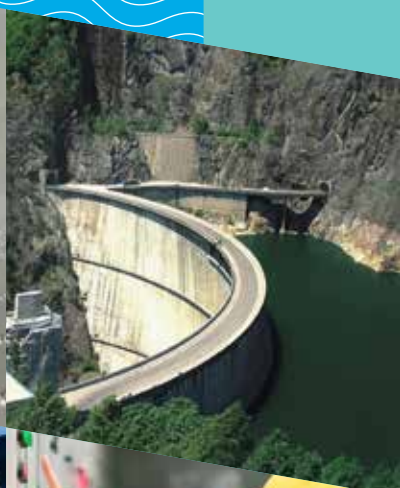
2022

Hydropower Status Report

Sector trends and insights



iha

international hydropower association

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The global certification label for sustainable hydropower

Hydropower Sustainability Standard

The Hydropower Sustainability Standard is the global certification scheme that provides minimum sustainability expectations for hydropower projects, using up-to date, industry-leading guidance.

Hydropower developers and operators can now gain international recognition for their environmental, social and governance performance by certifying their projects against the Standard.

Certify your project now to:

- Unlock green finance for your project
- Enhance your social licence to operate
- Align your project with sector leading environmental and social safeguards

Find out more: hydropower.org/standard

Hydropower Sustainability Council

iha international hydropower association

We are the voice for sustainable hydropower

Secure hydropower's place in the energy transition by joining the International Hydropower Association today

The International Hydropower Association (IHA) represents organisations and individuals committed to sustainable hydropower.

Since IHA was founded in 1995, the hydropower sector has more than doubled in size from 625 GW to over 1,300 GW. IHA's members operate around a third of current capacity at 450 GW.

Our mission is to advance sustainable hydropower by building and sharing knowledge on its role in renewable energy systems, responsible freshwater management and climate change solutions.

When delivered responsibly, hydropower offers clean, affordable and reliable electricity, while meeting our basic needs for water, irrigation, flood and drought control.

As the world's largest producer of renewable energy, hydropower ensures global decarbonisation goals remain within reach, while complementing variable renewables through its flexibility and storage.

100+
organisations
IHA's network of members

120+
countries
where our members operate

450
gigawatts
installed capacity of our members

iha

Find out more:
hydropower.org/take-action

WE CAN MAKE NET ZERO GOALS A REALITY

WE CAN WITH HYDROPOWER

Hydropower.org/WeCan
#WithHydropower

Foreword

As the world strives towards ambitious net zero emissions targets, the 2022 Hydropower Status Report is a stark wake-up call to governments around the world that we are falling short of the progress that is needed.

But there are reasons to be positive. The Glasgow Climate Pact signed by all 197 parties at the closure of the United Change climate change conference, COP26, signified the first global agreement to phase down coal. The conversation must now address how we will fill the hole left by coal.

Fortunately, we do not need to look very far, as the technology that we need to achieve net zero already exists. With the flexibility, security and grid services provided by sustainable hydropower, we can deploy wind and solar energy at scale and deliver reliable energy systems for future generations.

We are moving in the right direction, but the pace needs to be stepped up. The last five years have seen an annual average of 22 GW of new hydropower capacity, which is perilously short of the 45 GW per year that is needed if we are to keep the global temperature rise below 1.5°C and reach net zero emissions by 2050.

We can supercharge the progress firstly by accelerating the development of pumped storage hydropower around the world. Secondly, we need to look towards the immense untapped hydropower potential that exists in many regions of the world, particularly Asia and Africa. Finally, we need to make the most of our existing hydropower fleet by modernising it, as well as integrating hydropower facilities into non-power water infrastructure wherever suitable.

The sustainable hydropower community is ready to deliver. We are working with a coalition of stakeholders all over the world to ensure that any new development is delivered responsibly, and delivers net positive benefits to society and the environment. This message is emphasised in the historic San José Declaration on Sustainable Hydropower, launched in September 2021 at the conclusion of the World Hydropower Congress following months of public consultation. The Declaration is clear that "going forward, the only acceptable hydropower is sustainable hydropower".

These are not just words. The Declaration is reinforced by the Hydropower Sustainability Standard, which is the first ever sustainability standard in the renewable energy sector. Also launched in September 2021, and governed by a multistakeholder body, the Standard enables responsible hydropower developers to certify their projects as sustainable.

So, we have the technology to achieve net zero and the knowledge to deliver it sustainably. All that's needed is the political will to make it happen. We can, with hydropower.

Roger Gill
IHA President

Eddie Rich
IHA CEO

Executive summary

The 2022 Hydropower Status Report, now in its ninth edition, is published while both climate change and energy security are at the forefront of global discourse.

At COP26 (the United Nations climate change conference) in Glasgow in November 2021, welcome progress was made on some of the key climate change issues. Alongside headline deals on deforestation and methane emissions, important commitments were made by many countries, international financial institutions and banks to phase down coal and its financing.

Filling the hole left by coal will be a major task over the coming decade. Hydropower, with its ability to provide both flexible and reliable power, is ideally placed to deliver.

The conflict in Ukraine is a human tragedy with profound global consequences. The impact on fossil fuel prices is having a major impact on the cost of living around the world. It has served to demonstrate how vulnerable the world economy is in relying on sources of energy that are restricted to just a few key regions.

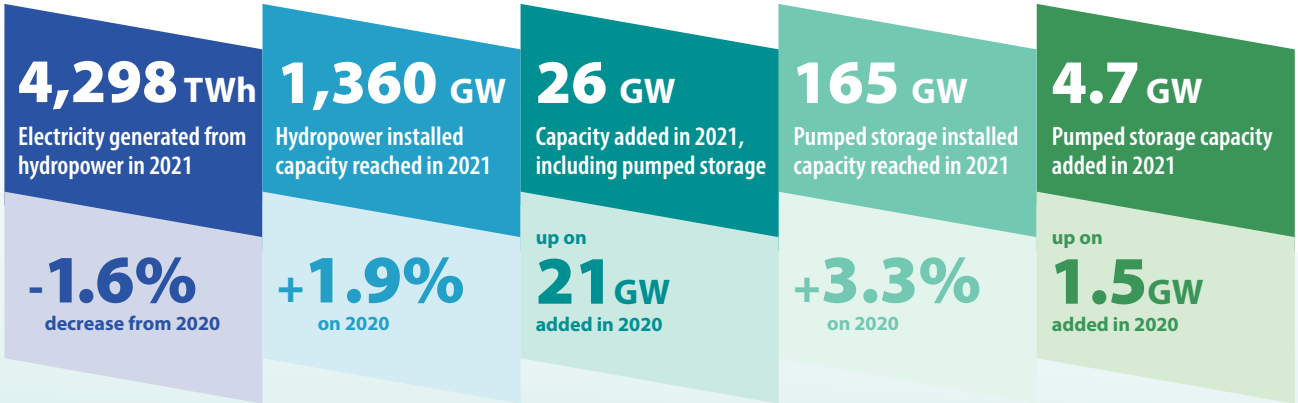
In generating around 16 per cent of the world's electricity, hydropower plays a key role providing low-carbon electricity at scale and free from many of the energy security concerns that plague fossil fuels. We know that to keep climate change below 2°C, or the more challenging 1.5°C net zero target, we will need to see a huge increase in low-carbon electricity generation. International agencies such as the International Renewable Energy Agency (IRENA) and the International Energy Agency (IEA) have consistently modelled a significant increase in the amount of hydropower needed in such energy systems.

To achieve a 2°C target, we need to see around 850 GW of additional hydropower capacity added by 2050, while to achieve a 1.5°C target we will need at least 1,200 GW more. Unfortunately, this is not capacity that can be easily substituted. Other low-carbon sources will, under the international agencies' models, be pushed to their limit.

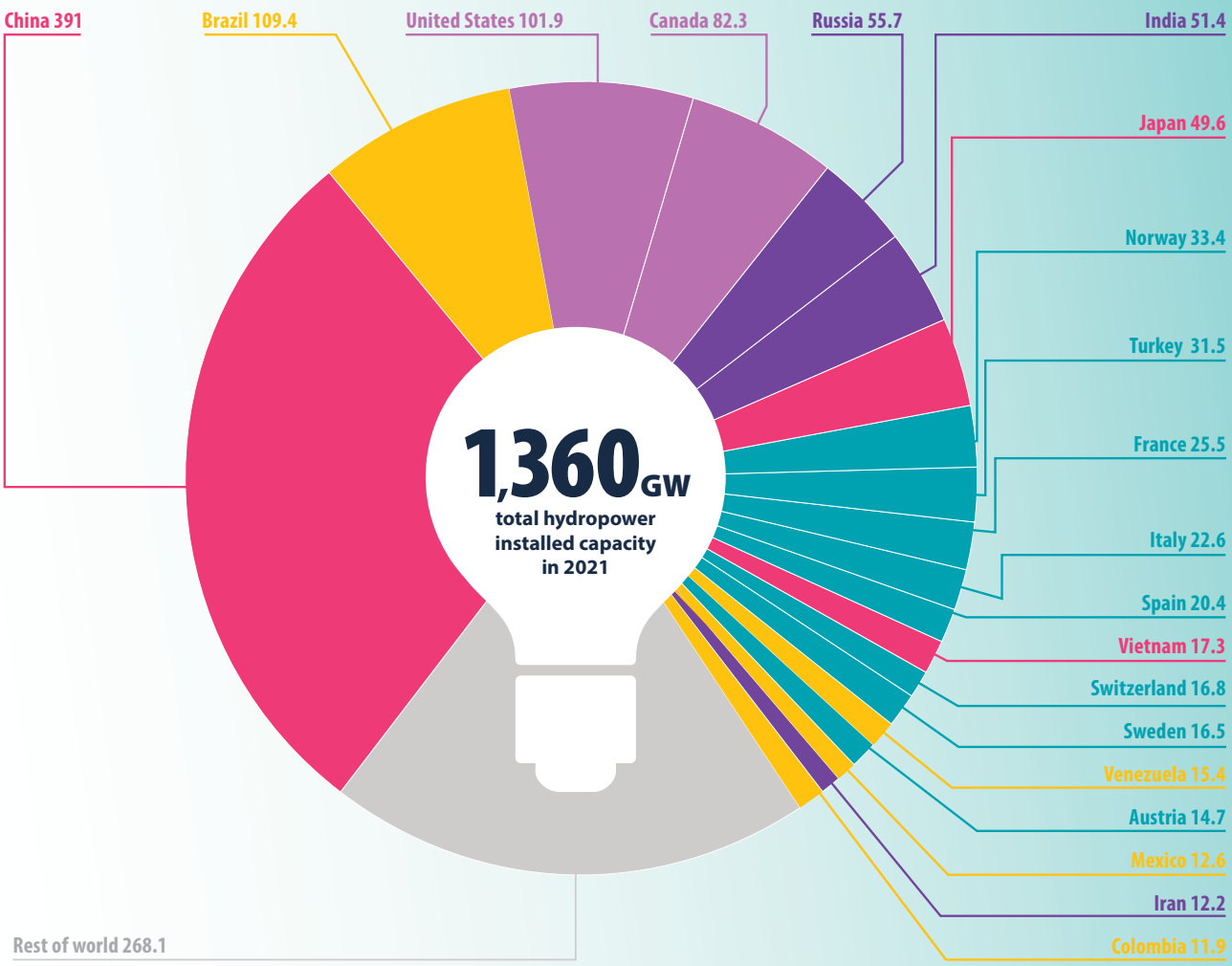
Landmark moments for sustainable hydropower development

For hydropower to play its role in the clean energy transition it is vital that it is developed sustainably. In 2021, leading hydropower companies and international organisations declared their support for a new sustainability certification scheme for hydropower – the Hydropower Sustainability Standard. Launched in September 2021 at the World Hydropower Congress, the Standard will help to ensure that hydropower projects across the world are recognised and certified for their environmental, social and governance performance.

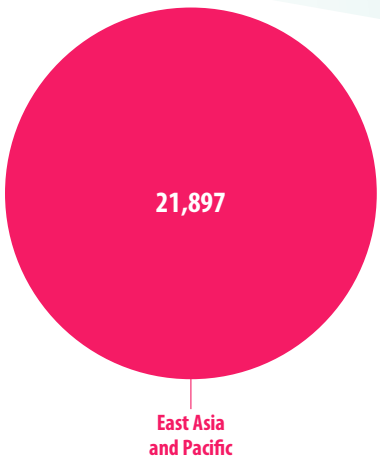
The San José Declaration on Sustainable Hydropower, issued on 24 September 2021 at the conclusion of the Congress, outlines a vision for hydropower's contribution to meeting global climate and development goals. At the heart of the Declaration is a recognition that "sustainable hydropower is a clean, green, modern and affordable solution to climate change". It says that "going forward, the only acceptable hydropower is sustainable hydropower".



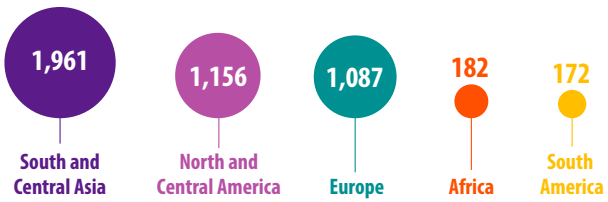
Hydropower installed capacity in 2021



Hydropower installed capacity (GW) of top 20 hydropower producers and the rest of the world, including pumped storage (2021)



New hydropower installed capacity by region in 2021 (MW)



Only China is keeping pace with net zero pathway for hydropower

We are falling short of the development needed to make net zero goals a reality. We need to build around 30 GW a year to keep on track to the 2°C target, and around 45 GW for the more ambitious net zero 1.5°C target. Over the last five years growth has averaged only 22 GW per year, and more than half of this has been in China.

We estimate that there is around 132 GW of hydropower under construction around the world, with just under 430 GW in various stages of pre-construction development. But it is by no means clear that all of this will be built, and even if it is, it would still leave a 300 GW+ gap in the provision of flexible low-carbon generation as coal and gas are taken offline. We run the risk of having to choose between blackouts or carbon emissions, despite a huge amount of remaining potential that can be developed sustainably and cost-effectively.

Hydropower development highlights last year

Hydropower generated around 4,300 terawatt hours (TWh) of clean electricity worldwide in 2021, down from the record of 4,370 TWh in 2020. Lower than average rainfall in many regions contributed to this downturn in generation. Hydropower's generation is equivalent to around one and a half times the entire electricity consumption of the European Union, reflecting hydropower's continued significant contribution to low-carbon generation globally.

Global hydropower installed capacity reached 1,360 gigawatts (GW) in 2021. This represents year-on-year growth of 1.9 per cent, higher than 2020, but still below the more than 2 per cent needed to enable hydropower's essential contribution to tackling climate change.

During 2021, 26 GW of new hydropower capacity was put into operation, up on 2020's 21 GW. Most of this growth came from China, which saw nearly 21 GW of new capacity come online.

