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Disruptive Technology in the Energy Sector

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On this page: Appendix B: Disruptive Technology in the Energy Sector.

The energy sector is currently undergoing a major transformation. Overall, the sector is shaped by a shift from fossil fuels to renewables; price drops in renewable energy technology and battery storage; and decentralization of centralized grids, while digitalization, AI, and related technologies make the energy sector "smarter."

Shift from Fossil Fuels to Renewables

One major transition of the power sector is the shift from fossil fuels to renewable energy.[1] As of 2019, oil, natural gas, and coal collectively accounted for 84.3 percent of the share of total global energy consumed.[2] Global renewables consumption represents only 5 percent of the total share, but consumption continues to grow at a rate of 12 percent to 13 percent each year.[3]

Table A.1: Fuel Shares of Primary Energy and Contributions to Growth in 2019

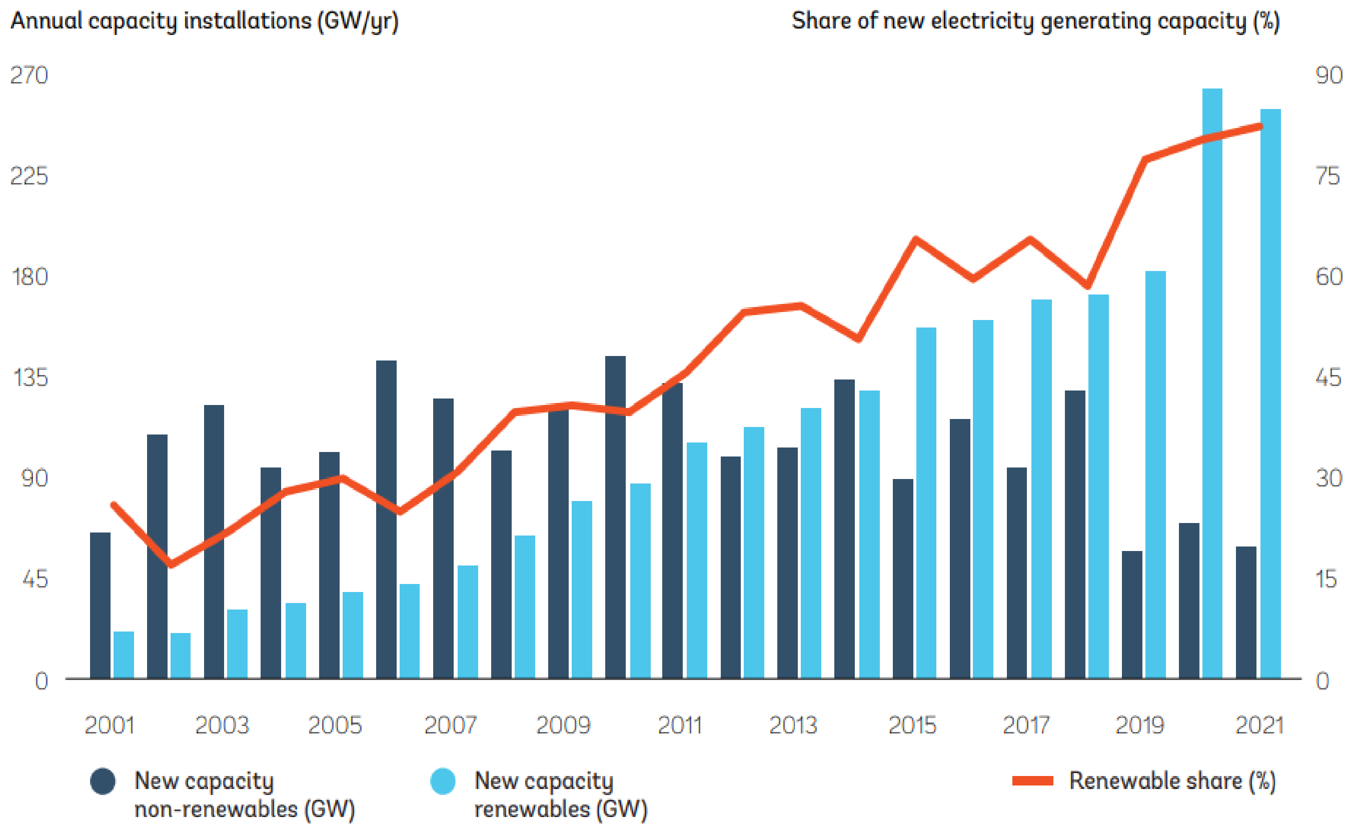
Energy source	Consumtion (exajoules)	Annual change (exajoules)	Share of primary energy	Percentage point change in share from 2018
Oil	193.0	1.6	33.1%	-0.2%

