HYDROPOWER

KEY FACTS FOR 2024

- New hydropower installations in 2024 are estimated at 15.1 GW, bringing total global capacity to 1,253 GW.
- Capacity additions in 2024 were similar to the preceding year but significantly lower than the five-year (2018-2023) average of 24.5 GW.
- Generation, affected by significant fluctuations in rainfall and snowmelt, recovered by an estimated 10% after falling around 5% the preceding year.
- Over the past 5 years, hydropower generation (+6%) has not grown in proportion to capacity expansion (+9%).
- Hydro-turbine deployment for pumped storage is growing rapidly and is expected to exceed deployment for hydropower within the coming decade.

90%
of capacity additions were in Asia and Africa.

103 GW
of hydropower capacity was added in the last 5 years (2019-2024); half of which in China.

11 countries
each installed at least 300 MW of new capacity in 2024.

MARKET DEVELOPMENT AND TRENDS

The global hydropower market saw moderate expansion in 2024, with **capacity additions** estimated around 15.1 gigawatts[i] (GW).[1] This was similar to the net additions in 2023 (14.9 GW) but significantly below the five-year average for 2018-2023, which was 24.5 GW.[2] Total global installed capacity[ii] was estimated to be 1,253 GW at year-end 2024.[3] The top eight countries for installed capacity represent nearly two-thirds of the global total (in descending order): China, Brazil, Canada, the United States, the Russian Federation, India, Türkiye and Norway.[4] (→ *See Figure H-1.*)

Recent market trends in these eight countries vary tremendously. China has been the dominant hydropower market for many years and Türkiye's hydropower capacity has grown quickly over the past decade, although growth has slowed in both countries in recent years, with total capacity expanding 15.7% and 15% respectively since 2019.[5] By contrast, over the same period, capacity additions have stalled in the United States. Brazil, which was a fast-growing market a decade ago, has seen less than 1% capacity growth as it has focused on the deployment of other renewable energy technologies.[6] As a group, the top eight countries saw their cumulative hydropower capacity increase about 8.9% from 2019 to 2024, while growth in the rest of the world over this period was somewhat higher, at 9.3%.[7]

i See endnotes 1 and 9 for details on this estimate.

ii Where possible, all capacity numbers exclude pure pumped storage capacity. Pure pumped storage plants are not energy sources but means of energy storage, which incur small conversion losses (maximum between 10% and 20%) and are powered by renewable and/or non-renewable electricity. Pumped storage plays an important role in balancing grid power and in the integration of variable renewable energy sources, such as solar PV and wind power. Even without pumping capability ("active storage"), many hydropower dams can and do provide "passive storage" by foregoing generation from their reservoirs opportunistically to accommodate power system needs – including at times of peak generation from variable renewable sources – thereby supporting power system function, efficiency and economics.

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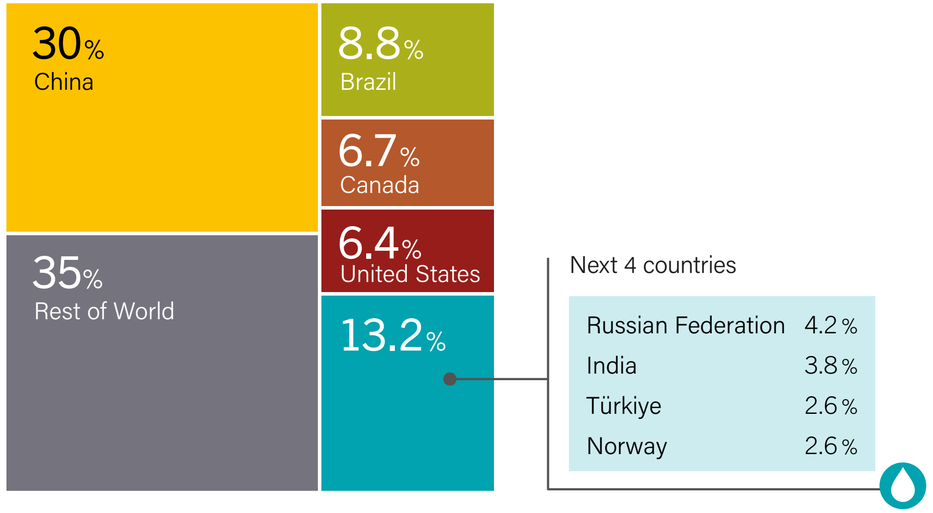
Three Gorges Dam Reservoir, China

FIGURE H-1
Global Hydropower Capacity, Shares of Top 8 Countries and Rest of World, 2024



Source: See endnote 4 for this section.

Excluding China, approximately

90%

of added capacity in 2024 was located outside the top 8 countries for existing capacity (Figure H-1).

