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42 S. Vorrath, "Milestone for Garden Island microgrid as Carnegie gets back on the wave", RenewEconomy, 6 February 2020, https://reneweconomy.com.au/milestone-for-garden-island-microgrid-as-carnegie-gets-back-on-the-wave-82694.

43 OES, op. cit. note 7, p. 8.

44 Bombora, "Two-thirds of contracts awarded for 1.5MW wave energy device project", 7 January 2020, https://www.bomborawave.com/latest-news/two-thirds-of-contracts-awarded-for-1-5mw-wave-energy-device-project.

45 Ibid.

46 LCEO, op. cit. note 1; OES, *Annual Report 2018* (Lisbon: March 2019), p. 5, http://report2018.ocean-energy-systems.org.

47 LCEO, op. cit. note 1; Directorate-General for Maritime Affairs and Fisheries of the European Commission, *Market Study on Ocean Energy* (Brussels: 20 June 2018), https://publications.europa.eu/en/publication-detail/-/publication/e38ea9ce-74ff-11e8-9483-01aa75ed71a1/language-en/format-PDF/source-99081151.

48 A. Copping, *The State of Knowledge for Environmental Effects Driving Consenting/Permitting for the Marine Renewable Energy Industry* (Richland, WA: OES and Pacific Northwest National Laboratory, January 2018), https://tethys.pnnl.gov/publications/state-knowledge-environmental-effects-driving-consentingpermitting-marine-renewable.

49 Ibid.

50 Directorate-General for Maritime Affairs and Fisheries of the European Commission, op. cit. note 47.

51 Directorate-General for Maritime Affairs and Fisheries of the European Commission, op. cit. note 47.

52 EC Strategies Energy Technologies Information System, *Ocean Energy – Implementation Plan* (Brussels: 2018), https://setis.ec.europa.eu/system/files/set_plan_ocean_implementation_plan.pdf.

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1 Stable or contracted slightly in 2018 based on the following: 102.4 GW added to the world's grids in 2018, up from 98.5 GW installed in 2017, from SolarPower Europe, *Global Market Outlook for Solar Power, 2019-2023* (Brussels: 2019), p. 5, https://www.solarpowereurope.org/global-market-outlook-2019-2023; figures of 103,226 MW installed during 2018, down from 103,554 MW installed in 2017, from International Energy Agency (IEA) Photovoltaic Power Systems Programme (PVPS), *Trends in Photovoltaic Applications 2019* (Paris: 2019), p. 97, https://iea-pvps.org/trends_reports/2019-edition/; and 2018 saw first annual decline in 50 years (a result of policy changes in China), with total industry demand down 5%, to 89.1 GWp (compared with 93.9 GWp in 2017), from P. Mints, SPV Market Research, *The Solar Flare*, no. 4 (31 August 2019), p. 8. Figures of at least 114.9 GW added in 2019 for a total of at least 627 GW are preliminary estimates from IEA PVPS, *Snapshot of Global PV Markets 2020* (Paris: April 2020), https://iea-pvps.org/snapshot-reports/snapshot-2020/, and from Becquerel Institute, Brussels, personal communication with Renewable Energy Policy Network for the 21st Century (REN21), 10 April 2020; increase over 2018 market based on idem, both sources, and on additions of 103 GW in 2018, from IEA PVPS, *Trends in Photovoltaic Applications 2019*, op. cit. this note, pp. 96-97. Additions of 113.9 GW in 2019, and cumulative shipments of cells to first buyer over the period 1975-2019 reached 591 GW in 2019, from P. Mints, SVP Market Research, *Photovoltaic Manufacturer Shipments: Capacity, Price & Revenues 2019/2020* (San Francisco: April 2020), pp. 15, 34, and just over 110 GW for a global total exceeding 600 GW, from EurObserv'ER, *Photovoltaic Barometer* (Paris: April 2020), p. 2, https://www.eurobserv-er.org/category/all-photovoltaic-barometers. The numbers published by IEA PVPS are based on official data in reporting countries; many of these countries account for decommissioning of existing capacity, but not all countries track either decommissioning or repowering of solar PV capacity. IEA PVPS assumes that decommissioning is relatively uncommon at this stage, given that most global installations were commissioned in 2005 and later, from IEA PVPS, *Snapshot of Global PV Markets 2020*, op. cit. this note, p. 13. A few countries report data officially in alternating current (AC) (e.g., Canada, Chile, India, Japan, Malaysia, Sweden and the United States); these data were converted to direct current (DC) by relevant sources provided in this section for consistency across countries. The difference between DC and AC power can range from as little as 5% (conversion losses, inverter set at DC level) to as much as 40% (due to some grid regulations limiting output or to the evolution of utility-scale solar PV plants), from IEA PVPS, *Trends in Photovoltaic Applications 2019*, op. cit. this note, p. 9. Most utility-scale solar PV plants built in 2019 have an AC-DC ratio between 1.1 and 1.6, from IEA PVPS, *Snapshot of Global PV Markets 2020*, op. cit. this note, p. 11. Conversions done by IEA PVPS and the Becquerel Institute use a multiplier of 1.3 for centralised capacity to convert capacity from AC to DC. In the United States, the median inverter loading ratio (ratio of DC nameplate rating to AC inverter nameplate rating) in 2018, for both tracked and fix-tilt utility-scale projects, was 1.33, but there is significant variation across projects, from M. Bolinger, J. Seel and D. Robson, *Utility-scale Solar: Empirical Trends in Project Technology, Cost, Performance, and PPA Pricing in the United States – 2019 Edition* (Berkeley, CA: Lawrence Berkeley National Laboratory, December 2019), p. ii, https://eta-publications.lbl.gov/sites/default/files/lbnl_utility_scale_solar_2019_edition_final.pdf. The argument is made that AC ratings are more appropriate for utility-scale capacity because other conventional and renewable utility-scale generating sources also are described in AC terms, and because the difference between a project's DC and AC capacity ratings is increasing in general (at least in the United States) due to a lower relative inverter rating, from M. Bolinger and J. Seel, *Utility-Scale Solar: Empirical Trends in Project Technology, Cost Performance, and PPA Pricing in the United States – 2018 Edition* (Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL), September 2018), p. 5, https://emp.lbl.gov/utility-scale-solar. However, most analysts, consultancies, industry groups, the IEA and many others report data in DC, from M. Schmela, SolarPower Europe, personal communication with REN21, 11 May 2019. In addition, DC capacity more accurately reflects the rating of panels, from C. Marcy, "Solar plants typically install more panel capacity relative to their inverter capacity", Today in Energy, US Energy Information Administration (EIA), 16 March 2018, https://www.eia.gov/todayinenergy/detail.php?id=35372. In order to maintain a consistent rating type across all solar PV capacity, and because the AC capacity of most countries is not available, GSR 2020 attempts to report all solar PV data in DC units; in addition, the GSR reports only capacity that has entered into operation by year's end.

2 More than making up for China from P. Mints, SPV Market Research, *The Solar Flare*, no. 6 (23 December 2019), p. 6; G. Masson, Becquerel Institute and IEA PVPS, Brussels, personal communication with REN21, 20 February 2020; IEA PVPS, *Snapshot of Global PV Markets 2020*, op. cit. note 1; decline in China from China's National Energy Administration (NEA), "PV grid-connected operation in 2019", 28 February 2020, http://www.nea.gov.cn/2020-02/28/c_138827923.htm (using Google Translate).

3 Based on data from IEA PVPS, *Trends in Photovoltaic Applications 2019*, op. cit. note 1, p. 97, and from IEA PVPS, *Snapshot of Global PV Markets 2020*, op. cit. note 1, p. 6.

4 For total at end of 2019, see endnote 1. Figure of 23 GW at end of 2009 from IEA PVPS, *Trends in Photovoltaic Applications 2019*, op. cit. note 1, pp. 96-97. **Figure 28** based on data from IEA PVPS, *Snapshot of Global PV Markets 2020*, op. cit. note 1, from IEA PVPS, *Trends in Photovoltaic Applications 2019*, op. cit. note 1, pp. 96, 97, and from Becquerel Institute, op. cit. note 1.

5 SolarPower Europe, op. cit. note 1, pp. 9, 13. See also, for example, International Renewable Energy Agency (IRENA), *Renewable Power Generation Costs in 2018* (Abu Dhabi: 2019), p. 9, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/May/IRENA_Renewable-Power-Generations-Costs-in-2018.pdf; B. Eckhouse, "Solar and wind cheapest source of power in most of the world", *Bloomberg*, 28 April 2020, https://www.bloomberg.com/news/articles/2020-04-28/solar-and-wind-cheapest-sources-of-power-in-most-of-the-world; BloombergNEF, "Solar, wind, batteries to attract $10 trillion to 2050, but curbing emissions long-term will require other technologies too", 18 June 2019, https://about.bnef.com/blog/solar-wind-batteries-attract-10-trillion-2050-curbing-emissions-long-term-will-require-technologies; M. Brown, "Solar energy prices hit tipping point as China reaches 'grid parity'", Inverse, 14 August 2019, https://www.inverse.com/article/58495-solar-energy-prices-hit-tipping-point-as-china-reaches-grid-parity; M. Brown, "Solar vs. coal: Why the '74 percent report' signals a new era for US energy", Inverse, 28 March 2019, https://www.inverse.com/article/54399-solar-energy-cheaper-than-coal-whats-next; https://www.nature.com/articles/s41560-019-0441-z; J. Weaver, "Solar price declines slowing, energy storage in the money", pv magazine, 8 November 2019, https://pv-magazine-usa.com/2019/11/08/sola-price-declines-slowing-energy-storage-in-the-money; M. Hutchins, "Solar 'could soon be UK's cheapest source of energy'", pv magazine, 12 December 2018, https://www.pv-magazine.com/2018/12/12/solar-could-soon-be-uks-cheapest-source-of-energy; K. Samanta, "India's renewable energy cost lowest in Asia Pacific: WoodMac", *Reuters*, 29 July 2019, https://www.reuters.com/article/us-india-renewables-woodmac/indias-renewable-energy-cost-lowest-in-asia-pacific-woodmac-idUSKCN1UO0L8; J. Yan et al., "City-level analysis of subsidy-free solar photovoltaic electricity price, profits and grid parity in China", *Nature Geoscience* (2019), cited in J. Gabbatiss, "Solar now 'cheaper than grid electricity' in every Chinese city, study finds", CarbonBrief, 12 August 2019, https://www.carbonbrief.org/solar-now-cheaper-than-grid-electricity-in-every-chinese-city-study-finds.

6 N. Ford, "Europe solar-storage costs fall below markets as learnings kick in", New Energy Update, 2 October 2019, https://analysis.newenergyupdate.com/pv-insider/europe-solar-storage-costs-fall-below-markets-learnings-kick.

7 Estimated 18 countries (Australia, Brazil, China, Chinese Taipei, Egypt, Germany, India, Japan, the Republic of Korea, Mexico, the Netherlands, Pakistan, South Africa, Spain, Ukraine, United Arab Emirates, the United States and Vietnam) in 2019 based on preliminary estimates for IEA PVPS, *Snapshot of Global PV Markets 2020*, op. cit. note 1, on data from Becquerel Institute, op. cit. note 1, and on data from country-specific sources provided throughout this section. Up from 11 countries (China, the United States, India, Japan, Australia, Germany, Mexico, the Republic of Korea, Turkey, the Netherlands and Brazil) in 2018 from SolarPower Europe, op. cit. note 1, p. 53; and up from 10 countries in 2018 from IEA PVPS, *Snapshot of Global PV Markets 2020*, op. cit. note 1, p. 9. There were nine countries in 2017 from IEA PVPS, *Trends in Photovoltaic Applications 2018: Survey Report of Selected IEA Countries Between 1992 and 2017* (Paris: 2018), p. 3, http://www.iea-pvps.org/fileadmin/dam/public/report/

statistics/2018_iea-pvps_report_2018.pdf, and from SolarPower Europe, *Global Market Outlook for Solar Power 2018-2022* (Brussels: 2018), p. 5, https://www.solarpowereurope.org/wp-content/uploads/2018/09/Global-Market-Outlook-2018-2022.pdf; and seven countries in 2016 from idem, p. 5.

8 Figure of 39 countries in 2019 based on data from numerous sources, including preliminary data from IEA PVPS, *Snapshot of Global PV Markets 2020,* op. cit. note 1, from A. Detollenaere, Becquerel Institute, personal communication with REN21, 10 April 2020, from IEA PVPS, *Trends in Photovoltaic Applications 2019*, op. cit. note 1, p. 96, and from numerous sources cited throughout this section. Figure of 31 countries in 2018 from IEA PVPS, *Trends in Photovoltaic Applications 2019*, op. cit. note 1, p. 6.

9 IEA PVPS, *Trends in Photovoltaic Applications 2018*, op. cit. note 7, p. 80.

10 IEA PVPS, *Snapshot of Global PV Markets 2020*, op. cit. note 1, p. 14. Based on cumulative capacity in operation at end-2019 and assumes close to optimum siting, orientation and long-term average weather conditions, from idem.

11 **Honduras** sourced 10.7% of its gross electricity generation from solar PV, based on data from T. Vindel, Secretario de Estado en el Despacho de Energía de la República de Honduras, and provided by G. Bravo, Fundación Bariloche, personal communication with REN21, 27 April 2020; **Italy** generated 24,326 GWh of electricity with solar PV in 2019, and total net production in the system was 283,846 GWh, for a solar PV share of 8.57%, from Terna, *Rapporto mensile sul Sistema Elettrico December 2019* (Rome: 2019), p. 5, https://download.terna.it/terna/Rapporto_Mensile_Dicembre%202019_8d79d92a335c3f2.pdf; **Greece** from multiple original sources, all in Greek, and provided by I. Tsipouridis, R.E.D. Pro Consultants, Athens, personal communication with REN21, April 2020; **Germany's** solar PV generation accounted for 8.2% of Germany's gross electricity generation in 2019 (up from 7.7% in 2018), from Federal Ministry for Economic Affairs and Energy and Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat), *Time Series for the Development of Renewable Energy Sources in Germany, Based on Statistical Data from the Working Group on Renewable Energy-Statistics (AGEE-Stat) (Status: February 2020)* (Dessau-Roßlau: February 2020), pp. 44, 45, https://www.erneuerbare-energien.de/EE/Navigation/DE/Service/Erneuerbare_Energien_in_Zahlen/Zeitreihen/zeitreihen.html; **Chile** share of generation from Asociación Chilena de Energías Renovables y Almacenamiento (ACERA), *Estadísticas Sector de Generacíon de Energía Eléctrica Renovable* (December 2019), p. 2, https://acera.cl/wp-content/uploads/2020/01/2019-12-Bolet%C3%ADn-estad%C3%ADsticas.pdf; **Australia** from Clean Energy Council, *Clean Energy Australia Report 2020* (Melbourne: 8 April 2020), p. 9, https://assets.cleanenergycouncil.org.au/documents/resources/reports/clean-energy-australia/clean-energy-australia-report-2020.pdf; **Japan** from Institute for Sustainable Energy Policies (ISEP), "Share of renewable energy electricity in Japan, 2019 (preliminary report)", 10 April 2020, https://www.isep.or.jp/en/879.