Energy source	Consumtion (exajoules)	Annual change (exajoules)	Share of primary energy	Percentage point change in share from 2018
Gas	141.5	2.8	24.2%	0.2%
Coal	157.9	-0.9	27.0%	-0.5%
Renewables*	29.0	3.2	5.0%	0.5%
Hydro	37.6	0.3	6.4%	-0.0%
Nuclear	24.9	0.8	4.3%	0.1%
Total	**583.9**	**7.7**		

Source: BP. 2020. Statistical Review of World Energy 2020, 69th edition.

Renewable electricity capacity additions have been outpacing those of non-renewables since 2014. Over the past decade, renewables capacity increased by 130 percent, whereas non-renewables only grew by 24 percent.[4]

Figure A.1: Share of New Electricity Capacity, 2001–2021



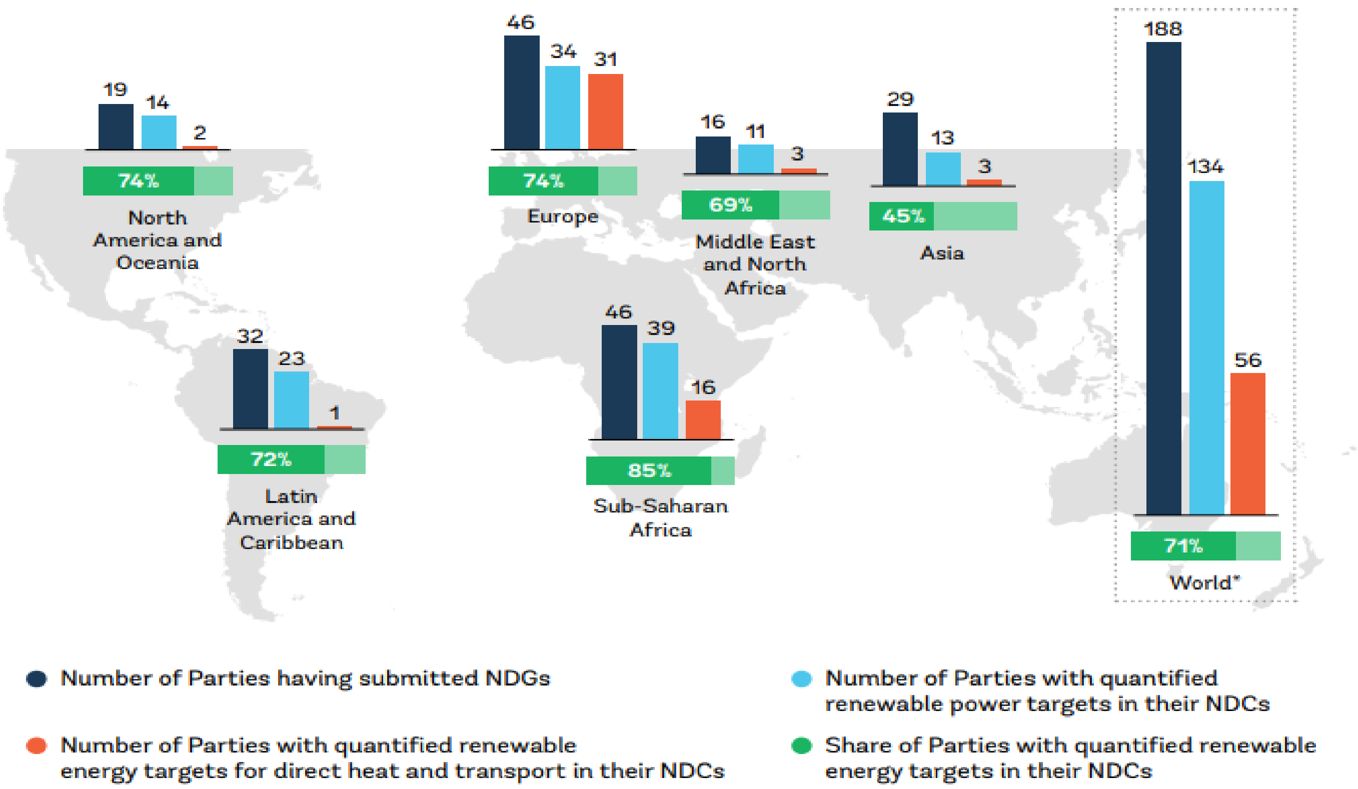
Source: IRENA. 2022. World Energy Transitions Outlook 2022.

