

RENEWABLE POWER: SHARPLY FALLING GENERATION COSTS



The cost of electricity from renewable energy technologies has fallen steadily, and even dramatically, in recent years. This is especially the case since 2000, with the rise of solar and wind power generation as viable commercial options. Today, power generation from renewable sources and technologies has become increasingly competitive with, or indeed, less costly than, fossil-based or nuclear power.

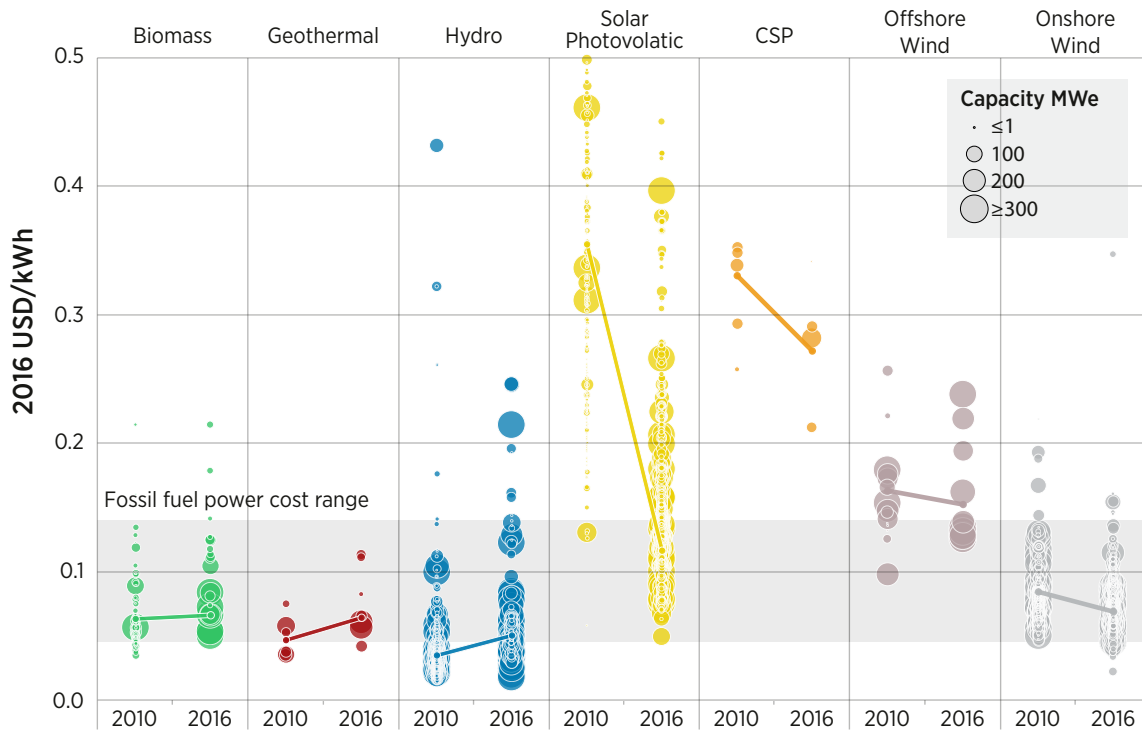
Where untapped and economical resources exist, bioenergy, hydropower and onshore wind all offer new, low-cost power generation. Recent and often rapid cost declines for electricity from solar photovoltaics (PV), offshore wind and concentrating solar power (CSP) mean that these technologies, too, can offer competitive electricity, either now or in the next few years when contracted plants are commissioned.

For plants commissioned in 2016, the global weighted average cost of electricity from bioenergy was USD 0.066 per kilowatt-hour (kWh), from hydropower USD 0.048/kWh, from onshore wind USD 0.07/kWh, from geothermal USD 0.064/kWh, from solar PV USD 0.11/kWh, from offshore wind USD 0.152/kWh and from CSP USD 0.27/kWh (Figure 1). The global weighted average costs of electricity from all renewable technologies except CSP and offshore wind now fall within the range of fossil fuels (USD 0.45/kWh to USD 0.14/kWh).¹

¹ All data provided here are adjusted for inflation and presented in real 2016 USD. The data exclude all financial support for a project. Similarly, the cost of electricity quoted excludes the benefits or costs associated with local and global pollutant emissions. The calculations for the cost of electricity refer to levelised cost of electricity (LCOE) calculations using a weighted average cost of capital of 7.5% in the OECD and China, and 10% elsewhere. Data are from IRENA Renewable Cost Database of 15 000 utility-scale projects.