12 Share of total global electricity generation based on the following: total global electricity generation in 2019 estimated at 27,011 TWh, based on 26,615 TWh in 2018 from BP, *Statistical Review of World Energy* (London: 2019), https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html, and on estimated 1.49% growth in global electricity generation in 2019. Growth rate in 2019 is based on the weighted average change in actual total generation for the following countries/regions (which together accounted for more than two-thirds of global generation in 2018): United States (-1.3% net generation), EU-28 (-1.2%), Russian Federation (+1.2%), India (+0.0%), China (+4.7%), Canada (-0.2%) and Brazil (+2.0%). Generation data for 2018 and 2019 by country or region from the following: US Energy Information Administration (EIA), *Electric Power Monthly with Data for December 2019* (Washington, DC: February 2020), Table 1.1, https://www.eia.gov/electricity/monthly/archive/february2020.pdf; European Commission (EC), Eurostat database, http://ec.europa.eu/eurostat, viewed April 2020; Ministry of Energy of the Russian Federation, "Statistics", https://minenergo.gov.ru/en/activity/statistic, viewed April 2020, Government of India, Ministry of Power, Central Electricity Authority (CEA), "Monthly generation report", http://www.cea.nic.in/monthlyarchive.html, viewed April 2020; National Bureau of Statistics of China, "Statistical communiqué of the People's Republic of China on the 2019 national economic and social development", press release (Beijing: 28 February 2020), http://www.stats.gov.cn/english/PressRelease/202002/t20200228_1728917.html (using Google Translate); Statistics Canada, "Electric Power Generation, monthly generation by type of electricity", https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=2510001501, updated 11 May 2020; National Electrical System Operator of Brazil (ONS), "Geração de energia", http://www.ons.org.br/Paginas/resultados-da-operacao/historico-da-operacao/geracao_energia.aspx, viewed April 2020. **Solar PV** worldwide production potential of 715.15 TWh, from Gaëtan Masson and Alice Detollenaere, Becquerel Institute and IEA PVPS, personal communication with REN21, 10 April 2020. Estimates for electricity generation from Masson and IEA PVPS are theoretical calculations based on average yield and installed solar PV capacity as of 31 December 2019..

13 SolarPower Europe, op. cit. note 7, p. 42; IEA PVPS, *Trends in Photovoltaic Applications 2019*, op. cit. note 1, p. 91; IEA PVPS, *Trends in Photovoltaic Applications 2018*, op. cit. note 7, pp. 4, 80.

14 Ibid.

15 Lower than a decade ago but challenges remain, fossil and nuclear, from Masson, op. cit. note 2, 20 February 2020, and 4 May 2020. Regarding utilities, in Brazil, for example, utilities are restricting approval and authorization of solar PV systems, saying that they lack the capacity to make grid connections and to integrate solar energy into the grid, among other things, from R. Baitelo, Associação Brasileira de Energia Solar Fotovoltaica (ABSOLAR), personal communication with REN21, 7 April 2020; in Australia, the energy market operator has largely prevented attempts by electricity network operators to discriminate against and financially penalise solar customers, but network operators have imposed delays and conditions on the approval of grid connections, which leads to increases in the soft costs of solar deployment, from IEA PVPS, Australian Photovoltaic Institute (APVI) and Australian Renewable Energy Agency (ARENA), *National Survey Report of PV Power Applications in Australia 2018* (Paris: 2019), prepared by R. Egan, APVI, p. 36, https://iea-pvps.org/wp-content/uploads/2020/01/NSR_Australia_2018.pdf.

16 IEA PVPS, *Trends in Photovoltaic Applications* 2019, op. cit. note 1, pp. 48-56; IEA PVPS, *Trends in Photovoltaic Applications 2018*, op. cit. note 7, p. 43.

17 IEA PVPS, *Trends in Photovoltaic Applications 2019*, op. cit. note 1, p. 48. Growth in grid-connected solar PV in particular has been due almost entirely to government support policies, mandates, and often a combination, from Mints, *Photovoltaic Manufacturer Shipments*, op. cit. note 1, p. 40.

18 Corporate purchasing from information and sources elsewhere in this section; self-consumption from IEA PVPS, *Snapshot of Global PV Markets 2020*, op. cit. note 1 , p. 15.

19 IEA PVPS, *Trends in Photovoltaic Applications 2019*, op. cit. note 1, p. 16; Schmela, op. cit. note 1; Masson, op. cit. note 2, 28 February 2019. See also E. Bellini, "Italy deployed 737 MW of solar in 2019", pv magazine, 21 April 2020, https://www.pv-magazine.com/2020/04/21/italy-deployed-737-mw-of-solar-in-2019; L. Stoker, "WoodMac: UK will join the subsidy-free solar club in 2019", PV-Tech, 22 January 2019, https://www.pv-tech.org/news/woodmac-uk-will-join-the-subsidy-free-solar-club-in-2019; T. Gualtieri, "Spanish developer plans 3.3 gigawatts of subsidy-free PV farms", *Bloomberg*, 28 October 2019, https://www.bloomberg.com/news/articles/2019-10-28/spanish-developer-plans-3-3-gigawatts-of-subsidy-free-pv-farms.

20 Seventh consecutive year based on data from IEA PVPS, *Trends in Photovoltaic Applications 2019*, op. cit. note 1, and from IEA PVPS, *Snapshot of Global PV Markets 2020*, op. cit. note 1; declines based on idem and from data and sources provided throughout this section; Asia accounted for half based on data from IEA PVPS, *Snapshot of Global PV Markets 2020*, op. cit. note 1, from Becquerel Institute, op. cit. note 1, 20 March 2020 and 10 April 2020, and from IEA PVPS, *Trends in Photovoltaic Applications 2019*, op. cit. note 1.

21 Based on data from IEA PVPS, *Snapshot of Global PV Markets 2020*, op. cit. note 1, from Becquerel Institute, op. cit. note 1, 20 March 2020 and 10 April 2020, and from IEA PVPS, *Trends in Photovoltaic Applications 2019*, op. cit. note 1.

22 Market and manufacturing from SolarPower Europe, op. cit. note 1, p. 89; share of additions in 2019 based on data from IEA PVPS, *Snapshot of Global PV Markets* 2020, op. cit. note 1, and from Becquerel Institute, op. cit. note 1; 44% in 2018 (and 52% in 2017) from SolarPower Europe, op. cit. note 1, p. 89; China's share of

total demand was 27% in 2014, 30% in 2015, 49% in 2016, 56% in 2017, 42% in 2018 and projected 29% in 2019, from P. Mints, SPV Market Research, *The Solar Flare*, no. 5 (31 October 2019), p. 5.

23 Top 10 countries and share of top 5 from IEA PVPS, *Snapshot of Global PV Markets 2020,* op. cit. note 1, and from Becquerel Institute, op. cit. note 1; about 75% in 2018 from Becquerel Institute, op. cit. note 1, 10 May 2019, and from IEA PVPS, *2019 Snapshot of Global PV Markets* (Paris: April 2019), p. 8, http://www.iea-pvps.org/fileadmin/dam/public/report/statistics/IEA-PVPS_T1_35_Snapshot2019-Report.pdf; less concentrated from IEA PVPS, *Snapshot of Global PV Markets 2020*, op. cit. note 1, p. 6. The share represented by the top 5 in 2017 was 84%, based on global additions of at least 98 GW_{DC}, and on additions of the top five countries (China, the United States, India, Japan and Turkey), from IEA PVPS, *Snapshot of Global Photovoltaic Markets 2018* (Paris: 2018), p. 4, http://www.iea-pvps.org/fileadmin/dam/public/report/statistics/IEA_PVPS-A_Snapshot_of_Global_PV-1992-2017.pdf.

24 Figure for 2019 based on preliminary estimates for IEA PVPS, *Snapshot of Global PV Markets 2020*, op. cit. note 1. This was up from 1.3 GW in 2018, from Becquerel Institute, op. cit. note 1, 10 May 2019, and from IEA PVPS, *2019 Snapshot of Global PV Markets*, op. cit. note 23, p. 7, and from 954 MW in 2017, from IEA PVPS, *Trends in Photovoltaic Applications 2018*, op. cit. note 7, p. 13. The market level to be among the top 10 for annual additions was 683 MW in 2016 and 675 MW in 2015, from IEA PVPS, idem.

25 Leading countries for total capacity based on data from IEA PVPS, *Snapshot of Global PV Markets 2020,* op. cit. note 1, and from Becquerel Institute, op. cit. note 1, 20 March 2020, and on data and sources provided throughout this section. Leaders per capita from IEA PVPS, *Snapshot of Global PV Markets 2020*, op. cit. note 1, p. 7. **Figure 29** based on historical global and country-specific data from IEA PVPS, *Trends in Photovoltaic Applications 2019*, op. cit. note 1, from IEA PVPS, *Snapshot of Global PV Markets 2020,* op. cit. note 1, from Becquerel Institute, op. cit. note 1, and based on country-specific data and sources provided throughout this section for China, Germany, India, Japan and the United States. India data from the following: data for 2009 from European Photovoltaic Industry Association (EPIA), *Global Market Outlook for Photovoltaics Until 2015* (Brussels: 2011), p. 10, http://www.cogen.com.br/content/upload/1/documentos/Solar/Solar_COGEN/EPIA_Global_Market_Photovoltaics_2015.pdf; data for 2010 and 2011 from EPIA, *Global Market Outlook for Photovoltaics Until 2016* (Brussels: May 2012), p. 14, https://www.helapco.gr/pdf/Global_Market_Outlook_2015_-2019_lr_v23.pdf; data for 2012 from IEA PVPS, *PVPS Report, A Snapshot of Global PV 1992-2012* (Paris: 2013), https://iea-pvps.org/wp-content/uploads/2020/01/PVPS_report_-_A_Snapshot_of_Global_PV_-_1992-2012_-_FINAL_4.pdf; data for 2013 from IEA-PVPS, *PVPS Report – Snapshot of Global PV 1992-2013: Preliminary Trends Information from the IEA PVPS Programme* (Paris: March 2014), https://iea-pvps.org/wp-content/uploads/2020/01/PVPS_report_-_A_Snapshot_of_Global_PV_-_1992-2013_-_final_3.pdf; data for 2014 from Bridge to India, May 2015, provided by S. Orlandi, Becquerel Institute, Brussels, personal communication with REN21, 11 May 2015; data for 2015 from IEA PVPS, *Trends in Photovoltaic Applications, 2016: Survey Report of Selected IEA Countries Between 1992 and 2015* (Paris: 2016), https://iea-pvps.org/wp-content/uploads/2020/01/Trends_2016_-_mr.pdf; data for 2016 from Government of India, Ministry of New and Renewable Energy (MNRE), "Physical progress (achievements)", data as on 31 December 2016, http://www.mnre.gov.in/mission-and-vision-2/achievements, viewed 19 January 2017; data for 2017 and 2018 from Becquerel Institute and IEA PVPS, personal communication with REN21, 3 June 2019 and 4 May 2020.

26 Year-end rally and 12.2 GW brought online from China Photovoltaic Industry Association (CPIA), cited in M. Hall, "China will add 35-38 GW of solar this year", pv magazine, 22 January 2020, https://www.pv-magazine.com/2020/01/22/china-will-add-35-38-gw-of-solar-this-year; a total of 30.11 GW was added in 2019, including 17.91 GW of utility-scale capacity and 12.2 GW of distributed, and representing a decline of 31.6% relative to 2018, from NEA, op. cit. note 2. Down more than 15% in 2018 based on 53,068 MW installed in 2017, and about 45 GW installed in 2018 (including unsubsidised capacity additions on top of official data for subsidised capacity), all from IEA PVPS, *Trends in Photovoltaic Applications 2019*, op. cit. note 1. An estimated 10 GW was installed in December 2019, from GlobalData Energy, "Solar PV capacity additions in China fell by 32% in 2019", Power Technology, 23 January 2020, https://www.power-technology.com/comment/solar-pv-capacity-additions-china-2019.

27 Second consecutive year based on data from IEA PVPS, *Trends in Photovoltaic Applications 2019*, op. cit. note 1, and from IEA PVPS, *Snapshot of Global PV Markets 2020*, op. cit. note 1, p. 6; down in almost every region (excluding Guizhou), from F. Haugwitz, Asia Europe Clean Energy (Solar) Advisory Co. Ltd. (AECEA), personal communication with REN21, 6 April 2020, and from NEA, op. cit. note 2; 12 provinces based on grid-connected capacity data from China National Renewable Energy Center, cited in China NEA, "2019 PV installations utility and distributed by province", 28 February 2020, http://www.nea.gov.cn/2020-02/28/c_138827923.htm (using Google Translate) (data do not include Hong Kong SAR, Macao SAR or Chinese Taipei); and more than double the size of the next largest market based on data and sources throughout this section. **Figure 30** based on IEA PVPS, op. cit. note 1, both references, and on national data and references for top 10 countries provided throughout this section (or see endnote for Reference Table R16).

28 NEA, op. cit. note 2; Guizhou considered one of the poorest provinces, from F. Haugwitz, AECEA, "China solar PV – 2019/2020 – On the ground dynamics", email newsletter, 1 April 2020.

29 Cumulative capacity was 204.66 GW (including off-grid), from IEA PVPS, *Snapshot of Global PV Markets 2020*, op. cit. note 1, p. 6; cumulative capacity at end-2019 was 204.3 GW, up 17.3% over 2018, including 141.67 GW of utility-scale projects and 62.63 GW of distributed systems (all grid-connected), all from NEA, op. cit. note 2; year-end capacity was 204,680 MW, up 17.4% over 2018, from China Electricity Council (CEC), "2019 electricity & other energy statistics (preliminary)", 21 January 2020, http://www.cec.org.cn/guihuayutongji/tongjxinxi/niandushuju/2020-01-21/197077.html (using Google Translate). The national target is part of the country's 13th Five-Year Plan (2016-2020), from Haugwitz, op. cit. note 28.

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35 Haugwitz, op. cit. note 28. See also Wood Mackenzie, op. cit. note 34.

36 Based on data from NEA and from China PV Industry Association (CPIA), provided by Haugwitz, op. cit. note 27, 15 May 2020 and 27 May 2020; Target of 3.5 GW based on earmarked budget of RMB 750 million, which theoretically could support 3.5 GW, from Haugwitz, op. cit. note 27, 21 April 2020. See also Shaw, op. cit. note 32.

37 Shares of capacity added are based on 30.11 GW added to the grid in 2019, including 17.91 GW of utility-scale capacity (down 22.9% relative to 2018) and 12.2 GW of distributed capacity (up 41.3% over 2018), from NEA, op. cit. note 2. Share of cumulative capacity based on 141.67 GW of utility-scale capacity and 62.63 GW of distributed capacity (all grid-connected) at

year's end, from idem, and on total grid-connected capacity of 204.3 GW. Centralised plants accounted for 53% of grid-connected installations in 2018, from NEA, "2018 added solar PV capacities," Finance World, 28 January 2019, https://baijiahao.baidu.com/s?id=1623876437525496663&wfr=spider&for=pc (using Google Translate).