Among renewable technologies, solar PV installations have seen the fastest growth, with a 21-fold increase in the 2010-21 period. By the end of 2021, the cumulative installed capacity of solar PV reached 843 gigawatts (GW) globally; 133 GW of capacity was commissioned in 2021 alone. Wind power also experienced significant growth, and wind installations increased more than four-fold from 2010 to 2021. In 2021, the cumulative installed capacity of onshore wind power reached about 769 GW across the globe. The offshore wind market remains small compared to onshore wind, with 56 GW of cumulative installed capacity by the end of 2021.[5]

Against this background, 2022 is set to be a record year in terms of the scale at which the switchover from fossil fuels to renewable sources will take place.[6] As the trend continues, it is possible to foresee fossil fuel infrastructure becoming more unattractive to investors and ultimately obsolete.

This development was to a large extent driven by international commitments and public policies. With increasing global awareness that fossil fuels are a main contributing factor to climate change, the worldwide ambition to decarbonize has grown significantly. This led to the adoption of the Paris Agreement on December 12, 2015,[7] under the United Nations Framework Convention on Climate Change (UNFCCC). The objective of the Paris Agreement is to respond to the threats of climate change by limiting the average global temperature increase, lowering greenhouse gas (GHG) emissions, and promoting climate-resilient development. It sets goals that require each country to reduce its emissions drastically. To achieve these goals, countries worldwide have adopted plans for actions, so-called Nationally Determined Contributions (NDCs), and based on their NDCs, introduced and implemented policies to reduce GHG emissions and to adapt to the effects of climate change. Although the NDCs vary among developed and developing countries, 71 percent of the parties included quantified targets to increase their share of renewable energy as a part of their NDCs. Of these parties, all included targets in the power sector, whereas a few also included targets in heating and transport.[8]

Figure A.2: Renewable Energy Components in Current NDCs



Note: Figures were last updated and verified on 9 December 2020.
Disclaimer: Boundaries and names shown on this map do not imply any official endorsement or acceptance by IRENA.

Source: IRENA. 2020. Renewable Energy and Climate Pledges: Five Years after the Paris Agreement.