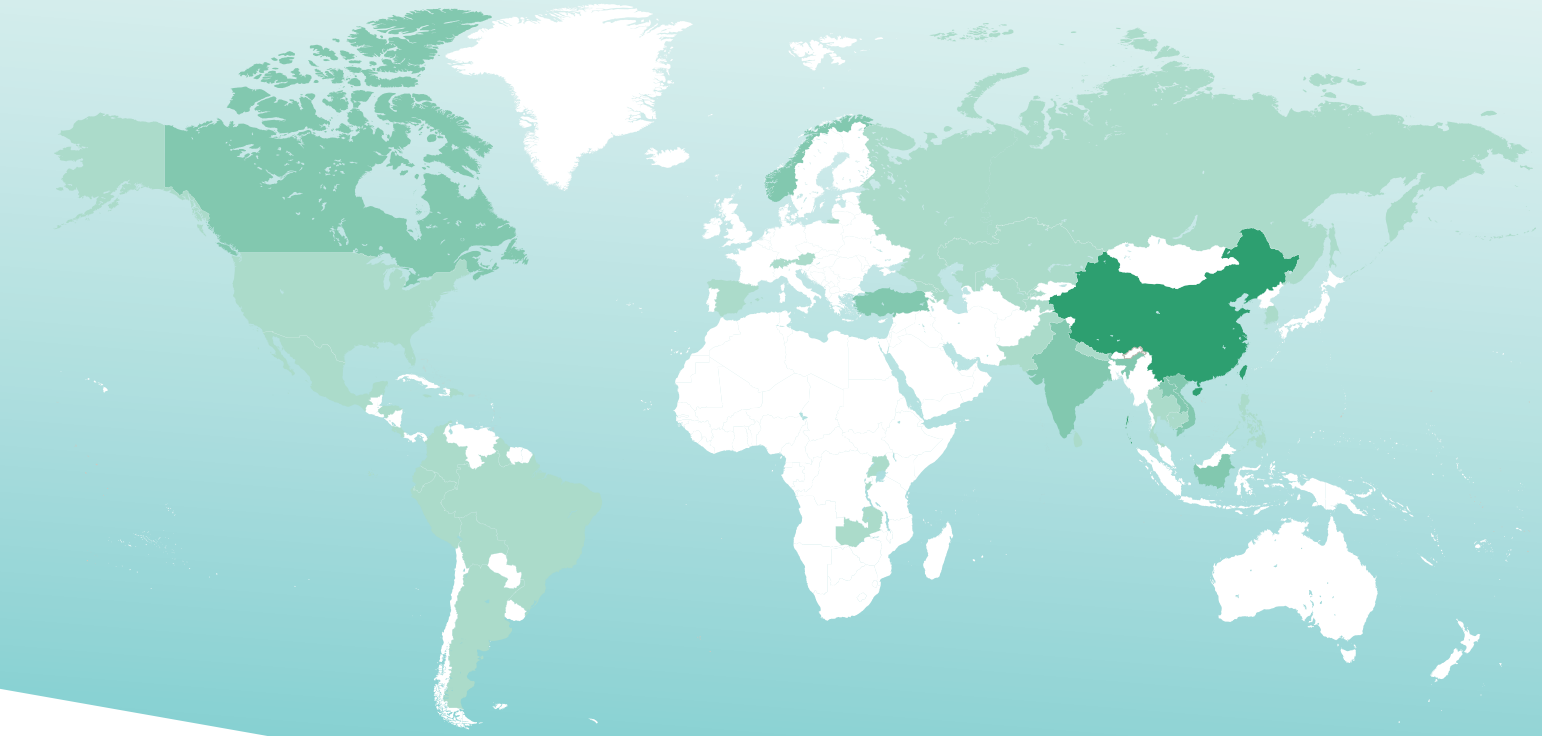
Pumped storage hydropower totalled 4.7 GW of the new additions in capacity, up on the 1.5 GW added in 2020. Again, most of this was in China (4.5 GW), including 600 MW of capacity at the Fengning pumped storage facility, which will be the largest in the world at 3,600 MW once it is complete in 2023.

Major additions in 2021 included: the 824 MW Muskrat Falls Hydroelectric Generating Station, part of the Lower Churchill Project in Canada; the remaining 600 MW of capacity at the 1,272 MW Nam Ou plant in Laos; Nepal's 456 MW Upper Tamakoshi project; units 3 and 4 of Kameng Hydropower Station in India, adding 300 MW; and a 324 MW unit added at the Dnesiter pumped storage plant in Ukraine, raising the plant's installed capacity to 1,296 MW.

In China, the first six 1,000 MW turbines at the giant Baihetan hydropower plant started generating in 2021. Once complete, the 16,000 MW facility will be the world's second largest. Other major additions in China included 3,400 MW at Wudongde, 2,500 MW at Lianghekou, and 1,500 MW brought into operation at Yangfanggou.

Hydropower capacity by region in 2021 (GW)

Where was capacity added in 2021?



Key

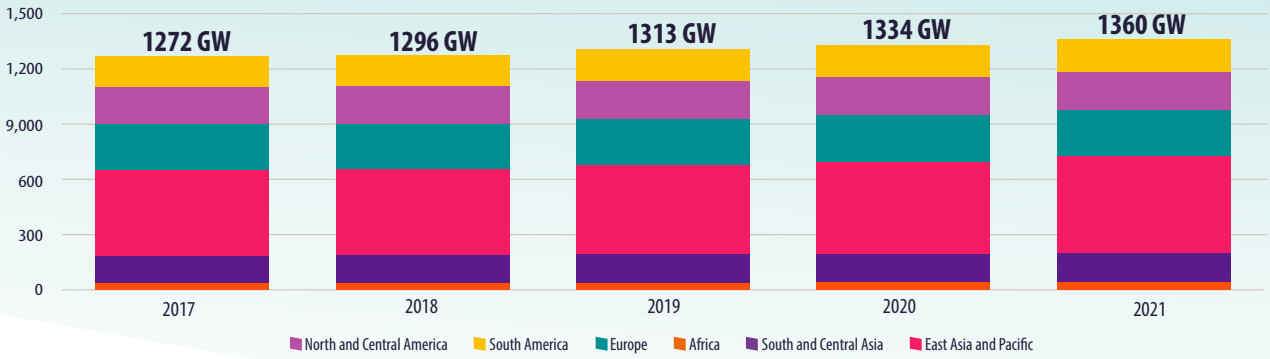
No new additions | 199 MW and below | 200 MW to 1,999 MW | 2,000 MW to 9,999 MW | 10,000 MW and over

Ranking	Country/Territory	Capacity added (MW)
1	China	20,842
2	Canada	924
3	India	803
4	Nepal	684
5	Laos	600
6	Turkey	513
7	Indonesia	481
8	Norway	396
9	Viet Nam	222
10	Brazil	175

Ranking	Country/Territory	Capacity added (MW)
11	USA	172
12	Russia	167
13	Austria	150
14	Zambia	150
15	Kazakhstan	129
16	Argentina	115
17	Philippines	85
18	Uzbekistan	76
19	Tajikistan	49
20	Costa Rica	48

Ranking	Country/Territory	Capacity added (MW)
21	South Korea	35
22	Sri Lanka	35
23	Ecuador	31
24	Uganda	24
25	Spain	16
26	Honduras	12
27	Switzerland	12
28	Georgia	10
29	Azerbaijan	8
30	Burundi	8

Hydropower installed capacity growth, 2017-2021 (GW)

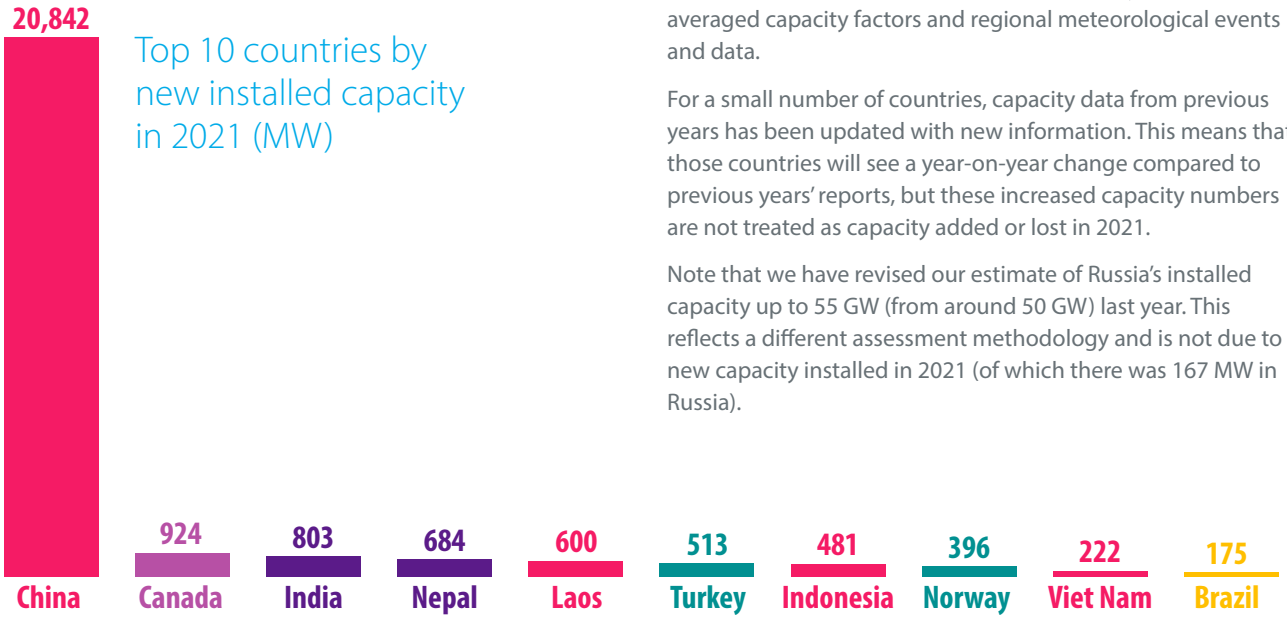


Where was capacity added in 2021?

China remains the world leader in respect to total hydropower installed capacity with over 390 GW, followed by Brazil (109 GW), the USA (102 GW) and Canada (82 GW). Russia, India and Japan also have around 50 GW or more.

38 countries added hydropower capacity in 2021 (including capacity added through modernisation), slightly up on the 35 countries that added capacity in 2020. The total amount of new capacity added, however, increased from 21 GW to 26 GW, led by China with 20.8 GW. No other country added more than 1 GW in 2021. Canada (924 MW), India (803 MW), Nepal (684 MW), Laos (600 MW) and Turkey (513 MW) all added more than 500 MW.

Top 10 countries by new installed capacity in 2021 (MW)



Methodology

The data presented in this report were continuously tracked and updated to account for new information in our global hydropower database, which tracks more than 13,000 stations in over 150 countries.

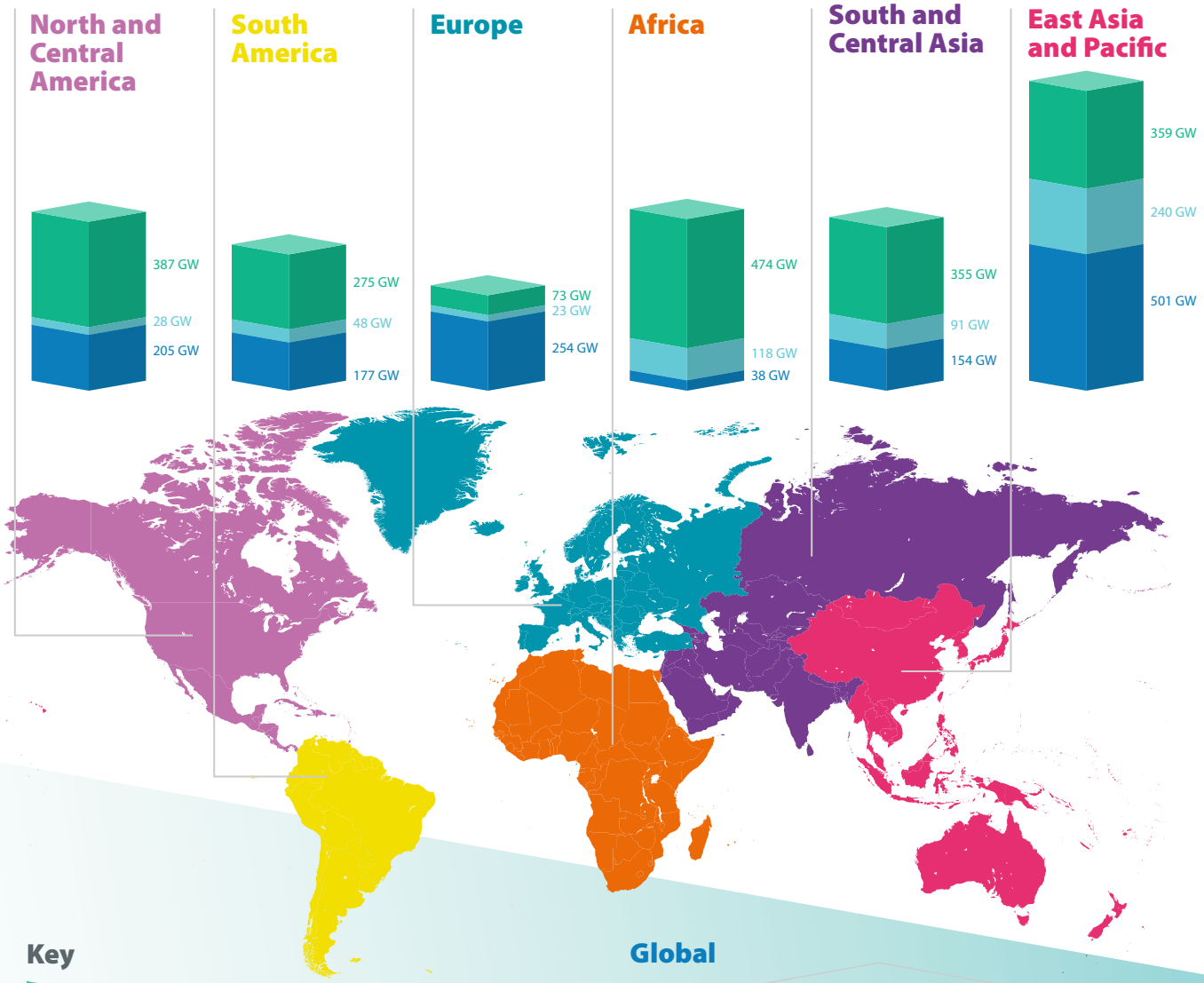
Data were compiled by a team of analysts using information sourced from (1) official statistics from governments, regulation agencies, transmission network operators and asset owners; (2) scientific articles and reports; (3) daily news reports involving hydropower plant development, official declarations of contracts, and equipment deals; and (4) direct consultation with operators and industry sources.

When generation data from primary sources are not available, estimates are prepared based on the previous year's figure, averaged capacity factors and regional meteorological events and data.

For a small number of countries, capacity data from previous years has been updated with new information. This means that those countries will see a year-on-year change compared to previous years' reports, but these increased capacity numbers are not treated as capacity added or lost in 2021.

Note that we have revised our estimate of Russia's installed capacity up to 55 GW (from around 50 GW) last year. This reflects a different assessment methodology and is not due to new capacity installed in 2021 (of which there was 167 MW in Russia).

Hydropower potential capacity

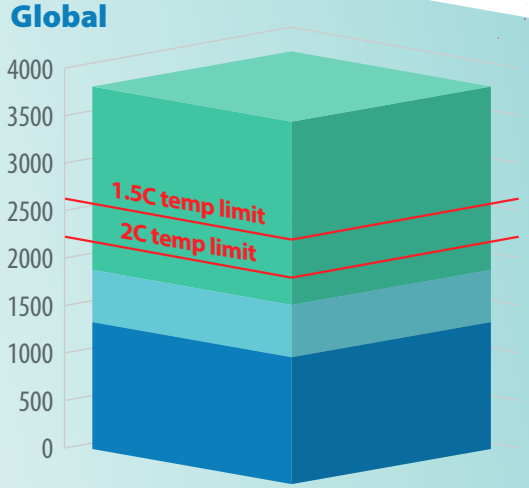


Key

- Remaining potential GW*
- Pipeline GW
- Installed GW

*Excluding pumped storage hydropower

Global



This infographic has been taken from IHA (2021) 'Hydropower 2050: Identifying the next 850+ GW towards Net Zero', page 16, available here.

Regional developments

North and Central America

In the United States, a government bill was passed with a commitment to invest US$909 million into conventional hydropower, pumped storage and the marine energy industry. The US Department of Energy also announced US$8.5 million of funding to improve the operational flexibility of the country's hydropower fleet.

In Canada, around 3 GW of new hydropower capacity neared completion, including four additional units at the Keeyask power plant in Manitoba.

The Mexican government continued its focus on the upgrade of existing hydropower capacity, with the bidding process beginning for the modernisation of the first nine hydroelectric plants.

Costa Rica's Reventazón project became the world's first hydropower plant to obtain climate bond certification using new Hydropower Criteria released by the Climate Bonds Initiative.