38 NEA, op. cit. note 2.

39 In Qinghai, curtailment was up 2.5 percentage points over 2018 to 7.2%; others with significant average rates of curtailment during 2019 were Tibet, which curtailed 24.1% (down 19.5 percentage points relative to 2018), followed by Xinjiang (7.4%, down 8.2) and Gansu (4%, down 5.6), all from NEA, op. cit. note 2.

40 Figures for 2019 based on output from grid-connected systems was up 26.3% to 224.3 TWh, from NEA, op. cit. note 2, and on output up 26.5% to 223.8 TWh, from CEC, op. cit. note 29. For comparison, output was up 50%, to 177.5 TWh in 2018, from NEA, op. cit. note 37.

41 Share of generation based on 223.8 TWh of solar electricity and total generation from all sources of 7,325 TWh, from CEC, op. cit. note 29. Share of generation in 2018 (2.6%) from NEA, "Photovoltaic power generation statistics for 2018", 19 March 2019, http://www.nea.gov.cn/2019-03/19/c_137907428.htm (using Google Translate); the share was 2.5% based on 1,775 billion kWh of solar generation (note, however, that this may include a small amount of CSP) and 69,940 billion kWh of total power generation, from China Electricity Industry Development and Environmental Resources Department, cited by CEC, "2018 power statistics annual express basic data list", 19 January 2019, http://www.cec.org.cn/guihuayutongji/tongjxinxi/niandushuju/2019-01-22/188396.html. Share of generation in 2017 was 1.9%, based on data from NEA, cited in "Energy Bureau conference informed of 2017 renewable energy grid operation", 24 January 2018, http://shupeidian.bjx.com.cn/news/20180124/876448.shtml (using Google Translate).

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50 Sanjay, op. cit. note 44.

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57 IEA PVPS, *Trends in Photovoltaic Applications 2019*, op. cit. note 1, p. 12. Japan's market has been trending downwards since 2015, from idem. Down 40% from peak year of 2015 based on 10 GW solar PV capacity installed in 2015, and 6 GW installed in 2019, from data of feed-in tariff scheme, Japanese Ministry of Economy, Trade and Industry (METI), provided by H. Matsubara, ISEP, Tokyo, personal communication with REN21, 14 April 2020.

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60 ISEP, op. cit. note 11.

61 Figures of 530,000 and 2 GW, from METI, https://www.meti.go.jp/shingikai/enecho/denryoku_gas/saisei_kano/pdf/008_03_00.pdf (in Japanese), p. 8, viewed 27 April 2020, provided by Matsubara, op. cit. note 57, 27 April 2020; self-consumption and net zero from idem. See also J. Movella, "End of the residential FIT in Japan. Post FIT RECs go to RE100 companies", Renewable Energy World, 19 November 2019, https://www.renewableenergyworld.com/2019/11/19/end-of-the-residential-fit-in-japan-post-fit-recs-go-to-re100-companies; Ohigashi and Kaizuka, op. cit. note 58.

62 Movella, op. cit. note 61.

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65 Figure of 4.8 GW added in 2019 for a total of 4.9 GW, based on preliminary data for IEA PVPS, *Snapshot of Global PV Markets 2020*, op. cit. note 1, and from Becquerel Institute, op. cit. note 1. Vietnam's additions in 2018 and 2017 from Maisch, op. cit. note 63. Vietnam ended 2018 with 106 MW and 2019 with 5,695 MW, meaning annual additions in 2019 of 5,589 MW, based on data from IRENA, op. cit. note 44.

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67 Post June from Kenning, op. cit. note 63; in December from Bellini, op. cit. note 64.

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70 Pakistan's additions are preliminary data from Becquerel Institute, op. cit. note 1. Pakistan's year-end total was about 5 GW, from A. Jäger-Waldau, EC, personal communication with REN21, 10 April 2020, and was 1.3 GW, from IRENA, op. cit. note 44.

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81 The Netherlands from SolarPower Europe, op. cit. note 76, pp. 9, 11. The Netherlands' rooftop market included residential and commercial and industrial uses; the commercial rooftop market was the largest segment, at about 40%, from idem., pp. 9, 49. Poland's market quadrupled based on 203 MW installed in 2018, from SolarPower Europe, op. cit. note 76, p. 10; rising incentives and extension of net metering in Poland from E. Bellini, "Poland tops 1.3 GW of PV capacity", pv magazine, 14 January 2020, https://www.pv-magazine.com/2020/01/14/poland-tops-1-3-gw-of-pv-capacity.

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Markets 2020, op. cit. note 1, from Becquerel Institute, op. cit. note 1, 20 March 2020, and data for 2018 from IEA PVPS, *Trends in Photovoltaic Applications 2019*, op. cit. note 1, p. 96. Poland also passed 1 GW cumulative capacity in 2019, from EurObserv'ER, op. cit. note 1, p. 6.

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CONCENTRATING SOLAR THERMAL POWER (CSP)

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WIND POWER

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15 **Ireland** based on EIRGRID, "Ireland fuel mix 2019", http://www.eirgridgroup.com/site-files/library/EirGrid/Fuel20Mix.jpg, updated January 2020; **Portugal** from Portugal Directorate General for Energy and Geology (DGEG), "Renováveis – Estatísticas Rápidas – janeiro 2020", 2 March 2020, http://www.dgeg.gov.pt, viewed 5 March 2020; **Germany** from Federal Ministry for Economic Affairs and Energy (BMWi) and Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat), *Time Series for the Development of Renewable Energy Sources in Germany – based on statistical data from the Working Group on Renewable Energy-Statistics (AGEE-Stat) (Status: February 2020)* (Dessau-Roßlau: February 2020), p. 45, https://www.erneuerbare-energien.de/EE/Navigation/DE/Service/Erneuerbare_Energien_in_Zahlen/Zeitreihen/zeitreihen.html; **Spain** based on provisional data from Red Eléctrica de España (REE), *The Spanish Electricity System – Preliminary Report 2019* (Madrid: January 2020), with estimated data as of

10 January 2020, p. 16, https://www.ree.es/sites/default/files/11_PUBLICACIONES/Documentos/InformesSistemaElectrico/2020/avance_ISE_2019_EN.pdf. Other European countries with high shares included the **United Kingdom** (19.8%), based on 9.9% onshore wind plus 9.9% offshore wind, from UK Department for Business, Energy & Industrial Strategy (BEIS), "Energy Trends: Renewables", Table 6.1. Renewable electricity capacity and generation, https://www.gov.uk/government/statistics/energy-trends-section-6-renewables, updated 26 March 2020; **Greece** (15.2%) from multiple original sources, all in Greek and provided by I. Tsipouridis, R.E.D. Pro Consultants, Athens, personal communication with REN21, 17 April 2020.

16 **Uruguay** generated 29.5% of its electricity with wind energy in 2019, based on production of 4,752.8 GWh from wind energy and 16,088.4 GWh total, from Ministerio de Industria, Energía y Minería (MIEM), Balance Energético Nacional Uruguay, "Balance preliminar 2019", https://ben.miem.gub.uy/preliminar.html, viewed 15 April 2020. Uruguay's share of electricity consumption from wind power was over 36%, based on generation data and on exports of 3,011.0 GWh and imports of 0.2 GWh, from idem. **Nicaragua** generated 17.44% of total net electricity output with wind energy, from Instituto Nicaragüense de Energía (INE), Ente Regulador, "Generación neta sistema eléctrico nacional año 2019", https://www.ine.gob.ni/DGE/estadisticas/2019/generacion_neta_dic19_actmar20.pdf, viewed 17 April 2020. Another source for Nicaragua has a 17.9% share of its electricity with wind power in 2019, from National Cargo Dispatch Center (NCDC), SIN (National Interconnected System) Operation Report, Centro Nacional de Desapacho de Carga, Nicaragua, http://www.cndc.org.ni, viewed 11 April 2020, provided by G. Bravo, Fundacion Bariloche, personal communication with REN21, 11 April 2020. This was down from 18.6% of net generation with wind energy in 2018, from INE, Ente Regulador, "Generación neta de energia electrica sistema eléctrico nacional año 2018", https://www.ine.gob.ni/DGE/estadisticas/2018/generacion_neta_2018_actfeb19.pdf, viewed 14 April 2019, and 15.1% in 2017, from INE, Ente Regulador, "Generación neta sistema eléctrico nacional año 2017", http://www.ine.gob.ni/DGE/estadisticas/2017/generacion_neta_2017_actmar18.pdf, viewed 12 April 2018. **Costa Rica** based on wind generated 1,796.34 GWh out of a total generation of 11,312.85 GWh, providing 15.85% of total generation (and 15.8% of total demand (11,334.11 GWh)), from Centro Nacional de Control de Energía, Instituto Costarricense de Electricidad, *Generación y Demanda Informe Anual, 2019* (San José: 2020), p. 4, https://apps.grupoice.com/CenceWeb/CenceDescargaArchivos.jsf?init=true&categoria=3&codigoTipoArchivo=3008.

17 Share of generation based on the following: total global electricity generation in 2019 estimated at 27,011 TWh, based on 26,615 TWh in 2018 from BP, *Statistical Review of World Energy* (London: 2019), https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html, and on estimated 1.49% growth in global electricity generation in 2019. Growth rate in 2019 is based on the weighted average change in actual total generation for the following countries/regions (which together accounted for more than two-thirds of global generation in 2018): United States (-1.3% net generation), EU-28 (-1.2%), Russian Federation (+1.2%), India (+0.0%), China (+4.7%), Canada (-0.2%) and Brazil (+2.0%). Generation data for 2018 and 2019 by country or region from the following: US EIA, *Electric Power Monthly with Data for December 2019* (Washington, DC: February 2020), Table 1.1, https://www.eia.gov/electricity/monthly/archive/february2020.pdf; European Commission, Eurostat database, http://ec.europa.eu/eurostat, viewed April 2020; Ministry of Energy of the Russian Federation, "Statistics", https://minenergo.gov.ru/en/activity/statistic, viewed April 2020, Government of India, Ministry of Power, Central Electricity Authority (CEA), "Monthly generation report", http://www.cea.nic.in/monthlyarchive.html, viewed April 2020; National Bureau of Statistics of China, "Statistical communiqué of the People's Republic of China on the 2019 national economic and social development", press release (Beijing: 28 February 2020), http://www.stats.gov.cn/english/PressRelease/202002/t20200228_1728917.html (using Google Translate); Statistics Canada, "Electric power generation, monthly generation by type of electricity", https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=2510001501, updated 11 May 2020; National Electrical System Operator of Brazil (ONS), "Geração de energia", http://www.ons.org.br/Paginas/resultados-da-operacao/historico-da-operacao/geracao_energia.aspx, viewed April 2020. Wind power estimated wind generation of 1,600 TWh, based on wind power capacity at end-2019 from the following sources: Europe (excluding Turkey) from WindEurope, *Wind in Europe in 2019* (Brussels: 2020), p. 7, https://windeurope.org/about-wind/statistics/european/wind-energy-in-europe-in-2019/; United States from AWEA, op. cit. note 12, p. 3; remaining countries and regions from GWEC, "Global Wind Statistics 2019", op. cit. note 1; generation estimated with selected weighted average capacity factors by region, and for both onshore and offshore wind power, from the following sources: Asia and China offshore for 2018 (latest data available) from Zhao, op. cit. note 7, 14 May 2019; Brazil from ONS, *Boletim Mensal de Geração Eólica Março 2020* (Brasilia: 2020), p. 20, http://www.ons.org.br/AcervoDigitalDocumentosEPublicacoes/Boletim_Geracao_Eolica_202003.pdf; China estimated at 0.24 using national average productivity of 2082 full-load hours for wind turbines from China Energy Portal, "2019 wind power installations and production by province", 28 February 2020, https://chinaenergyportal.org/en/2019-wind-power-installations-and-production-by-province; Europe from WindEurope op. cit. this note, p. 18; United States for 2018 (latest available) from US Department of Energy (DOE), Office of Energy Efficiency & Renewable Energy (EERE), *2018 Wind Technologies Market Report* (Washington, DC: August 2019), p. ix, https://www.energy.gov/sites/prod/files/2019/08/f65/2018%20Wind%20Technologies%20Market%20Report%20FINAL.pdf; remaining countries and regions from A. Whiteman, IRENA, personal communications with REN21, May 2020.

18 Share of total in 2019 (50.5%) and in 2018 (51.9%), and total regional capacity at end-2019 (all including Turkey), based on data from GWEC, "Global Wind Statistics 2019", op. cit. note 1. The share in 2017 was 48%, based on data from GWEC, *Global Wind Report – Annual Market Update 2017* (Brussels: April 2018), p. 17, https://gwec.net/publications/global-wind-report-2/.

19 Regional shares based on data from GWEC, "Global Wind Statistics 2019", op. cit. note 1, and from WindEurope, op. cit. note 13, p. 10. Numbers here are based on regional groupings that include Turkey as part of Asia, rather than Europe, and Mexico as part of Central America or Latin America, rather than North America.

20 GWEC, *Global Wind Report 2019*, op. cit. note 1, p. 36.

21 Based on data from GWEC, "Global Wind Statistics 2019", op. cit. note 1.

22 Based on data from Ibid. and from WindEurope, op. cit. note 13, p. 10. **Figure 38** based on country-specific data and sources provided throughout this section (see also endnote for Reference Table R19).

23 China's increase in 2019 relative to 2018 and data for 2019 based on data from H. Yu, Chinese Wind Energy Association (CWEA) and from GWEC, "Global Wind Statistics 2019", op. cit. note 1; China added 26,785 MW, including 24,292 MW onshore and 2,493 MW offshore), from Hui, op. cit. this note; and from China added 23,760 MW onshore and 2,395 MW offshore for a year-end total of 236,401.7 MW, from GWEC, "Global Wind Statistics 2019", op. cit. note 1; note that figure of 2.4 GW offshore was preliminary data provided to GWEC by the CWEA. China added 27.5 GW in 2019 for total of 237,029 MW, from WWEA, op. cit. note 1, and China added a net of 25,813 MW for a total of 210,478 MW, based on data from IRENA, op. cit. note 1. See also endnote 24.

