Energy Technologies 2030

Wind and solar PV will keep taking the lead

Global Future Council on Energy Technologies

COMMUNITY REPORT

AUGUST 2020

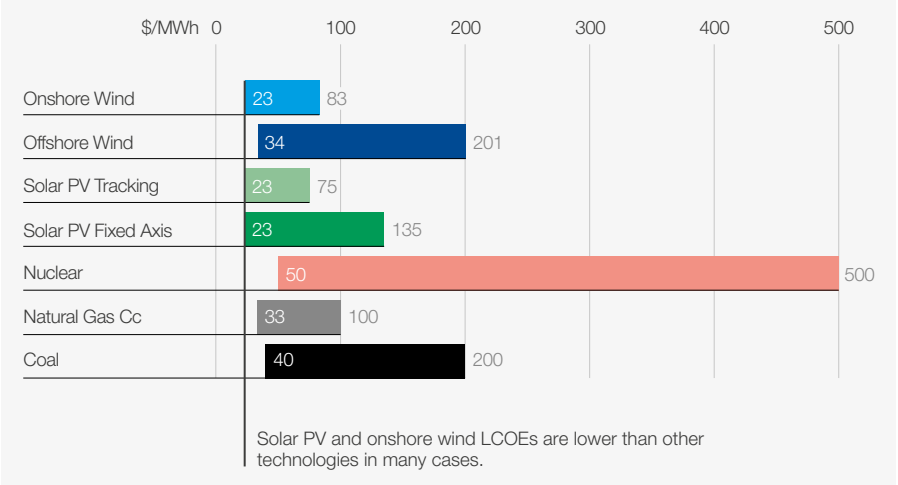
Predicting the future is not easy, but some predictions are easier than others.

The World Economic Forum convened experts from several organizations including IEA, IRENA, BNEF and IHS Markit as well as manufacturers and other energy leaders to agree the 2030 trajectory for wind and solar PV. Together, the group looked at past performance, new developments and other facts to come up with a forecast for their likely evolution to 2030. The experts agreed that cost reductions and performance improvements will continue. Costs of solar PV energy will decrease by 50% while onshore and offshore wind energy costs will fall by 25 and 50%, respectively, driven by technological improvements and economies of scale.

Lowest LCOE for new-build power plants in a given country[1]

Levelized cost of energy (LCOE) excluding subsidies, tax-credit or grid connection costs.

Global LCOE ranges–H2 2020 updates[2]

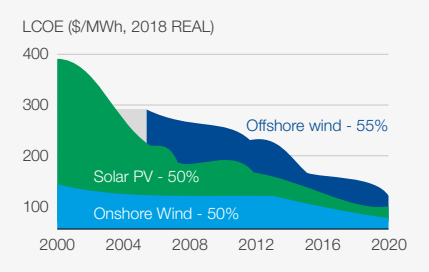


Solar PV and onshore wind LCOEs are lower than other technologies in many cases.

Today wind and solar PV are the most cost-efficient power sources

Wind and solar have started – on global average – to outperform newly built fossil fuel-based electricity generation in terms of cost. In two-thirds of the world, the cost of energy from wind and solar PV is now lower than new coal and gas plants.[3]

Historical view on costs of wind and solar PV



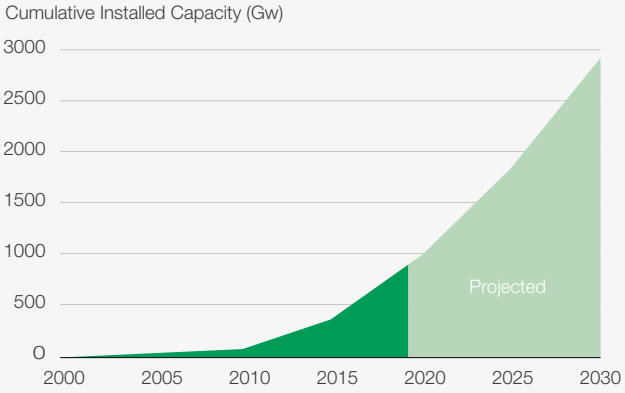
Wind and solar PV industries have demonstrated their ability to lower energy costs drastically in the last 10 years, while increasing efficiency.[4] Declining costs will continue to drive the industry's exponential growth.