In Honduras, the 104-MW Patuca III hydropower plant came online at the end of 2020 to become the second largest in the country, but it will not be able to connect its full power to the grid until the transmission system is upgraded.

South America

Paraguay became the only country in the world with a 100 per cent renewable electricity supply, with hydropower as the backbone, after closing its last thermal plant in December 2021.

The expansion of the Yacyretá hydropower plant on the border of Argentina and Paraguay continued, which will increase its overall output by 10 per cent.

Brazil suffered its worst drought in 91 years in 2021 and sought to stabilise the grid by bolstering connectivity, increasing its energy imports from Argentina and Uruguay, and accelerating infrastructure projects to distribute power from the north-east of the country to the south.

The Congress of Colombia passed the Energy Transition Bill in June 2021, incentivising renewable energy development (including small hydropower) through a comprehensive regulatory framework.

Despite Covid-19 causing a slowdown in the construction of several projects, Peru's overall electricity generation in 2021 surpassed pre-pandemic levels, with hydropower accounting for 56 per cent of supply.

Europe

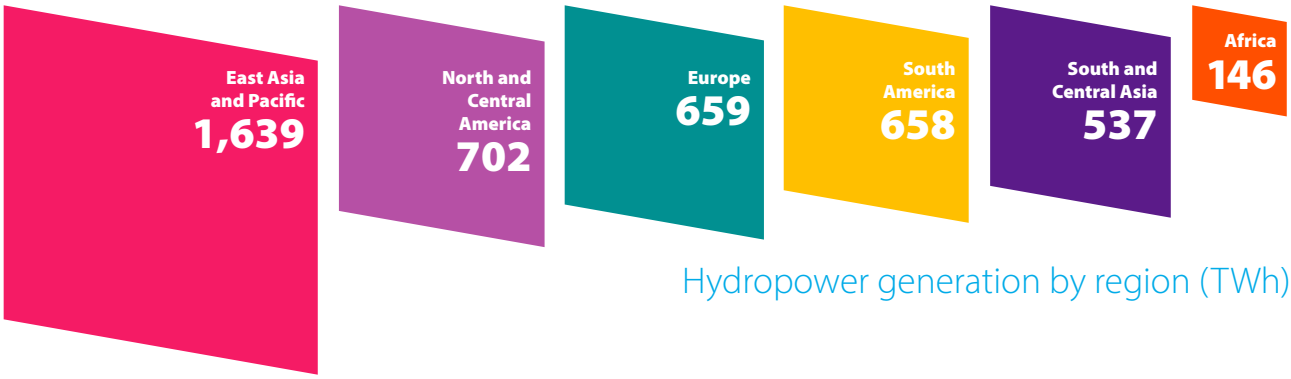
Turkey and Norway led in new capacity added in Europe, making up most of the continent's 1 GW hydropower growth in 2021.

Europe plans to diversify its energy sources and accelerate transition to renewables including hydropower, with the REPowerEU policy package announced to reduce reliance on gas imports in response to the war in Ukraine.

EU-27 countries added a record 34 GW of wind and solar capacity in 2021, while hydropower continues to be the leading renewable source of generation.

The North Sea Link was commissioned connecting UK's grid to Norway, becoming the world's longest subsea electricity interconnection and providing a new export route for Norwegian hydropower reserves.

The European Commission published the EU Taxonomy Climate Delegated Act, prompting calls for clarification and consistency in the investment criteria for hydropower.



Hydropower generation by region (TWh)

Africa

With 60 per cent of Africa's installed hydropower capacity over 20 years old, new efforts are being made to advance modernisation across the continent. IHA is supporting the African Development Bank's Africa Hydropower Modernization Program, which aims to increase generation capacity at low cost, with short leads times and minimal environmental impact.

The Grand Ethiopian Renaissance Dam (GERD) began electricity production in February 2022, commissioning two units with an installed capacity of 375 MW each, Once complete, it will be Africa's largest hydropower plant at 5.3 GW.

Zambia commissioned the first 150 MW unit of the 750 MW Kafue Gorge Lower hydropower station in July 2021.

In Nigeria, the first 175 MW unit at the 700 MW Zungeru Hydropower Station was commissioned in Q1 2022.

The construction of a transmission line connecting Kenya to Ethiopia is near completion, and will enable 2,000 MW to be transferred between the countries.

South and Central Asia

Many countries across the region are planning to increase their hydropower capacity in the coming decade to reduce reliance on fossil fuel generation and preserve water.

India saw the largest increase in total hydropower capacity in the region in 2021, with over 800 MW of new installed capacity coming online.

Nepal significantly increased its installed hydropower capacity with the commissioning of the 456 MW Upper Tamakoshi project.

Extreme weather has had an increasingly negative impact on hydropower operations across the region, with droughts affecting power output in Iran, Sri Lanka, Kyrgyzstan and Uzbekistan, in some instances leading to civil unrest.

To address the ongoing issue of regional interconnectivity, work has continued on the CASA-1000 transmission line, with its Tajikistan section close to completion and preliminary construction under way in Kyrgyzstan.

Covid-19 continued to cause significant project delays across the region, including Pakistan's 720 MW Karot run-of-river scheme, which is now due to be commissioned in 2022.

East Asia and Pacific

China's mid-term and long-term plans for pumped storage hydropower development, published in September 2021, set out ambitious targets to reach a total installed capacity of at least 62 MW by 2025 and 120 GW by 2030.

The first two generators at China's Fengning pumped storage facility went into operation in December 2021. Once all twelve generators are operational in 2023, it will be the world's largest pumped storage facility, with a total installed capacity of 3,600 MW.

Work commenced on the world's first "solar-hydro" station in Australia, using heat generated from PV to push turbines in a water-based reservoir. The project will provide an installed capacity of 300 MW when it is completed in 2023.

Indonesia published plans to phase out coal by 2056 and achieve net zero by 2060, identifying hydropower as the main source with 25.6 per cent of the national electricity supply.

Construction began in 2021 on the largest floating PV station in South-east Asia at Indonesia's Cirata hydropower station, which will have an installed capacity of 145 MW when complete.

2021: Pumped storage hydropower in the spotlight

Changlongshang Pumped Storage Power Station, China
Credit: Cui Xubo, CTG

In November 2021, the UK hosted COP26, the United Nations climate change conference, which set the eyes of the world on Glasgow. While in Scotland for the event, Malcolm Turnbull, IHA Board member and former Prime Minister of Australia, visited Cruachan's pumper storage hydropower (PSH) scheme. He remarked: "We need green energy security solutions. It was fascinating to visit Drax's Cruachan Power Station in Scotland. It reminds me that this is a tried and tested technology."

Mr Turnbull co-chaired the International Forum on Pumped Storage Hydropower (IFPSH) alongside Kelly Speakes-Backman, Acting Assistant Secretary at the US Department of Energy. Formed in November 2020 to research practical recommendations for governments and markets aimed at addressing the urgent need for green, long-duration energy storage in the clean energy transition, the Forum launched its findings on 16 September 2021 at a level-panel held as part of the World Hydropower Congress.

Pumped Storage Hydropower International Forum

The Forum consists of 13 governments led by the US Department of Energy and the International Hydropower Association (IHA), and involved more than 80 multilateral banks, research institutes, NGOs, and public and private companies.

The findings of the Forum concluded that: "Without adequate storage, there is a very real risk that electricity grids of the future will not be able to provide reliable power without recourse to high-carbon sources of back-up such as gas turbines".

As part of the Forum, there were three working groups:

1. Sustainability
2. Capabilities, Costs and Innovation
3. Policy and Markets

Sustainability Working Group findings

The overall objective of the Sustainability Working Group was to develop guidance and recommendations on how PSH can best support future power systems in the clean energy transition in the most sustainable way.

The main recommendations include:

- The sustainability assessment of PSH projects should rely on a multi-level approach, including system-level needs options assessment and project optimisation.
- Existing hydropower sustainability tools, including the Hydropower Sustainability Standard, are adequate for PSH technology and project assessment.
- PSH projects, as with many hydropower projects, can generate one-time or permanent local benefits of various kinds, which should be considered in their sustainability profile assessment.

Capabilities, Costs and Innovations Working Group findings

PSH is a low-cost proven technology solution for high-capacity, long-duration energy storage. The Capabilities, Costs and Innovations Working Group provided comparisons across major storage technologies and presented the following conclusions regarding PSH's increasingly important role in the energy system:

- With an increasing share of variable renewable energy and phasing out fossil-fuel power plants, energy storage and flexibility are increasingly needed. A range of flexibility options are available and should be assessed based on system characteristics and priorities.
- Grid stability, grid resilience and sufficient flexibility options for load-generation balancing will be central to planning for low-carbon electricity grids of the future.
- Simplistic capital expenditures (CAPEX) comparisons can be misleading without taking replacement life-cycles and maintenance costs into consideration. For example, the total cost of PSH is significantly cheaper than that of lithium-ion battery systems when accounting for PSH's full lifespan of 80 years and considering storage capacity in the GWh class.

In addition to this comparisons work, the working group also provided a brief series of peer reviews of innovations for PSH. These new approaches for PSH covered three broad categories: furthering PSH potential (such as seawater PSH), retrofitting and upgrading PSH systems (such as utilising abandoned mines), and developing hybrid systems (such as combined with thermal storage).

Policy and Markets Working Group: seven policy recommendations

The Policy and Markets Working group of the IFPSH put forward seven major recommendations for governments around the world to avert the risk of policymakers and grid operators falling back on fossil fuels to provide clean energy storage:

1. Assess long-term storage needs now, so that the most efficient options, which may take longer to build, are not lost.
2. Ensure consistent, technology-neutral comparisons between energy storage and flexibility options.
3. Remunerate providers of essential electricity grid, storage and flexibility services.
4. Licensing and permitting should take advantage of internationally recognised sustainability tools.
5. Ensure long-term revenue visibility with risk-sharing to deliver the lowest overall cost to society.
6. Assess and map for pumped storage hydropower among potential existing hydropower assets and prospective sites.
7. Support and incentivise pumped storage hydropower in green recovery programmes and green finance mechanisms.

Regional developments in pumped storage hydropower

China

China has been responsible for most of the recent growth in PSH in recent years, and in 2021 announced plans to double national capacity to 120 GW by 2030. This would represent a nearly fourfold increase from 32 GW in 2021 in less than ten years. In September 2021, China's National Energy Administration (NEA) published the mid-term and long-term plan from 2021 to 2035 for PSH development. According to this plan, the installed capacity of PSH will be at least 62 GW in 2025, and around 120 GW in 2030.

The Jilin Dunhua 1.4 GW PSH project in China had its first two pump turbine units come online in June and October 2021, and was completed in April 2022, when the fourth of its 350 MW units went into operation. In December 2021, the first units of Fengning's 3.6 GW PSH plan were commissioned, providing 600 MW to support the Winter Olympics.

Elsewhere in East Asia and Pacific

Australia announced that financial closure was reached on the Kidston Stage 2 project in May 2021. When completed, the 250 MW PSH plant will be able to store and discharge energy for up to eight hours. The plant will convert a decommissioned gold mine into a reservoir and provide rapid-response, emissions-free flexible power to Australia's National Electricity Market, and is set to be completed in 2024.

In September 2021, Indonesia announced its first pumped storage plant. The World Bank-supported project, Upper Cisokan PSH, is expected to be 1,040 MW and located between Jakarta and Bandung. It will provide important system flexibility to the electricity in the region.

At the 2021 Hydropower Industry Day, the South Korean Hydropower Industry Association announced the construction of three new projects with a total capacity of 1.8 GW in Pocehon, Hongcheon and Yeongdong, which are set to be completed by 2034.

India

In India's Draft National Electricity Policy (NEP) 2021, it noted the potential for 96.5 GW PSH; however, only 4.78 GW has been developed so far. To support the development of this immense potential, India's Ministry of Power constituted several committees to suggest ways and means to promote PSH and form a comprehensive framework for development, policy and regulatory aspects, technology, and financial and taxation issues. The policy is currently being assessed and should be announced in 2022, as "a hope that this will give the necessary investment signals for developing PSH in India".

The first draft was shared in January 2022 at a meeting between Shri RK Singh (the Union Minister of Power and New and Renewable Energy) and companies to gain their insights. As part of the discussion, Shri Singh shared that energy storage developers will be granted inter-state transmission system connectivity to sell and purchase power from any part of the country with transmission costs waived at the time of charging storage and selling stored renewable energy. He also stated that curtailment of renewable energy will be penalised under the provision of the policy, and storage will be part of the Renewable Purchase Obligation.

Elsewhere in South and Central Asia

In April 2021, Uzbekhydroenergo announced a plan to develop a 200 MW PSH and floating PV station at a reservoir in the Tashkent region of Uzbekistan.

Israel will double its existing PSH from 300 MW to 644 MW when the Kokhav Hayarden pumped storage project is commissioned in early 2023.

USA

In 2021, the United States added roughly 70 MW of PSH. Furthermore, in November, the US Department of Energy released a new tool to aid PSH project development. The Valuation Tool is a web-based platform that takes users through the process as set out in the Hydropower Valuation Guidebook and is intended to help developers accurately assess the full potential of a PSH project, especially within the overall power system.

Global pumped storage installed capacity (GW)

Africa

In October 2021, the African Development Bank approved a US$86 million loan for the second phase of the 1 GW Lesotho Highlands Water Project, which will provide critical energy storage to the small southern African country. The project represents a partnership between Lesotho and South Africa, and will provide additional generation and water security in the Gauteng region.

Europe

Following the final construction phase in 2021, the 880 MW Gouvães pumped storage hydroelectric plant as part of the Tâmega Giga Battery project in Portugal was officially commissioned in early 2022. In December 2021, the largest PSH plant in Europe became operational, with an initial 324 MW of 1,296 MW installed capacity and 1,684 MW in pumping mode at the Dniester site in Ukraine. The plant will eventually have a total capacity of 2,268 MW.

In July 2021, as part of the Future Energy Systems and Flexibility paper, the UK's Department of Business, Energy and Industrial Strategy (BEIS) released a consultation on large-scale and long duration energy storage, which gave UK hydropower operators the opportunity to review potential market mechanisms and policy interventions, including a cap and floor scheme, with the Government's response due in Q2 of 2022.

Developments and innovations in other technologies

During the reporting period, co-located solar and floating solar projects were announced in many countries. In Albania, the Qyrsaq ground-mounted solar is the first of its kind in the country and will provides an additional 5.1 MW capacity. In Nepal, a desk study report was undertaken on a floating photovoltaic solar plant in Indrasharowar, Kulekhani, which would be the country's first floating solar project.

Kyrgyzstan's Minister of Energy has signed an MoU with Masdar to support renewables projects, including floating solar PV and hydropower projects with the potential capacity of up to 1 GW.

Ghana has commissioned the first 50 MW of a 250 MW floating solar project at Bui, which will complement the existing 400 MW hydropower capacity. In early 2022, a co-located concentrated solar pilot project was commissioned next to a 1,540 MW hydro plant in São Paulo state, Brazil. Meanwhile, the Swiss Government announced a green hydrogen production facility at the Lake Schiffenen reservoir, with the site to be commissioned in 2023.

Forum's steering committee:

Sponsoring partners:

North and Central America

Overview

Keeyask Hydroelectric Project, Canada
Credit: Voith Hydro

Due to the abundance of natural resources in North and Central America, the region has continued to count on hydropower for much of its electricity generation, as has been the case for decades.

Many countries have adopted policies to increase the share of renewables as they seek to transition to a low-carbon economies. Modernising the existing hydropower fleet and developing new projects to meet energy demands and enable renewable development is increasingly important.

In Canada, hydropower continued to provide approximately 60 per cent of the country's total annual electricity generation, and represents more than half of its total generation capacity. In 2021 nearly 3 GW of new projects continued to advance toward completion. At the Keeyask power plant in Manitoba (695 MW), four more units were brought online in 2021. A total of five units are now online, and the remaining two units are scheduled for completion in 2022.

The government of Ontario, Canada's most populous province, also asked utility Ontario Power Generation to look to new hydropower projects as part of a pathway to a zero-emissions electricity grid, and announced policy changes to accelerate the development process.