24 Newly installed grid-connected wind power capacity was 25.74 GW, including 23.76 GW onshore and 1.98 GW offshore, for cumulative total of 210.05 GW (204 GW onshore and 5.93 GW offshore), based on 2019 data from China National Energy Administration (NEA), "Wind power grid-connected operation in 2019", 28 February 2020, http://www.nea.gov.cn/2020-02/28/c_138827910.htm (using Google Translate), and from China NEA and China Electricity Council (CEC), cited in China Energy Portal, op. cit. note 17, and on year-end 2018 data (184 GW cumulative), from NEA, "2018 wind power grid operation", 28 January 2019, http://www.nea.gov.cn/2019-01/28/c_137780779.htm (using Google Translate), and from China NEA and CEC, cited in China Energy Portal, op. cit. note 17. Additions of 25.74 GW were up 21% over the 21.27 GW added in 2018, and cumulative capacity increased 14%, from 184.27 GW at end-2018 to 210.05 GW at end-2019, from CEC, "Statistics of China Power Industry 2019", http://english.cec.org.cn/No.110.1941.htm, viewed 13 March 2020. The difference in statistics among Chinese organisations and agencies results from the fact that they count different things: installed capacity refers to capacity that is constructed and usually has wires carrying electricity from the turbines to a substation (i.e., CWEA annual statistics); capacity qualifies as grid-connected (i.e., included in CEC statistics) once certification is granted and

operators begin receiving the feed-in tariff (FIT) premium payment, which can take weeks or even months. Due to transmission constraints in China, there is still often a several-month lag from when turbines are wire-connected to the substation until the process of certification and payment of the FIT premium is complete. No Chinese statistics provide actual grid-connected capacity, and discrepancies among available statistics can be large. Data cited by CWEA include some capacity that is not 100% grid-connected by year's end, but they are believed to most closely reflect the status of the market in China, from L. Qiao, GWEC, personal communication with REN21, 2 May 2018 and confirmed by Yu, op. cit. note 23, 19 May 2020. For the year, investment in new wind power projects in China was up more than 81%, to RMB 117.1 billion (USD 16.5 billion), from CEC, op. cit. this note.

25 GWEC, *Global Wind Market Outlook Update Q3 2019*, op. cit. note 11, p. 8; GWEC, *Global Wind Report 2019*, op. cit. note 1, p. 37.

26 EurObserv'ER, *Wind Energy Barometer* (Paris: March 2020), p. 3, https://www.eurobserv-er.org/wind-energy-barometer-2020.

27 Ibid., p. 3.

28 Ibid., p. 3.

29 Majority based on additions in 2019 as well as on 72% at the end of 2018, from the following: share of cumulative based on central and eastern share of 27.9% and "three north" region share of 72.1%; share of additions based on 47% of total, all from NEA, "2018 added solar PV capacities", *Finance World*, 28 January 2019, https://baijiahao.baidu.com/s?id=1623876437525496663&wfr=spider&for=pc (using Google Translate). Henan added 3,260 MW followed by Hebei (2,480 MW), Shanxi and Shandong (both 2,080 MW), based on cumulative capacity for end-2018 and end-2019, from China Energy Portal, op. cit. note 17; Jiangsu added 1,596 MW, from Yu, op. cit. note 24. Also, note that the top installers in 2019 were Shanxi, Inner Mongolia, Henan, Hebei and Jiangsu, from idem. Curtailment rates from NEA, "Wind power grid-connected operation in 2019", op. cit. note 24. Curtailment rates during 2019 were 0% in Henan, 4.8% in Hebei, 1.1% in Shanxi and 0.1% in Shandong, compared with rates of 7.1% to 14% in the northern and western provinces of Inner Mongolia, Gansu and Xinjiang, from idem.

30 Curtailed generation and curtailment rates in 2019 and 2018 based on data from NEA, "Wind power grid-connected operation in 2019", op. cit. note 24. In late 2018, China re-emphasised its aim to keep curtailment of wind generation below 10% in 2019 and 5% in 2020, from Bloomberg News Editors, "China hopes to lessen solar, wind curtailment in 2019", *Renewable Energy World*, 3 December 2018, https://www.renewableenergyworld.com/articles/2018/12/china-hopes-to-lessen-solar-wind-curtailment-in-2019.html; "China targets cut in wind-, solar-power blocked from grid access", *Bloomberg*, 1 December 2018, https://www.bloomberg.com/news/articles/2018-12-01/china-targets-cut-in-wind-solar-power-blocked-from-grid-access. National curtailment in 2017 was 12% (41.9 TWh), from China National Energy Board, cited in NEA, "Wind grid operation in 2017", 1 February 2018, http://www.nea.gov.cn/2018-02/01/c_136942234.htm (using Google Translate); national curtailment in 2016 was 17% (49.7 TWh), from NEA and CEC, provided by S. Pengfei, CWEA, personal communication with REN21, 21 March 2017, and from NEA, "Wind power grid operation in 2016", 26 January 2017, http://www.nea.gov.cn/2017-01/26/c_136014615.htm (using Google Translate).

31 In Xinjiang, the curtailment rate fell more than 9 percentage points relative to 2018, to 14%; Gansu's declined 11.4 percentage points, to 7.6%; Inner Mongolia's fell nearly 3 percentage points, to 7.1%, based on 2019 data from NEA, "Wind power grid-connected operation in 2019", op. cit. note 24, and on 2018 data from NEA, "2018 added solar PV capacities", op. cit. note 29.

32 Generation in 2019 from NEA, "Wind power grid-connected operation in 2019", op. cit. note 24; increase in generation was about 10.9%, based on generation of 365.8 TWh in 2018, and 2019 share of total output based on wind generation relative to total generation (405.6 TWh) from CEC, op. cit. note 24. Figure of 5.2% in 2018 from China Energy Portal, "2018 wind power installations and production by province", 28 January 2019, https://chinaenergyportal.org/en/2018-wind-power-installations-and-production-by-province, and also based on data from China Electricity Council Express, cited in NEA, "National Energy Administration released statistics on national power industry in 2018", 18 January 2019, http://www.nea.gov.cn/2019-01/18/c_137754977.htm (using Google Translate). In 2017, wind energy generation was 305.7 TWh and its share of total generation was 4.8%, from China National Energy Board, cited in NEA, "Wind grid operation in 2017", 1 February 2018, http://www.nea.gov.cn/2018-02/01/c_136942234.htm (using Google Translate).

33 Based on data from GWEC, "Global Wind Statistics 2019", op. cit. note 1.

34 Figure of 8.5% based on 2,377 MW installed in 2019 and 2,191 MW added in 2018, from GWEC, *Global Wind Report 2019*, op. cit. note 1, p. 44; down nearly 50% in 2018 based on 2018 additions from Idem and 4,148 MW added in 2017, from GWEC, op. cit. note 7, p. 29. In 2017, India saw a rush to capitalise on national incentives before they expired and on FIT-based power purchase agreements (PPAs) before a shift to auctions. Reverse auctions from A. Parikh, "India's wind power installations flat in 2019 with 2.4 GW", Mercom India, 20 February 2020, https://mercomindia.com/india-wind-installations-flat-2019; R. Ranjan, "India's wind sector failed to gain speed in 2019", Mercom India, 23 December 2019, https://mercomindia.com/india-wind-failed-gain-speed.

35 Year-end capacity of 37,505.18 MW, from Government of India, Ministry of New and Renewable Energy (MNRE), cited in Ministry of Power, CEA, "All India installed capacity (in MW) of power stations (as on 31.01.2019) (Utilities)", p. 1, http://www.cea.nic.in/reports/monthly/installedcapacity/2020/installed_capacity-01.pdf; net additions of 2,367.03 based on Idem, and on end-2018 capacity of 35,138.15, from Government of India, MNRE, cited in Ministry of Power, CEA, "All India installed capacity (in MW) of power stations (as on 31.01.2018) (Utilities)", p. 1, http://www.cea.nic.in/reports/monthly/installedcapacity/2018/installed_capacity-12.pdf. India added 2.4 GW in 2019 for a total of 37.5 GW, from GWEC, *Global Wind Report 2019*, op. cit. note 1, p. 18; added 2.4 GW for a total of 37,529 MW, from WWEA, op. cit. note 1; added 2,217 MW for a total of 37,505 MW, from IRENA, op. cit. note 1; added 2.9 GW for a total of almost 38 GW, from Campbell, op. cit. note 5; and ended 2019 with 37,733.16 MW, from J. Hossain, Renewable Energy Welfare Society, presentation for WWEA, "Webinar: Wind power markets around the world", 16 April 2020, https://wwindea.org/blog/2020/04/08/webinar-wind-power-markets-around-the-world.

36 Figure of around 8.6 GW was the total active pipeline as of year-end 2019, from GWEC and MEC Intelligence, op. cit. note 9, p. 15. Of the 8.6 GW, nearly 3 GW was scheduled to be commissioned in 2020, 5.2 GW in 2021 and the remainder during 2022, from idem. Note that 9.355 GW of capacity was under implementation at year's end, from Government of India, MNRE, *Annual Report 2019-20* (New Delhi: 2020), p. 8, https://mnre.gov.in/img/documents/uploads/file_f-1585710569965.pdf. For delays, see sources for the following paragraph.

37 Undersubscribed from, for example, Ranjan, op. cit. note 34, and from "Undersubscription becoming a norm", Bridge to India, 3 September 2019, https://bridgetoindia.com/undersubscription-becoming-a-norm; delays and renegotiate tariffs from "Investors losing interest in troubled Indian market", Windpower Monthly, 7 October 2019, https://www.windpowermonthly.com/article/1661651/investors-losing-interest-troubled-indian-market; withdrawal from existing PPAs from A. Parikh, "Even with court's stay order in place, Andhra Pradesh to cancel 21 wind PPAs", Mercom India, 30 July 2019, https://mercomindia.com/stay-order-andhra-pradesh-cancel-wind-ppas. See also GWEC and MEC Intelligence, op. cit. note 9, p. 13, and IRENA, *Renewable Energy Auctions: Status and Trends Beyond Price* (Abu Dhabi: 2019), p. 14, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Dec/IRENA_RE-Auctions_Status-and-trends_2019.pdf. Over the past three years, more than 17 GW of capacity has been auctioned, but more than one-third of this has gone unsubscribed or been cancelled after being awarded; meanwhile, more than 80% of awarded projects have been delayed by 6-12 months, from MEC Intelligence, cited in GWEC, *Global Wind Report 2019*, op. cit. note 1, p. 18. Andhra Pradesh severely curtailed wind generation, despite the national government's "must run" status for renewables, shifting from wind to coal generation, from S. Prateek, "After high court's stay, Andhra Pradesh begins curtailing wind power severely", Mercom India, 26 July 2019, https://mercomindia.com/wind-curtailment-andhra-ppa-revision; the state decided to renegotiate PPAs, from Parikh, op. cit. note 34, and it withdrew existing PPAs with 21 wind power projects, amounting to nearly 0.8 GW of capacity, from Parikh, op. cit. this note. Turbine deliveries and domestic manufacturing from S. Tenddulkar, "Indian downturn hits manufacturing production", Windpower Monthly, 26 April 2019, https://www.windpowermonthly.com/article/1583075/indian-downturn-hits-manufacturing-production.

38 Challenges from, for example, GWEC and MEC Intelligence, op. cit. note 9, p. 9; Ranjan, op. cit. note 34; Parikh, op. cit. note 34; R. K. Singh, "Developers struggle to actually build low-cost wind farms in India", Renewable Energy World, 6 December 2019, https://www.renewableenergyworld.com/2019/12/06/developers-struggle-to-actually-build-low-cost-wind-farms-in-india; Campbell, op. cit. note 5; Tenddulkar, op. cit. note 37. Projects have become financially unattractive due to low tariff caps, and most of the wind resource-rich sites are no longer available, making it difficult to acquire land; in addition, the windiest states are also those with the highest rates of curtailment, from Ranjan, op. cit. note 34. In addition, disputes between federal and state governments on the level of support needed for older wind farms have stalled India's repowering potential, from Campbell, op. cit. note 5.

39 S. Gsänger, "A dangerous trend is challenging the success of wind power around the globe: Concentration and monopolization", WindTech International, 4 February 2020, https://www.windtech-international.com/view-from-inside/a-dangerous-trend-is-challenging-the-success-of-wind-power-around-the-globe-concentration-and-monopolisation; geographically concentrated from J. Hossain, WWEA, "Experience with auctions in India", from WWEA, "Webinar: Wind power and renewable energy policies: What is best to reach 100% RE", 14 May 2020, https://wwindea.org/blog/2020/05/07/wweawebinar-wind-power-and-renewable-energy-policies-what-is-best-to-reach-100-re-14-may.

40 Turkey installed 687 MW onshore, for a total of 8,056 MW at end-2019, and added 497 MW in 2018, all from Turkish Wind Energy Association (TWEA), *Turkish Wind Energy Statistic Report* (Ankara: January 2020), p. 9, http://www.tureb.com.tr/files/bilgi_bankasi/turkiye_res_durumu/istatistik_raporu_ocak_2020.pdf. Turkey added 686 MW for a total of 8,056 MW, from WindEurope, op. cit. note 13, p. 10; added 687 MW for a total of 8,056 MW, from WWEA, op. cit. note 1; and added 586 MW for a total of 7,591 MW, from IRENA, op. cit. note 1.op. cit. note 40, p. 11.

41 Fourth and capacity based on data from GWEC, *Global Wind Report 2019*, op. cit. note 1, pp. 44, 53; drop in FIT rates and investor confidence, from GWEC, "Market to watch: Thailand", press release (Brussels: 28 February 2020), https://gwec.net/market-to-watch-thailand. Thailand added 322 MW in 2019, down from 567.5 MW in 2018, for a total of 1,532 MW, from idem, both sources; added 323 MW for a total of 1,538 MW, from WWEA, op. cit. note 1; and added 404 MW for a total of 1,507 MW, from IRENA, op. cit. note 1.

42 Based on data from GWEC, *Global Wind Report 2019*, op. cit. note 1, p. 44. Pakistan added 396.6 MW in 2019 for a total of 1,185 MW, from I. Mirza, WWEA Pakistan, presentation for WWEA, "Webinar: Wind power markets around the world", 16 April 2020, https://wwindea.org/blog/2020/04/08/webinar-wind-power-markets-around-the-world.

43 T. Leonard, "Wind market storming ahead in Vietnam, but possible obstacles remain", DNV GL, 24 June 2019, https://blogs.dnvgl.com/energy/wind-market-storming-ahead-in-vietnam-but-possible-obstacles-remain.

44 Vietnam had a total of 228 MW at the end of 2018; the government targets 800 MW by 2020, 2 GW by 2025, and 6 GW by 2030, from idem. Vietnam added 160 MW for a total of 388 MW, from GWEC, *Global Wind Report 2019*, op. cit. note 1, pp. 44, 51, and from WWEA, op. cit. note 1; and added 138 MW for a total of 375 MW, from IRENA, op. cit. note 1.

45 GWEC, "Industry pulse: South East Asia energy transition", press release (Brussels: 28 February 2020), https://gwec.net/industry-pulse-south-east-asia-energy-transition; GWEC, op. cit. note 42.

46 All Europe (not including Turkey) added 11,056 MW onshore and 3,627 MW offshore (14,683 MW total), for a year-end total of 196,758 MW (174,687 MW onshore and 22,071 MW offshore), based on data from WindEurope, op. cit. note 13, p. 10. Europe added 14,023 MW for a total of 195,908 MW, from IRENA, op. cit. note 1.