Figure 1: Levelised cost of electricity by project and renewable generating technology in 2010 and 2016



Solar PV and onshore wind have seen very rapid cost reductions in recent decades. PV modules have experienced learning rates² of 18% to 22%, and module prices have fallen by around 80% since 2010. Onshore wind has experienced a learning rate of 15% for the cost of electricity delivered, as installed cost reductions (wind turbine prices have fallen 38% on average since 2009) and performance improvements have raised yields.

Between 2010 and 2016, the global weighted average cost of electricity from utility-scale solar PV plants commissioned in those years fell 69%, from USD 0.36 to USD 0.11/kWh. At the same time, the 1st and 99th percentile values fell from a range of USD 0.13 to USD 0.49/kWh to a range of USD 0.07 to USD 0.26/kWh. Recent auction and tender results suggest that the lower range could fall to just USD 0.04/kWh by 2019. Where excellent solar resources exist in the sunbelt, low-cost financing is available, and competitive installed costs and operation and maintenance (O&M) costs can be achieved. Auction results in Abu Dhabi, Chile, Dubai, Mexico and Saudi Arabia all suggest that USD 0.03/kWh will be achievable from 2019 and beyond.

Where good resources exist, onshore wind now represents one of the least-cost sources of new electricity generation capacity. The global weighted average cost of electricity from onshore wind fell 18% between 2010 and 2016, from USD 0.085 to USD 0.07/kWh, with projects regularly delivering electricity for just

² Learning rates refer to the percentage reduction in cost for every doubling of the cumulative installed capacity of a technology.

USD 0.04/kWh. Recent auction results suggest costs as low as USD 0.03/kWh within the next two to three years in areas with excellent wind sites. This decline has been driven by falling wind turbine costs since 2009, as well as by increasing hub heights and larger swept areas that allow today's turbines to harvest much more electricity from the same site than turbines from five to ten years ago. Over the space of 17 years, the average capacity factor of new wind farms commissioned in Denmark doubled, while those in Brazil increased 83%, in the United States 46% and in Germany 41%.

Although recently commissioned offshore wind and CSP projects have been relatively expensive, 2016 and 2017 represented watershed years for these technologies. Both are still in the infancy of their deployment, at 13 gigawatts (GW) and 5 GW, respectively. In 2016 and 2017 the results of auctions for offshore wind delivery up until around 2022 in Denmark, Germany, the Netherlands and the United Kingdom saw the cost of electricity fall to the range of USD 0.06 to USD 0.10/kWh, which is highly competitive for new generation capacity in Europe. Similarly, CSP tenders in Australia and Dubai yielded highly competitive prices of around USD 0.07/kWh for a dispatchable, renewable generation technology that has less than 2% of the cumulative installed capacity of solar PV.

While solar and wind power technologies are commercially mature, they still have significant potential for cost reduction. By 2025 the global weighted average cost of electricity from solar PV could fall by as much as 59%, and from CSP by up to 43%. Onshore and offshore wind could see cost declines of 26% and 35%, respectively.

FACILITATING THE NEXT PHASE OF ENERGY TRANSFORMATION

Significant progress is being made in decarbonising the electricity sector, notably with the growth of the variable renewable electricity technologies, meaning solar and wind power. Experience in leading markets has demonstrated the viability of integrating high shares of these sources smoothly into existing power grids, with smart technologies helping to manage daily and seasonal variations in power supply. The focus must now increasingly shift to how to integrate renewables in the end-use sectors (heating, cooling, transport, etc.).

