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INFRASTRUCTURE

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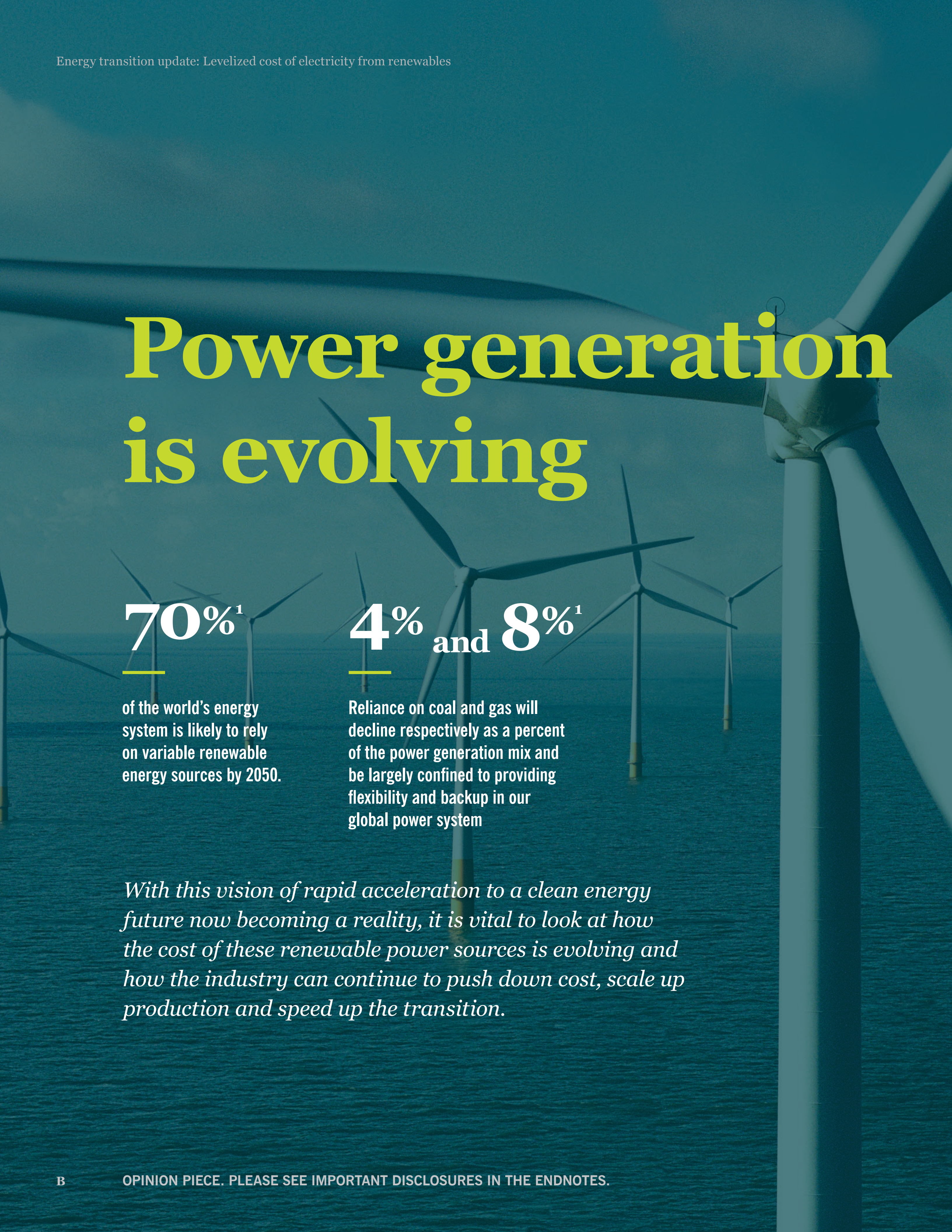
Energy transition update: *Levelized cost of electricity from renewables*

OPINION PIECE. PLEASE SEE IMPORTANT DISCLOSURES IN THE ENDNOTES.



Power generation is evolving

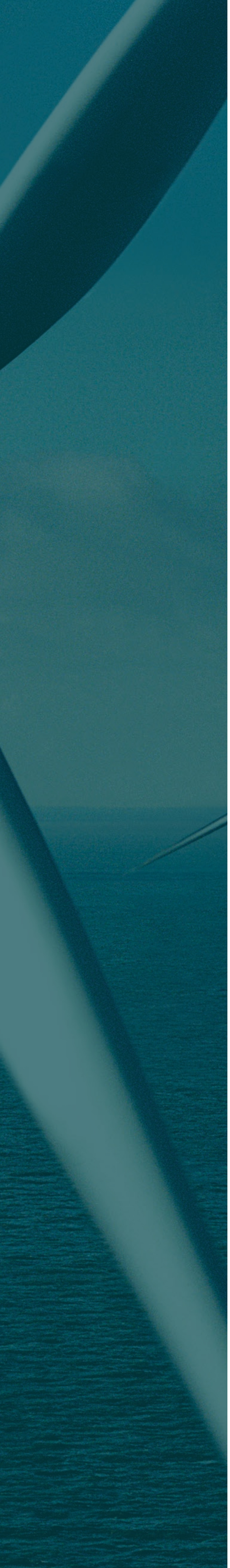
70%[1]

of the world's energy system is likely to rely on variable renewable energy sources by 2050.

4% and 8%[1]

Reliance on coal and gas will decline respectively as a percent of the power generation mix and be largely confined to providing flexibility and backup in our global power system

With this vision of rapid acceleration to a clean energy future now becoming a reality, it is vital to look at how the cost of these renewable power sources is evolving and how the industry can continue to push down cost, scale up production and speed up the transition.