Solar PV cost reductions will continue

The cost of solar PV energy is projected to halve in the next decade.[6] By 2030 at the latest, and in some markets earlier, solar PV is expected to deliver the lowest cost of energy for new power generation installations. This decline reflects a series of technological improvements mainly driven by:

- Increasing module efficiency (i.e. using better manufacturing techniques and new cell structures)[7]
- Reducing overall usage of material content, in addition to the effect of rising module efficiency through reducing wafer thickness, decreasing silicon losses, silver paste, etc.[8]
- Improvements in manufacturing processes, which increase throughput, reduce labour costs and achieve greater economies of scale[9]

Global Installed Solar PV Capacity



Global installed capacity of solar PV would rise six-fold by 2030 (2,840 GW)[5]

By 2030, onshore and offshore wind costs will converge at around $30/MWh in most parts of the world

By 2030, onshore and offshore wind costs will converge at around $30/MWh in most parts of the world.[10] This reflects technological innovations, a more efficient supply chain and economies of scale created by market growth.

The cost of onshore wind energy is projected to reduce by 25%-30%[11] in the next decade mainly due to:

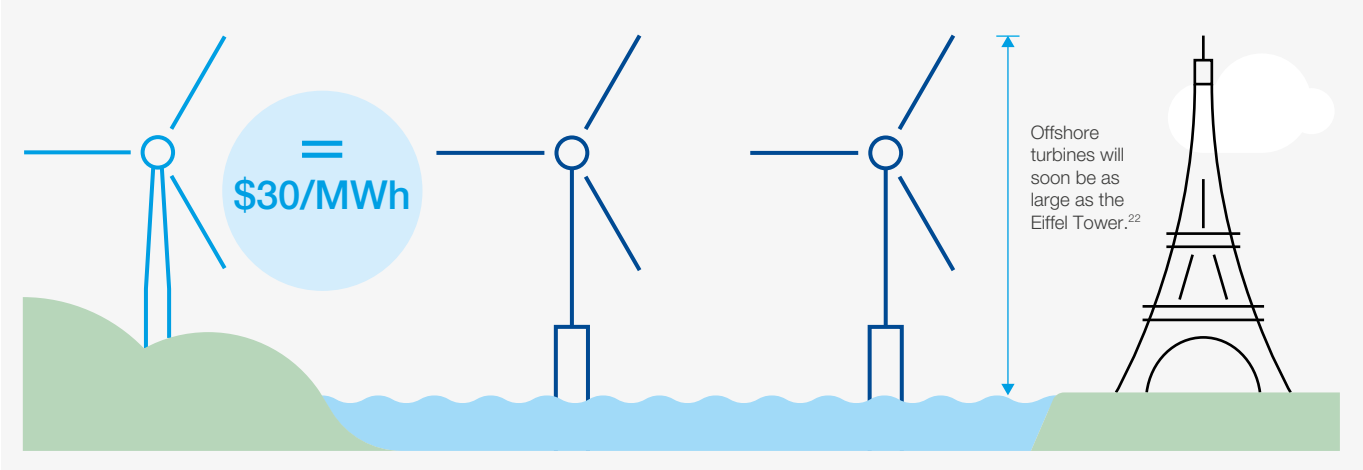
- Larger turbines with increased power output (on average, 6.5 MW per turbine), reducing the investment per power plant to achieve the same or even more electricity output with fewer turbines[12]
- Increased swept-area-to-power-output ratios, which give rise to greater energy generation at low wind speeds[13]
- Digitalization through better data analysis, combined with larger turbines and increased power output ratios, mean that an array of suitable locations worldwide become available[14]

These improvements are helping not only to reduce costs, but also to increase the annual capacity factor (on average, 40% for onshore[15] and 50% for offshore[16] by 2030).

Offshore wind installed capacity is expected to increase ten-fold by 2030[17] and will become a more important part of the electricity landscape than it is today, first in Europe but later elsewhere. Costs are set to reduce by 40%-50% by 2030[18] driven by:

- Larger turbines can be deployed offshore (up to 15-20MW by 2030)[19]
- Lack of land limitation issues offshore plus opportunities for deep water deployment
- Increased supplier competition[20] and improvement of efficiencies in the supply chain to reduce installation cycles[21]

Cost convergence by 2030



It's not just about cost

Competitiveness is not only about costs, but also the positive or negative value that these technologies provide to the energy system and to society at large.