Over the past 5 years, hydropower capacity grew 8.9% in the top 8 countries, against

9.3%

in the rest of the world.

This trend is reflected in the country rankings for added capacity in 2024. Aside from China, which maintained the lead in commissioning new hydropower capacity (6.3 GW), the bulk of new additions in 2024 were found outside the eight historically dominant markets. Following China were Tanzania, Pakistan, Ethiopia, Uganda, Indonesia, Bhutan, Vietnam, Canada, Nepal and Cameroon.[8] (→ *See Figure H-2.*) These 10 countries, along with China, each installed at least 300 MW and together were responsible for an estimated 84% of all newly installed capacity in 2024.[9] These developments suggest that established and mature markets are increasingly yielding to new ones.

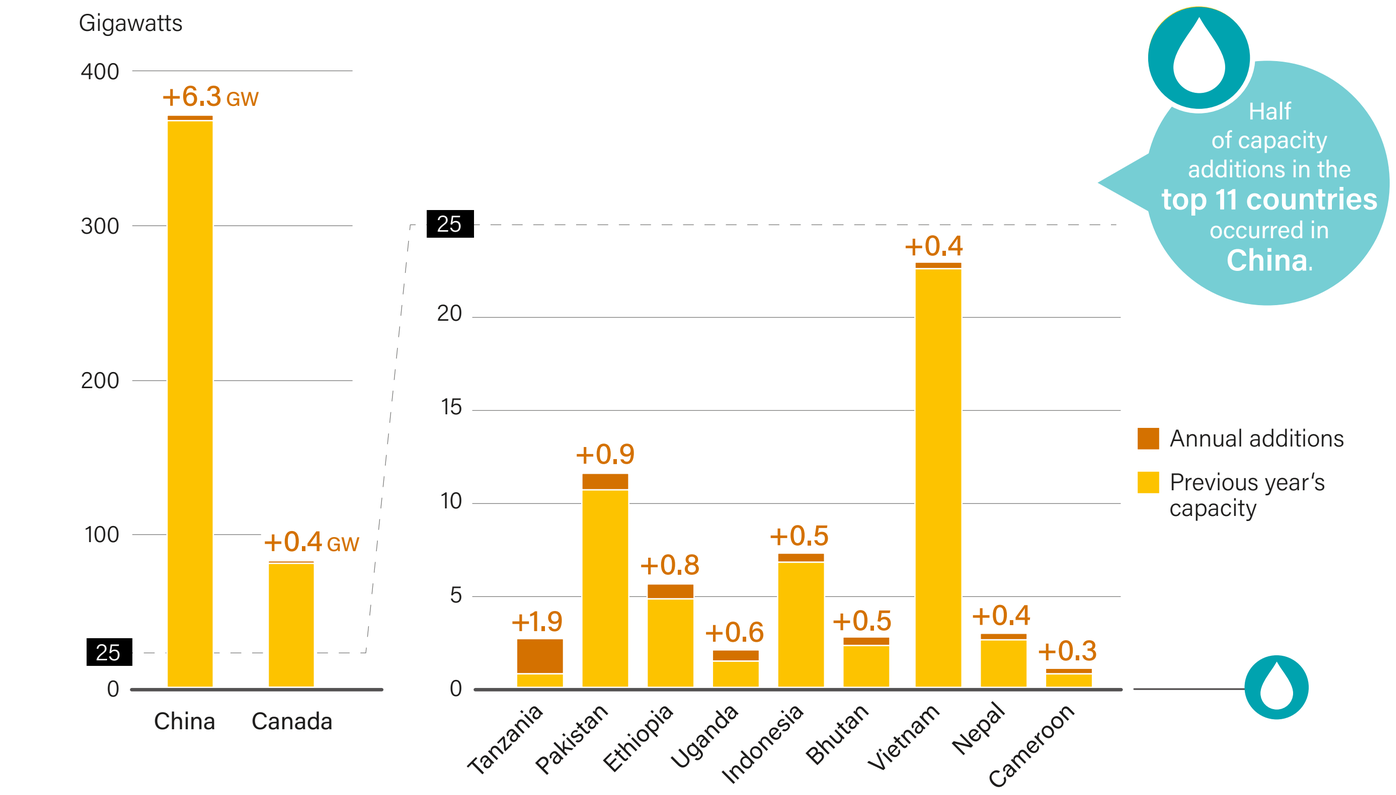
All regions of the world have significant remaining technical hydropower potential.[10] However, economically feasible potential is more limited and further constrained by various locally-defined environmental, political and social constraints.[11] Further, local economic needs, opportunities and policy priorities determine different regional trajectories. For example, North America's hydropower project pipeline[i] in 2024 (5 GW) represented 1.4% of the region's estimated unrealised potential (360 GW), while for East Asia and the Pacific (currently led by China, Indonesia and Laos) the pipeline was 160 GW, or 32% of unrealised potential (501 GW).[12]