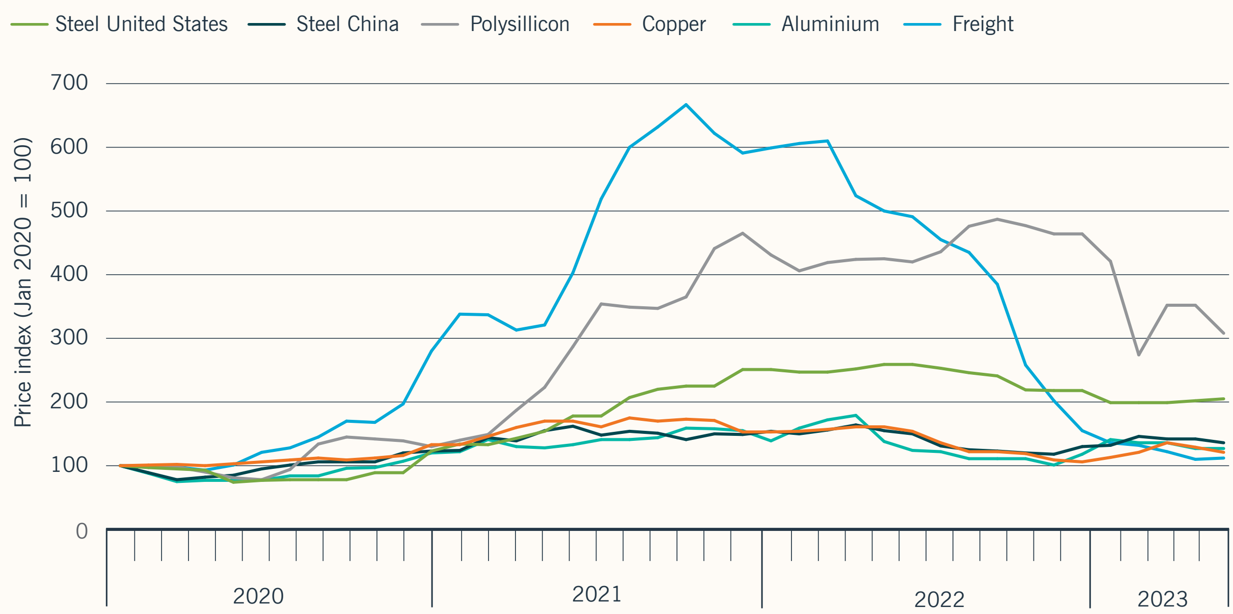


In this paper we examine the state of the levelized cost of electricity (LCOE) today and present an outlook on the cost of power generated from key renewable technologies: onshore and offshore wind, and solar PV. As renewables industries have grown and matured, there has been a remarkable drop in the cost of the energy from these technologies and over the past 10-15 years, this has been the main driver of deployment.

However, recent economic turmoil has caused this downward trend to temporarily reverse, and the cost of these technologies has increased for the first time. Global macroeconomic risks associated with rising inflation, higher interest rates and the energy crisis caused by Russia's invasion of Ukraine, have led to supply chain challenges and higher capital cost for renewable energy projects.[2] In order for the clean energy transition to continue at the pace needed, it is critical – and fortunately, expected – that these price rises are an anomaly, and that costs continue to decline over time. In this report we look at the cost predictions after this period of turbulence, outlining the factors that should once again drive cost down.

According to the International Energy Agency (IEA), the average LCOE for utility-scale photovoltaic (PV) and wind are expected to remain 10-15% higher in 2024 than in 2020. However, there is consensus that the increases in cost have peaked and recent data demonstrates that the LCOE may begin to fall after 2024. In its recent report into solar PV and wind costs, the IEA notes that commodity and freight prices have already dropped from their record highs in 2022[3] – a welcome relief for project developers and manufacturers who have struggled with the high prices of the last couple of years.[4]

Figure 1: Monthly commodity and freight price indexes, 2020-2023[10]



Notes: Steel United States: North America steel plate spot price ex-works. Steel China: China domestic 20-mm steel plate average spot price. Polysilicon: BNEF solar-grade silicon spot price. Copper and aluminium: London Metal Exchange 3-month forward contract price. Freight: WCIDCOMP Index.

We expect this downwards trend to continue and the economic case for investing in renewables and the energy transition ***remains strong.***

3 main reasons for this:

Onshore wind and solar PV remain the cheapest new-build technologies to produce electricity in countries covering 82% of global electricity generation.

1. Despite recent higher costs, solar PV and onshore wind remain the cheapest option for new electricity generation in most countries.[5] Over the longer term, LCOE from wind and solar PV will continue to fall, whereas the cost of legacy energy technologies based on fossil fuels will rise.[6] The last few years of turmoil have been an exception to otherwise consistent project cost declines over a longer time period, according to the latest analysis by BloombergNEF. Onshore wind and solar PV remain the cheapest new-build technologies to produce electricity in countries covering 82% of global electricity generation.[7]

2. The current LCOE may be slightly higher than pre-2020 levels, but this is only one side of the economic equation. Power prices, and therefore the revenue from power production, have risen by a far greater margin than the cost. Since power prices are driven by the cost of fossil fuel power in most markets, these prices remain well above pre-2020 levels and renewables benefit proportionally more. Power contracts for the end of 2023 and into 2024 in the EU, the U.S., Japan, Australia and India all indicate wholesale electricity prices two to three times above 2020 averages.[8]

3. Continued innovation is also expected to reduce costs further, improving competitiveness even with existing plants fuelled by fossil fuels.[9]

Levelized cost over the past decade

Sharp decline since 2009

Since 2009, there has been a remarkable decline in the LCOE for solar and wind power: LCOE for solar PV has declined by 89%, for onshore wind by 67%, and for offshore wind by 66%. The global weighted-average LCOE of utility-scale solar PV plants declined by 85% between 2010 and 2020, from USD 0.381/kWh to USD 0.057/kWh. This 2020 figure also represents a 7% year-on-year decline from 2019. The largest reduction in the utility-scale solar PV sector was in India, where between 2010 and 2020 costs declined by 85%, to USD 0.038/kWh – a value 33% lower than the global weighted average for that year. After India, China and Spain achieved the most competitive LCOE of utility-scale solar PV, with values of USD 0.044/kWh and USD 0.046/kWh respectively for 2020. Other dramatic declines include Turkey's LCOE, which halved between 2016 and 2020, and a 23% year-on-year decline in Australia.[11]

For onshore wind projects, the global weighted-average cost of electricity between 2010 and 2020 fell by 56%, from USD 0.089/kWh to USD 0.039/kWh, as average capacity factors rose from 27% to 36% and total installed costs declined from USD 1,971/kW to USD 1,355/kW.

The global weighted-average LCOE of offshore wind declined by 48% between 2010 and 2020, from USD 0.162 to USD 0.084/kWh. From its peak in 2007, the global weighted-average LCOE of offshore wind fell by 53% to 2020. Belgium saw the highest percentage reduction (56%) in country weighted-average LCOE values between 2010 and 2020, with the highest starting point in 2010, at USD 0.198/kWh. Meanwhile, Denmark had a reduction of 20% between 2010 and 2020.[12]

The last few years of economic upheaval have been an exception to otherwise consistent project cost declines over a longer time period. Cost reductions are set to continue long term with increasing innovation, greater economies of scale and reduced financing costs.[13]

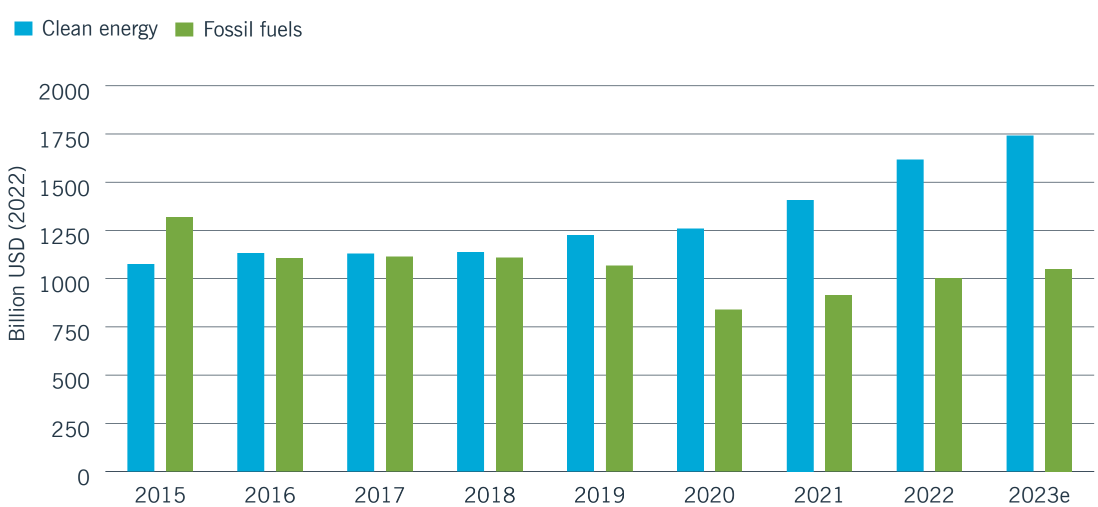
Transforming the energy landscape by increasing investment