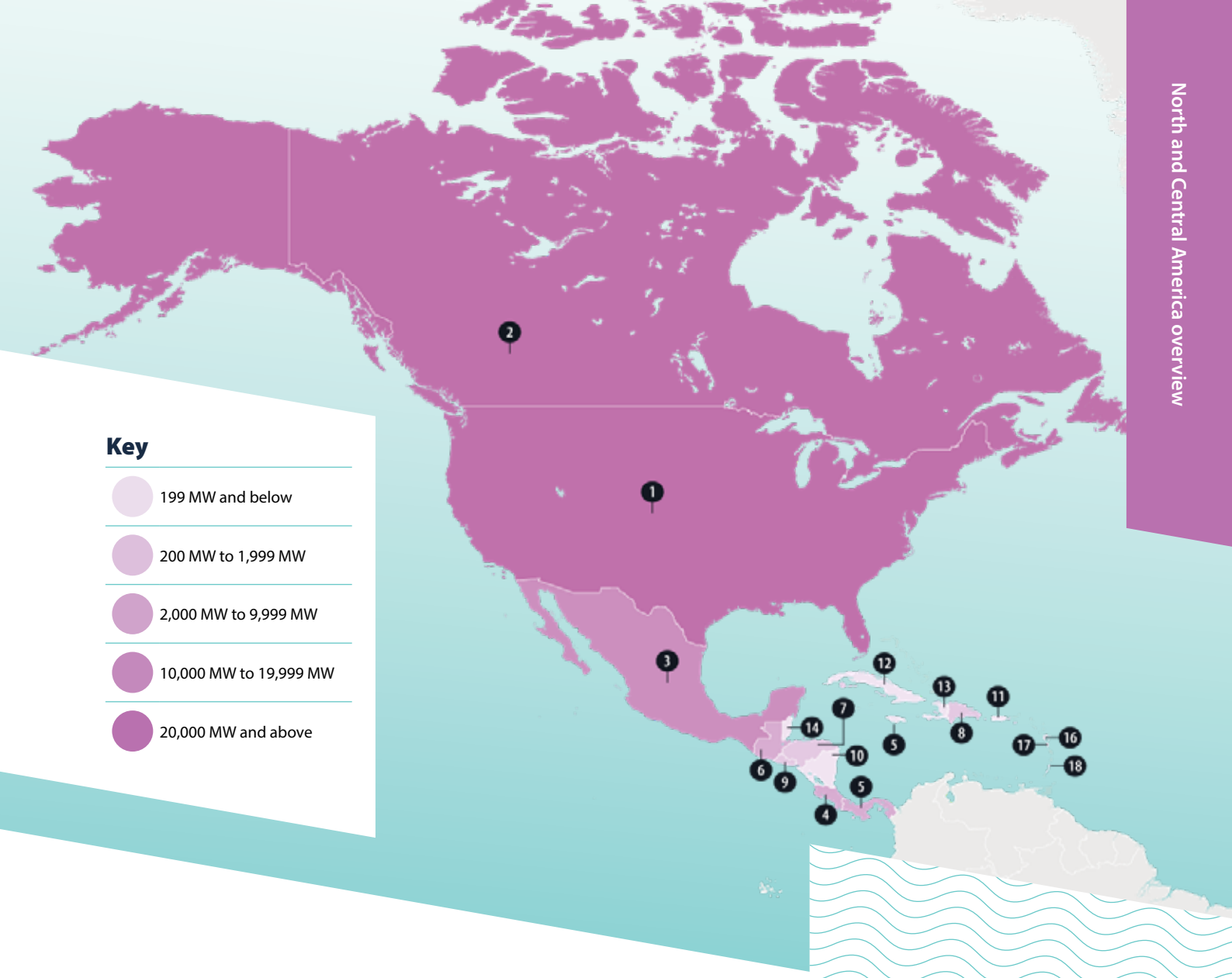
This year there were also developments in two transmission projects planned to send hydropower from Quebec to US markets. The Champlain Hudson Power Express project was selected after a competitive bid to bring clean electricity directly into the City of New York. However, another project saw a setback. Work was halted on the England Clean Energy Connect (NECEC) transmission line, which was planned to deliver hydropower from Quebec into Massachusetts, after voters in the State of Maine chose to reject the project in a referendum.

The 824-MW Muskrat Falls Hydroelectric Generating Station, part of the Lower Churchill Project, was completed in November and released to the Newfoundland and Labrador System Operator (NLSO) for service. The associated Labrador-Island Link transmission line is due to become fully operational in 2022.

While the U.S. has the third largest installed hydropower capacity in the world, hydropower only accounts for about 6 per cent of its total annual electricity generation.

An ongoing project to upgrade the Bad Creek pumped hydro station in South Carolina resulted in an increase of 70 MW of installed capacity. The summer of 2021 was marked by widespread, intense drought conditions, particularly in California. Despite this, hydropower plants in the state provided a significant amount of generation from April to September 2021.

In September 2021, the Department of Energy (DOE) announced an US$8.5



Ranking by total installed hydropower capacity

Rank	Country/Territory	Installed capacity (MW)*
1	United States	101,943
2	Canada	82,300
3	Mexico	12,614
4	Costa Rica	2,379
5	Panama	1,754
6	Guatemala	1,516
7	Honduras	849
8	Dominican Republic	623
9	El Salvador	573

Rank	Country/Territory	Installed capacity (MW)*
10	Nicaragua	157
11	Puerto Rico	98
12	Haiti	78
13	Cuba	65
14	Belize	55
15	Jamaica	30
16	Guadeloupe	11
17	Dominica	7
18	Saint Vincent And The Grenadines	6

*including pumped storage

North and Central America
Developments

million funding opportunity to improve the operational flexibility of the U.S. hydropower fleet. Under this solicitation, DOE's Water Power Technologies Office will fund up to six awards to advance hydropower technologies to enhance grid reliability through its HydroWIRES (Water Innovation for a Resilient Electricity System) initiative. The mission of HydroWIRES is to understand, enable and improve hydropower's contributions to reliability, resilience and integration in the rapidly evolving U.S. electricity system.

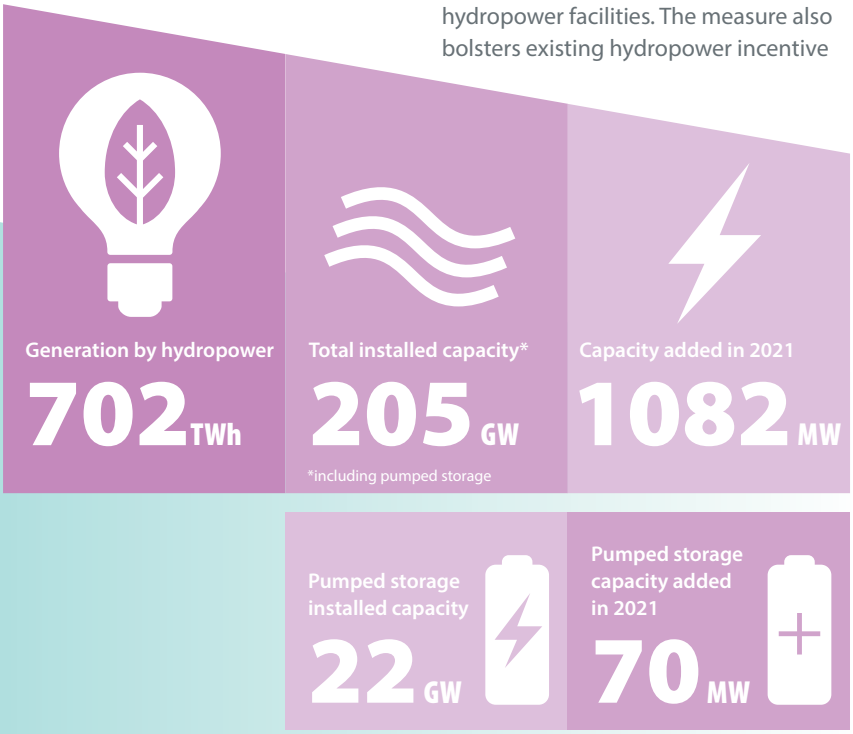
In November 2021, the U.S. passed the House Infrastructure and Investment Jobs Act. The bill included investments for the waterpower industry, including US$909 million for conventional hydropower, pumped storage and the marine energy industry. This infrastructure bill recognises that hydropower and marine energy will play a major role in decarbonising the country's electricity grid. It creates a new grant program that provides US$553 million in DOE grants to support grid resilience, dam safety upgrades and environmental enhancements at existing hydropower facilities. The measure also bolsters existing hydropower incentive programs, including US$125 million to incentivise adding hydropower generation to existing non-powered dams and conduits, and US$75 million for hydropower efficiency improvements, such as new low-head turbines.

In early 2022, conservation organisations, hydropower industry groups and indigenous tribes sent a package to Congress and the White House to improve hydropower processes and restore authority to native American tribes. Specifically, the package proposes amendments to the Federal Power Act to restore autonomy and self-determination for tribal nations, retain states' decision-making authority, enhance cooperation and improve clarity.

The Mexican government is focused on increasing hydropower capacity through the rehabilitation and modernisation of the state-owned company Comisión Federal de Electricidad's (CFE) existing assets. In 2021, the bidding process began to modernise the first nine hydroelectric plants. In 2022, the bidding processes for four mini-hydroelectric power plants and three dam facilities will continue, and CFE will carry out modernisation studies of 16 mini-hydroelectric plants. The culmination of these efforts is expected to result in an increase of hydropower generation capacity by over 300 MW.

In October 2021, the Mexican government tabled a bill that demonstrates its preference for prioritising hydroelectric power supplied by a public utility over privately owned wind and solar generation, as the nation restructures its electricity network.

Costa Rica produced almost all of its electricity from renewable sources in 2021 once again, with hydropower representing 74 per cent of the energy mix. This year marked the lowest thermal generation in the country since 1956,



Lay Dam Rotor Replacement, United States of America
Credit: Alabama Power (operating company of Southern Company)

Top 5 countries by capacity added in 2021

1st	Canada	924 MW
2nd	USA	172 MW
3rd	Costa Rica	48 MW
4th	Honduras	12 MW
5th	Dominican Republic	8 MW

due in part to hydroelectric generation, which was 12 per cent higher in 2021 than in 2020. In addition, the Reventazón hydroelectric plant operated by the Costa Rican Electricity Institute (ICE) became the world's first hydropower plant to obtain climate bond certification using new Hydropower Criteria released by the Climate Bonds Initiative. The project is also a recipient of the IHA Blue Planet Prize, awarded in 2019 after it was independently assessed using the Hydropower Sustainability Assessment Protocol.

In El Salvador, work continued on 3 de Febrero (previously named El Chaparral). a flagship 65.7-MW hydropower project that will contribute towards the decarbonisation of the country's electricity system. The reservoir started to fill in October 2021 and the project is expected to begin operation in 2022.

In Honduras, the Patuca III hydropower plant, the second largest in the country at 104 MW which came online at the end of 2020, starting generating electricity, but transmission system upgrades are needed before its full power can be connected to the grid. The country's power grid coordinator, ODS, released its long-term operational planning report in early 2022, stating that electricity use is projected to grow over the next three years, and the bulk of the new installed capacity between now and 2025 will be hydropower (36 per cent).

Panama continued to rely heavily on hydropower for its energy needs, providing 71 per cent of its electricity generation in 2021.

Jamaica's government had previously announced plans to develop pumped storage hydropower that would help achieve 50 per cent renewable energy generation by 2030. At the beginning of 2022, it received an unsolicited proposal from a consortium to build a facility that would pump water into reservoirs at high elevations using solar power, then use it for electricity generation and for residential use and irrigation.

South America

Overview

Baixo Iguaçu Hydroelectric Project, Brazil
Credit: GE Renewables

South America has seen significant demand for hydropower development in recent years, making it one of the fastest-growing regions in the world. In several countries hydropower provides more than half of total electricity supply, and it is expected to remain the largest renewable source across the region for years to come. With many hydropower facilities decades-old, modernisation is a priority for plant operators and grid operators. Drought conditions in some parts of the continent have resulted in low water levels and reduced hydroelectric output.

Argentina met 13 per cent of its power demand with renewable energy in 2021, an increase from the 10 per cent mark recorded in the previous year. This was due to the connection of 26 large-scale renewable power plants to the grid, most of which were wind and bioenergy, but the number also included 115 MW of small hydropower plants. Construction was suspended on the Santa Cruz project, comprising two new hydropower plants, due to financing issues.

Work continued on the expansion of the Yacyretá hydropower plant, which straddles the border of Argentina and Paraguay. The addition of three new turbines will increase the output of the plant by 10 per cent. Paraguay closed its last thermal power plant in December 2021, and, mainly thanks to hydropower, is now the only country in the world with a 100 per cent renewable electricity supply.

Brazil has been suffering drought conditions for many years, and 2021 saw its worst drought in 91 years. The consequences of this are significant, as the country relies on hydropower reservoirs to generate over 60 per cent of its electricity. In 2021, Brazil introduced a "water scarcity" electrical rate, increased energy imports from Argentina and Uruguay, accelerated infrastructure projects that can distribute power from the less-affected north-east to the south, and created a national committee that can swiftly reverse regional rules to optimise power and water usage. It also increased generation from gas-fired plants to compensate and stabilise electricity prices.

Brazil also plans to add more solar to its energy mix, including the 15-hectare floating solar plant at the Batalha hydropower plant, which will have an installed capacity of 30 MW. This project is currently in the permitting phase, and is expected to be commissioned in 2022.

In Chile, work continued on the Los Lagos project (53 MW), which is expected to be commissioned in 2022. However, other hydroelectric projects have faced difficulties, including a steep drop in power prices paid by the system due to the growth of wind and solar projects, lower water availability, and community opposition. Projects facing delays include the Los Cóndores run-of-

Ranking by total installed hydropower capacity

Rank	Country/Territory	Installed capacity (MW)*
1	Brazil	109,446
2	Venezuela	15,393
3	Colombia	11,945
4	Argentina	11,345
5	Paraguay	8,810
6	Chile	6,812
7	Peru	5,340
8	Ecuador	5,107
9	Uruguay	1,538
10	Bolivia	736
11	Suriname	180
12	French Guiana (France)	119
13	Guyana	2.5

*including pumped storage

South America

Developments

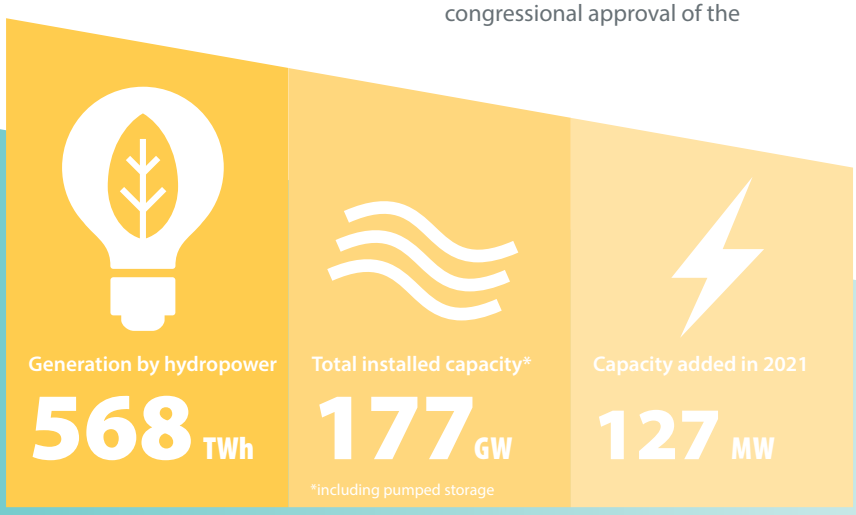
river project (51.6 MW), the Rucalhue run-of-river project (90 MW) and the Ñuble hydroelectric project (136 MW), which was suspended when its owner reassessed its financial situation in light of low price forecasts.