Significant potential also lies in the modernisation and refurbishment of older facilities, particularly in mature markets such as Europe and the United States.[13] The benefits of plant modernisation include greater efficiency of operation and enhanced power system integration and support.[14]

Global hydropower **generation** grew an estimated 10% in 2024 to around 4,578 terawatt-hours (TWh), after falling approximately 5% in 2023.[15] Hydropower generation varies significantly due to annual and seasonal fluctuations in rainfall and snowmelt; regional variation is more pronounced. Some regions have suffered sustained droughts leading to underutilisation of capacity, while others contend with extreme rainfall patterns that have caused disruption and damage to hydropower facilities.[16] Climate change, with its associated shifts in weather patterns and loss of glaciers, creates uncertainty and risk that can be detrimental to hydropower infrastructure and function, both physically and economically, but dams can also help to mitigate climate impacts such as droughts and floods.[17]

i Projects that have been announced (intent to build), that are in the approval process, or already under construction.

FIGURE H-2
Hydropower Capacity and Additions, Top 11 Countries for Capacity Added, 2024



Source: See endnote 8 for this section.

Over the past five years, increases in generation have not kept pace with capacity growth: capacity increased by around 9%, whereas generation grew only around 6%.[18] The reasons for this include the effect of changing weather patterns; prioritisation of load-following operation and growing dispatch of variable resources (solar PV and wind power); and the gradual deterioration of often decades-old facilities that have not undergone modernisation and refurbishment to enhance efficiency and climate change resilience.[19] The downward trend was most pronounced in the United States and Canada, where generation declined 13% while capacity grew 1.8%, and for Türkiye, where generation declined 14%, even as capacity increased 15%.[20]

The Hydropower Sustainability Alliance, a multi-stakeholder organisation formed in 2023, certifies hydropower projects for their performance against the sustainability standard established in 2021 by the Hydropower Sustainability Council.[21] Four projects received certifications in 2024, located in Brazil, New Zealand, Philippines and Zambia.[22] The oldest of these facilities commenced operation in 1956 (New Zealand) while Zambia's project is to commence construction by mid-2025.[23]

Some markets experience persistent

generation decline

despite capacity growth.

DEVELOPMENTS IN TOP MARKETS

In line with the long-established trend, Asia remained the most robust regional market for hydropower development in 2024, home to 6 of the top 11 countries for capacity additions. It was followed by Africa, representing all remaining top countries with the exception of Canada.

China was by far the world's largest market with 6.25 GW of new capacity added, for a year-end total of at least 377 GW.[24] Over the five-year period of 2019-2024, China added more than 51 GW, around half of total global capacity additions.[25] However, only 14% of China's additions over this period came in 2023 and 2024 as the country's focus shifted towards the construction of pumped storage facilities[i]: in 2024, pumped storage additions (7.5 GW) exceeded hydropower installations for the second year running.[26] (→ *See Box 1.*)

Hydropower generation in China grew 20% between 2016 and 2024.[31] Despite this significant increase in output, hydropower's share of China's total electricity supply decreased over this period from a peak of 19.4% to 14.5% (with a more than 20-year low of 13.5% in 2023).[32] This was due to a combination of factors: overall electricity consumption increased 61%; other generation technologies expanded at a faster pace; and changing weather patterns and other operating constraints affected hydropower output.[33]

i Some conventional hydropower plants incorporate pumping capability (mixed plants), providing both net energy production and active (not merely passive) storage capability.

BOX 1. PUMPED STORAGE DRAWS CURRENT

Pumped storage frequently causes confusion in the context of hydropower capacity and generation because it relies on hydropower technology and sometimes is co-located with hydropower plants. However, the term refers only to energy storage and is not a source of energy. As is true for any storage technology, it is subject to energy conversion losses both in the pumping process (storage) and the subsequent generation process (discharge).

Pump storage facilities pump water from a lower to a higher reservoir and then reverse the process for discharge. In addition, hydropower facilities, which harness the gravitational and kinetic energy of rivers by means of dams, channels and turbine generators, can be designed to incorporate pumping capability by means of reversible turbines.

Pumped storage remains the largest means of energy storage in the world. In 2024, 8.4 GW of new capacity was added for a total of 189 GW.[27] In addition, pumped storage facilities with a combined capacity of over 105 GW are under construction and it is expected that demand for turbines for new storage facilities will exceed that for hydropower facilities within the coming decade.[28] China is the largest market, responsible for nearly 90% of 2024 capacity additions.[29] The current global pipeline of pumped storage projects amounts to 600 GW, significantly larger than the pipeline for hydropower projects, at 475 GW.[30]

Upper Reservoir of Turlough Hill Pumped Storage Scheme, Louch Nahanagan, Ireland

90%

of pumped storage additions in 2024 occurred in China.