47 WindEurope, op. cit. note 13, pp. 8, 10. Based on additions of 9,552 MW onshore and 3,627 MW offshore (less 178 MW of decommissioned capacity), for a year-end total of 192,231 MW, of which 170,162 MW was onshore and 22,069 MW was offshore, from idem, pp. 8, 10. The EU installed 12,238.3 MW in 2019 (including 3,050 MW offshore), and decommissioned 208 MW, for a year-end total of 191,509.3 MW (including 21,803.6 MW offshore), from EurObserv'ER, op. cit. note 26, pp. 4, 10. Figure for EU-27 cumulative capacity (168,716 MW) based on data from WindEurope, op. cit. note 13, pp. 10, 14. Cumulative capacity for EU-27 was 167,578 MW, from EurObserv'ER, op. cit. note 26, p. 4.

48 Up 34% based on net additions of 13,001 MW in 2019, from WindEurope, op. cit. note 13, pp. 10, 16, and on net additions in 2018 of 9,690 MW (7,450 MW added onshore and 2,661 MW offshore, less 421 MW decommissioned), from WindEurope, *Wind Energy in Europe in 2018: Trends and Statistics* (Brussels: 2019), p. 10, https://windeurope.org/wp-content/uploads/files/about-wind/statistics/WindEurope-Annual-Statistics-2018.pdf.

49 Greece, Spain and Sweden from GWEC, *Global Wind Report 2019*, op. cit. note 1, p. 13. Greece additions of 727 MW, and Sweden additions of 1,588 MW and year-end total of 8,985 MW, from WindEurope, op. cit. note 13, pp. 10, 11, 13. Wind power installations reached a record 727.5 MW in Greece during 2019, more than double the previous annual high of 311 MW, from I. Tsipouridis, RED PRO Consultants, personal communication with REN21, April 2020. Greece added 732 MW and Sweden added 1,579 MW from WWEA, op. cit. note 1; and Greece added 670 MW and Sweden added 1,588 MW from IRENA, op. cit. note 1.

50 Figure of 19 countries in 2019 based on data (9 EU member states added no new capacity) from WindEurope, op. cit. note 13, p. 13; figure of 16 countries in 2018 based on data from WindEurope, op. cit. note 48, p. 10.

51 Top countries in 2019 from WindEurope, op. cit. note 13, p. 12, and share of installations based on data from idem., pp. 10, 16. The share was down from 80% in 2018, from WindEurope, op. cit. note 48, p. 10. France contraction from WindEurope, op. cit. note 13; for Germany, see text and sources below.

52 WindEurope, op. cit. note 13, pp. 10, 15. Also based on data from IRENA, op. cit. note 1. France added 1,336 MW for total of 16,646 MW (all but 2 MW onshore), and Italy added 456 MW for a total of 10,512 MW, from WindEurope, op. cit. note 13, p. 10. France added 1,360 MW for a total of 16,494 MW, from Réseau de transport d'électricité (RTE), *Bilan Électrique 2019* (Paris: 2020), p. 27, https://www.rte-france.com/sites/default/files/bilan-electrique-2019_1.pdf. Italy added 456 MW for a year-end total of 10,512 MW, from WindEurope, op. cit. this note, and added 450 MW for a total of 10,600 MW, from D. A. Garcia, Italian Wind Energy Association, presentation for WWEA, "Webinar: Wind power markets around the world", 16 April 2020, https://wwindea.org/blog/2020/04/08/webinar-wind-power-markets-around-the-world.

53 The United Kingdom added 629 MW onshore and 1,764 MW offshore, and decommissioned 17 MW of capacity, for net additions of 2,376 MW and a year-end total of 23,515 MW, based on data from WindEurope, op. cit. note 13, pp. 8, 16. The UK ended 2018 with 21,771 MW (including 8,217 MW offshore) and ended 2019 with an estimated 23,975 MW (including 9,792 MW offshore), for total additions in 2019 of 2,204 MW, from UK BEIS, op. cit. note 15. The UK added 2,358 MW (1,728 MW added offshore) in 2019, for a total of 24,128 MW, from IRENA, op. cit. note 1; and added 2,772 MW for a total of 23,515 MW, from WWEA, op. cit. note 1.

54 WindEurope, op. cit. note 13, p. 12.

55 Ibid., p. 12.

56 Lows for coal and rise of wind, from A. Lee, "UK coal power hits 19th century lows as offshore wind roars on", Recharge, 26 September 2019, https://www.rechargenews.com/wind/1855732/uk-coal-power-hits-19th-century-lows-as-offshore-wind-roars-on; share of generation from wind energy was 19.8% (half of which was from onshore capacity and half from offshore wind power capacity), from UK BEIS, *Energy Trends* report, cited in D. Snieckus, "Wind delivers 'more than half' of record UK renewables power output", Recharge, 26 March 2020, https://www.rechargenews.com/transition/wind-delivers-more-than-half-of-record-uk-renewables-power-output/2-1-781960.

57 Spain added 2,319 MW for a total of 25,808 MW, from REE, cited in WindEurope, op. cit. note 13, pp. 8, 10; more than five times 2018 installations of 392 MW, from GWEC, "Global Wind Statistics 2019", op. cit. note 1, and from WindEurope, op. cit. note 48, p. 10. Spain added 2,243 MW for a total of 25.7 GW, from Spanish wind energy association, AEE, cited in D. Weston, "Spain surpasses 25GW after 'intense' 2019", Windpower Monthly, 25 February 2020, https://www.windpowermonthly.com/article/1675099/spain-surpasses-25gw-intense-2019, and added 2,148 MW based on year-end 2019 capacity of 25,742 MW and year-end 2018 capacity of 23,594 MW, from REE, "Potencia instalada nacional (MW)", as of 31 December 2019, https://www.ree.es/es/datos/publicaciones/series-estadisticas-nacionales.

58 WindEurope, op. cit. note 13, p. 8.

59 P. Dorronsoro, "Spain's new renewable energy 'reasonable return' law", Pinsent Masons, 4 December 2019,

https://www.pinsentmasons.com/out-law/analysis/spains-new-renewable-energy-reasonable-return-law.

60 WindEurope, op. cit. note 13, p. 7; Germany was the leading installer in Europe from 2011 through 2018; Spain added slightly more capacity than Germany did during 2010, based on data from past editions of the REN21 *Renewables Global Status Report*.

61 Added 2,189 MW (1,078 gross onshore and 1,111 MW offshore) and decommissioned 97 MW (onshore), for net additions of 2,092 MW (981 MW onshore and 1,111 MW offshore), for a total of 61,357 MW (53,912 MW onshore and 7,445 MW offshore) at end-2019, from WindEurope, op. cit. note 13, p. 10. Similar numbers for onshore and offshore, with the exception of a year-end total of 7,516 MW offshore, from Deutsche Windguard, *Status of Onshore Wind Energy Development in Germany, Year 2019* (Varel, Germany: 2020), p. 3, https://www.windguard.com/year-2019.html, and from Deutsche Windguard, *Status of Offshore Wind Energy Development in Germany, Year 2019* (Varel, Germany: 2020), p. 3, https://www.windguard.com/year-2019.html. Also, similar numbers for onshore and offshore additions, but 7.77 GW total offshore at end-2019, from Windpower Intelligence, cited in Campbell, op. cit. note 5. Official data are net additions of 886 MW onshore and 1,111 MW offshore for net total additions of 1,997 MW, and cumulative year-end capacity of 60.8 GW (including 53.3 GW onshore and 7.5 GW offshore), based on data from BMWi and AGEE-Stat, op. cit. note 15, p. 7. Note that Germany data from WindEurope are used in text, figures and reference table for consistent methodology across all countries in Europe.

62 WindEurope, op. cit. note 13, p. 13; U. Hessler, "German wind energy stalls amid public resistance and regulatory hurdles", DW, 4 September 2019, https://www.dw.com/en/german-wind-energy-stalls-amid-public-resistance-and-regulatory-hurdles/a-50280676; D. Weston, "Why Enercon is struggling and Senvion has gone under", Windpower Monthly, 14 November 2019, https://www.windpowermonthly.com/article/1665862/why-enercon-struggling-senvion-gone; J. S. Hill, "'Collapse' of Germany onshore wind is 'jeopardizing' German & EU renewable targets", CleanTechnica, 13 May 2020, https://cleantechnica.com/2019/05/13/collapse-of-german-onshore-wind-is-jeopardizing-german-eu-renewable-targets; R. Hinrichs-Rahlwes, European Renewable Energies Federation and German Renewable Energy Federation (BEE), personal communication with REN21, 3 April 2020. Figure of 16% of the 2017 volume from GWEC, *Global Wind Report 2019*, op. cit. note 1, p. 24; auction model introduced in 2017, from WWEA and Landesverband Erneuerbare Energien Nordrhein-Westfalen (LEE NRW), *Community Wind Under the Auctions Model: A Critical Appraisal* (Bonn/Düsseldorf: September 2019), WWEA Policy Paper Series, p. 8, https://wwindea.org/download/community-power-study-september-2019. The downturn results from a number of so-called citizen-owned projects that secured contracts in 2017 without permits and with longer lead times before needing to be online, and many of these have been held up by legal proceedings, from Weston, op. cit. this note. The onshore market has been stalled by permitting, legal and administrative delays as well as NIMBY-ism and the rise of a climate-sceptic political party, from GWEC op. cit. this note, pp. 24, 25.

63 Figure of more than 10 GW stuck in the permitted process based on more than 10 GW from FA Wind, cited in GWEC, *Global Wind Report 2019*, op. cit. note 1, p. 25; an estimated 11 GW from reve, "Germany wind power industry in crisis", 17 December 2019, https://www.evwind.es/2019/12/17/germany-wind-power-industry-in-crisis/72559; increase from 10 months to more than two years from EurObserv'ER, op. cit. note 26, p. 7. The time required to get through the permitting process has nearly tripled since 2010, from GWEC, *Global Wind Report 2019*, op. cit. note 1, p. 25. See also WindEurope, "Collapse in wind energy growth jeopardises German and EU renewables targets", press release (Brussels: 10 May 2019), https://windeurope.org/newsroom/press-releases/collapse-in-wind-energy-growth-jeopardises-german-and-eu-renewables-targets.

64 Aviation and military from GWEC, *Global Wind Report 2019*, op. cit. note 1, p. 25; public resistance and setback from idem, p. 25. Public resistance also from GWEC, *Global Wind Market Outlook Update Q3 2019*, op. cit. note 11, p. 9., and due to projects believed to be too close to residential areas or to concerns about impacts on birds and other wildlife, from Hessler, op. cit. note 62; D. Wetzel, "Collapse of wind power threatens Germany's green energy transition", *Die Welt*, 26 July 2019, https://www.thegwpf.com/collapse-of-wind-power-threatens-germanys-green-energy-transition; setback distance also from Campbell, op. cit. note 5. See also WWEA and LEE NRW, op. cit. note 62. The proposed setback was pending as of early 2020 and the legislative process had stalled, but already the proposed setback was having a significant impact on development of wind power projects in Germany, from Hinrichs-Rahlwes, op. cit. note 62. In May 2020, Germany's coalition government decided to leave the decision on turbine setbacks up to individual regions, from J. Parnell, "Onshore wind compromise averts German solar market crisis", GTM, 18 May 2020, https://www.greentechmedia.com/articles/read/onshore-wind-policy-dispute-could-decimate-germanys-distributed-solar-industry.

65 Deterrents and impacts on community wind from WWEA, "German government clearly misses all three self-imposed goals associated with auctions", press release (Bonn/Düsseldorf/Berlin: 2 September 2019), https://wwindea.org/blog/2019/09/02/german-government-clearly-misses-all-three-self-imposed-goals-associated-with-auctions, and from WWEA and LEE NRW, op. cit. note 62; deterring investors also from Wetzel, op. cit. note 64; privileges for community projects from Institute for Energy Research, "Wind power is collapsing in Germany", 20 August 2019, https://www.instituteforenergyresearch.org/international-issues/wind-power-is-collapsing-in-germany.

66 WindEurope, op. cit. note 13, pp. 13, 21; GWEC, *Global Wind Report 2019*, op. cit. note 1, p. 25. Five of six onshore wind auctions were undersubscribed, from idem, both sources. Volume tendered was 3,675 MW and only 1,847 MW was awarded, and undersubscription was due to difficulties obtaining necessary permits, from Deutsche Windguard, *Status of Onshore Wind Energy Development in Germany, Year 2019*, op. cit. note 61, p. 8. A tender held in December was Germany's first onshore wind power tender to be oversubscribed since August 2018, from C. Richard, "Oversubscribed tender brings glimmer of hope to beleaguered German onshore sector", Windpower Monthly, 20 December 2019, https://www.windpowermonthly.com/article/1669738/oversubscribed-tender-brings-glimmer-hope-beleaguered-german-onshore-sector. For more on tenders during the year, see C. Richard, "German tender undersubscribed again", Windpower Monthly, 9 August 2019, https://www.windpowermonthly.com/article/1593487/german-tender-undersubscribed-again; reve, op. cit. note 63.

67 J. Harper, "German wind power blown off course", DW, 21 November 2019, https://www.dw.com/en/german-wind-power-blown-off-course/a-51341340; J. Harper, "Winds of change push German power grid to brink", DW, 3 November 2019, https://www.dw.com/en/winds-of-change-push-german-power-grid-to-brink/a-52701005.

68 Up almost 12% on land and 27% offshore, and total generation in 2019 was 125,975 GWh (101,270 GWh onshore and 24,705 GWh offshore), and share of total gross generation was 21.8% (17.5% onshore and 4.3% offshore), all based on data from BMWi and AGEE-Stat, op. cit. note 15, pp. 44-45. Net generation was up 13% on land (to 106 TWh), from Deutsche Windguard, *Status of Onshore Wind Energy Development in Germany*, op. cit. note 61, p. 11; up about 25% offshore (to 25.8 TWh) from Deutsche Windguard, *Status of Onshore Wind Energy Development in Germany*, op. cit. note 61, p. 11; 24.8% share of net generation, based on 127.23 TWh total net generation from wind energy and 513.76 TWh total net generation from all sources, from Fraunhofer ISE, "Annual electricity generation in Germany in 2019", https://www.energy-charts.de/energy.htm?source=all-sources&period=annual&year=2019, updated 1 February 2020.

69 J. Deign, "Germany's maxed-out grid is causing trouble across Europe", GTM, 31 March 2020, https://www.greentechmedia.com/articles/read/germanys-stressed-grid-is-causing-trouble-across-europe; Harper, "Winds of change push German power grid to brink", op. cit. note 67.

70 Curtailment decline from I. Komusanac, WindEurope, Brussels, personal communication with REN21, 29 April 2020; electricity exports declined from 48 TWh in 2018 to about 30 TWh in 2019, and were mostly to Austria and Poland, from Fraunhofer ISE, "Public net electricity generation in Germany 2019: Share from renewables exceeds fossil fuels", press release (Freiburg: 15 January 2020), p. 4, https://www.ise.fraunhofer.de/content/dam/ise/en/documents/News/0120_e_ISE_News_Electricity%20Generation_2019.pdf; transmission target and completion from Bundesnetzagentur, "Bundesnetzagentur veröffentlicht Jahresbericht 2019", press release (Bonn: 30 April 2020), https://www.bundesnetzagentur.de/SharedDocs/Pressemitteilungen/DE/2020/20200429_Jahresbericht.html.