Dramatic decreases in cost have transformed the energy landscape by making the core sources of renewable energy – solar PV and wind – cheaper than conventional and fossil fuel energy sources. New solar PV and wind projects are consistently undercutting even the cheapest existing coal-fired power plants.[14] Bloomberg New Energy Finance's (BNEF) analysis shows that the global benchmark for offshore wind is now equivalent to coal, the cheapest since BNEF started collecting data in 2009.[15] The convergence of the cost of clean energy with that of legacy energy sources means that the heavy wind and solar subsidies prevalent in Europe in the 2010s are no longer needed.

Scaling up investment into renewable projects is vital to a sustainable and secure transformation of the energy sector. Fortunately, the sustained drop in the LCOE since 2009, in tandem with decarbonisation moving up the political agenda, has caused investment in clean energy to outstrip that of investment in fossil fuels by an increasing amount each year since 2016. Clean energy investment received a major boost from the response to the global energy crisis, as volatility in fossil fuel markets caused by Russia's invasion of Ukraine stepped up momentum to find alternative fuel sources and pursue energy independence.

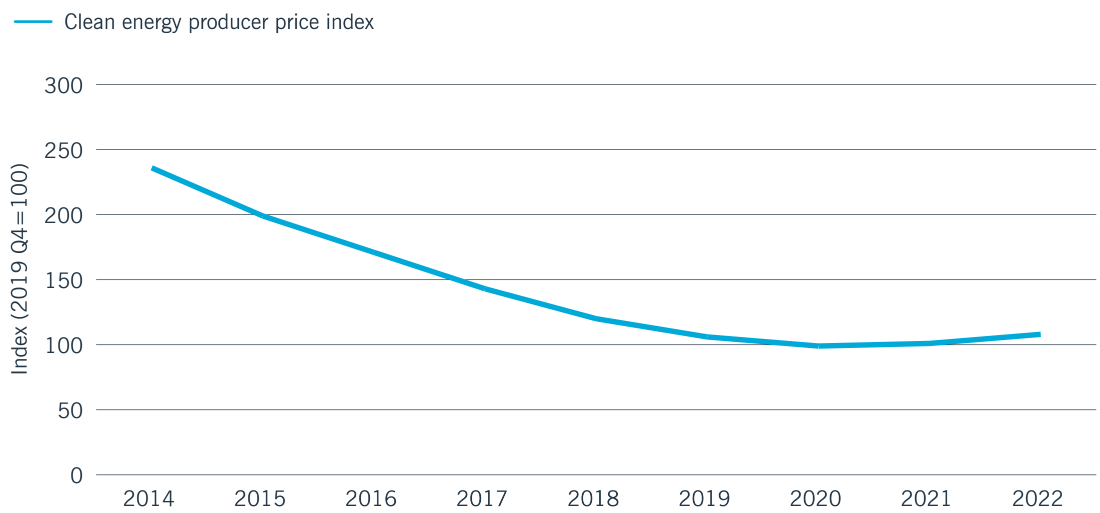
The IEA estimates that between 2021 and 2023, annual investment in clean energy has risen faster than in fossil fuels (24% vs 15%). It predicts around USD 1.7 trillion will be invested into clean energy in 2023, noting that for every USD 1 spent on fossil fuels, USD 1.7 is now spent on clean power generation (see figure 2). This is in contrast to a ratio of 1:1 five years ago. Policy support through instruments such as the U.S. Inflation Reduction Act of 2022, alongside new initiatives in Europe, Japan, China and emerging economies should serve to strengthen this trend. There is also a strong positive feedback loop, where increasing scale and investment drives efficiency and innovation in solar PV and wind, thereby further decreasing the LCOE in these key technologies.[16]

Figure 2: Global energy investment in clean energy and in fossil fuels, 2015-2023e[17]



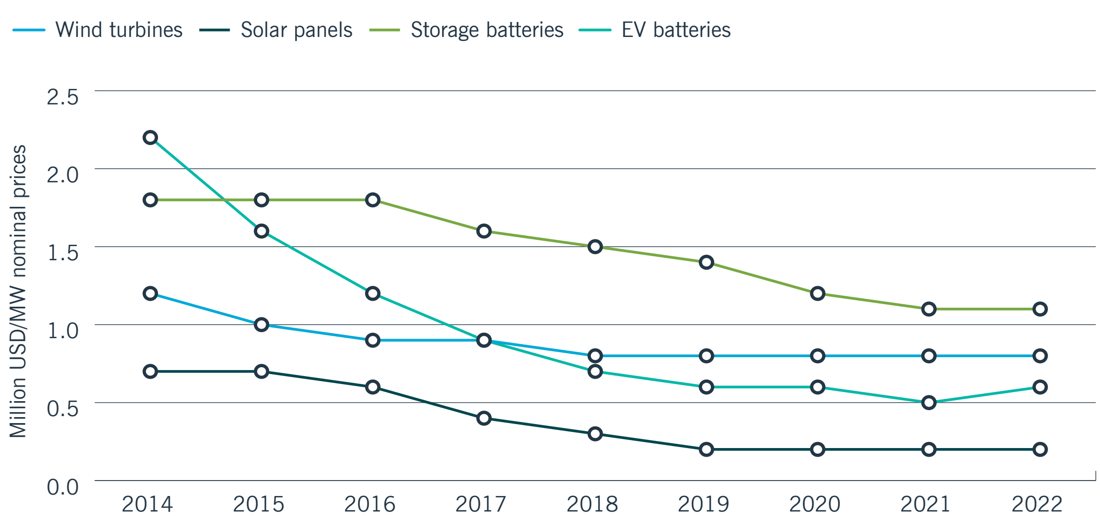
Source: IEA.

Figure 3: IEA clean energy equipment price index, 2014-2022[18]



Source: IEA.

Figure 4: Average equipment prices for selected technologies, 2014-2022[19]



Source: IEA.

Focus on LCOE

The levelized cost of electricity is a measure of the average total cost of building and operating a power plant per unit of total electricity generated over its assumed lifetime.

$$\underbrace{\text{LCOE}}\ \left[\frac{\text{USD}}{\text{Wh}}\right] = \frac{\text{NPV of Total Costs over project lifetime}}{\text{NPV of Electrical Energy produced over project lifetime}}$$

LCOE: a definition

The LCOE determines the average minimum price at which the electricity generated must be sold in order to offset the total costs of production over the plant's assumed lifetime. Working out the LCOE gives investors and developers a comprehensive and sensible economic comparison of different energy generating projects and is used to determine whether a project is a worthwhile investment.

