weighted average capacity factor.
Major onshore markets show increased w avg. CFs despite decline of w avg. wind speeds in 2010-2020.

This confirms that technology improvements contributed greatly to an increase in the global w avg. CF.

The decline in wind speed could be due to less access to better wind resources.

Might be the result of projects in areas with lower wind speeds (now economic).

Source: IRENA Renewable Cost Database.
Global LCOE of onshore wind has declined by 90% between 1984-2021:
- USD 0.320/kWh - USD 0.033/kWh
Cost trends for smaller onshore wind markets

### Total installed costs

- Argentina
- Australia
- Austria
- Chile
- Costa Rica
- Croatia
- Cyprus
- Dominican Republic
- Egypt
- Ethiopia
- Finland
- Greece
- Indonesia
- Ireland
- Israel
- Peru
- Philippines
- Poland
- Portugal
- Republic of Korea
- Russian Federation
- South Africa
- Ukraine
- Uruguay
- Viet Nam

Source: IRENA Renewable Cost Database.

### Capacity factors

- Argentina
- Australia
- Austria
- Chile
- Costa Rica
- Croatia
- Cyprus
- Dominican Republic
- Egypt
- Ethiopia
- Finland
- Greece
- Indonesia
- Ireland
- Morocco
- Netherlands
- New Zealand
- Norway
- Pakistan
- Panama

Source: IRENA Renewable Cost Database.

### LCOE

- Argentina
- Australia
- Austria
- Chile
- Costa Rica
- Croatia
- Cyprus
- Dominican Republic
- Egypt
- Ethiopia
- Finland
- Greece
- Indonesia
- Ireland
- Morocco
- Netherlands
- New Zealand
- Norway
- Pakistan
- Panama
- Peru
- Philippines
- Poland
- Portugal
- Republic of Korea
- Russian Federation
- South Africa
- Ukraine
- Uruguay
- Viet Nam

Source: IRENA Renewable Cost Database.
Offshore Wind
Between 2010-2021, the global weighted average:

- Total installed cost reduced by 41% to USD 2,858/kW (3.1 GW to 55.7 GW)
- CF at 39% (drop after 2017 is due to increased share of Chinese deployment lower resource)
- LCOE reduced by 60% to USD 0.075/kWh
- China accounted for 82% (17.4 GW) of new capacity in 2021

Source: IRENA Renewable Cost Database.
Offshore wind project characteristics - Deeper waters and farther from shore

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

Source: IRENA Renewable Cost Database.
Larger turbines, longer blades and higher hub heights

Turbine size and wind farm capacity

Source: IRENA Renewable Cost Database.
China vs Europe

Total installed costs

Capacity factors

LCOE

Source: IRENA Renewable Cost Database.
Mature Technologies

HYDROPOWER

BIOENERGY

GEOTHERMAL
Between 2010-2021, the global weighted average:

- Total installed cost increased in 2021 to USD 2,135/kW, higher than the USD 1,939/kW in 2020.
- Capacity factor increased from 44% to 45%
- LCOE increased by 23% from USD 0.039/kWh to USD 0.048/kWh
Geothermal cost trends and performance

In 2021, the global weighted average total installed cost of the eight geothermal power plants in IRENA’s database was USD 3 991/kW.

Capacity factor between 2010-2021 decreased from 87% to 77%.

LCOE increased to USD 0.068 /kWh in 2021.

Source: IRENA Renewable Cost Database.
Bioenergy cost trends and performance

Between 2010-2021, the global weighted average:

- Total installed cost reduced by 13% from USD 2 714 to USD 2 353/kW
- Capacity factor declined to 68%
- LCOE reduced by 14% from USD 0.078/kWh to USD 0.067/kWh

Source: IRENA Renewable Cost Database.
Improved competitiveness in 2021, already resulting in savings

- frees economies from volatile fossil fuel prices
- curbs energy costs
- reduces fossil fuel imports
- creates tangible savings for communities

At least USD 55 billion potential global net savings by 2022
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The Renewable Cost Database

- Largely reflects the deployment of renewable energy technologies over the last ten to fifteen years
- Project-level cost and performance data for around 2,100 GW of capacity from ~21,000 projects, commissioned up to and including 2021
- 806 GW of project data available from 1983 onwards for onshore wind
- 582 GW of projects for solar PV
Weighted average LCOE of utility scale solar PV compared to fuel and CO2 cost only for fossil gas in Europe

- USD 0.27/kWh is 4 to 6 times more expensive than the new solar and onshore wind capacity added in Europe in 2021.