71 Deign, op. cit. note 69; Komusanac, op. cit. note 70.

72 WindEurope, op. cit. note 13, pp. 18, 19. Wind energy generated an estimated 417 TWh in the EU during the year, from idem, p. 8. Wind energy generated an estimated 425.984 TWh in the EU-28 during 2019, from EurObserv'ER, op. cit. note 26, p. 6.

73 WindEurope, op. cit. note 13, p. 17.

74 Norway added 780 MW for a total of 2,444 MW, from WindEurope, op. cit. note 13, p. 10; Norway added 769 MW for a total of 2,444 MW, from WWEA, op. cit. note 1; and Norway added 734 MW for a total of 2,444 MW, from IRENA, op. cit. note 1.

75 D. Weston, "Local protests kill Norway's wind plans", Windpower Monthly, 17 October 2019, https://www.windpowermonthly.com/article/1662940/local-protests-kill-norways-wind-plans.

76 Ukraine added 637.1 MW in 2019, up from 67.8 MW in 2019, for a year-end total of 1169.9 MW (including occupied territories in the east), and policy transition all from Ukrainian Wind Energy Association (UWEA), *Wind Power Sector of Ukraine 2019* (Kyiv: 2020), pp. 8, 9, 21. Wind generation was curtailed for the first time in Ukraine in November 2019, due to imports of electricity from the Russian Federation and Belarus; also in 2019, Ukraine transitioned to a new wholesale electricity market in July, based on bilateral, day-ahead, intra-day balancing and ancillary services, compared with the previous single buyer model, all from idem, pp. 15, 29. Ukraine added 577 MW for a total of 1,170 MW, from WWEA, op. cit. note 1; and added 637 MW for a total of 1,258 MW, from IRENA, op. cit. note 1.

77 Capacity of PPAs in Europe during 2019 from Komusanac, op. cit. note 12; auctions from WindEurope, op. cit. note 13, p. 21.

78 Americas added 13,427 MW for a total exceeding 148 GW, from GWEC, "Americas wind installations rise 12% in 2019 to 13.4GW", 4 February 2020, https://gwec.net/americas-wind-installations-rise-12-in-2019-to-13-4gw; regional share of new capacity based on idem, and on data for 2018 (11,891 MW added) from GWEC, "Global Wind Statistics 2019", op. cit. note 1. The Americas (including North and South America, Central America and Caribbean) added 13,233 MW for a total of 146,187 MW, based on data from IRENA, op. cit. note 1.

79 US share based on total regional additions and US-only installations of 9,143 MW, from AWEA, op. cit. note 12, p. 3; third biggest year from idem. The top years were 2012 (13 GW added) and 2009 (10 GW), from GWEC, op. cit. note 78.

80 Additions were 9,143 MW for a year-end total of 105,583 MW, from AWEA, op. cit. note 12, p. 3; additions were 9,137 MW for a year-end total of 105,591, from AWEA, "Wind Powers America Annual Report", press release (Washington, DC: 16 April 2020), https://www.awea.org/resources/news/2020/wind-is-now-america%E2%80%99s-largest-renewable-energy-pro. Total US year-end wind power summer capacity at end-2019 was 103,584.5 MW, including 29.3 MW offshore, not including capacity from facilities with a total generator nameplate capacity of less than 1 MW, from US EIA, op. cit. note 17, Table 6.1; and annual additions totalled 7,165 MW for total available installed US generating capacity at end-2019 of 101.93 GW, from Federal Energy Regulatory Commission, Office of Energy Projects, *Energy Infrastructure Update for December 2019* (Washington, DC: 2019), https://www.ferc.gov/legal/staff-reports/2019/dec-energy-infrastructure.pdf.

81 Figure of 22,115 MW, from AWEA, op. cit. note 12, pp. 3, 4.

82 GWEC, op. cit. note 78. The USD 0.015 per kWh production tax credit (or 18% investment tax credit) is available for wind power projects that begin construction during 2020 and come into operation before the end of 2023, from GWEC, *Global Wind Report 2019*, op. cit. note 1, p. 60.

83 AWEA, Washington, DC, personal communication with REN21, 8 May 2020. Corporate and utility wind PPAs reached 8,726 MW in 2019, of which 5,266 MW was with utilities, all from AWEA, op. cit. note 12, pp. 3, 4. RPS mandates and corporates also from GWEC, *Global Wind Report 2019*, op. cit. note 1, p. 37.

84 AWEA, op. cit. note 12, pp. 3, 4. Utilities signed 5,085 MW, their second highest amount, out of a record total of 8,726 MW of PPAs, from AWEA, *Wind Powers America – Annual Report 2019*, Executive Summary (Washington, DC: 2020), p. 5, https://www.awea.org/resources/publications-and-reports/market-reports/2019-u-s-wind-industry-market-reports/amr2019_executivesummary. Most of the projects under construction were expected to come online in 2020 to receive the full PTC value, from AWEA, op. cit. note 12, pp. 3, 4.

85 AWEA, op. cit. note 12, p. 7.

86 The six states were Texas with 28,843 MW, Iowa (10,190 MW), Oklahoma (8,172 MW), Kansas (6,128), California (5,973 MW) and Illinois (5,350 MW), and cumulative capacity in Texas, all from AWEA, op. cit. note 12, pp. 7, 8. Another 13 states had more than 1 GW at year's end, from idem.

87 The Southwest Power Pool, the grid throughout much of the US Midwest, saw wind's share of generation reach 66.5% in April 2019, from C. Walter, "Wind breaks a new record in Southwest Power Pool", AWEA, 26 April 2019, https://www.aweablog.org/wind-breaks-new-record-southwest-power-pool. Several other regional grids also broke wind output or penetration records in 2018 and 2019, from idem. See, for example: G. Alvarez, "2018 highlights: Six trends shaping the future of wind power", AWEA, 10 January 2019, https://www.aweablog.org/2018-highlights-six-trends-shaping-future-wind-power; E. Douglas, "Texas wind generation breaks record, ERCOT reports", *Houston Chronicle*, 20 December 2018, https://www.chron.com/business/energy/article/Texas-wind-generation-breaks-record-ERCOT-13481063.php; R. Druzin, "Texas grid operator reports record amount of wind generation", *Houston Chronicle*, 16 November 2018, https://www.chron.com/business/energy/article/Texas-grid-operator-reports-record-amount-of-wind-13398202.php; G. Alvarez, "A huge record in the Southwest Power Pool", AWEA, 22 March 2018, http://www.aweablog.org/huge-new-record-southwest-power-pool.

88 K. Balaraman, "Wind plants can provide grid services similar to gas, hydro, easing renewables integration: CAISO", Utility Dive, 13 March 2020, https://www.utilitydive.com/news/wind-plants-can-provide-grid-services-similar-to-gas-hydro-easing-renewab/574070; C. Loutan et al., *Avangrid Renewables Tule Wind Farm: Demonstration of Capability to Provide Essential Grid Services* (Folsom, CA: California ISO, Avangrid Renewables, General Electric, 11 March 2020), http://www.caiso.com/Documents/WindPowerPlantTestResults.pdf.

89 Based on data from US EIA, op. cit. note 17, Tables 1.14.B and 1.3.B

90 States include Iowa (42%), Kansas (41.4%), Oklahoma (34.6%), North Dakota (26.8%), South Dakota (23.9%), Maine (23.8%), Nebraska (19.9%), New Mexico (19.5%), Colorado (19.4%), Minnesota (19.1%), Vermont (17.6%), Texas (17.5%) and Idaho (16.2%), all based on data from US EIA, op. cit. note 17, Tables 1.14.B and 1.3.B. Figures of 7.3% in 2019 and 6.5% of US total generation in 2018 based on data for utility-scale facilities net generation during 2018 from idem, Table ES1.B.

91 US EIA, "Wind has surpassed hydro as most-used renewable electricity generation source in U.S.", 26 February 2020, https://www.eia.gov/todayinenergy/detail.php?id=42955.

92 The region added 3,686.5 MW in 2019 based on data from GWEC, "Global Wind Statistics 2019", op. cit. note 1. Added 3,470 MW for a total of 29,190 MW, based on data for Central America and the Caribbean, South America and Mexico, from IRENA, op. cit. note 1.

93 The decline in installations relative to 2018 was about 1.3%, based on data from GWEC, "Global Wind Statistics 2019", op. cit. note 1; due to decline in Brazil and others made up for Brazil's decline based on data from idem, and from GWEC, *Global Wind Report 2019*, op. cit. note 1, p. 39.

94 Figure of 29.2 GW based on data from GWEC, *Global Wind Report 2019*, op. cit. note 1, p. 44; number of countries based on data from GWEC, "Global Wind Statistics 2019", op. cit. note 1.

95 Mexico added 1,284 MW, followed by Argentina (931 MW), Brazil (745 MW), and Chile added a record 526 MW, all from GWEC, op. cit. note 78. Data align for every country except Chile, which added only 170 MW in 2019, from Windpower Intelligence, cited in Campbell, op. cit. note 5. Argentina ended the year with a total of 1,571 MW, Chile with a total of 1,889 MW, and Uruguay added no new capacity and ended the year with a total of 1,647 MW, all from Windpower Intelligence, op. cit. this note. Mexico added 1,716 MW for a total of 6,591 MW, Argentina added 859 MW for a total of 1,609 MW, Brazil added 531 MW for a total of 15,364 MW, and Chile added 96 MW for a total of 1,620 MW, from IRENA, op. cit. note 1; and Mexico added 1,280 MW for a total of 6,215 MW, Argentina added 882 MW for a total of 1,604 MW, Brazil added 745 MW for a total of 15,452 MW, and Chile added 529 MW for a total of 2,150 MW, from WWEA, op. cit. note 1.

96 GWEC, op. cit. note 78; a total of 1,174 MW of wind power capacity, in seven projects, received 15-year PPAs, from GWEC, *Global Wind Report 2019*, op. cit. note 1, p. 46. Ecuador also launched a tender for wind power, in July 2019, from G. Fenés, "Exclusivo: los pliegos de la subasta de energías renovables que lanzó el Gobierno de Ecuador", 2 August 2019, Energía Estratégica, https://www.

energiaestrategica.com/exclusivo-los-pliegos-de-la-subasta-de-energias-renovables-que-lanzo-el-gobierno-de-ecuador (using Google Translate).

97 OLADE and GWEC, cited in GWEC, "Public tenders and auctions have driven 80% of current renewable energy capacity in Latin America and the Caribbean", op. cit. note 11; OLADE, "Public tenders and auctions have boosted 80% of the current renewable energy capacity in Latin America and the Caribbean", 19 March 2020, http://www.olade.org/noticias/public-tenders-and-auctions-have-boosted-80-of-the-current-renewable-energy-capacity-in-latin-america-and-the-caribbean/?lang=en. Role of auctions also from GWEC, *Global Wind Report 2019*, op. cit. note 1, p. 48.

98 Rankings, Mexico's additions (1,281 MW) and cumulative capacity of 6,215 MW based on data from GWEC, "Global Wind Statistics 2019", op. cit. note 1. Mexico had a total of nearly 6 GW at year's end, from Windpower Intelligence, cited in Campbell, op. cit. note 5. Wind power grew 26%, adding a record 1,280 MW, from Mexican Association of Wind Energy, cited in "Las energías renovables baten su récord en México pese a las tensiones con el Gobierno", *El País*, 26 February 2020, https://elpais.com/economia/2020/02/26/actualidad/1582694040_481642.html (using Google Translate). In 2019, about 65% of production resulted from long-term power auction, especially the first and second auctions, in 2015 and 2016; the third auction was in 2017, and about half of contracted capacity was under construction as of early 2020, from idem. Note that Mexico had 6,590 MW of wind power capacity at the end of 2019, up from 4,875 MW (net additions of 1,715 MW), and wind energy accounted for 8% of Mexico's electricity generation during the year, from "Sector eólico alerta: riesgo en empleos", Heraldo de México, 12 March 2020, https://heraldodemexico.com.mx/mer-k-2/sector-eolico-alerta-riesgo-en-empleos (using Google Translate).

99 GWEC, *Global Wind Market Outlook Update Q3 2019*, op. cit. note 11, p. 4; GWEC, op. cit. note 78.

100 On-off policies and auctions, from GWEC, *Global Wind Report 2019*, op. cit. note 1, and from Zhao, op. cit. note 7, 4 May 2020. Doubling and year-end capacity based on data from GWEC, "Global Wind Statistics 2019", op. cit. note 1. Argentina added 931 MW in 2019 for a year-end total of nearly 1,604 MW, from idem. See also S. Marcacci, "Argentina may be the hottest renewable energy market you haven't heard of. Can it spur a global boom?" *Forbes*, 15 October 2019, https://www.forbes.com/sites/energyinnovation/2019/10/15/argentina-may-be-the-hottest-renewable-energy-market-you-havent-heard-of-can-it-spur-a-global-boom.

101 Reve, "Wind energy in Argentina: The largest wind farm begins to operate", EV Wind, 26 September 2019, https://www.evwind.es/2019/09/26/wind-energy-in-argentina-the-largest-wind-farm-begins-to-operate/71068. It has been estimated that the project will generate some 987 GWh annually, from idem.

102 Lowest since 2011 based on data from GWEC, "Global Wind Statistics 2019", op. cit. note 1, and from Windpower Intelligence, cited in Campbell, op. cit. note 5; break in auction schedule from Zhao, op. cit. note 7; Brazil added more wind (971 MW) than thermal (776 MW) power capacity in 2019, from reve, "75% of Brazil's new power comes from hydroelectric, wind energy and solar power", 19 January 2020, https://www.evwind.es/2020/01/19/75-of-brazils-new-power-comes-from-hydroelectric-wind-energy-and-solar-power/73131. Note, however, that GWEC data provide a lower number for wind power additions in 2019, of 745 MW, from GWEC, op. cit. this note.

103 GWEC, *Global Wind Report 2019*, op. cit. note 1, p. 23. About 70% has been sold for private PPAs compared with 30% for private auctions, from E. Feitosa, Eólica Tecnologia, Brazil, presentation for WWEA, "Webinar: Wind power markets around the world", 16 April 2020, https://wwindea.org/blog/2020/04/08/webinar-wind-power-markets-around-the-world.

104 Brazil added 745 MW to end 2019 with 15,452.4 MW of wind power capacity, compared with a regional total (including Mexico) of 29,223 MW, based on data from GWEC, "Global Wind Statistics 2019", op. cit. note 1. Brazil had a total of 15,418 GW of wind power capacity in place as of mid-December 2019, up from 14,704 MW at the end of 2018, from Associação Brasileira de Energia Eólica (ABEEólica), *Infowind Brazil* (No. 14, 13 December 2019), http://abeeolica.org.br/wp-content/uploads/2020/02/Infovento-14_ENG.pdf. Brazil added a net of 855 MW in 2019, based on year-end capacity of 6,385 MW, from ONS, "Geração de energia – composição", for period 1 January 2019 to 31 December 2019, http://www.ons.org.br/Paginas/resultados-da-operacao/historico-da-operacao/geracao_energia.aspx; and on end-2018 capacity of 5,530 MW, from ONS, "Geração de energia – composição", for period 1 January 2018 to 31 December 2018, http://www.ons.org.br/Paginas/resultados-da-operacao/historico-da-operacao/geracao_energia.aspx. Brazil added 971 MW in 2019, from reve, "75% of Brazil's new power comes from hydroelectric, wind energy and solar power", 19 January 2020, https://www.evwind.es/2020/01/19/75-of-brazils-new-power-comes-from-hydroelectric-wind-energy-and-solar-power/73131.