LCOE in detail

The components of the LCOE for a solar PV project would include the cost of modules; the balance of plant cost (such as racking, inverters, cabling and grid connection), the cost of design, installation and financing. In the sections below we take a deep dive into these individual elements, examining the trends and outlook for the future.

Figure 5: Components of the LCOE for a PV project[20]

CAPITAL EXPENDITURE (INITIAL COSTS)

Modules Inverters Cables Mounting structures Construction	**Dependent on:** • Land area • Country laws • Regulations • Prices • Accessibility to material

OPERATING EXPENDITURE

Maintenance Cleaning Operation Fuel when relevant	**Dependent on:** • Land area • Country laws • Regulations • Prices • Accessibility to material

$$LCOE = \frac{\displaystyle\sum_{t=1}^{n} \frac{CapEx(t)+OpEx(t)+F(t)}{(1+WACC_{nom})^{t}}}{\displaystyle\sum_{t=1}^{n} \frac{CF_{t} \times NP \times (1-Deg)^{t}}{(1+WACC_{real})^{t}}}$$

ENERGY PRODUCTION

A function of Capacity Factor (CF) and Normal Power (NP) Degradation factor	**Dependent on:** • Climate & environment • PV plant performance • Grid curtailment

NET PRESENT VALUE

Applies a discount on future expenses to account for depreciation and calculates the equivalent value in today's currency	**Dependent on:** • Risk associated to the type of capital used (e.g. equity, debt). • ***WACC*** – discount rate • ***t*** – years • ***n*** – project lifetime

Learning rates

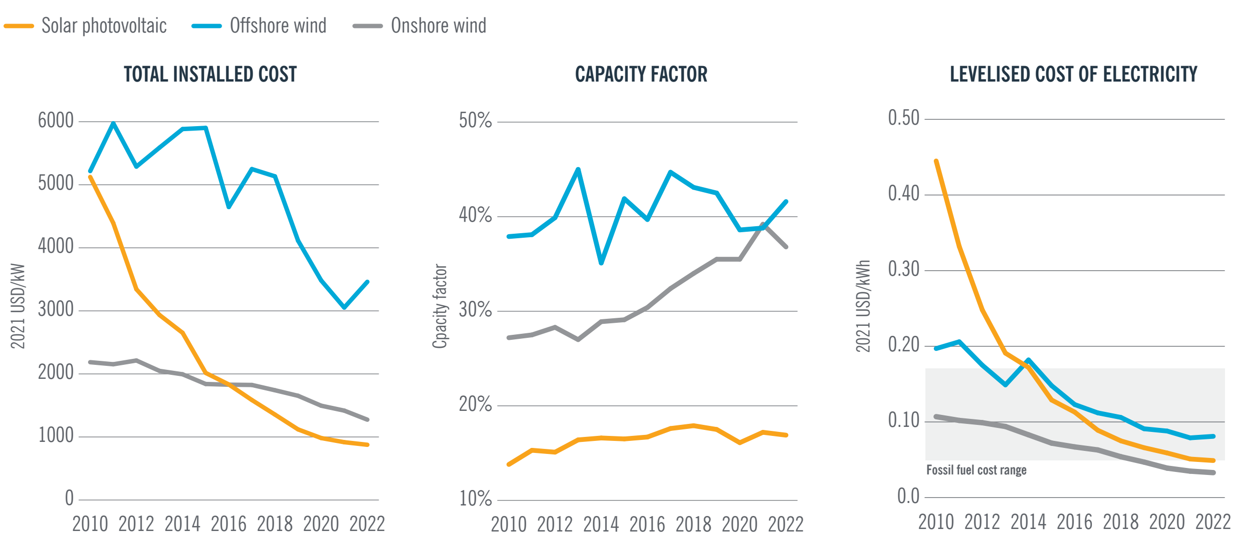
The learning rate is the average cost reduction (in percentage terms) experienced for every doubling of cumulative installed capacity.[21] Learning rates will have a sizeable impact on wind power cost reduction, particularly in regions where wind power (especially offshore wind power) is currently nascent. Accurately predicting the future cost of wind and solar power generation can help inform investors and renewable project developers.[22]

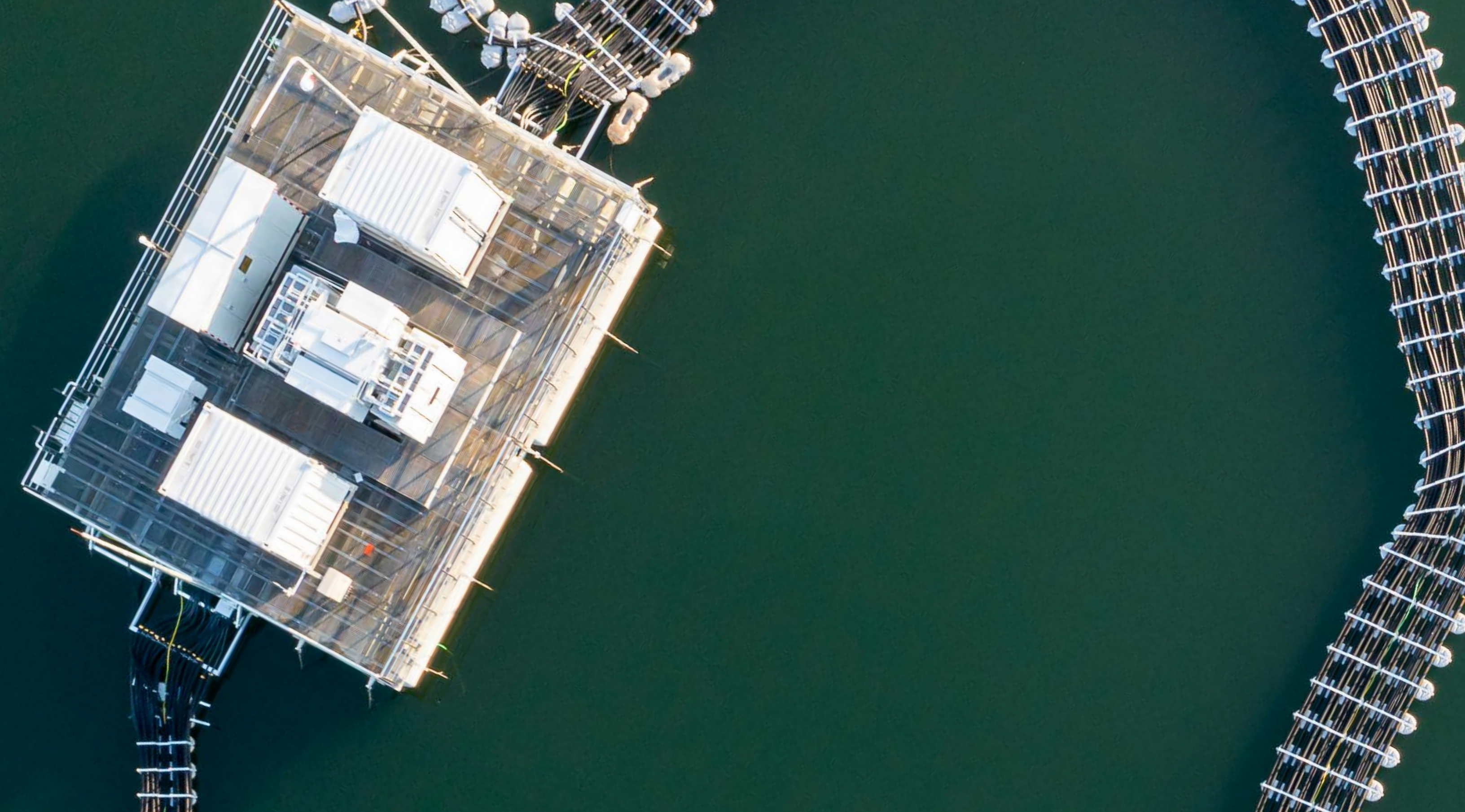
Over the period 2010 to 2020, utility-scale solar PV has the highest estimated learning rate for the global weighted-average total installed cost, at 34%. This period, 2010 to 2020, saw the deployment of 94% of global cumulative installed solar PV capacity. The total installed cost learning rate for offshore wind for the period 2010 to 2020 is estimated at 9.4%, with new capacity additions over this period estimated to be 91% of the cumulative installed offshore wind capacity. For onshore wind, the total installed cost learning rate for the period 2010 to 2020 is estimated to be 16.6%. The decline in wind turbine prices, as well as greater regional supply chain maturity and competitive procurement of projects, has contributed to lower costs in recent years.[23]