Renewable Energy Is Getting Cheaper and Cheaper

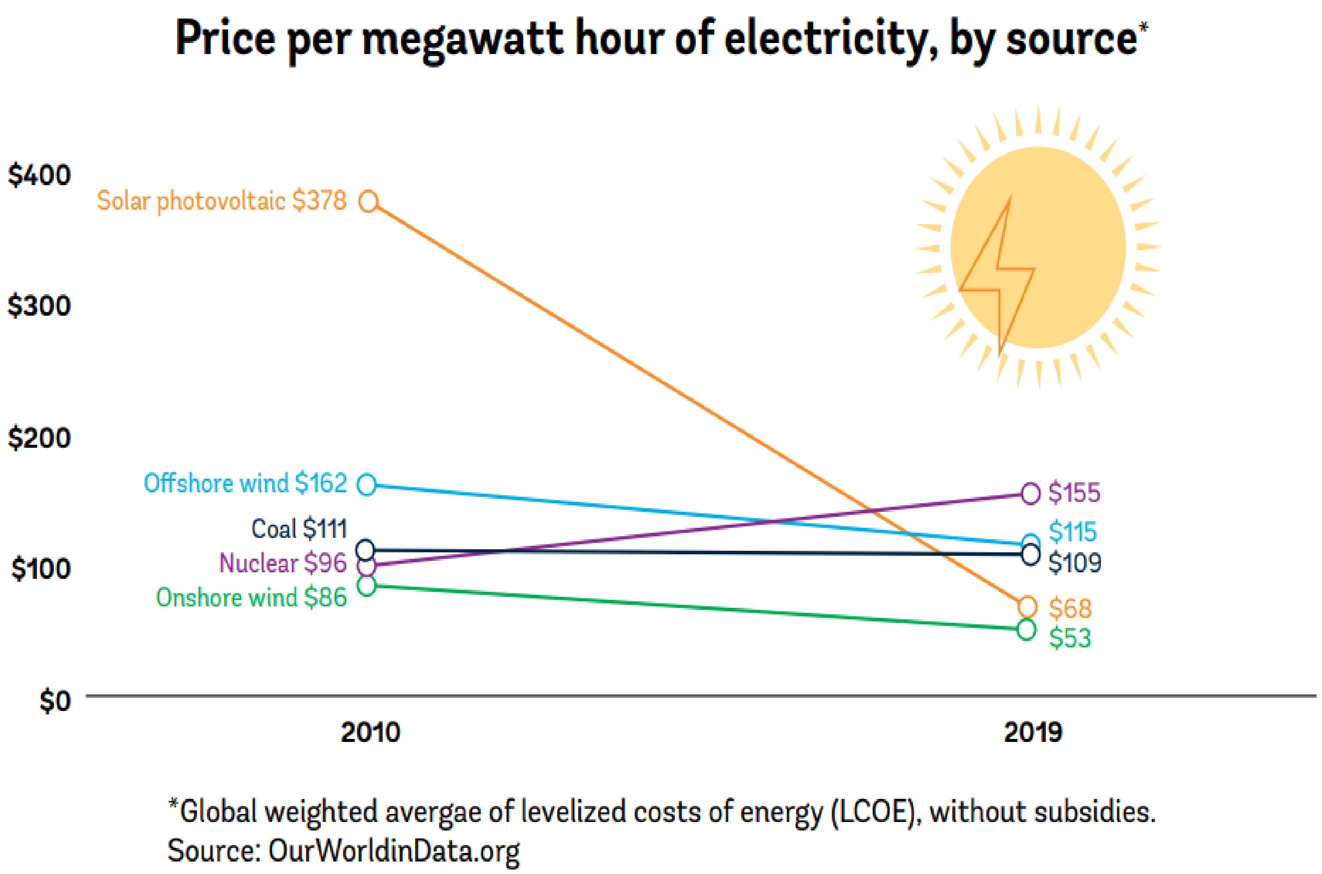
Another driver for the shift towards renewable energy—one that goes hand in hand with ambitious global climate change goals—is that the costs of renewables have been falling steadily during recent decades, making them increasingly the most cost-effective and sustainable energy source for transport, heating, and many industrial production processes. Renewables are now the cheapest power options in most regions.[9]

This development was initially spurred by a number of support policies to encourage renewable energy on the grid during a time when generation of renewable energy was not yet competitive. To reach global climate change targets, the deployment of renewable energy, in particular solar PV and wind generation, was bolstered by many national regulatory and pricing support mechanisms (e.g., feed-in tariffs).