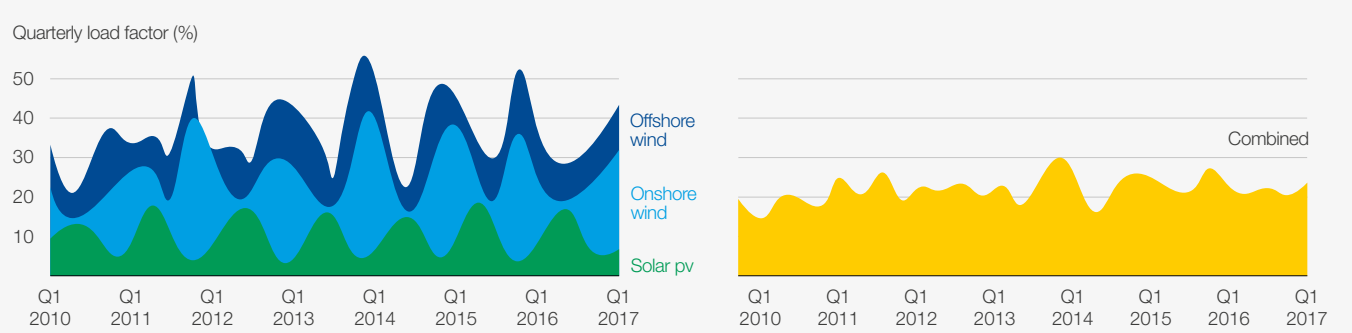
Wind and solar present several system benefits – beyond being cost-competitive – that are not compensated today:

- Society not only benefits from lower-cost energy, but also from lower emissions
- Wind and solar are unique in terms of power generation technologies because they can be rapidly deployed and scaled up

In addition, wind and solar are not competing technologies, but rather complementary, which combined could reduce their individual inherent volatility[23] in output and contribute to a more affordable, sustainable and reliable power system.

After permitting is completed, it takes less than one year to deploy a PV or wind power plant.

The Combination Of Wind And Solar Can Reduce Quarterly Volatility By More Than 50%



The chart shows that the combination of wind and solar reduces the volatility of these individual technologies.[24]

Energy systems need to evolve

The experts agree that cost reductions and performance improvements will continue, and that wind and solar PV will become the most cost-efficient power sources by 2030. Large-scale transformation and deployment will, however, require rethinking energy systems and policy interventions.

As more wind and solar PV are deployed, new policies should encourage increasing efficiency and flexibility of the overall system.[25] Investments in smart electricity networks and storage will typically be required to integrate a high penetration of wind and solar, and in most regions, the power market design will need to be restructured. The traditional approach of distinguishing power plants based on baseload, intermediate and peak load needs to evolve.

Delivering high system value

The COVID-19 pandemic has created a global health and economic crisis. Quantifying the impact of wind and solar PV using a "system value" lens demonstrates the role of these technologies for both economic recovery and the clean energy transition. System value encompasses not only the levelized cost of energy but also the societal value that a clean energy transition will deliver. This includes reduced emissions and water usage, better air quality and health, more jobs, and contributing to an energy system that is scalable, resilient and reliable.

Policy Interventions

Rethinking the system will require more flexible options, policy intervention and continued investment for innovation.

Wind and solar PV are cost competitive and deployment is encouraged now. Looking to the future, for large-scale transformation and deployment, an additional focus on integration and market design will be necessary.