Among project completions in China during 2024 was the 1,200 MW Yangqu plant in Tibet, in the upper Yellow River (Machu River, locally).[34] The project was criticised for its ecological impacts, as well as for displacing over 15,000 people and causing the destruction of a Tibetan monastery, allegedly in conflict with the government's stated intent to fully respect the religion, culture and customs of local communities.[35] Farther south on the Yellow River, the also newly completed 2.32 GW Maerdang hydropower station is said to be the highest-altitude facility of its kind at 3,300 metres.[36]

In 2024, China committed to construct a long-planned 60 GW hydropower project on the Yarlung Tsangpo River[i] near the China-India border in Tibet.[37] While the exact location is unknown, the plant would be expected to take advantage of the deep canyons carved out by the river, allowing it to generate three times more energy than the Three Gorges Dam, the world's largest existing hydropower plant.[38] Downstream states India and Bangladesh have raised concerns about the facility's potential impact on the river, downstream ecosystems and economic sectors, and water security.[39]

Pakistan ranked second in Asia and third globally for capacity additions in 2024, with one project completed: the 884 MW Suki Kinari facility, situated on a tributary of the Jhelum River in the northwest of the country.[40] Constructed as part of the China-Pakistan Economic Corridor initiative, the project is said to be the largest greenfield[ii] hydropower project by a Chinese company overseas.[41]

i Known as the Brahmaputra River downstream in India.

ii A greenfield refers to an area of land or project site that has not been previously developed.

Other top installers in the region during 2024 included **Indonesia**, which added 486 MW for a cumulative total of just over 7 GW; **Bhutan**, with 458 MW of newly completed capacity; **Vietnam** (360 MW) and **Nepal** (at least 350 MW).[42] In addition to meeting rising domestic demand for electricity, Bhutan's new projects aim to serve power demand from neighbouring India,[43] and Vietnam – which has rapidly increased its solar PV and wind power capacity in recent years[44] – aims for new hydropower facilities to improve power system efficiency and provide grid stability.[45]

Nho Que, Ha Giang, Vietnam

Nepal's hydrology and geography provide immense hydropower potential but due to extreme variations in rainfall its hydropower facilities are highly vulnerable, especially during monsoon season.[46] Among Nepal's newly completed projects was the 111 MW run-of-river Rasuwagadhi project, designed to significantly modulate output with seasonal fluctuations in rainfall.[47] Also in 2024, work continued to repair the 456 MW Upper Tamakoshi plant, completed in 2021 but soon damaged by landslides caused by heavy rainfall; the plant's production was restored by mid-2025.[48]

East Africa saw significant additions during 2024. **Tanzania**, which ranked second globally for capacity additions, nearly doubled its overall power generating capacity in 2024 and early 2025 by completing the 2.1 GW Julius Nyerere hydropower facility (1.9 GW operational at year end).[49] The project was expected to end Tanzania's electricity rationing and improve rural electricity access. However, there are concerns about its possible negative impacts downstream on the Selous Game Reserve World Heritage Site, one of Africa's largest protected wildlife habitats.[50] This 'Belt and Road' project set a record as China's largest single export contract for hydropower development to date.[51]

After 13 years of project construction at the Grand Ethiopian Renaissance Dam on the Blue Nile (5.15 GW upon completion), **Ethiopia** (ranking fourth for additions globally) completed the final stage of raising the reservoir level and the installation of the third and fourth turbines (400 MW each), increasing the power of the facility to 1.55 GW.[52] The project, long a source of tension with downstream countries concerned about the security of water supply (particularly Egypt), enables Ethiopia to export electricity to its neighbours in East Africa.[53]

In **Uganda**, the fifth largest hydropower market in 2024, the 600 MW Karuma plant was commissioned after many years of delays and setbacks.[54] Majority-funded by China, the project represents nearly a third of the country's current generation capacity, which is dominated by hydropower.[55]

Across the continent, **Cameroon** installed 300 MW to complete the Nachtigal plant, which is expected to cover 30% of domestic electricity demand while also facilitating future export of electricity to neighbouring Chad.[56]

Canada, the only top installer not in Asia or Africa, was also the only traditionally strong market aside from China to rank among the top 11 (in ninth place) in 2024. The construction process at British Columbia's Site C dam finally neared its end, with the reservoir filled and two of six 180 MW turbines coming online late in the year.[57] The 1.1 GW project faced decades of opposition and legal challenges from local populations before authorities ultimately pushed for completion.[58] The facility is expected to be fully operational in 2025.[59]

Europe and the Americas

each represented approximately 5% of global installations in 2024.

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ADD ACKNOWLEDGEMENTS

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