Thanks to innovation and economies of scale, the costs of renewable energy generation technologies, e.g.,solar PV panels, have dropped steadily and drastically. As improvements, for example to solar PV modules, enhanced efficiency, durability, and capacity, solar PV modules began to meet the demands of mainstream markets, thereby increasing production of the modules and decreasing prices exponentially.

In 2020, a total of 162 gigawatts (GW), or 62 percent of the total new renewable power generation capacity added globally, had electricity costs lower than the cheapest source of new fossil fuel-fired capacity. The global weighted-average levelized cost of electricity (LCOE) of newly commissioned utility-scale solar PV projects fell by 85 percent between 2010 and 2020, that of concentrated solar power (CSP) by 68 percent, and onshore wind by 56 percent and offshore wind by 48 percent. Renewables are now the default option for capacity additions in the power sector, where they dominate investments.

Figure A.3: The Falling Cost of Renewable Energy.



Source: Statistica. https://www.statista.com/chart/26085/price-per-megawatt-hour-of-electricity-by-source/.

This price decline, together with advances and price drops in battery storage technology, in particular lithium-ion battery technology and green hydrogen (see “Stationary and mobile energy storage devices” in Appendix A) made efficient peak time provision of renewable energy possible, and further accelerated the adoption of renewable energy sources.

As the costs of renewables plummeted, the world started to move from specific support mechanisms that relied on high levels of direct government subsidies (e.g., feed-in tariffs) to more competitive tools. Although feed-in policies remain a widely used policy mechanism for supporting renewable power, in 2020 the shift to competitive remuneration through tenders and auctions continued. In the first half of 2020, 13 countries awarded nearly 50 GW in new capacity, breaking a record for auctioned capacity. Although the total number of countries that held renewable power auctions decreased during the year (from 41 to at least 33), several new countries held auctions for the first time. Alongside significant and ongoing cost reductions in solar PV and wind power, the growth of auctions has created a highly competitive bidding environment that has placed strong downward pressure on price levels for renewable power projects. In 2020, developers around the world continued to submit bids for tenders at record-low prices for utility- scale solar PV and wind power.[10]

Decentralization

Another trend that can be witnessed is a switch from centralized power generation and large transmission nets to decentralized energy generation, where more power is generated closer to the point of consumption by smaller local power grids at competitive prices (e.g., solar farms).

With falling prices of renewable energy deployment as well as small-scale renewable power generation and storage technology, the energy sector has become less dependent on centralized utility scale power generation. Instead, distributed generation of electricity is steadily increasing, particularly within emerging and developing markets because it allows electricity to be produced onsite or near to where the electricity will be consumed, in areas that are not yet connected to a central grid. Advances in AI and other disruptive technologies have enabled distributed generation to become an even bigger component of global power generation, because the development and integration of numerous smaller networks requires complex AI algorithms.[11]

Centralized generation refers to the large-scale generation of electricity at centralized facilities. These facilities are usually located away from end-users and connected to a network of high-voltage transmission lines. The electricity generated centrally is distributed through the electric power grid to multiple end-users. Centralized generation facilities include fossil fuel-fired power plants, nuclear power plants, hydroelectric dams, wind farms, and more.

Distributed generation refers to a variety of technologies that generate electricity at or near where it will be used, such as solar panels, small wind turbines, or combined heat and power systems. Distributed generation can be interconnected with or independent from the centralized grid. It may serve a single structure, such as a home or business, and can also be part of a nanogrid or microgrid (smaller grids that are also tied into the larger electricity delivery system), such as at a major industrial facility. When connected to the electric utility’s lower voltage distribution lines, distributed generation can help support delivery of clean, reliable power to additional customers and reduce electricity losses along transmission and distribution lines.[12]

The Power Sector is Getting ‘Smarter’

Together with the ability to generate power from renewables at very small scale and store it in batteries, digital technologies are re-shaping the energy sector. Around the globe, innovative digital solutions are increasingly implemented, ranging from smart meters and other IoT devices that can communicate with each other to smart grids, smart EV charging infrastructure, and smart city concepts. These innovative solutions will help improve power management, efficiency, and transparency, and will make it easier to manage the integration of renewables and the increasing number of EVs.