105 Data for 2019 based on total annual generation of 593,591 GWh and annual wind energy generation of 55,932 GWh, and 2018 based on total annual generation of 581,923 GWh and annual wind energy generation of 48,443 GWh, all from ONS, "Geração de energia – composição", for period 1 January 2019 to 31 December 2019, op. cit. note 104.

106 Figures of 597 MW added and year-end total of 13,413 MW, from Canadian Wind Energy Association (CanWEA), "Installed capacity", December 2019", https://canwea.ca/wind-energy/installed-capacity, viewed 5 March 2020. Canada added a modest 537 MW for total of about 13.5 GW, Campbell, op. cit. note 5.

107 CanWEA, "National", https://canwea.ca/wind-energy/national, viewed 25 March 2020; drivers from P. McKay, CanWEA, cited in N. Hendley, "Windfall in wind energy?" Canadian Metal Working, 1 April 2020, https://www.canadianmetalworking.com/canadianmetalworking/article/metalworking/windfall-in-wind-energy.

108 Ontario ended the year with 5,436 MW, followed by Quebec (3,882 MW) and Alberta (1,685 MW), from CanWEA, op. cit. note 106.

109 Zhao, op. cit. note 7.

110 Clean Energy Council, *Clean Energy Australia Report 2020* (Melbourne: 8 April 2020), pp. 78-82, https://assets.cleanenergycouncil.org.au/documents/resources/reports/clean-energy-australia/clean-energy-australia-report-2020.pdf.

111 Australia added 837.1 MW across eight projects for a total of 6,279.4 MW, from Ibid., pp. 9, 78, 79, 82. Australia added 837 MW for a total of 6,199 MW, from GWEC, *Global Wind Report 2019*, op. cit. note 1, p. 44.

112 Wind power generated 19.487 TWh in 2019, accounting for 8.5% of Australia's total generation, followed (among renewables) by hydropower (14.166 TWh) and large-scale solar power (5.141 TWh), from Clean Energy Council, op. cit. note 110, pp. 6, 9, 79, 81.

113 Based on data for South Australia (29.2%), Victoria (27.8%) and New South Wales (22.9%), from Green Energy Markets, cited in Clean Energy Council, op. cit. note 110, p. 80; shares in 2018 were South Australia (35%), Victoria (28%) and New South Wales (19%), from Clean Energy Council, op. cit. note 9, pp. 72-76.

114 Clean Energy Council, op. cit. note 110, pp. 4, 7. See also Solar PV section in this chapter for more on challenges in Australia, and S. Paul, "Australia's solar, wind boom to power past grid woes in 2019", *Reuters*, 20 January 2019, https://www.reuters.com/article/us-australia-renewables-idUSKCN1PE0V8. Australia is seeing an increasing number of large-scale projects (both wind and solar) that need connection to a 5,000-kilometre transmission line that was built to carry electricity from coal plants near three large mining areas, and not designed to carry electricity from variability and remote wind and solar projects. Delays in project approvals and grid connections are causing project delays and unanticipated costs for developers who fail to account for grid-related issues (e.g., congestion, curtailment), all from Paul, op. cit. this note.

115 Clean Energy Council, op. cit. note 110, p. 78.

116 Based on data from GWEC, "Global Wind Statistics 2019", op. cit. note 1.

117 Figure of 2.6% from GWEC, "Over 60GW of wind energy capacity installed in 2019, the second-biggest year in history", 25 March 2020, https://gwec.net/gwec-over-60gw-of-wind-energy-capacity-installed-in-2019-the-second-biggest-year-in-history. An estimated 894 MW was added in 2019, from GWEC, "Africa and Middle East add 894MW of wind energy capacity in 2019, market expected to grow by over 10GW by 2024", 12 February 2020, https://gwec.net/africa-and-middle-east-add-894mw-of-wind-energy-capacity-in-2019-market-expected-to-grow-by-over-10gw-by-2024. All Africa added 300 MW and the Middle East added 109 MW, for total additions of 409 MW in 2019, bringing the year-end totals for 5,765 MW in Africa and 723 MW in the Middle East, for combined cumulative capacity of 6,488 MW at end-2019, based on data from IRENA, op. cit. note 1.

118 Numbers of countries by region from Zhao, op. cit. note 7, and

capacities based on data from GWEC, *Global Wind Report 2019*, op. cit. note 1, p. 44, and GWEC, "Global Wind Statistics 2019", op. cit. note 1. Similar year-end capacities for these countries (2,094 MW in South Africa, 1,220 MW in Morocco, and 1,375 MW in Egypt) from IRENA, op. cit. note 1. Capacity also was added during 2019 in Israel (89 MW for a total of 374 MW) and Iran (20 MW for a total of 302 MW), with a total of 19 countries in Africa and 9 in the Middle East having wind capacity in operation (although many of the additional countries have fewer than 5 MW), all from idem.

119 GWEC, "Africa and Middle East add 894MW of wind energy capacity in 2019", op. cit. note 117.

120 GWEC, "Global Wind Statistics 2019", op. cit. note 1; GWEC, "Africa and Middle East add 894MW of wind energy capacity in 2019", op. cit. note 117. All of Ethiopia's new capacity was in the Aysha II Wind Farm project. Data were supplied by Chinese Dongfang to GWEC, from Zhao, op. cit. note 7. Egypt added 363 MW for a total of 1,573 MW, from Campbell, op. cit. note 5. Note that several sources say the Lake Turkana wind project in Kenya commenced operations during 2019. See, for example, "Kenya launches largest wind power plant in Africa", CNN Marketplace Africa, 20 July 2019, https://edition.cnn.com/2019/07/20/africa/africas-largest-wind-farm-intl. However, the project was announced by Vestas (Denmark) in 2018, so was included in GWEC's data for 2018, from Zhao, op. cit. note 7, and was reported as connected to the national grid as of December 2018, from Lake Turkana Wind Power, "Lake Turkana wind power connected to the national grid", 9 December 2018, https://ltwp.co.ke/ltwp-connected-to-grid. As a result, the project was included as newly installed capacity in GSR 2019. Data also conflict for South Africa, probably due to differences in timing of reporting: the local wind energy association in South Africa reported to GWEC that no new capacity came online in 2019, from Zhao, op. cit. note 7, whereas the country added 120 MW in 2019, from Campbell, op. cit. note 5. Per IRENA, Africa added capacity during 2019 only in Egypt (250 MW) and Senegal (50 MW), from IRENA, op. cit. note 1.

121 R. Ranjan, "ENGIE Africa commissions Egypt's largest wind farm", Mercom India, 12 November 2019, https://mercomindia.com/engie-africa-commissions-egypt-largest-wind-farm.

122 Egypt's target from Campbell, op. cit. note 5; pipeline from K. Benhamou, Sahara Wind, presentation for WWEA, "Webinar: Wind power markets around the world", 16 April 2020, https://wwindea.org/blog/2020/04/08/webinar-wind-power-markets-around-the-world.

123 C. Richard, "First power from first West African wind farm", Windpower Monthly, 12 December 2019, https://www.windpowermonthly.com/article/1668654/first-power-first-west-african-wind-farm; A. Frangoul, "West Africa's first large-scale wind farm starts generating power", CNBC Sustainable Energy, 13 December 2019, https://www.cnbc.com/2019/12/13/west-africas-first-large-scale-wind-farm-starts-generating-power.html; A. O. Diallo, "Sénégal: le plus grand parc éolien d'Afrique de l'Ouest prend forme à Taiba Ndiaye", Jeune Afrique, 27 May 2019, https://www.jeuneafrique.com/780416/economie/senegal-le-plus-grand-parc-eolien-dafrique-de-louest-prend-forme-a-taiba-ndiaye.

124 Jordan added 190 MW and Iran added 50 MW, from GWEC, "Africa and Middle East add 894MW of wind energy capacity in 2019", op. cit. note 117.

125 "Oil giant Saudi Arabia set to build first wind-power plant", Bloomberg, 26 July 2019, https://www.bloomberg.com/professional/blog/oil-giant-saudi-arabia.

126 Ibid.

127 GWEC, *Global Wind Report 2019*, op. cit. note 1, p. 13, GWEC, "Record 6.1 GW of new offshore wind capacity installed globally in 2019", 19 March 2019, https://gwec.net/record-6-1-gw-of-new-offshore-wind-capacity-installed-globally-in-2019; Europe data also from WindEurope, op. cit. note 13, p. 10. Note that 16 new offshore windfarms went into operation (meaning all turbines in the project were installed and first electricity had been generated by end-2019) in six countries (China, United Kingdom, Germany, Denmark, Belgium and Chinese Taipei) for record annual additions of 5,194 GW in 2019, bringing total capacity to 27,213 MW, from World Forum Offshore Wind, *Global Offshore Wind Report 2019* (Hamburg: February 2020), pp. 3, 4, https://x6a3i7a8.stackpathcdn.com/wp-content/uploads/2020/02/WFO_WindReport2019.pdf. This compares with 2018, when seven countries in Europe and two in Asia connected 4.5 GW (same capacity as in 2017), increasing cumulative global capacity by 24% to 23.1 GW, based on data from GWEC, op. cit. note 7. Note that offshore capacity increased by 4,679 MW in 2019, to a total of 28,308 MW, based on data from IRENA, op. cit. note 1.

128 Figure of less than 5% of capacity based on data from GWEC, "Global Wind Statistics 2019", op. cit. note 1; figures of 10% of global installations in 2019, up from 5% in 2015, from GWEC, op. cit. note 127. Offshore accounted for 12% of commissioned wind power capacity in 2019, up from 8% in 2018, from C. Richard, "Vestas leads the pack with squeezed market share", Windpower Monthly, 18 February 2020, https://www.windpowermonthly.com/article/1674420/vestas-leads-pack-squeezed-market-share. Investment from C. Richard, "Offshore wind spending reaches record high in 2019", Windpower Monthly, 16 January 2020, https://www.windpowermonthly.com/article/1671093/offshore-wind-spending-reaches-record-high-2019; "Late surge in offshore wind financings helps 2019 renewables investment to overtake 2018", BloombergNEF, 16 January 2020, https://about.bnef.com/blog/late-surge-in-offshore-wind-financings-helps-2019-renewables-investment-to-overtake-2018.

129 GWEC, op. cit. note 127.

130 China completed 2,395 MW of capacity in 2019, from GWEC, op. cit. note 127; total of 6,838 MW, from GWEC, *Global Wind Report 2019*, op. cit. note 1, pp. 44, 61. China completed nine projects for a total of 2,450 MW, from Campbell, op. cit. note 5. National target from GWEC, *Global Wind Report 2019*, op. cit. note 1, p. 61.

131 Record installations and policy drivers from GWEC, "Webcast on wind: Market update and outlook for global offshore wind", 19 March 2020; reductions in the FIT from L. Yuanyuan, "China drops electricity subsidy price for offshore wind power", Renewable Energy World, 1 July 2019, https://www.renewableenergyworld.com/articles/2019/07/china-drops-electricity-subsidy-price-for-offshore-wind-power.html; take advantage before it expires from Richard, "Offshore wind spending reaches record high in 2019", op. cit. note 128.

132 GWEC, *Global Wind Report 2019*, op. cit. note 1, p. 61.

133 Ibid., p. 63. More than 40 GW of projects had been approved by national or provincial governments by year's end, with half located in Guangdong, from idem, p. 62.

134 Commissioned 120 MW and 2025 target, from Campbell, op. cit. note 5; figure of 120 MW and first utility-scale offshore project from GWEC, op. cit. note 131; further 10 GW target from "Taiwan plans additional 10GW offshore", reNEWS, 12 November 2019, https://renews.biz/56366/taiwan-plans-additional-10gw-offshore, and from GWEC, "Market to watch: Taiwan offshore wind", 16 January 2020, https://gwec.net/market-to-watch-taiwan-offshore-wind.

135 Japan's 3 MW of floating capacity from GWEC, op. cit. note 127; Japan had 65.6 MW of offshore capacity including 19 MW of floating capacity in five turbines, from B. Backwell, GWEC, "Take offshore wind global", presentation for Renewable Energy Institute, REvision – Webinar, 4 March 2020, Slide 16, https://www.renewable-ei.org/pdfdownload/activities/11_BenBackwell.pdf; capacity in the pipeline (14 GW) from Japan Wind Power Association, "Total capacity of wind in Japan by end of 2019" (Japanese only), provided by H. Matsubara, Institute for Sustainable Energy Policies, personal communication with REN21, April 2020. Capacity in pipeline was 13 GW, from Japan's Ministry of Economy, Trade and Industry, cited in O. Tsukimori, "With coal under fire, 2020 could be a big year for wind power in Japan", *Japan Times*, 2 January 2020, https://www.japantimes.co.jp/news/2020/01/02/business/wind-power-2020-japan. Getting through Japan's environmental assessment process takes 4-5 years; as of January 2020, there was 14.8 GW of offshore wind capacity in the pipeline, from GWEC, *Global Wind Report 2019*, op. cit. note 1, p. 64. Vietnam from GWEC, op. cit. note 131, and from GWEC, *Global Wind Report 2019*, op. cit. note 1, p. 50; India from GWEC, *Global Offshore Wind Report 2019* (Brussels: 2019), p. 9.

136 Europe added 3,627 MW for total of 22,069 MW, and national data all from WindEurope, op. cit. note 13, pp. 8, 10. Up 36% based on 2,661 MW added in 2018, from Komusanac, op. cit. note 12, and increase of 36.5% over 2018, from Zhao, op. cit. note 7. Europe added a gross capacity of 3,627 MW (3,623 MW net), and two turbines of 2 MW each were decommissioned in the United Kingdom, for a cumulative total of 22,072 MW offshore, from WindEurope, *Offshore Wind in Europe: Key Trends and Statistics 2019* (Brussels: February 2020), pp. 7, 8, https://windeurope.org/wp-content/uploads/files/about-wind/statistics/WindEurope-Annual-Offshore-Statistics-2019.pdf.

137 WindEurope, op. cit. note 13, pp. 8, 10. Denmark's 407 MW Horns Rev 3, completed in 2019, is reportedly the country's largest wind

farm and was expected to increase wind generation in Denmark by 12%, from "Denmark opens country's largest wind farm with royal inauguration", Smart Energy International, 23 August 2019, https://www.smart-energy.com/renewable-energy/denmark-opens-countrys-largest-wind-farm-with-royal-inauguration, and from A. Frangoul, "Scandinavia's biggest offshore wind farm is officially open", CNBC, 23 August 2019, https://www.cnbc.com/2019/08/23/scandinavias-biggest-offshore-wind-farm-is-officially-open.html.