However, installed cost is just one of a handful of inputs (which also include operating costs, financing cost and annual energy production) that affect the LCOE generated, and each of these cost components can also benefit from learning. LCOE, rather than installed costs, can be used to assess historical learning curves.[24]

With its higher full-period learning rate of 24%, coupled with greater deployment projections, the LCOE of solar is expected to drop below that of wind within the next few years. Irrespective of what the ultimate rate of decline ends up being, with positive learning rates and the increasing deployment of both technologies, learning curves predict that the cost of both wind and solar will continue to decline.[25]

Figure 6: Global weighted average of costs, capacity factors and LCOE of utility-scale solar PV, onshore and offshore wind, 2010-2021[26]



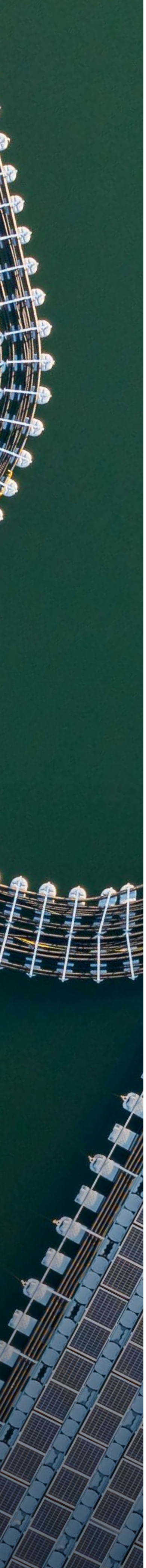


LCOE in solar PV

The cost of solar PV has fallen by around 90% over the last 10 years and, with continuous improvement in solar PV technologies and economies of scale, will be the benchmark for low-cost electricity generation in many more markets over the next few years. This rapid expansion of solar PV is underpinned by the expected continuation of cost decline, increasing module efficiency and the development of larger projects.[29]

Despite the LCOE of solar PV increasing for the first time in 2020, due to global supply chain disruption and inflation in key commodity prices, it is still much cheaper to produce electricity from this clean energy source than from new fossil fuel sources or nuclear power.[30] Declining technology and production costs indicate that by 2030, the levelized cost of electricity generated from solar power could fall by as much as 55% globally. The global average LCOE for utility-scale PV in the first half of 2021 was US$48/MWh, according to BloombergNEF. The LCOE of solar, including integration costs, falls by 40-55% by 2030 across three scenarios explored in a report by BP, looking at the evolution of the global energy system over the next 30 years.[31] It is expected that utility-scale production will continue to dominate, as smaller installations cannot compete on energy cost.[32]

The global weighted average LCOE for solar PV in 2022 was around USD 50/MWh for solar and USD 120/MWh for solar plus storage. This is expected to drop to around USD 30/MWh by 2050, with individual project costs below USD 20/MWh. The main driver for this reduction in the LCOE is the reduction of unit investments costs, which are around USD 900/kW as a global average now.[33]



Main factors in solar PV LCOE

Module cost

Solar PV module costs have declined so fast since 2009 that new solar PV markets continue to emerge. Cost reduction in inverters, racking and other balance-of-system (BoS) hardware, contributed another 18% to the LCOE reduction during that period.[34]

2010 – 2020

The fall in module costs contributed 46% to the LCOE reduction of utility-scale PV.

DECEMBER 2009 – DECEMBER 2020

Crystalline silicon module prices declined between 89% and 95% for modules sold in Europe, depending on the type.

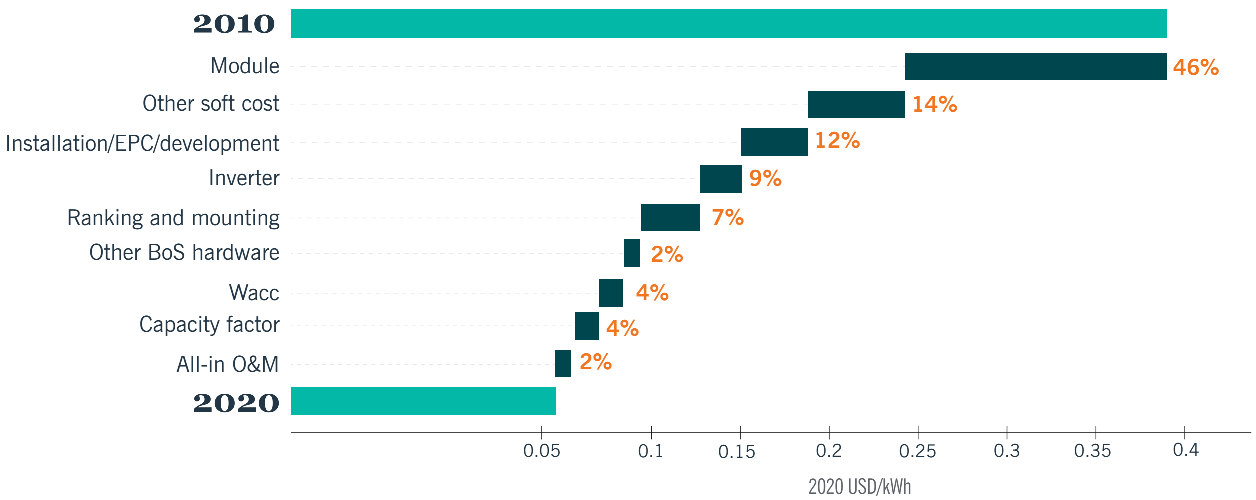
The weighted average cost reduction was around 93% during that period. Between 2019 and 2020, the yearly average module price declined between 5% and 15% for crystalline modules.[36]