Smart grids are electricity networks that allow for two-way communication between the utilities, the consumers, and any intermediary third-party service providers. They use digital and other advanced technologies (e.g., smart meters, sensors, AI, IoT, and big data analytics) to collect, store and analyze data. Thereby they give utility operators a way to monitor and manage usage and network performance in real time, allowing them to meet the varying electricity demands of end users, to spot failures as they happen, and, under some circumstances, even to restore power by rerouting service around the failed transmission or generating equipment.[13] Smart grids coordinate the needs and capabilities of all generators, grid operators, end users, and electricity market stakeholders to operate all parts of the system as efficiently as possible with real-time data, minimizing costs and environmental impacts while maximizing system reliability, resilience, and stability.[14]

Smart EV charging infrastructure demand is rising. As the popularity of and need for EV rises, so does the demand for readily available public and private EV charging infrastructure. Such infrastructure is commonly seen as a necessary component of a smart grid. Electric vehicle supply equipment (EVSE) delivers electricity to EVs to recharge the vehicles' batteries. Currently, the majority of EVSEs are wired, and the EVs need to be plugged in for charging. With concerns related to battery range and plug-in options, wireless EV charging technology, known as wireless power transfer (WPT), has been developed and will likely be widely adopted in the near future.

Smart grid technology will be key for the deployment and flexibility of EV charging infrastructure. Because EVs are idle most of the time, they can be a tool for improving grid stability. Wide-scale use of EVs will dramatically increase global energy storage capacity, helping to harness renewable energy that would otherwise be lost. An EV's average useable battery capacity is about 40 kWh.125 Smart grid technology will allow EVs with bidirectional charging capabilities to be distributed energy resources, supplying the grid during peak demand and offtaking excess electricity when supply is high, known as vehicle-to-grid (V2G) technology or vehicle-grid integration (VGI). Furthermore, EVs could also power home (vehicle-to-home, or V2H) and building (vehicle-to-building, or V2B) technology. Many EV manufacturers are now introducing bidirectional charging capabilities as a standard feature on new models.

Footnote 1: Renewable energy sources are sustainable sources to generate power, the majority of which do not emit carbon. These sources include wind, solar, hydroelectric, hydrokinetic, biomass, and geothermal.

Footnote 2: BP. 2020. Statistical Review of World Energy 2020, 69th edition.

Footnote 3: BP. 2020. Statistical Review of World Energy 2020, 69th edition.

Footnote 4: IRENA. 2022. World Energy Transitions Outlook 2022.

Footnote 5: IRENA. 2022. World Energy Transitions Outlook 2022.

Footnote 6: Marr, Bernard. 2022. "The Five Biggest New Energy Trends In 2022." Forbes, March 1, 2022.

Footnote 7: On December 12, 2015, 196 countries adopted the Paris Agreement, which has since then been ratified by 189 countries.

Footnote 8: IRENA. 2020. Renewable Energy and Climate Pledges: Five Years after the Paris Agreement.

Footnote 9: IRENA. 2022. World Energy Transitions Outlook 2022.

Footnote 10: Ren21. 2021. Renewables 2021 - Global Status Report 2021.

Footnote 11: Marr, Bernard. 2022. "The Five Biggest New Energy Trends In 2022." Forbes, March 1, 2022.

Footnote 12: The global average of losses during transmission and distribution is 8 to 9 percent of the electricity generated, although many developing countries see well over 20 percent of it lost (Electric power transmission and distribution losses (% of output), Data bank of The World Bank (last visited: September 13, 2022).

Footnote 13: Manyika, James, Michael Chui, Jacques Bughin, Richard Dobbs, Peter Bisson, and Alex Marrs. 2013. Disruptive technologies: Advances that will transform life, business, and the global economy. McKinsey Global Institute.

Footnote 14: IEA (International Energy Agency). 2021. Smart Grids.

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