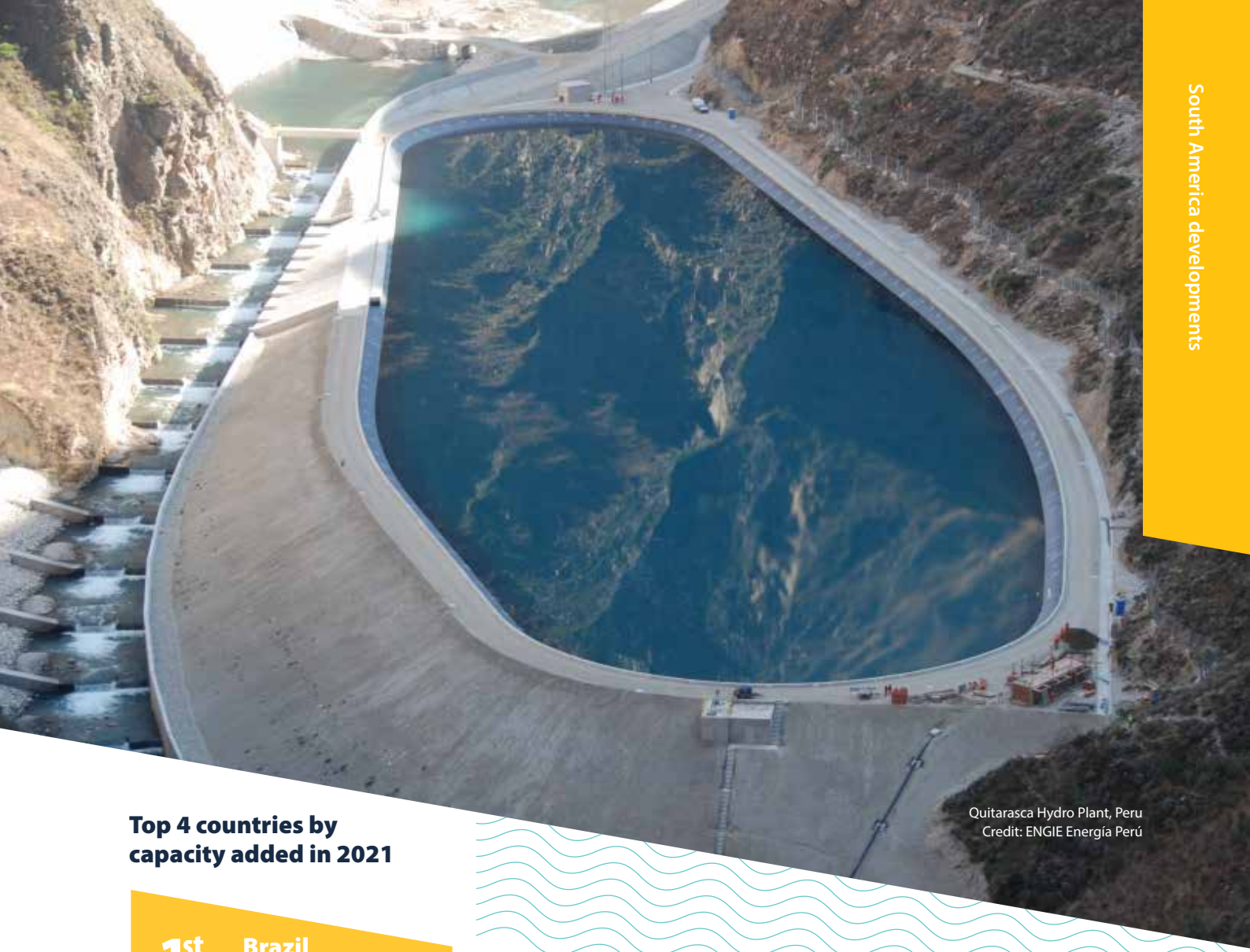
Colombia, where hydropower currently accounts for about 70 per cent of electricity production, has moved forward with plans to rapidly increase the share of wind and solar in its energy mix. By diversifying, the government seeks to strengthen the resilience of the system while maintaining one of the cleanest electricity systems in the world. Work also continued on the Ituango hydropower project following a major construction incident in 2018. Owner Empresas Publicas de Medellin (EPM) received insurance payouts of more than US$1 billion for civil liability claims related to serious design and construction problems. An independent study concluded that it has no choice but to continue remediation and finish the project.

A milestone in Colombia's energy transition plan came through the congressional approval of the Energy Transition Bill in June 2021 to promote investment in hydrogen, renewable energy and sustainable transport. It incentivises renewable energy development (including small hydropower) through a comprehensive regulatory framework, and auctions for renewable energy and storage were held in 2021. The energy ministry also published the country's hydrogen roadmap to consolidate Colombia's energy transition for the next 30 years.

In Peru, the Covid-19 pandemic caused a slowdown in construction on a number of hydropower plants, resulting in delays to planned commissioning dates. The affected power plants include the Lluclla hydro project (288 MW), Alcaparrosa (9.5 MW), Anto Ruiz III (102.1 MW), Casca (8.4 MW), Marca (9 MW), Miraflores (9.9 MW), San Gabán III (205.8 MW), San Juan (88 kW) and Tulumayo (83.2 MW). The country's overall electricity generation in 2021 actually surpassed pre-pandemic levels, with 56 per cent of it being supplied by hydropower.

In Ecuador, where hydropower accounts for about 80 per cent of electricity generation, surplus generation is exported to Colombia and Peru, which has been the case since 2015. The government updated the 2031





Quitarasca Hydro Plant, Peru
Credit: ENGIE Energía Perú

Top 4 countries by capacity added in 2021

1st	Brazil	175 MW
2nd	Ecuador	115 MW
3rd	Colombia	4 MW
4th	Bolivia	1 MW

electricity master plan to add 1,440 MW of renewable energy capacity (excluding hydropower projects over 50 MW) in addition to what is already planned to come online by the end of the planning period. It launched a tender for a block of 500 MW of renewable energy, including 150 MW of small hydropower (less than 50 MW) to come online by 2024. Technical and financial problems continued to plague the construction of the Toachi Pilatón power plant.

Bolivia announced the reactivation of hydroelectric projects in March, and its state power company Ende issued a call for expressions of interest for the pre-investment technical study of the 380 MW Cañahuecal hydro project. The consultancy work falls under a pre-investment support program for the country, financed by the Inter-American Development Bank (IADB). The government's roadmap for the basin envisions a cascade system of seven hydropower plants on the Grande River.

Europe

Overview

Serre-Ponçon, France
Credit: Christophe Meireis, Abaca press, EDF Hydro

Across Europe, electricity demand recovered to pre-pandemic levels in 2021. Hydropower generation continues to be the leading source of renewable energy, with around 660 TWh generated across the continent. In the EU-27 countries, all renewables combined contributed 37 per cent of total electricity production last year, approximately matching the share of fossil fuels in the mix, with most of the remainder provided by nuclear. Repeating the pattern from 2020, new hydropower additions in 2021 were mainly in Turkey and Norway.

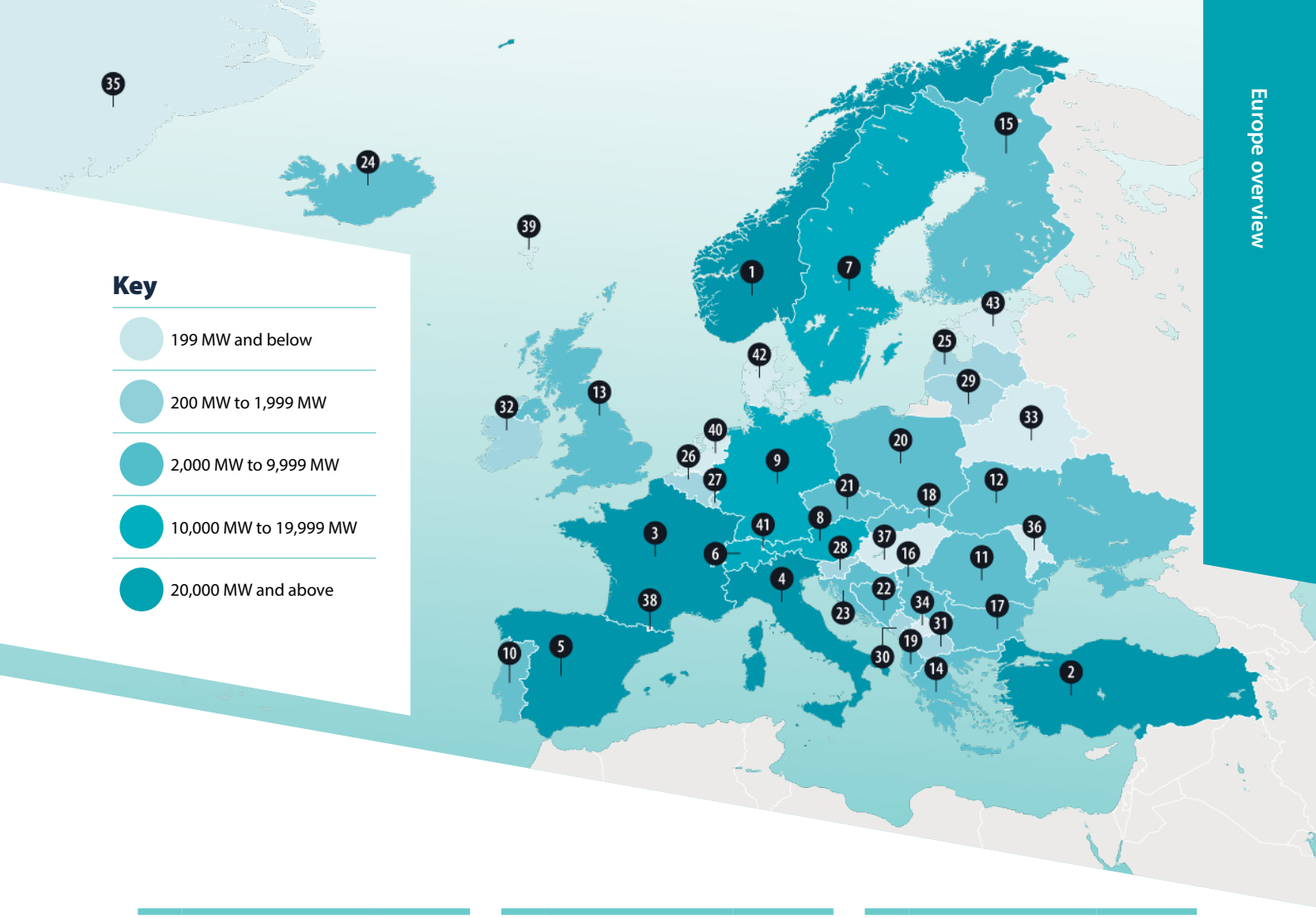
In response to the ongoing war in Ukraine, the European Commission has published plans to accelerate its transition to clean energy, both to reduce reliance on Russian gas imports and to help meet climate targets. In a speech made in March 2022, the President of the Commission emphasised the long-term need to switch to renewables, including hydropower.

Recent measures put forward under the REPowerEU plan will look to diversify gas supplies and speed up the rollout of renewable gases and power sources. This includes raising the EU's renewable energy target to 45 per cent as part of the ambitious 'Fit for 55' package aiming to reduce emissions overall by 55 per cent by 2030 in comparison to 1990 levels.i Progress continues to be made towards decarbonising the power sector, with a record 34 GW of new wind and solar added in 2021, reaching 350 GW total installed capacity.

Last year the Commission also published the EU Taxonomy Climate Delegated Act, defining the screening criteria for economic activities contributing to climate change mitigation and adaptation. As part of reporting requirements for the 100gCO2c/kwh threshold, projects can use the G-res tool and IEA Hydro Framework. The criteria for hydropower were updated in line with the Water Framework Directive, but IHA and regional trade associations have issued calls for a clarification of terms to ensure consistency and appropriateness.

Hydropower will play an essential role in Europe's energy transition, as has been recognised by the Commission and others such as IEA, IRENA, the International Forum on Pumped Hydropower Storage (IFPSH) and Hydropower Europe. IEA's first Hydropower Special Market Report, published in 2021, forecasts around 8 per cent growth in total installed capacity in Europe by 2030, from greenfield hydropower projects as well as the modernisation and expansion of existing infrastructure.

Publications by the IEA, IFPSH and Hydropower Europe highlight the challenges in securing investment in



Rank	Country/Territory	Installed capacity (MW)*
1	Norway	33,391
2	Turkey	31,497
3	France	25,494
4	Italy	22,593
5	Spain	20,425
6	Switzerland	16,842
7	Sweden	16,478
8	Austria	14,747
9	Germany	10,883
10	Portugal	7,199
11	Ukraine	6,317
12	Romania	6,313
13	United Kingdom	4,713
14	Greece	3,421
15	Finland	3,263

Rank	Country/Territory	Installed capacity (MW)*
16	Serbia	3,133
17	Bulgaria	3,129
18	Slovakia	2,522
19	Albania	2,390
20	Poland	2,385
21	Czechia	2,281
22	Bosnia and Herzegovina	2,187
23	Croatia	2,155
24	Iceland	2,086
25	Latvia	1,588
26	Belgium	1,427
27	Luxembourg	1,330
28	Slovenia	1,301
29	Lithuania	1,028
30	Montenegro	649

Rank	Country/Territory	Installed capacity (MW)*
31	Macedonia	644
32	Ireland	508
33	Belarus	97
34	Kosovo	92
35	Greenland	91
36	Moldova	76
37	Hungary	58
38	Andorra	45
39	Faroe Islands	39
40	Netherlands	38
41	Liechtenstein	35
42	Denmark	7
43	Estonia	4

*including pumped storage

Europe

Developments

new projects, and in particular how the lack of long-term revenue certainty can hinder new pumped hydro schemes. But as growth of wind and solar accelerates, hydropower is also receiving growing recognition for its vital storage and flexibility services to support a sustainable energy system, alongside its multipurpose benefits in water management and climate adaptation.

In 2021, Turkey commissioned approximately 500 MW of new hydropower capacity, half of which came from the new 250 MW Alpaslan II dam and hydropower plant. Its reservoir is among the ten largest in Turkey. The 58 MW Gürsögüt scheme was also completed last year, along with over 30 smaller-scale hydropower plants.

Norway, which has the largest installed hydropower fleet in Europe, increased its capacity by 396 MW in 2021, which included around 70 MW from upgrades at existing plants. Most of the 50+ new projects commissioned were small-scale hydro below 10 MW in size, in addition to the 62 MW Jølstra, 42 MW Tolga and 22 MW Herand larger hydropower stations. The small hydropower plants were completed in time to meet the deadline for green electricity certificates, a national subsidy scheme covering all renewable energy sources that came to an end in December 2021. Last year a change in the tax regime was also favourable to larger-scale hydropower developments in Norway.

In parallel to growth in renewable energy, another priority for the Nordic region has been building electricity interconnections with other European countries. 2021 saw the North Sea Link with the UK put into commercial operation, following the NordLink to Germany commissioned in 2020. The North Sea Link is the world's longest subsea interconnector, developed under a joint venture between the respective Norwegian and UK system operators Statnett and National Grid. The project took six years to build and, when operating at maximum, allows 1,400 MW of power to be transferred between the countries. Depending on the weather conditions and power demand, the line will enable Norway to export electricity stored in its hydropower reservoirs to the UK and, when running in the other direction, UK to export excess wind generation to Norway. The project will play a key role in bolstering decarbonisation and system security across the North Sea.

Elsewhere in Western Europe, key milestones have been reached at the 1,158 MW Tâmega hydroelectric

Generation by hydropower

659 TWh

Total installed capacity*

255 GW

*including pumped storage

Capacity added in 2021

1087 MW

Pumped storage installed capacity

55 GW

Pumped storage capacity added in 2021

324 MW

Top 5 countries by capacity added in 2021

1st	Turkey	513 MW
2nd	Norway	396 MW
3rd	Austria	150 MW
4th	Spain	16 MW
5th	Switzerland	12 MW

Gouvaes, Portugal
Credit: ANDRITZ

complex under construction in Portugal, comprising the Gouvães, Daivões and Alto Tâmega power stations. The first filling of the Daivões reservoir was completed, which when fully operational will include a 118 MW power station. The water body also acts as the lower reservoir to the Gouvães pumped storage station, which had the first of its four 220 MW turbines commissioned at the beginning of 2022. When complete, the Tâmega 'giga battery' will provide enough energy storage capacity to serve two million Portuguese households for an entire day. Two wind farms totalling 300 MW are also being developed to be linked to the Tâmega complex as a hybrid system.