The price of polysilicon rose sharply from just below 10 USD/kg in early 2021, to a peak of around 38 USD/kg in December 2022.[37] Other product prices along the value chain soared as well, resulting in the cost of solar modules increasing in 2021-22 and the first rise in solar PV's LCOE after a decade of constant decline, climbing from 36 USD/MWh in 2021 to 60 USD/MWh in 2023. Despite this increase, solar power remains considerably cheaper than energy generated from fossil fuels and nuclear. With the significant increase in production capacity and the improvement of global supply chains, prices for solar products have now decreased considerably along the value chain – from silicon to modules in the first half of 2023 – and are anticipated to reach pre-crisis levels.[38]

The latest PV price forecast from U.S. engineering consultancy Clean Energy Associates (CEA) predicts that between the first quarter of 2024 and the first quarter of 2025, module prices in China will drop by an average of 6%. Global PV manufacturing is expected to grow rapidly between now and 2027, with capacities doubling in the ingot/wafer stages and potentially quadrupling for polysilicon. By 2027, module production capacity could exceed 1,000 GW per year, while installations should be near 500 GW.[39]

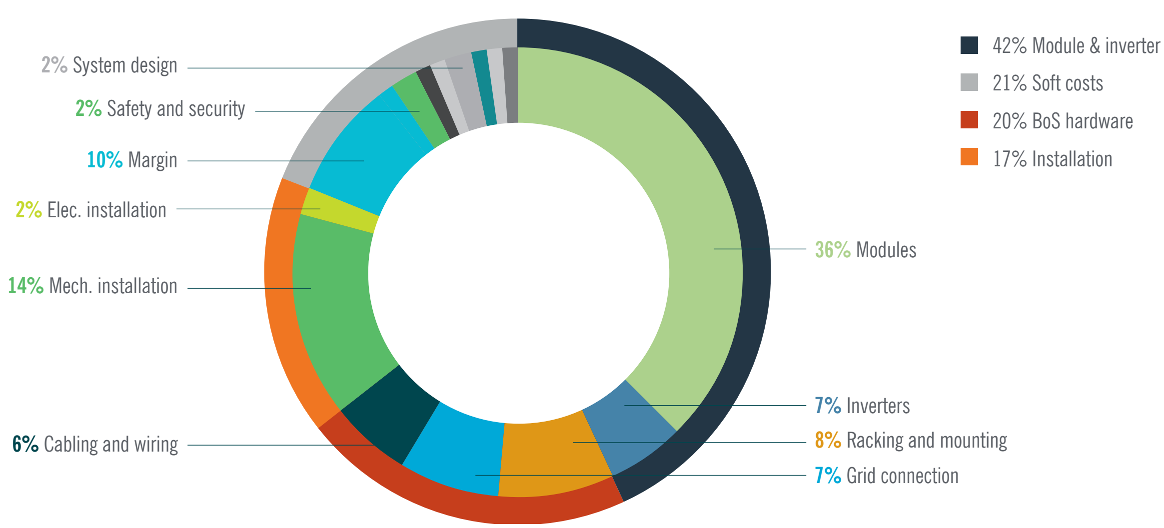
Compared to the end of 2022, equipment costs for fixed-axis solar are down 2% due to lower polysilicon prices. Shipping rates from Asia peaked in September 2021 and are now back to early 2020 levels. Shipping routes from Asia are critical to deliver solar panels, inverters, batteries and other components.[40] This all suggests that the temporary upward trend in solar PV costs may have reached its apex and that the return to a longer term trend of declining cost may already be underway.

Figure 7: Drivers of the decline of LCOE of utility-scale solar PV (2010-2020)[35]



Source: IRENA renewable cost database

Figure 8: Breakdown of costs – PV utility scale U.S. in 2022[41]



Source: IRENA, 2022

The growth of solar PV has been remarkable: ***it is currently the fastest growing renewable energy sector and the lowest cost source of energy in many markets.*** In 2017, Solar PV provided around 2% of the world's electricity, but is expected to expand its market share by a factor of at least seven in the coming decade – generating 15% of the world's electricity by 2030.[27] In 2050, more than half of all installed capacity globally will be solar and will account for 30% of global on-grid electricity generation.[28]

Balance of plant costs

As solar PV technology develops, the relevance of balance of system (BOS) costs (such as racking, inverters, cabling and grid connection) also increases, as the BoP share of total installed costs has increased with time (see figures 8 and 9 above). This is because module and inverter costs have declined at a higher rate than non-module costs. Installation, engineering, procurement and construction (EPC), and development costs, combined with other soft costs, were responsible for about a quarter of LCOE decline. Better financing conditions as solar PV markets matured, reduced operating and maintenance (O&M) costs and an increased global weighted-average capacity factor between 2010 and 2013 also contributed to a decline in the LCOE.[42] The main components in BoP hardware are steel and copper. Prices were affected by the 2021-2022 wave of inflation in global commodities, but these too are beginning to normalise.[43]

Soft costs: financing and installation

Both debt and equity financing have increased in cost since 2020, driven by central bank rate increases in response to inflation. Financing costs for renewable energy assets have long been very low so this increase trickles into the overall cost of constructing and operating the plant. However, rates are now near their likely peak and will fall over time as inflation cools.[44]

The cost of installation has also risen in recent years due to labour cost inflation in many markets, but this is also starting to level out. In the first quarter of 2023 the hourly labour costs rose by 5-5.3% compared to the first quarter of 2022.[45] Unit investment costs are expected to fall significantly with every doubling of solar PV installation globally, reaching USD 650/kW in 2050.[46]

Innovation, design and operation

Despite the recent successes of solar there is a long way to go in the global energy transition with huge strides to be made in efficiency and innovation. Technological developments have occurred along the whole solar PV value chain, from the increased adoption of larger polysilicon factories and improved ingot growth methods, to innovations in diamond wafering methods and new cell architectures.[47] By continuing to both drive down unit cost and drive up performance, these innovations will be key contributors to lowering LCOE over time.

There is further room for improvement of crystalline silicon PV panels. Silicon PV has a market share of nearly 95% and will continue to dominate the market. The increased efficiency and reliability of PERC technologies will be key over the next few years, with technologies such as TOPCon and heterojunction becoming more competitive. With silicon module efficiency approaching 25% by 2030, rival technologies will struggle to gain market share without substantial changes to their cost structure or capex for manufacturing.[48]

Better plant design and innovations such as bifacial modules and trackers will help to squeeze more production out of solar plant equipment. The International Technology

Roadmap for Photovoltaic (ITRPV) predicts a more than 60% bifacial market share by 2030. Dual glass modules should extend useful life, and single axis trackers and advanced control algorithms will serve to increase the energy yield of these systems. Smart inverters and larger string inverters for grid integration and dynamic control will also reduce integration costs, while digital tools will enable higher performance systems and lower O&M costs.[49]

Developing technologies such as perovskite solar cells could significantly lower solar PV costs, promising greater efficiencies (over 24%) and lower-cost manufacturing. Tandem photovoltaics are viewed as way to push module efficiency toward 30%, increasing energy yield and driving down BoP costs, from racking to installation. Perovskite tandems may provide low cost, high efficiency modules, but perovskite on silicon tandem cells and modules could also upgrade the efficiency of existing and future silicon technologies and leverage the existing infrastructure and supply chain. Advanced data analytics will help to model new technologies, as well as aiding the performance of these systems as they are deployed.[50]

Continued innovation in the production of solar PV modules will continue to drive down costs. The panel cost-learning rate for solar PV will remain high. It is currently 26%, and while that rate will decline to 17% in 2050, solar PV could become the cheapest source of new electricity globally. The OpEx-learning rate of 9% is expected to remain unchanged until mid-century, as enhanced data monitoring, remote inspections and predictive maintenance continue to drive down operating costs.[51] Solar panels need regular maintenance and inspection, to ensure their effectiveness and extend plant life. Fortunately, the development of drone technology has made solar panel inspections simpler, safer and more affordable, lowering OpEx.[52]

Recycling

Nearly all of the components of a solar plant are recyclable or have some end-of-life value. As of now there is generally no value ascribed to this when investors consider the economics of a solar investment, but if the case is demonstrated more over time and this is considered in the future, it will help to reduce the overall CapEx of a given solar plant.