Contributors

Energy Technologies 2030 project lead and lead author
Sergio Platon, World Economic Forum Project Fellow, Iberdrola

Lead authors
Rina Bohle Zeller, Senior Specialist, Global Public Affairs, Vestas

Agustin Delgado, Chief Innovation and Sustainability Officer, Iberdrola

Gerard Reid, Founder and Partner, Alexa Capital

Kristen Panerali, Head of Electricity Industry, World Economic Forum

The authors would like to thank the following contributors:
Pietro Altermatt, Principal Scientist, Trina Solar

Heymi Bahar, Senior Analyst - Renewable Energy Markets and Policy, International Energy Agency

Fabrizio Bizzarri, Head of Solar Innovation, Enel Green Power

Stuart Bradley, Practice Manager Renewables and Shipping Energy Systems Catapult

Simon Engelke, Global Future Council Fellow, University of Cambridge

Pilar Gonzalez, Energy Manager, Iberdrola

Joseph Goodman, Solar Principal, Rocky Mountain Institute

Tom Harris, Global Head of Wind Insight, Bloomberg NEF

Jules Kortenhorst, Chief Executive Officer, Rocky Mountain Institute

Thomas Krupke, Chief Executive Officer, Clere

Christian Langen, Chairman of the Board, Oxford PV

Torben Hvid Larsen, Chief Technology Officer, MHI Vestas Offshore Wind

Cecilia L'Ecluse, Solar Analyst, Bloomberg NEF

Vincent Minier, Vice-President Global Energy Public Policy Schneider Electric

Thomas Odijk Håvardstun, Senior Engineer Solar Technology, Equinor

Morten Rasmussen, Head of Technology, Offshore Siemens Gamesa

Daniel Roman, Head of Technology Insight and Foresight, Siemens Gamesa

Eduard Sala de Vedruna, Executive Director – Global Power, IHS Markit

Gerhard Salge, Global Head, Technology Power Grids ABB

Eric Smith, Chief Executive Officer, Keystone Tower Systems

Sune Strøm, Head of Wind Power Regulatory Affairs Ørsted

Michael Taylor, Senior Analyst, Renewable Cost Status and Outlook, International Renewable Energy Agency (IRENA)

Fernando Torrico, Senior Innovation Analyst, Iberdrola

Anders Vedel, Executive Vice-President and Chief Technology Officer, Vestas

Andreas Wade, Global Sustainability Director, First Solar

Chester Wang, Senior Product Manager, Longi Solar

Brent Wanner, Lead, Power Generation WEO International Energy Agency

Nicholas Wagner, Programme Officer, (Remap), International Renewable Energy Agency (IRENA)

Sam Wilkinson, Associate Director, Solar and Energy Storage, IHS Markit

Stephen Wyatt, Director of Research and Innovation, Offshore Renewable Energy Catapult

Global Future Council on Energy Technologies
Christina Lampe-Onnerud, Founder and Chief Executive Officer, Cadenza Innovation, USA; **Tejpreet Singh Chopra**, Founder and Chief Executive Officer, Bharat Light & Power (BLP), India; **Atul Arya**, Senior Vice-President and Chief Energy Strategist, IHS Markit; **Wu Changhua**, Chief Executive Officer, Beijing Future Innovation Center; **Fiona Cousins**, Member of the Board; Digital Executive, Arup Group Ltd; **Agustin Delgado**, Chief Innovation and Sustainability Officer, Iberdrola; **Heriberto Diarte**, Senior Vice-President, External Innovation and Corporate Ventures, Schneider Electric; **Simon Engelke**, Global Future Council Fellow, University of Cambridge; **Philip Lake**, Research and Analysis Specialist, Shaping the Future of Energy, World Economic Forum **Khee Poh Lam**, Dean, School of Design and Environment, National University of Singapore; **Marcello Losasso**, Senior Applied Physicist, Knowledge Transfer Group, European Organization for Nuclear Research (CERN); **Chen Wei Nee**, Chief Strategic Officer, Sustainable Energy Development Authority Malaysia; **Clay Nesler**, Vice-President, Global Sustainability and Regulatory Affairs, Johnson Controls; **Philip New**, Chief Executive Officer, Energy Systems Catapult Limited; **Claudia Vergueiro Massei**, Chief Executive Officer, Siemens LLC Oman; **Kristen Panerali**, Head of Electricity Industry, World Economic Forum; **Emily Reichert**, Chief Executive Officer, Greentown Labs; **Gerard Reid**, Founder and Partner, Alexa Capital; **Gerhard Salge**, Global Head, Technology Power Grids ABB; **Nancy Vandycke**, Founder and Manager, Sustainable Mobility for All Initiative, The World Bank