In central Europe, the 17.5 MW Traunleiten hydropower plant was commissioned in Upper Austria, and further capacity was added through modernisations of current plants. The development of advanced pumped storage continues to be a focus in the region to support expected growth in variable wind and solar energy on the grid. For example, orders were announced last year for new variable-speed generators for the Kühtai 2 pumped storage power plant and Reisseck II pumped storage plant extension under development in Austria. Both projects will use modern full-size frequency converter technology for maximum operating range and flexibility. Orders were also placed to modernise three units at the 1,080 MW Coo-Trois-Ponts pumped storage plant in Belgium. Further east, last year a 324 MW unit was added at the Dnesiter pumped storage plant in Ukraine, raising the plant's installed capacity to 1,296 MW.

New projects are also being planned; for example, the Swiss government has recently identified multiple new potential hydropower sites and opportunities for dam enlargements, which could offer up to 2 TWh additional hydroelectric production with minimal impact on biodiversity and the surrounding landscape. Other projects under development include the 160 MW Dabar hydropower scheme in Bosnia and Herzegovina, part of the proposed Gornji Horizonti 250 MW hydropower complex.

Africa

Overview

Mwadingusha, Congo
Credit: ANDRITZ

Africa has among the largest untapped potential for hydropower development in the world. New projects are steadily increasing hydropower capacity, and it remains the main renewable resource in the region.

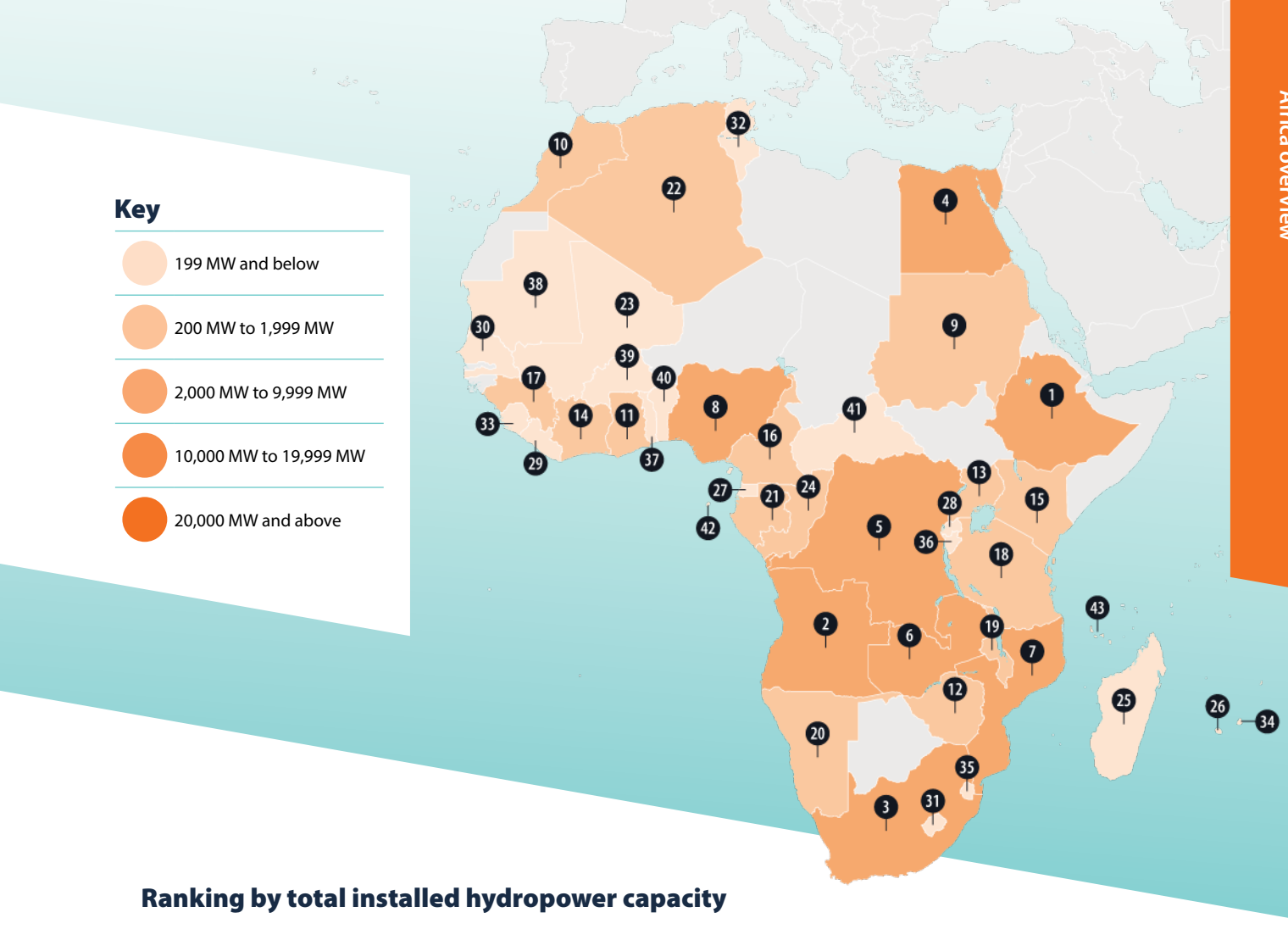
Africa has the opportunity to be the first continent to develop its economy using renewable energy. Despite being home to 17 per cent of the world's population, it accounts for just 4 per cent of global power. Africa has vast natural resources, but access to electricity across the continent is limited and uneven. According to the IEA, Africa's population without access to electricity increased in 2021 after experiencing a decline for the past six years. Only three countries in West and Central Africa are on track to provide electricity for all their populations by 2030. It is estimated that by 2070, the West African Power Pool (WAPP) region will represent one-third of the continent's total population, with over 1.5 billion people.

Hydropower presents an opportunity for economic development and the achievement of the UN's Sustainable Development Goals. Hydropower potential exceeds current and medium-term demand in Africa and, according to the International Renewable Energy Agency (IRENA), the cost of electricity from new hydropower projects remains among the cheapest renewable energy sources globally. As 60 per cent of the hydropower installed capacity in the region is over 20 years old, modernisation efforts are an important element in improving access to clean and reliable energy. To help address this, the African Development Bank (AfDB) is undertaking the Africa Hydropower Modernization Program, supported by IHA. This provides an opportunity to increase generation capacity at a low-cost, and with relatively short lead times and minimal environmental impact.

Although Africa produces just 2 per cent of the global energy-related CO2 emissions, climate-related effects are disproportionately higher in the region, impacting hydropower capacity and a very wide range of other infrastructure and critical services, including food supply.

Once the Grand Ethiopian Renaissance Dam (GERD) reservoir is filled with water (which started in 2020 and will take 4–7 years), it will be the largest hydropower plant in Africa and one of the largest in the world, with a total installed capacity of 5.3 GW. It started electricity production in February 2022, commissioning two units with an installed capacity of 375 MW each.

Egypt has expressed concerns about the impact of GERD on the flow of the Nile, and therefore to its water security. Ethiopia contends that the project will have no major impact on water flow and instead provide significant benefits to itself and others in the region.



Ranking by total installed hydropower capacity

Rank	Country/Territory	Installed capacity (MW)*
1	Ethiopia	4,074
2	Angola	3,836
3	South Africa	3,600
4	Egypt	,2876
5	Democratic Republic of the Congo	2,760
6	Zambia	2,703
7	Mozambique	2,216
8	Nigeria	2,111
9	Sudan	1,923
10	Morocco	1,770
11	Ghana	1,584
12	Zimbabwe	1,081
13	Uganda	1,073
14	Cote D'Ivoire	879
15	Kenya	837

Rank	Country/Territory	Installed capacity (MW)*
16	Cameroon	822
17	Guinea	706
18	Tanzania	562
19	Malawi	371
20	Namibia	347
21	Gabon	331
22	Algeria	269
23	Mali	220
24	Congo	218
25	Madagascar	186
26	Reunion	134
27	Equatorial Guinea	128
28	Rwanda	111
29	Liberia	93
30	Senegal	81

Rank	Country/Territory	Installed capacity (MW)*
31	Lesotho	73
32	Tunisia	66
33	Sierra Leone	64
34	Mauritius	61
35	Eswatini	60
36	Burundi	57
37	Togo	49
38	Mauritania	48
39	Burkina Faso	34
40	Benin	33
41	Central African Republic	19
42	Sao Tome And Principe	2
43	Comoros	1

*including pumped storage

Africa
Developments

Earlier in 2022, the Kikagati hydropower plant with an installed capacity of 15.57 MW was commissioned by Voith Hydro on the natural border of Tanzania and Uganda, serving both countries.

In 2021, the Uganda Electricity Generation Company Ltd (UEGCL) invited bids for the implementation of the 44.7 MW Muzizi scheme, to be built on the Muzizi River.

Zambia commissioned the first 150 MW unit of the 750 MW Kafue Gorge Lower hydropower station in July 2021. The station is owned by Zambia Electricity Supply Corp. (ZESCO), with Sinohydro Corporation as contractor.

In 2022, the first 175 MW unit at Nigeria's Zungeru Hydropower Station was commissioned. When complete, the project will provide 700 MW to the grid.

National energy generator Kenya Electricity Generating Company (KenGen) reported that it will meet the growing demand through production from geothermal, hydro and wind power. This came after electricity demand in the country reached a record high of 2,036 MW.

In Mali, in March 2022, the Mariguina hydropower station with an installed capacity of 140 MW entered a trial operation of its first unit, ready to be connected to the national grid. The overall project consists of 3 x 49 MW Kaplan generators units. Ongoing work is underway to commission the two other units. The construction of this project created 1,000 jobs, helping to drive economic development in the country.

The Burundian government approved a project to build two hydroelectric power stations on the Mulembwe and Ruvyironza rivers. These facilities, which will inject 10.65 MW into the local electricity grid, will be built by Songa Energy.

Major investment is needed in Africa's electricity grid infrastructure. Despite its size it has only 26,000 km of high voltage transmission lines. By way of comparison, India, with a similarly sized population, has 430,000 km. With electricity demand expected to triple by 2040, efforts are being made to improve and increase transmission and distribution assets in Africa.

Generation by hydropower

146 TWh

Total installed capacity*

38 GW

*including pumped storage

Capacity added in 2021

182 MW

Pumped storage installed capacity

3.4 GW

Pumped storage capacity added in 2021

0 MW

Nachtigal Hydropower Project, Cameroon
Credit Nachtigal Hydro Power Company (NHPC) subsidiary of EDF

Top 3 countries by capacity added in 2021

1st	Zambia	150 MW
2nd	Uganda	24 MW
3rd	Burundi	9 MW

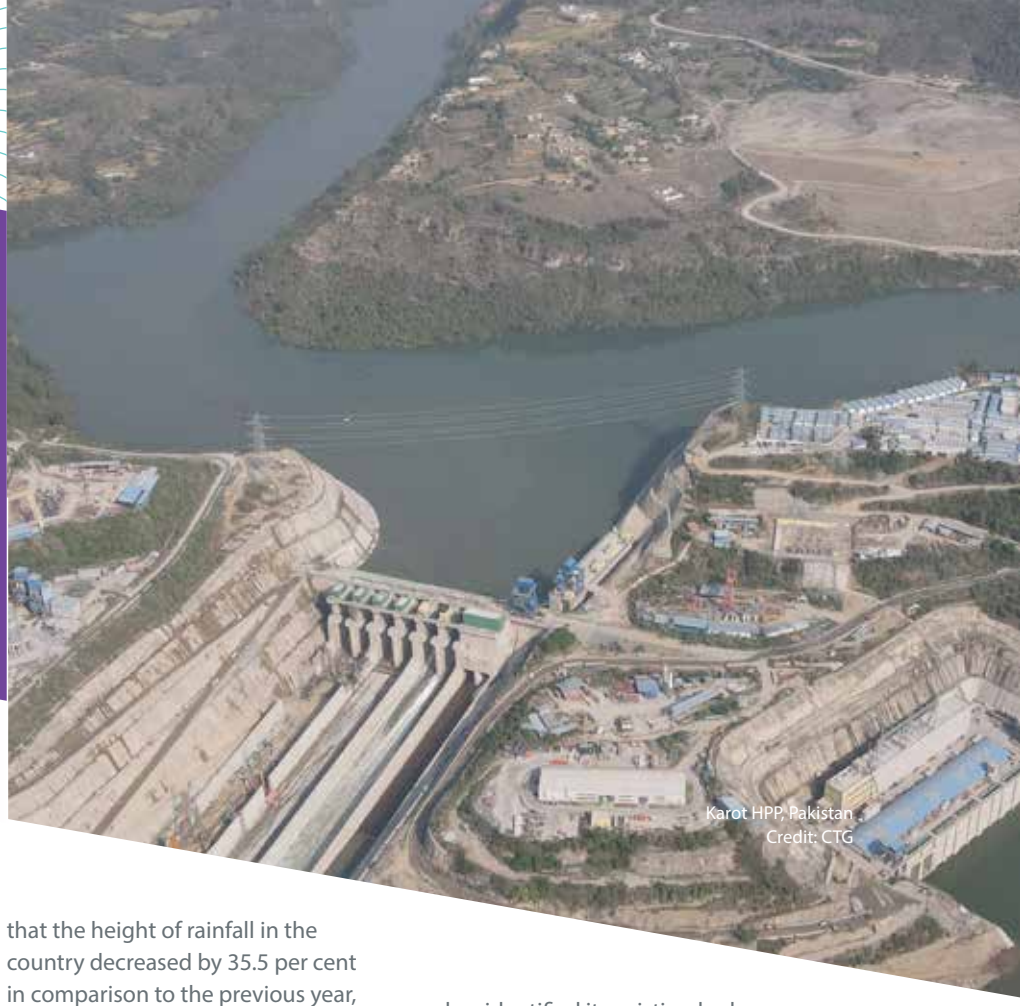
Some African countries are leading the way forward. The construction of a transmission line connecting Kenya to Ethiopia, the longest in East and Central Africa, is near completion, with a capacity of 2,000 MW.

The government of Angola is set to reap the benefits of investing in transmission lines to harmonise access to the country's national resources. A 343 km long transmission line connecting the north and south grids and allowing for the transfer of approximately 1,000 MW of primarily low-cost hydropower is set to be operational in 2023. It is financed largely by AfDB, and its implementation in the south of Angola will avoid consumption of 46 billion litres of diesel per year, and 125 Mt of CO_2 emissions.

In 2021, AfDB provided financing to the Southern African Power Pool (SAPP) through the NEPAD Infrastructure Project Preparation Facility (NEPAD-IPPF) towards the cost of the Baynes hydropower plant 400 kV transmission lines project. It is currently undergoing technical and economic feasibility studies and is planned for completion in 2025.

South and Central Asia

Overview



Karot HPP, Pakistan
Credit: CTG

The dry, mountainous geography of South and Central Asia makes wind or solar deployment more difficult. The potential for significant hydropower growth in the region is enormous, and many countries have included plans to substantially upscale their hydropower capacity in the coming decade. As many countries look to shift from their fossil fuel reliance, hydropower will provide much of the necessary renewable dispatchable generation both to protect water supplies amidst droughts affecting the region, and on the other end of the spectrum flash flooding due to high rainfall.

Amid large-scale projects under construction across the region, many of the commissioned hydropower additions this year came from small hydropower sites in rural communities. Large-scale hydropower projects are either an important component of existing grid infrastructure or a critical part of energy transition strategies.