LCOE in wind

Wind power provided 6% of the world's electricity output in 2020, almost exclusively in the form of onshore wind.[53] By 2050, wind will generate almost 50% of on-grid electricity in Europe, 40% in North America and Latin America, and more than a third of electricity generation in Greater China. The share of offshore wind in total global wind electricity generation will increase steadily, surpassing onshore wind, and rising from 8% in 2020 to 34% in 2050. Of this figure, 6% is projected to be floating offshore.[54]

The LCOE for fixed and floating offshore wind are expected to reduce by 39% and 84%, respectively, in the period from 2020 to 2050. The majority of the cost savings will be from capacity factors and turbine costs for fixed offshore wind, while capacity factors and non-turbine investment costs will decrease the most for floating offshore wind, as experience of installing and operating offshore wind turbines grows.[55] The costs of new-build offshore wind and storage projects fell by a respective 2% and 12% and the global benchmark costs for onshore wind are down 6% over the last 12 months as of June 2023.[56] As most wind farm components are made of steel and copper, the cost of building wind farms is tied to the price of these commodities.

Even the relatively mature onshore wind sector foresees cost reductions of 52% over the same period, but the greatest reduction in the average LCOE from onshore wind will come from higher capacity factors and lower turbine costs. As conflicts over onshore wind turbine locations continue in higher-income countries, onshore wind projects will move to less favourable locations and regions with higher costs. This will result in a slighter decrease in the 'non-turbine investment cost' component — comprising non-turbine material costs and soft costs such as labour and tax.[57]

Wood Mackenzie reports that 'the average LCOE for onshore wind across Europe will drop by more than half to 23 €/MWh by 2050 compared to 2022, making it the most cost-competitive [renewable] technology.'[58]

The LCOE for wind has been driven by some of the same factors listed for solar PV above, and will benefit from cost reductions in the same ways looking forward. Bottlenecks in the supply chain and commodity price inflation saw LCOE figures for renewables and energy storage rise an average in 2022. Challenges include permitting and finding skilled labour – costs that equipment manufacturers need to recuperate. Fortunately, capital cost (excluding interconnection cost of offshore wind) will decline as the sector scales up.[60]

Supply chain challenges

Supply chain bottlenecks have been even more pronounced than in the solar industry due to several factors specific to wind. Firstly, the concentration of tier-1 turbine components in just a few manufacturers. Secondly, the difficulty of shipping extra-large wind turbine components, especially with steep increases in shipping costs in 2021-2022. Thirdly, the current scarcity of suitable vessels and ports for deploying offshore wind. Much is being invested in ports and expanded installation and maintenance fleets, so this should be alleviated in the long term.

Providing extra value

Wind, and especially offshore wind, has a value to the overall energy supply which is not reflected in its LCOE. Wind production is less correlated to the hours of the day. Offshore wind especially, produces at a high capacity factor on a much more consistent basis throughout the day and night and therefore produces more of a "baseload" generation asset compared to solar PV. This reduces the need for as much storage and helps to smooth out supply and demand patterns.

Offshore wind remains expensive in comparison, although costs are set to have the most dramatic decline in this sector by 2050. With over USD 1 trillion of projected investment over the next decade, the offshore wind market is set to soar.[59]

Scaling up turbine capacity

For both offshore and onshore wind, the sizing up of turbine capacity will have an impact on driving down the LCOE. New turbine types and bigger turbines, blades and towers will raise capacity factors for onshore wind from 26% to 34%, and from 38% to 43% for offshore wind by 2050. This, together with cheaper turbines, are the main drivers of cost reductions of 52% for onshore wind over the period 2020 to 2050.[61]

Average hub heights are expected to double to 200m by 2050 and turbine ratings are set to increase from 9 to 25 megawatts.[62] Increased turbine sizes with larger rotor diameters will capture more of the power generated by the wind. For offshore wind to be successful, the development of large wind turbines with a rating of 10+ MW is key.[63] Many offshore wind farms currently under development will use the next generation of 15-16MW turbines, a 50%+ increase over many current models. Although these may cost more per turbine, the huge increase in output will lead to a reduced LCOE. Models of 20MW+ are expected by the end of the decade.

New turbine types will lead to better performance in varying wind conditions.[64] Wind turbine technology will continue to develop over the coming years, with new materials and advanced monitoring and control leading to even greater cost reductions.[65]

The increasing size of offshore wind farms is another driver of cost reduction. These now often come in single or clustered sizes of more than 1 GW (1000 MW). The use of multi-turbine structures in the future may further reduce the balance of plant (BoP) cost, as well decreasing annual operation and maintenance costs. Larger towers, foundations, and cable arrays are needed for larger turbines, but there is still a sizeable net gain in efficiency, as the capacity of the wind farm can go up by 50% or more with the same number of foundations and towers.[66]

Floating offshore wind

Floating offshore wind (FOW) is expected to see an 84% decrease in the LCOE between 2020 and 2050, as the technology is still in its nascency compared to other mainstream renewable energy sources, and has a lot of room for innovation, scaling and learning curve effects. FOW will eventually be the prevailing technology in most countries due to sea depth and seabed conditions. Cost reductions will enable new geographic areas to be developed where previously limited land availability or lack of shallow water hindered wind energy development.