Endnotes

1. BNEF: 2H 2019 LCOE Update, 10/2019. https://about.bnef.com/ (Link as of 20/02/2020)

2. BNEF 1H 2020 LCOE Update. https://www.bnef.com/ (Link as of 03/08/2020)

3. BNEF: 2H 2019 LCOE Update, 10/2019. https://about.bnef.com/ (Link as of 06/01/2019)

4. BNEF: New Energy Outlook 2019. https://about.bnef.com/new-energy-outlook/ (Link as of 13/12/2019). IRENA shows a decrease of 77% for PV, 20% for offshore wind, and 35% for onshore wind. Renewable Power Generation Costs in 2018. https://www.irena.org/publications/2019/May/Renewable-power-generation-costs-in-2018 (Link as of 13/12/2019)

5. IRENA: Future of Solar PV 2019. https://www.irena.org/publications/2019/Nov/Future-of-Solar-Photovoltaic (Link as of 13/12/2019)

6. Outcomes of World Economic Forum workshop on solar PV held on September 3rd, 2019

7. Two sources, including IEA. Solar PV. https://www.iea.org/reports/tracking-power-2019/solar-pv) and BNEF: New Energy Outlook 2019. https://about.bnef.com/new-energy-outlook/ (Links as of 13/12/2019)

8. Two sources, including IRENA: Future of Solar PV 2019. https://www.irena.org/publications/2019/Nov/Future-of-Solar-Photovoltaic and BNEF: New Energy Outlook 2019. https://about.bnef.com/new-energy-outlook/ (Links as of 13/12/2019)

9. Two sources, including IRENA: Future of Solar PV 2019. https://www.irena.org/publications/2019/Nov/Future-of-Solar-Photovoltaic and BNEF: New Energy Outlook 2019. https://about.bnef.com/new-energy-outlook/ (Links as of 13/12/2019)

10. Outcomes of World Economic Forum workshop on wind energy, held on May 22nd, 2019

11. Outcomes of World Economic Forum workshop on wind energy, held on May 22nd, 2019

12. BNEF: New Energy Outlook 2019. https://about.bnef.com/new-energy-outlook/ (Link as of 13/12/2019)

13. BNEF: New Energy Outlook 2019. https://about.bnef.com/new-energy-outlook/ (Link as of 13/12/2019)

14. Outcomes of World Economic Forum workshop on wind energy, held on May 22nd, 2019

15. BNEF: New Energy Outlook 2019. https://about.bnef.com/new-energy-outlook/ (Link as of 13/12/2019)

16. IRENA: Future of Wind. https://www.irena.org/publications/2019/Oct/Future-of-wind (Link as of 13/12/2019)

17. IRENA: Future of Wind. https://www.irena.org/publications/2019/Oct/Future-of-wind (Link as of 13/12/2019)

18. Outcomes of World Economic Forum workshop on Wind Energy held in May 22nd, 2019

19. Two sources, including IEA: World Energy Outlook. https://www.iea.org/topics/world-energy-outlookand IRENA: Future of Wind. https://www.irena.org/publications/2019/Oct/Future-of-wind (Link as of 13/12/2019)

20. Two sources, including BNEF: New Energy Outlook 2019. https://about.bnef.com/new-energy-outlook/ and IRENA: Future of Wind. https://www.irena.org/publications/2019/Oct/Future-of-wind (Link as of 13/12/2019)

21. Ørsted in offshore wind: Energy & Transport summit III. http://energytransportsummit.com/onewebmedia/Thomas%20Thune%20Andersen%20%C3%98rsted%20DEC3-18%20FINAL.pdf (Link as of 13/12/2019)

22. IEA: World Energy Outlook 2019. https://www.iea.org/topics/world-energy-outlook (Link as of 20/02/2020)

23. Fraunhofer ISE, Energy charts, Monthly electricity generation 2019. https://www.energy-charts.de/energy.htm?source=all-sources&period=monthly&year=2019 (Link as of 06/01/2020)

24. Goldman Sachs: More Lean, More Green II. Article published on October 30, 2018.

25. IEA: Status of Power System Transformation 2018 https://webstore.iea.org/status-of-power-system-transformation-2018 (Link as per 19/12/2019)

Cover: Getty Images/Yang Photo