However, droughts have increasingly impacted the region's hydropower abilities. Iran's Water Authority noted that the height of rainfall in the country decreased by 35.5 per cent in comparison to the previous year, impacting its hydropower capacity and there have been periodic protests over a decades-long drought impact on the population. Likewise, in Sri Lanka, significant outages and protests followed power cuts in part due to prolonged drought. In Kyrgyzstan, drought has significantly impacted reservoir in-flows even as energy demand has increased by 9.9 per cent. Severe dust storms mixed with drought struck Uzbekistan in November 2021 and caused the hydropower output to fall by 23 per cent.

Modernisation of existing infrastructure will be critical for the region in the years ahead, as many hydropower projects are 30-40 years old. Some countries, including Uzbekistan and Kyrgyzstan, have announced plans to modernise their existing hydropower assets to increase installed capacity and ensure energy security. Jordan has identified its existing hydropower assets for modernisation requirements and pumped storage hydropower (PSH) as a potential route for the country's growing energy storage needs. In Russia, the installed capacity increased by more than 165 MW in 2021 due to modernisation works that were completed at Ust-Srednekanskaya HPP, Nizhegorodskaya, Irkutsk, Barsuchkovskaya, and Votkinskaya.

In January 2022, a region-wide blackout saw power disruption across Tajikistan, Uzbekistan and Kazakhstan due to outages that started in Uzbekistan following a short circuit in a 500kV high voltage overhead line. The outage took place amid a week of protests in Kazakhstan, which started over the price of liquified petroleum gas.

Regional interconnectivity is a critical issue. Many hydropower-rich countries rely on transmission networks to export

Ranking by total installed hydropower capacity

Rank	Country/Territory	Installed capacity (MW)*
1	Russia	55,674
2	India	51,352
3	Iran	12,187
4	Pakistan	9,929
5	Tajikistan	6,444
6	Kyrgyzstan	3,892
7	Georgia	3,459
8	Kazakhstan	3,087
9	Iraq	2,753
10	Bhutan	2,335
11	Uzbekistan	2,081

Rank	Country/Territory	Installed capacity (MW)*
12	Nepal	1,988
13	Sri Lanka	1,857
14	Syria	1,505
15	Armenia	1,324
16	Azerbaijan	1,149
17	Afghanistan	461
18	Israel	307
19	Lebanon	282
20	Bangladesh	230
21	Jordan	12
22	Turkmenistan	5

*including pumped storage

South and Central Asia

Developments

power to neighbouring countries that are experiencing escalating energy demands. As part of this, work on the CASA-1000 project continues; substantial preliminary construction has taken place in Kyrgyzstan, and the Tajikistan section is close to completion. This high-voltage power transmission line will run through Kyrgyzstan, Tajikistan, Uzbekistan, Afghanistan and Pakistan.

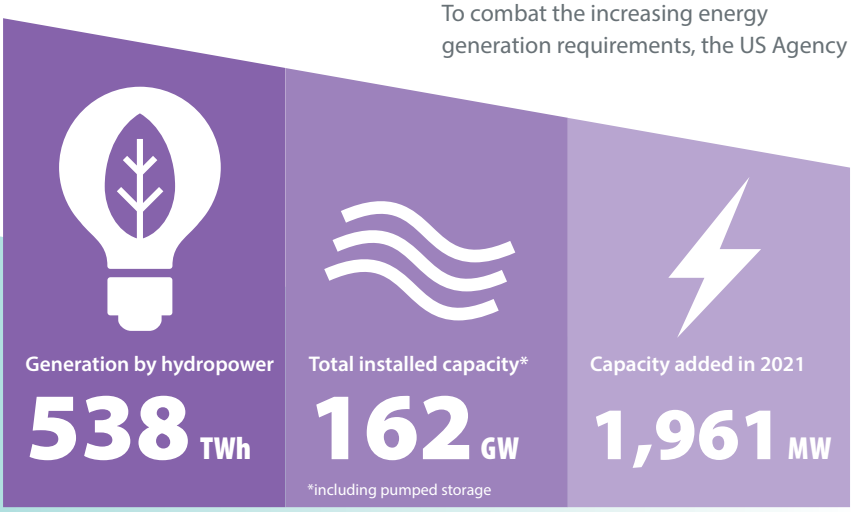
Increasing grid connectivity will be an important means to ensure energy security and increase access to electricity for rural communities across the region, especially for small hydropower projects. Delays in transmission networks have meant that some hydropower projects have completed construction, but are not yet connected to the grid and so are unable to provide energy services, such as the 30 MW Nyadi HPP, 27 MW Dordi Khola and 12 MW Dordi I hydropower projects in Nepal.

Energy consumption and demand is growing annually across the region, and to date much of the energy security relies on interconnected grids. To combat the increasing energy generation requirements, the US Agency for International Development (USAID) announced a US$39 million five-year regional program, "USAID – Energy in Central Asia", to help countries such as Tajikistan receive economic benefits from cross-border energy trade and improve energy security through greater regional integration. For Tajikistan in particular, this will include hydropower development.

Regional partnerships are growing and an important component to decarbonising existing grids as well as improving regional energy security. For example, there have been agreements for cooperation between Nepal and India over transmission networks and hydropower assets. In June 2021, Tajikistan and Uzbekistan signed an agreement to establish a joint stock company, preparing a feasibility study for the construction and operation of two hydropower plants in the Zeravshan river basin. While its hydropower potential is limited, Bangladesh is planning to phase out ten coal-fired power plants, and will improve transmission network links to Nepal and India as they have significantly hydropower-intensive grids. Bangladesh also announced its intention to invest US$1 billion in a mega-hydro project in Bhutan, as well as investing in hydropower plants in Nepal.

The governments of India and Pakistan met on several occasions to discuss water access rights and a treaty as part of the Permanent Commission on Indus Waters, and subsequently the World Bank announced it would be resuming the two separate processes requested by India and Pakistan in relation to the 330 MW Kishenganga and 850 MW Ratle hydroelectric power plants, in line with its responsibilities under the Indus Waters Treaty, which had been delayed since 2016.

India saw the largest increase in total installed capacity during 2021, with just over 800 MW new operational



Upper Tamakoshi, Nepal
Credit: ANDRITZ

Top 5 countries by capacity added in 2021

1st	India	803 MW
2nd	Nepal	684 MW
3rd	Russia	167 MW
4th	Kazakhstan	129 MW
5th	Uzbekistan	76 MW

installed capacity, including Units III and IV of Kameng Hydropower Station adding 300 MW, as well as Rongnichu adding 113 MWs in June 2021 and Sorang 100 MWs in September 2021. Numerous hydropower projects are at early development stages across the country, including the 300 MW Lakhwar multipurpose project, first conceptualised in the 1970s, and in December 2021 Prime Minister Modi laid the foundation stone at the site. The same month, India's Cabinet approved Ken-Betwa, the first project for interlinking rivers under the National Perspective plan to help drought areas, which will include a 106 MW hydropower facility.

To support its renewable energy deployment, India has been working on an energy storage policy framework that will be launched later in 2022 and emphasises the importance of pumped storage hydropower for its variable renewable energy deployment.

Nepal's 456 MW Upper Tamakoshi project commissioned in 2021 represents the largest project and significantly increased Nepal's installed capacity. The Investment Board of Nepal noted the country's immense economic potential hydropower capacity of 43 GW and released a guide to enable foreign investment.

In Russia, the Sayano-Shushenskaya and Zeiskaya hydropower plants set new all-time high annual record outputs, up by 10.4 per cent and 37.9 per cent respectively. Their substantial increase in generation was partially because water inflows to reservoirs in Siberia, the Far East and Northern Caucasus were above the normal level and, similarly, the generation of hydropower plants in the South increased by 5.1 per cent in the fourth quarter of 2021.

Covid-19 continued to cause significant project delays across the region for commissioning. For example, Pakistan's 720 MW Karot run-of-river scheme was due to be commissioned in 2021 and is now planned for 2022. In 2021, Pakistan announced hydropower as a critical part of its net zero strategy. The Water and Power Administration of Pakistan declared a "decade of dams" that would

South and Central Asia

Developments

see the country doubling its existing 9,000 MW capacity by 2029 through ten new projects. In addition to the decade of dams, the government launched Pakistan's first green Eurobond, called "Indus Bond", to finance the construction of the 4,800 MW Diamer Bhasha and 800 MW Mohmand dams. The Indus bond seeks to raise US$500m with a 7.5 per cent interest rate floated over ten years.

In 2021, Bhutan published a national sustainable hydropower plan that noted the economic potential for 37 GW, generating roughly 154 TWh. As part of the strategy, it was noted that hydropower is the "raison d'être for fulfilling the country's aspirations of social wellbeing and economic prosperity" by providing universal access to sustainable energy and reducing poverty.

The Hashemite Kingdom of Jordan is aiming to increase renewables' share of electricity generation by 2030, and announced in 2021 that USD 846.2m will be spent to build hydropower plants, with prequalification bids for small hydropower projects already announced.

Georgia released an energy strategy document that outlines an ambition to double its hydropower capacity over the next decade, from 3,300 MW in 2019 to 6,536 MW in 2030. The strategy includes a contract for difference policy mechanism to assist private investment in the hydropower sector.

In Uzbekistan, 76 MW new hydropower capacity was added in 2021. The "Development Strategy of New Uzbekistan for 2022–2026", launched in 2021, emphasised green energy and projected that Uzbekistan's hydroelectric capacity will reach 2,920 MW by 2026. As part of the strategy, 15 new hydropower projects are planned and five existing plants will be upgraded between 2022 and 2026. In 2022 alone, seven projects with a total capacity of 173 MW will be commissioned. In 2021, Uzbekistan's Ministry of Energy, together with the Asian Development Bank (ADB) and the World Bank, developed a ten-year plan for electricity supply in the country, setting goals and specific measures to create additional electricity capacity. With electricity demand expected to grow over the coming decade, hydropower development will be critical.

Kazakhstan installed roughly 281 MW of hydropower in 2021, including Zarchob 1 and 2. Kazakhstan's Energy Balance 2035 Plan includes 2 GW of new hydropower projects, 6 GW of renewable generation (wind and solar), and 2.4 GW of nuclear, as well as including requirements for electricity storage systems. It aims to achieve carbon-neutral status by 2060.

The UN Environmental Programme ranked the air quality of Kyrgyzstan's

Upper Tamakoshi, Nepal
Credit: ANDRITZ

capital city Bishkek as the second worst globally, and in response the government announced it would reduce coal-fired generation and increase the installed capacity of alternative options including hydropower. In February 2022, Kyrgyzstan's Head of Cabinet Ministers, Akylbek Zhaparov, announced plans to develop 6 GW of new hydropower projects making use of the 70 per cent of economic potential currently unrealised. To implement the proposed reforms in the draft strategy will require approximately US$14 billion by 2030. Kyrgyzstan's Ministry of Energy has issued permits to over 90 companies for the construction of solar, wind and small hydropower plants, with the intention of building 938 MW of small hydropower.

Construction continues on the Rogun Dam in Tajikistan which has 3,600 MW planned capacity. Its current capacity stands at 600 MW after its first units were commissioned in 2018. In 2021, Tajik Finance Minister, Fayziddin Kakhhorzoda, stated that the government will continue to finance the construction of the project. Work is still ongoing for the rehabilitation of the Nurek hydropower project, the largest in Central Asia, which started in 2020 and represents roughly 50 per cent of total electricity capacity for Tajikistan. The World Bank signed an agreement in December 2021 for US$65 million for the works, and a protocol of negotiations was signed. To promote sustainable water use, Tajikistan held a National Workshop on Water Sector Reform Coordination with the UNDP, as well as International Decade for Action event across the year.

East Asia and Pacific

Overview

Wudongde, China
Credit: GE Renewables

The East Asia and Pacific region continues to be the powerhouse for hydropower globally. China continues to lead the way with over 20 GW of new capacity in 2021, while others in the region added another 1 GW. With rapidly growing economies, continued population growth in many countries and an awareness of the impacts of climate change that will increase the pressure to remove coal, the region is likely to remain a new hydropower hotspot for the foreseeable future.

Along with South and Central Asia, the untapped potential in the region is the highest in the world. Developed sustainably it can help to relieve stresses on electricity grids as more solar is deployed, potentially with less significant land-use impacts.

At the end of 2021, the total installed capacity of hydropower in China reached 395.6 GW, almost one-third of the world total. Furthermore, nearly 2 GW of new hydropower capacity started operation in the country in the first two months of 2022.

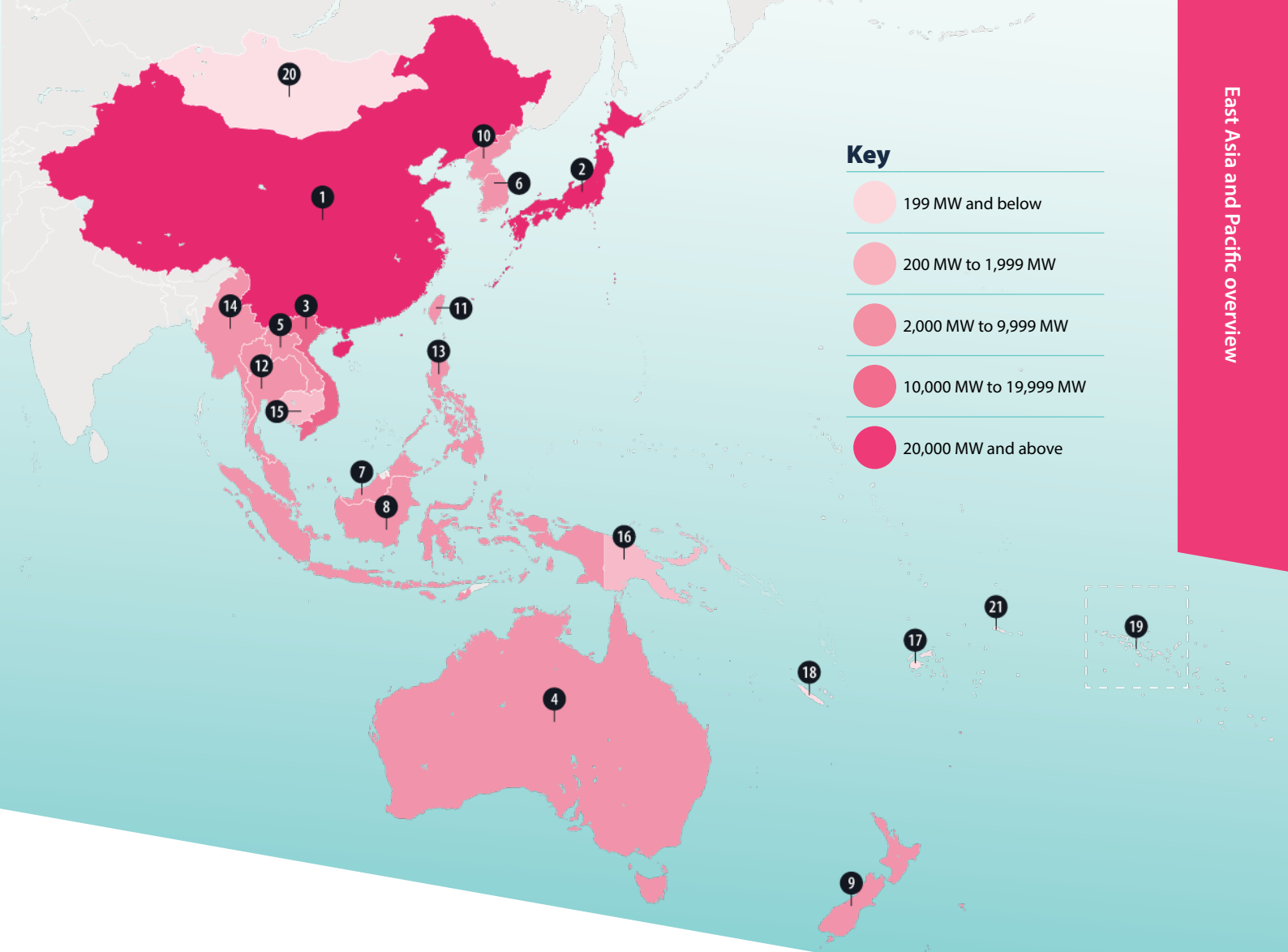
In September 2021, China's National Energy Administration (NEA) published the mid-term and long-term plan from 2021 to 2035 for pumped storage hydropower development. According to this plan, the installed capacity of pumped storage hydropower will be at least 62 GW in 2025, and around 120 GW in 2030 – equivalent to 75 per cent of the entire world's installed pumped storage capacity today.