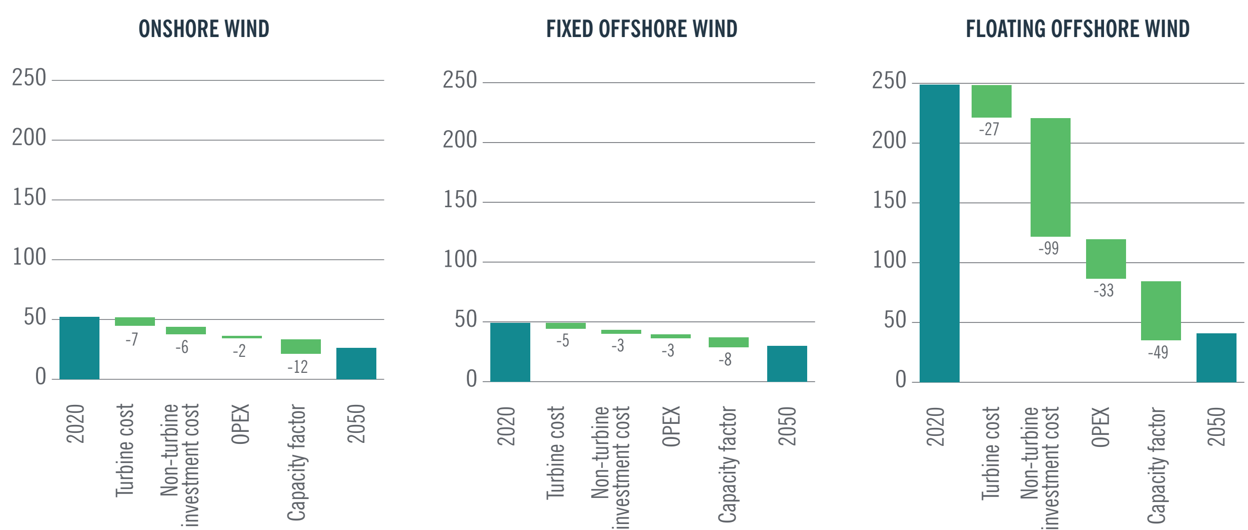
One advantage of FOW is the almost limitless space available out at sea. Floating structures will allow the installation of 10+ MW turbines or multi-turbine designs. With offshore wind projects being standardised it will be possible to scale up manufacturing this decade, reducing the LCOE further, as project costs are lower with larger turbines.[69] It is estimated that the LCOE will come down to USD 50/MWh for fixed offshore and USD 70/MWh for floating offshore wind in 2030.[70] FOW also has some added efficiencies in installation compared to bottom-fixed, such as the ability to fully assemble foundations, towers and turbines at quayside and tow them out to site. The infrastructure needed on the seabed is also less with only anchors and cables to be installed in deep waters.

A potentially complicating factor to lowering installed costs for wind farms comes in the form of local content requirements. Some developers and project sponsors believe that regulators have made the requirements for local production manufacturing too rigid, thereby restricting the competition and economies of scale need to boost global offshore wind development.[71]

Operations, maintenance and beyond

As in solar, there will also be cost reductions in operations and maintenance through the use of drones to check blades and other hard-to-reach components, better computer monitoring systems, and enhanced servicing vessels. As wind technology is still relatively young, it is unclear when existing capacity will complete its technical life and what might happen afterwards. However, it is likely that early wind installations that complete their lifetimes will be repowered with new wind turbines, using cutting edge technology. Some existing wind farms are already being repowered before the end of their technical lifetimes to take advantage of favourable financial conditions.[72]

Figure 9: Drivers of change for the global average levelized cost of wind between 2020 and 2050 (USD/MWh)[73]

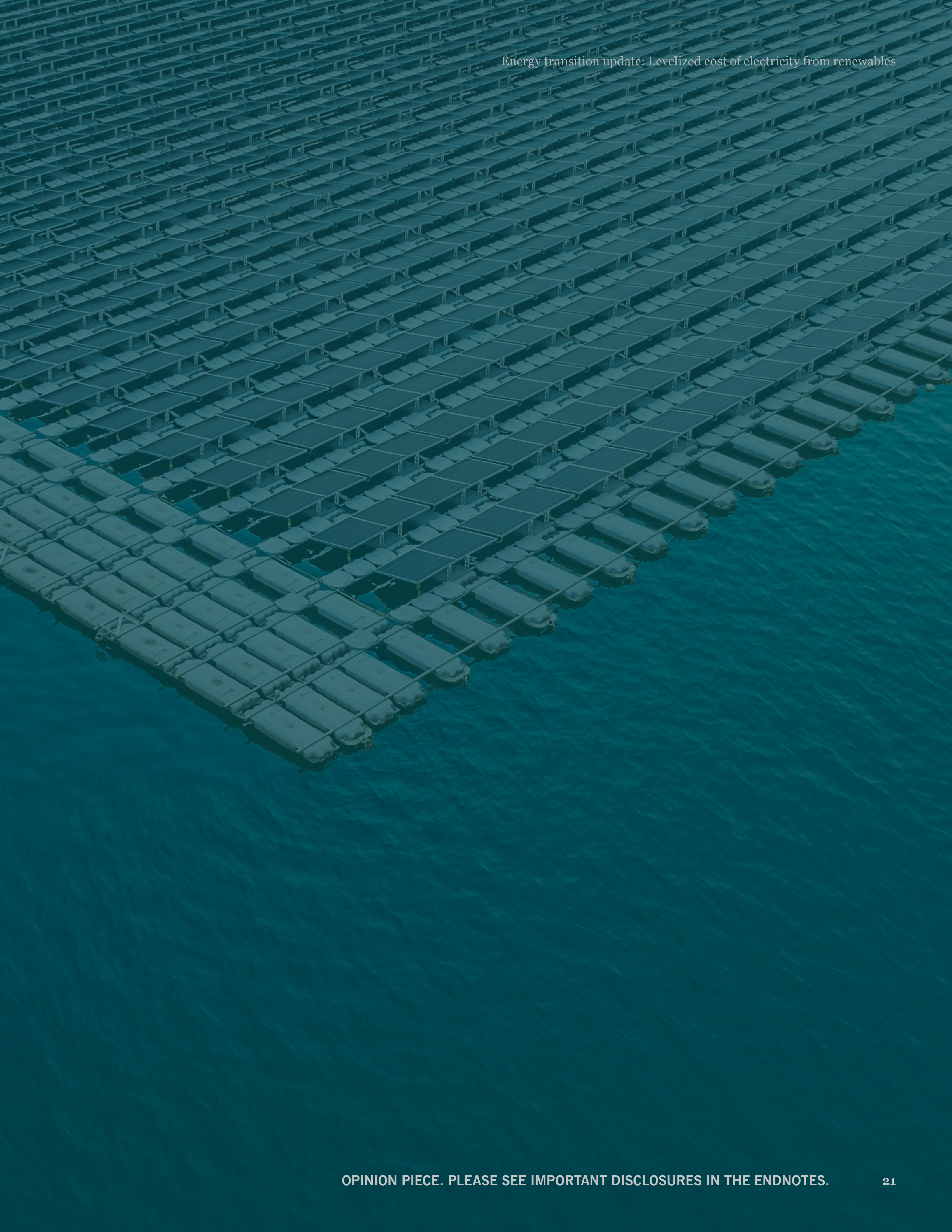


Source: Energy Transition Outlook 2022, DNV, October 2022.

Conclusion

Innovations in renewable technologies are boosting efficiency, while economies of scale are transforming the energy landscape and driving the transition to clean power.

The recent cost increases caused by inflation and the global energy crisis reflect a short-term spike, not a long-term problem with the levelized cost of electricity from renewables. The outlook over the mid to long term is good: the LCOE generated by solar PV and wind will continue to decline after 2024. By 2030 the LCOE of solar PV could fall by 55%, while the LCOE for fixed and floating offshore wind are expected to reduce by 39% and 84%, respectively, in the period from 2020 to 2050. Fossil fuels are no longer the go-to cheap option, as solar PV and offshore wind farms are grabbing their share of markets across the globe and renewables are attracting more and more new investment.



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