This need to accommodate variable energy supply while providing uninterrupted output in the electricity sector, as well as efforts to integrate renewables into the end-use sectors has brought into sharp relief the significant potential, as well as crucial importance, of electricity storage to facilitate deep decarbonisation.

Electricity storage that is based on rapidly improving batteries and other technologies will permit greater system flexibility, a key asset as the share of variable renewables increases. More directly, electricity storage makes possible a transport sector dominated by electric vehicles; enables effective, 24-hour off-grid solar home systems; and supports 100% renewable mini-grids.

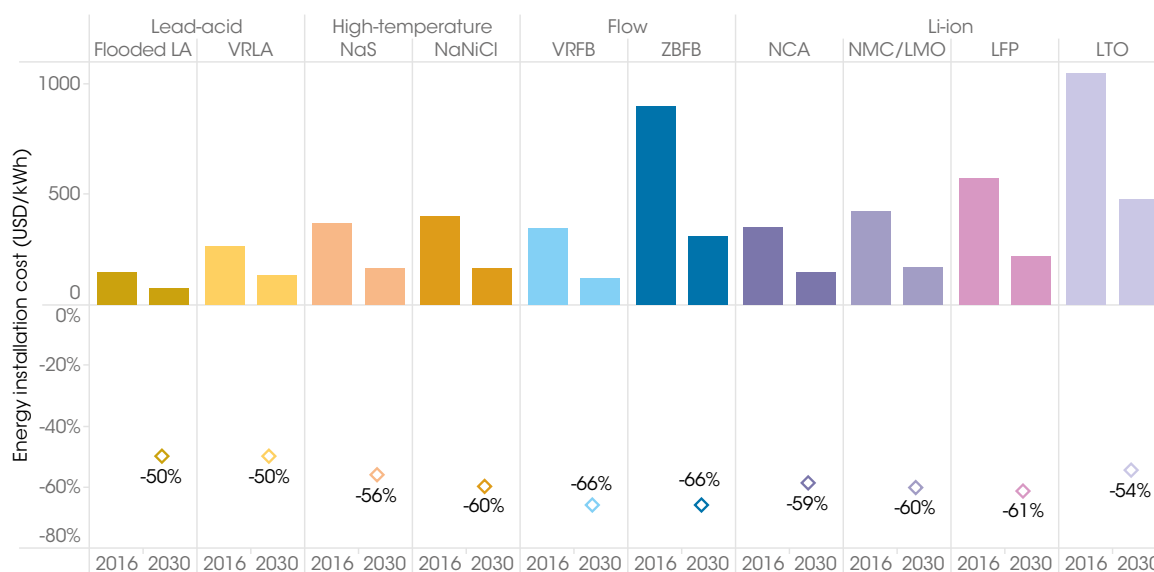
Cost reduction potential in the crucial years until 2030

Total electricity storage capacity could triple in energy terms by 2030, in tandem with rapid uptake of renewable energy. This assumes sufficient uptake to double the share of renewables in the global energy mix in less than a decade and a half. With growing demand for electricity storage from stationary and mobile applications, the total stock of electricity storage capacity will need to grow more than 150%, from an estimated 4.67 terawatt-hours (TWh) in 2017 to 12 TWh or more by 2030.

The cost reduction potential for new and emerging electricity storage technologies is significant. The total installed cost of a lithium-ion battery could fall by at least an additional 54% by 2030 in stationary applications (Figure 2). This will open up new economic markets for electricity storage, as well as increase their role in providing flexibility services to the grid.

Other battery storage technologies also offer large cost reduction potential. The total installed cost of “flow batteries” could drop two-thirds by 2030. High-temperature sodium sulphur (NaS) and sodium nickel chloride batteries also will become much more affordable. Their installed cost could fall 56% to 60% by 2030, at the same time that their performance improves. The installed cost of flywheels could fall 35% by 2030. Compressed air energy storage (CAES), although based on a combination of mature technologies, could see a 17% cost decline by 2030.

**Figure 2 Battery electricity storage systems:
Installed energy cost reduction potential, 2016-2030**



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