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152 European countries and capacities from WindEurope, op. cit. note 13, p. 10, with the exception of Germany, from BMWi and AGEE-Stat, op. cit. note 15, p. 7, and from GWEC, "Global Wind Statistics 2019", op. cit. note 1; rest of world, including China, from idem.

153 Europe home to 75% and Asia nearly all the rest, based on data from GWEC, op. cit. note 131; 79% in 2018, down from 84% in 2017 and 88% in 2016, based on data from GWEC, op. cit. note 7. **Figure 39** based on data from the following: GWEC, *Global Wind Report – Annual Market Update 2015* (Brussels: April 2016), pp. 50-51, http://www.gwec.net/wp-content/uploads/vip/GWEC-Global-Wind-2015-Report_April-2016_19_04.pdf; GWEC, *Global*

Wind Report – Annual Market Update 2016 (Brussels: April 2017), p. 58, http://www.gwec.net/strong-outlook-for-wind-power; GWEC, op. cit. note 18, p. 55; GWEC, op. cit. note 7, pp. 29, 33; GWEC, "Global Wind Statistics 2019, op. cit. note 1; S. Pengfei, CWEA, personal communication with REN21, April 2010 and March 2017; FTI Consulting, *Global Wind Market Update – Demand & Supply 2016, Part Two – Demand Side Analysis* (London: March 2017), p. 60; WindEurope, *The European Offshore Wind Industry – Key Trends and Statistics 2016* (Brussels: January 2017), p. 17, https://windeurope.org/wp-content/uploads/files/about-wind/statistics/WindEurope-Annual-Offshore-Statistics-2016.pdf; WindEurope, *Offshore Wind in Europe – Key Trends and Statistics 2017* (Brussels: February 2018), p. 6, https://windeurope.org/wp-content/uploads/files/about-wind/statistics/WindEurope-Annual-Offshore-Statistics-2017.pdf; WindEurope, op. cit. note 136, p. 11, https://windeurope.org/wp-content/uploads/files/about-wind/statistics/WindEurope-Annual-Offshore-Statistics-2019.pdf; AWEA, "First US offshore wind farm unlocks vast new ocean energy resource", press release (Block Island, RI: 12 December 2016), https://www.awea.org/resources/news/2016/first-us-offshore-wind-farm-unlocks-vast-new-ocean.

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156 GWEC, "Global Wind Statistics 2019", op. cit. note 1.

157 An estimated 178 MW of capacity was decommissioned in Europe, from WindEurope, op. cit. note 13, p. 16. Austria and Denmark decommissioned 32 MW each, the United Kingdom 17 MW and France 0.2 MW; 174 MW of the total was onshore capacity and 4 MW was offshore, all from idem. An estimated 174 MW was decommissioned in Europe, including in Germany (97 MW), Austria (32 MW), Denmark (31.9 MW) and the United Kingdom (13 MW), based on data from GWEC, "Global Wind Statistics 2019", op. cit. note 1.

158 IRENA, op. cit. note 9, p. 9; Eckhouse, op. cit. note 9; Frankfurt School/UNEP Collaborating Centre and BloombergNEF, *Global Trends in Renewable Energy Investment 2018* (Frankfurt: 2019), pp. 16-17, https://www.fs-unep-centre.org/wp-content/uploads/2019/11/Global_Trends_Report_2018.pdf; S. Sawyer, GWEC, personal communication with REN21, 13 December 2017; W. Steel, "Bigger turbines, better economics, more digitization on deck for 2018 wind power market", Renewable Energy World, 14 February 2018, http://www.renewableenergyworld.com/articles/print/volume-21/issue-1/features/wind/bigger-turbines-better-economics-more-digitization-on-deck-for-2018-wind-power-market.html.

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163 Frankfurt School-UNEP Centre and BloombergNEF, op. cit. note 9, p. 28.

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FEATURE: PUBLIC SUPPORT FOR RENEWABLES

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17 **Table R17** from the following sources: New Energy Update, "CSP Today global tracker", http://tracker.newenergyupdate.com/tracker/projects, viewed on numerous dates leading up to 27 April 2020; US National Renewable Energy Laboratory, "Concentrating solar power projects", https://solarpaces.nrel.gov, with the page and its subpages viewed on numerous dates leading up to 27 April 2020 (some subpages are referenced individually throughout the CSP section) and references cited in the CSP section of Renewable Energy Policy Network for the 21st Century (REN21), *Renewables 2019 Global Status Report* (Paris: 2019), pp. 107-09, https://www.ren21.net/wp-content/uploads/2019/05/gsr_2019_full_report_en.pdf. In some cases, information from the above sources was verified against additional country specific sources, as cited in the endnotes for the CSP section. Global CSP data are based on commercial facilities only; demonstration and pilot facilities are excluded, with the exception of certain plants in China that are described as "demonstration" plants by the government but are nonetheless large- (utility-) scale, grid-connected plants that are operating or will operate commercially. Data discrepancies between REN21 and other reference sources are due primarily to differences in categorisation and thresholds for inclusion of specific CSP facilities in overall global totals.

18 **Table R18** from the following sources: cumulative solar thermal capacity in operation nationally and globally at end-2018 from M. Spörk-Dür, AEE-Institute for Sustainable Technologies (AEE INTEC), Gleisdorf, Austria, personal communications with REN21, March-May 2020; W. Weiss and M. Spörk-Dür, *Solar Heat Worldwide. Global Market Development and Trends in 2019, Detailed Market Figures 2018* (Gleisdorf, Austria: IEA Solar Heating and Cooling Programme, 2020), https://www.iea-shc.org/solar-heat-worldwide. Gross additions on a national level from the following associations and experts: David Ferrari, Sustainability Victoria, Melbourne, Australia; Werner Weiss, AEE INTEC, Vienna, Austria; Danielle Johann, Brazilian Solar Thermal Energy Association (ABRASOL), São Paulo, Brazil; Hongzhi Cheng, Shandong SunVision Management Consulting, Dezhou, China; Panayiotis Kastanias, Cyprus Union of Solar Thermal Industrialists (EBHEK), Nicosia, Cyprus; Daniel Trier and Jan Erik Nielson, PlanEnergi, Skørping, Denmark; Andrea Liesen, BSW Solar, Berlin, Germany; Costas Travasaros, Greek Solar Industry Association (EBHE), Piraeus, Greece; Jaideep Malaviya, Solar Thermal Federation of India (STFI), Pune, India; Eli Shilton, Elsol, Kohar-yair, Israel; Federico Musazzi, ANIMA, the Federation of Italian Associations in the Mechanical and Engineering Industries, Milan, Italy; Daniel Garcia, Solar Thermal Manufacturers Organisation (FAMERAC), Mexico City, Mexico; Janusz Staroscik, Association of Manufacturers and Importers of Heating Appliances (SPIUG), Warsaw, Poland; Karin Kritzinger, Centre for Renewable and Sustainable Energy Studies, University of Stellenbosch, Stellenbosch, South Africa; Pascual Polo, Spanish Solar Thermal Association (ASIT), Madrid, Spain; Abdullah Azzam, Palestinian Central Bureau of Statistics, Ramallah, State of Palestine; David Stickelberger, Swissolar, Zurich, Switzerland; Abdelkader Baccouche, ANME, Tunis, Tunisia; Kutay Ülke, Bural Heating, Kayseri, Turkey; Les Nelson, Solar Heating & Cooling Programs at the International Association of Plumbing and Mechanical Officials (IAPMO), Ontario, California, United States, all personal communications with REN21, February-April 2020. Data for China and World Total assume that systems in China have a 10-year operational lifetime; national data for all other countries reflect a 25-year lifetime, with the exceptions of Turkey (14 years prior to 2018, and 15 years starting with 2018) and Germany (20 years). Total gross additions worldwide for 2018 are based on estimates from Spörk-Dür, op. cit. this note.

19 **Table R19** from the following sources: Unless noted otherwise, data are from the following: Global Wind Energy Council (GWEC), *Global Wind Report 2019* (Brussels: March 2020), pp. 13, 42, 43, https://gwec.net/global-wind-report-2019; GWEC, "Global Wind Statistics 2019: Status as End of 2019" (Brussels: March 2020); WindEurope, *Wind Energy in Europe in 2019: Trends and Statistics* (Brussels: 2020), pp. 8, 10, 13, 15, 16, https://windeurope.org/wp-content/uploads/files/about-wind/statistics/WindEurope-Annual-Statistics-2019.pdf; World Wind Energy Association (WWEA), "Global wind installations", https://library.wwindea.org/global-statistics, viewed 16 April 2020. **China:** Official total for end-2018 from NEA, "2018 wind power grid operation", 28 January 2019, http://www.nea.gov.cn/2019-01/28/c_137780779.htm (using Google Translate), and from NEA and CEC, cited in China Energy Portal, "2018 wind power installations and production by province", 28 January 2019, https://chinaenergyportal.org/en/2018-wind-power-installations-and-production-by-province, viewed 30 April 2020; official data for 2019 additions and total from NEA, cited in National Energy Board, "2019 wind power grid operation", 28 February 2020, http://www.nea.gov.cn/2020-02/28/c_138827910.htm (using Google Translate), and from NEA and CEC, cited in China Energy Portal, "2019 wind power installations and production by province", 28 February 2020, https://chinaenergyportal.org/en/2019-wind-power-installations-and-production-by-province. Unofficial data from H. Yu, Chinese Wind Energy Association, personal communication with REN21, 18 May 2020, and from GWEC, "Global Wind Statistics 2019", op. cit. this note; unofficial data for 2019 additions and total from GWEC, idem. **United States:** American Wind Energy Association (AWEA), *U.S. Wind Industry Quarterly Market Report, Fourth Quarter 2019* (Washington, DC: January 2020), p. 3, https://www.awea.org/resources/publications-and-reports/market-reports/2019-u-s-wind-industry-market-reports/4q2019_marketreport; AWEA, "Wind Powers America Annual Report", press release (Washington, DC: 16 April 2020), https://www.awea.org/resources/news/2020/wind-is-now-america%E2%80%99s-largest-renewable-energy-pro. **United Kingdom:** WindEurope, op. cit. this note, pp. 8, 16. Also based on data from UK BEIS, op. cit. note 1, viewed 29 April 2020. **India:** Government of India, MNRE, cited in Ministry of Power, Central Electricity Authority (CEA), "All India installed capacity (in MW) of power stations (as on 31.01.2019) (utilities)", p. 1, http://www.cea.nic.in/reports/monthly/installedcapacity/2020/installed_capacity-01.pdf; Government of India, MNRE, cited in Ministry of Power, CEA, "All India installed capacity (in MW) of power stations (as on 31.01.2018) (utilities)", p. 1, http://www.cea.nic.in/reports/monthly/installedcapacity/2018/installed_capacity-12.pdf; GWEC, *Global Wind Report 2019*, op. cit. this note. **Spain:** WindEurope, op. cit. this note, pp. 8, 10; Red Eléctrica de España, "Potencia instalada nacional (MW)", as of 31 December 2019, https://www.ree.es/es/datos/publicaciones/series-estadisticas-nacionales. **Germany:** WindEurope, op. cit. this note, pp. 10, 16; Federal Ministry for Economic Affairs and AGEE-Stat, op. cit. note 16, p. 7; Deutsche Windguard, *Status of Offshore Wind Energy Development in Germany, Year 2019* (Varel, Germany: 2020), p. 3, https://www.windguard.com/year-2019.html; Deutsche Windguard, *Status of Offshore Wind Energy Development in Germany, Year 2019* (Varel, Germany: 2020), p. 3, https://www.windguard.com/year-2019.html. **Sweden:** WindEurope, op. cit. this note, pp. 10, 11, 13. **France:** WindEurope, idem, p. 10. Also based on data from Réseau de transport d'électricité (RTE), *Bilan Électrique 2019* (Paris: 2020), p. 27, https://www.rte-france.com/sites/default/files/bilan-electrique-2019_1.pdf. **Mexico:** GWEC, "Global Wind Statistics 2019", op. cit. this note; Mexican Association of Wind Energy, cited in "Las energías renovables baten su récord en México pese a las tensiones con el Gobierno", *El Pais*, 26 February 2020, https://elpais.com/economia/2020/02/26/actualidad/1582694040_481642.html (using Google Translate). **Argentina:** GWEC, "Global Wind Statistics 2019", op. cit. this note. **Brazil:** GWEC, idem. Also based on data from Associação Brasileira de Energia Eólica (ABEEólica), *Infowind Brazil*, no. 14

(13 December 2019), http://abeeolica.org.br/wp-content/uploads/2020/02/Infovento-14_ENG.pdf; Operador Nacional do Sistema Eléctrico (ONS), "Geração de energia – composição", for period 1 January 2019 to 31 December 2019, http://www.ons.org.br/Paginas/resultados-da-operacao/historico-da-operacao/geracao_energia.aspx; ONS, "Geração de energia – composição", for period 1 January 2018 to 31 December 2018, http://www.ons.org.br/Paginas/resultados-da-operacao/historico-da-operacao/geracao_energia.aspx. **Canada:** End-2018 from CanWEA, "Installed capacity", December 2018, https://canwea.ca/wind-energy/installed-capacity, viewed 11 March 2019; additions and total in 2019 from CanWEA, "Installed capacity", December 2019, https://canwea.ca/wind-energy/installed-capacity, viewed 5 March 2020. **Italy:** WindEurope, op. cit. this note, p. 10. Also based on data from D. A. Garcia, Italian Wind Energy Association, presentation for WWEA, "Webinar: Wind power markets around the world", 8 April 2020, https://wwindea.org/blog/2020/04/08/webinar-wind-power-markets-around-the-world. See Wind Power section in Market and Industry chapter and related endnotes for additional statistics and details.

20 **Table R20** from the following sources: share of population with access derived from IEA, *World Energy Outlook 2019 Access to Electricity Database*, https://iea.blob.core.windows.net/assets/ecaa2844-dce8-4710-80fb-4085a58f292f/WEO2019-Electricity-database.xlsx, viewed 25 April 2020; population without access derived from idem and from A. Contejean, IEA, Paris, personal communication with REN21, 20 May 2020; targets derived from World Bank, Access to Electricity Database, https://data.worldbank.org/indicator/eg.elc.accs.zs, viewed 25 April 2020, and from J. Rafalowicz, "Power for All Fact Sheet: Energy Access Target Tracker" (Power for All, 4 April 2017), https://www.powerforall.org/application/files/4715/2385/7938/Energy_Access_Target_Tracker_Fact_Sheet_April_2017.pdf.

21 **Table R21** from the following sources: IEA, World Energy Outlook 2019 Access to Clean Cooking Database, https://iea.blob.core.windows.net/assets/b6baec29-6a12-40d6-8333-b89519660299/WEO2019-Clean-Cooking-database.xlsx, viewed 25 April 2020; Rafalowicz, op. cit. note 20.

22 **Table R22** from Frankfurt School–United Nations Environment Programme Centre for Climate & Sustainable Energy Finance and BloombergNEF, *Global Trends in Renewable Energy Investment 2020* (Frankfurt: May 2020).

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