Two of the twelve generators at the Fengning pumped storage facility went into operation in December 2021, providing 600 MW capacity. Once fully operational in 2023, it will, with 3,600 MW capacity, be the world's largest pumped storage facility, providing over 6,600 GWh of electricity annually.

The world second largest hydropower station, Baihetan in China, has been in operation since July 2021. Three generators are in full operation, and the others are expected to be online in July 2022. The total installed capacity of the Baihetan station is 16 GW, providing 62,000 GWh every year.

In Australia, the AU$777 million Kidston Stage 2 pumped storage project reached financial close. Upon completion in 2024, the 250-MW plant will be able to store and discharge energy for up to eight hours. Hydro Tasmania announced Lake Cethana as the preferred site for a pumped storage hydropower station as part of its Battery of the Nation initiative, with a proposal to double the capacity of the Tarraleah power station.

Australia also started the world's first "solar-hydro" station, using heat generated from PV to push turbines in a water-based reservoir. The project will provide an installed capacity of 300 MW and annual generation of 3.6 GWh when it is completed in 2023.



Ranking by total installed hydropower capacity

Rank	Country/Territory	Installed capacity (MW)*
1	China	391,000
2	Japan	49,643
3	Viet Nam	17,333
4	Australia	8,162
5	Laos	8,108
6	Indonesia	6,602
7	South Korea	6,541
8	Malaysia	6,275
9	New Zealand	5,354
10	North Korea	5,010
11	Taiwan (China)	4,696

Rank	Country/Territory	Installed capacity (MW)*
12	Thailand	4,515
13	Philippines	4,470
14	Myanmar	3,331
15	Cambodia	1,332
16	Papua New Guinea	234
17	Fiji	125
18	New Caledonia	78
19	French Polynesia (France)	47
20	Mongolia	23
21	Samoa	12

*including pumped storage

East Asia and Pacific

Developments

The Australian Infrastructure Financing Facility for the Pacific signed financing agreements with the Solomon Islands Electricity Authority and Solomon Islands. Australia is funding construction of a 22-kilometre transmission system to deliver renewable energy generated by the Tina River Hydropower Project to the Solomon Island's capital, Honiara.

Cambodia and Lao further strengthened their cooperation on hydropower projects, building on an agreement signed in 2019. Under the first phase of the agreement, Laos will export 2,400 MW of electricity in 2024.

The Mekong River Commission (MRC) Council has approved the Sustainable Hydropower Development Strategy for the Lower Mekong Basin to address the future potential for hydropower developments on the river.

In October 2021, Lao's 1,272 MW Nam Ou hydropower plant started commercial operations, with annual generation expected to reach 5,000 GWh.

Two hydropower projects are currently under construction in Cambodia. One is the Stung Pursat project (80 MW), which went into construction stage in the fourth quarter of 2021, and is expected to start generating in 2026; the other is the Stung Tatai Leu project (150 MW), which is now expected to be completed in 2025 due to delays arising from the impact of Covid-19.

Vietnam's Power Development Plan 8 was published in 2021, targeting a 75 per cent share of total generation for renewable energy by 2045. The total capacity of small hydropower sources is targeted to reach 4,800 MW in 2025, about 5,000 MW in 2030 and nearly 6,000 MW in 2045. In 2021, two new hydropower stations started operation in the country: Thuong Kon Tum (220 MW) and Bach Dang (5.3 MW).

Vietnam plans to accelerate the process for key hydropower projects, including the expansion of the Hoa Binh and Ialy hydropower plants in 2022. Furthermore, 20 MW of capacity will be added to the Dak Di hydropower project located in the Nam Tra My district, Quang Nam province. In 2022, the largest hydropower plant in southern Vietnam, the 400 MW Tri An hydropower plant in the Dong Nai Province, will see 200 MW added to its total capacity.

Indonesia published its "RUPTL PLN 2021–2030" with the national mid-term plan of achieving net zero by 2060. The plan aims to phase out coal by 2056, while hydropower will be the main source with 25.6 per cent of the national

Generation by hydropower
1,639 TWh

Total installed capacity*
523 GW
*including pumped storage

Capacity added in 2021
21,897 MW

Pumped storage installed capacity
76 GW

Pumped storage capacity added in 2021
4,344 MW

Lianghekou Hydropower Station, China
Credit: Yalong Hydro

Top 5 countries by capacity added in 2021

1st	China	20,842 MW
2nd	Laos	600 MW
3rd	Indonesia	481 MW
4th	Viet Nam	222 MW
5th	Philippines	85 MW

electricity supply, followed by solar with 11.5 per cent. With the inclusion of mini-hydropower, Indonesia's potential is now estimated at 95 GW.

Indonesia added over 400 MW of new capacity in 2021, the most significant being a 260 MW expansion of the Poso hydropower plant, which finished construction in December 2021. Furthermore, the 105 MW Kerinchi hydropower station began construction and is expected to come online in 2023.

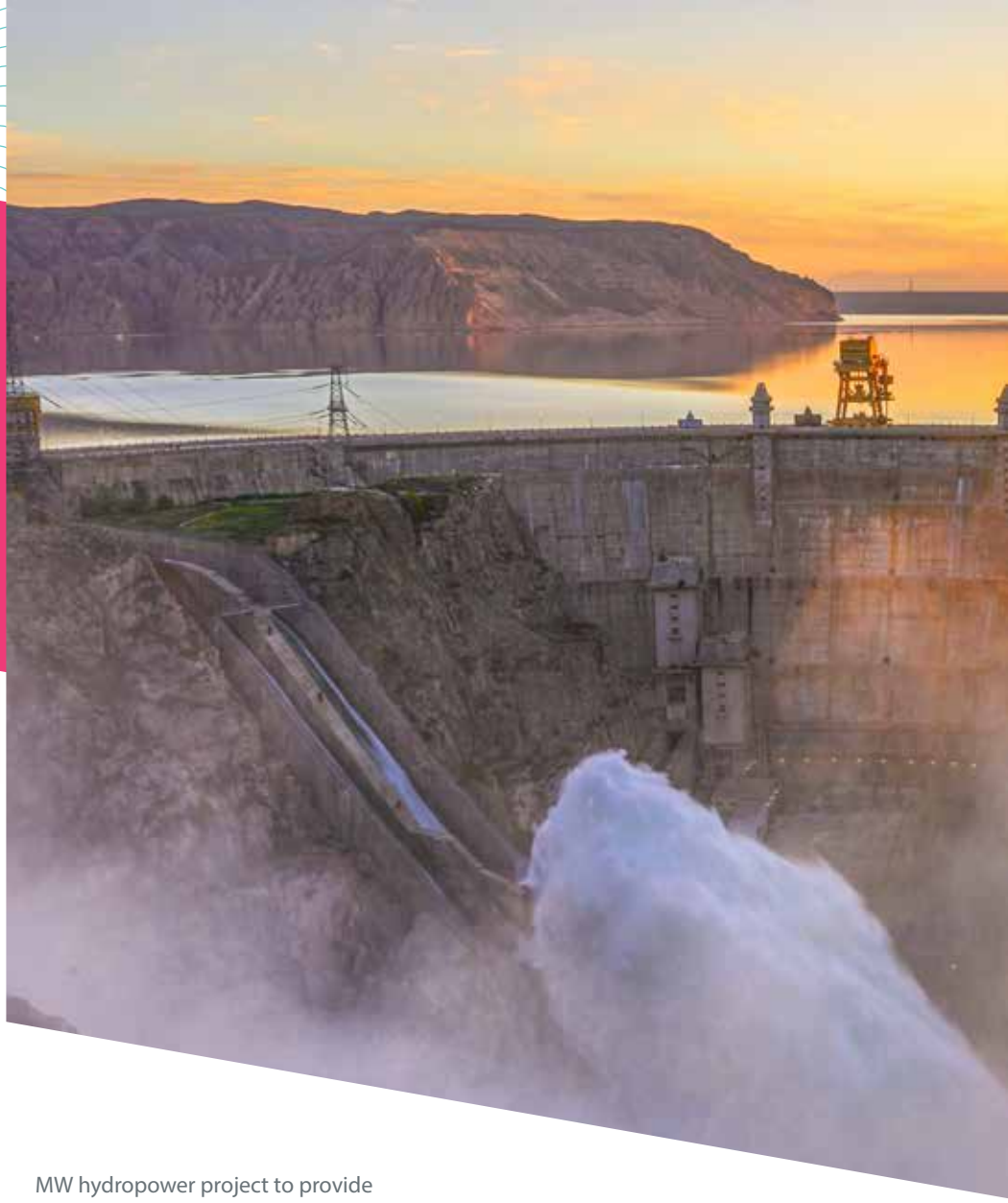
The Indonesian government stated that hydropower and floating solar will be the backbones of the national net zero strategy to resolve intermittency on the grid. The country has a floating-hydro program and is expected to include all existing reservoirs in Java as potential sites for floating PV, with a combined potential of 28 GW. Construction began on a floating PV project at Cirata hydropower station in 2021, which will be the largest floating PV station in Southeast Asia at 145 MW when complete.

In September 2021, the World Bank approved a US$380 million loan to develop the Upper Cisokan pumped storage hydropower plant – Indonesia's first – located between Jakarta and Bandung, with an expected capacity of 1,040 MW.

Mongolia signed an agreement with China in September 2021 to develop the Erdeneburen hydropower plant, located on Khovd River in the Khovd Province, with an installed capacity of 90 MW.

East Asia and Pacific

Developments



Papua New Guinea signed a master development agreement with Fortescue Future Industries to start feasibility studies for seven hydropower projects with a total capacity of 15 GW in November 2021. The projects have the potential to produce up to 2.3 million tonnes of green hydrogen per year.

Japan announced its goals for carbon reduction and renewable energy in 2030. Renewable energy will provide more than a third of the national electricity supply, with solar (14–16 per cent) and hydropower (increasing its share from around 9 per cent today to around 11 per cent) as the top two energy sources.

In Malaysia, Tenaga Nasional Berhad received a notification from the Ministry of Energy and Natural Resources in September 2021 to develop a 300 MW hydropower project to provide peak load for the national grid, as well as providing flood control benefits. The station will be in Kelantan and construction will start in 2026.

The Republic of Korea is promoting the construction of new pumped storage hydropower plants with a total capacity of 1.8 GW in Pocheon, Hongcheon and Yeongdong, with construction aimed to be completed in 2034.

The Philippines government updated its proposed National Renewable Energy Program (NREP) 2020–2040 in November 2021. The country aims to reach a 35 per cent share for renewable energy in the total generation mix by 2030, and 50 per cent by 2040. The Philippines Department of Energy opened a tender for 17 potential hydropower projects and five geothermal projects with a combined capacity of 150 MW in 2021. The International Energy Agency (IEA) reported that the capacity of hydropower in the Philippines will increase by 1.1 GW by 2030, with 0.5 GW from pumped storage hydropower, 0.3 GW from reservoir and 0.2 GW from run-of-river hydropower.

Longyangxia Hydropower Plant, China
Credit: SPIC, Photo courtesy of ZHANG Yong

A number of new projects were announced in the country, including the 22 MW Siayan (Sindangan) hydropower plant in Zamboanga del, the 42 MW Bago plant in Negros Occidental, Aya in Pantabangan with 120 MW, and a 300 MW pumped storage hydropower station in Malay, Aklan, which will be the first pumped storage facility in the Philippines.

The Asian Development Bank and the Vanuatu government are extending their work on renewable energy projects for the islands of Malekula and Espiritu Santo. The Vanuatu Energy Access Project will help build a 400-kilowatt hydropower plant and extend the two islands' electricity grids to deliver sustainable, affordable power.

Installed capacity and generation 2021

Africa

Country/Territory	Total installed capacity including pumped storage (MW)	Pumped (MW)	Generation (TWh)
Algeria	269	0	<1
Angola	3,836	0	11
Benin	33	0	<1
Botswana	0	0	0
Burkina Faso	34	0	<1
Burundi	57	0	<1
Cameroon	822	0	6
Cape Verde	0	0	0
Central African Republic	19	0	<1
Chad	0	0	0
Comoros	1	0	0
Congo	218	0	1
Cote D'Ivoire	879	0	3
Democratic Republic of the Congo	2,760	0	9
Djibouti	0	0	0
Egypt	2,876	0	14
Equatorial Guinea	126	0	<1
Eritrea	0	0	0
Eswatini	60	0	<1
Ethiopia	4,074	0	14
Gabon	331	0	2
Gambia	0	0	0
Ghana	1,584	0	7
Guinea	706	0	2
Guinea-bissau	0	0	0
Kenya	837	0	3
Lesotho	73	0	<1
Liberia	93	0	<1
Libya	0	0	0
Madagascar	186	0	<1
Malawi	371	0	1
Maldives	0	0	0
Mali	220	0	1
Mauritania	48	0	<1
Mauritius	61	0	<1
Morocco	1,770	465	1
Mozambique	2,216	0	15
Namibia	347	0	1
Niger	0	0	0
Nigeria	2,111	0	8
Reunion	134	0	<1
Rwanda	111	0	<1
Sao Tome And Principe	2	0	<1
Senegal	81	0	<1
Seychelles	0	0	0
Sierra Leone	64	0	<1
Somalia	0	0	0
South Africa	3,600	2,912	6
South Sudan	0	0	0
Sudan	1,923	0	8
Tanzania	562	0	2
Togo	49	0	<1
Tunisia	66	0	<1
Uganda	1,073	0	4
Western Sahara	0	0	0
Yemen	0	0	0
Zambia	2,706	0	15
Zimbabwe	1,081	0	7
Total	**38,469**	**3,377**	**146**

South and Central Asia

Country/Territory	Total installed capacity including pumped storage (MW)	Pumped (MW)	Generation (TWh)
Afghanistan	460	0	<1
Armenia	1,324	0	2
Azerbaijan	1,149	0	1
Bahrain	0	0	0
Bangladesh	230	0	<1
Bhutan	2,335	0	11
Georgia	3,459	0	10
India	5,1351	4,746	160
Iran	12,187	1,040	24
Iraq	2,753	240	2
Israel	307	300	<1
Jordan	12	0	<1
Kazakhstan	3,087	0	9
Kuwait	0	0	0
Kyrgyzstan	3,892	0	13
Lebanon	282	0	<1
Nepal	1,988	0	3
Oman	0	0	0
Pakistan	9,929	0	39
Qatar	0	0	0
Russia	55,674	1,385	229
Saudi Arabia	0	0	0
Sri Lanka	1,857	0	6
Syria	1505	0	<1
Tajikistan	6,444	0	20
Turkmenistan	5	0	<1
United Arab Emirates	0	0	0
Uzbekistan	2,081	0	7
Total	**162,313**	**7,711**	**538**

East Asia and Pacific

Country/Territory	Total installed capacity including pumped storage (MW)	Pumped (MW)	Generation (TWh)
American Samoa	0	0	0
Australia	8,162	2,461	16
Brunei	0	0	0
Cambodia	1,332	0	4
China	391,000	36,000	1,340
Taiwan (China)	4,696	2,603	7
Cook Islands	0	0	0
Fiji	125	0	<1
French Polynesia (France)	47	0	<1
Guam	0	0	0
Hong Kong	0	0	0
Indonesia	6,601	0	19
Japan	49,643	27,470	99
Kiribati	0	0	0
Laos	8,108	0	21
Macau	0	0	0
Malaysia	6,275	0	16
Marshall Islands	0	0	0
Micronesia, Federated States Of	0	0	0
Mongolia	23	0	<1
Myanmar	3,331	0	7
Nauru	0	0	0
New Caledonia	78	0	<1
New Zealand	5,354	0	24
Niue	0	0	0
North Korea	5,010	0	12
Papua New Guinea	234	0	<1
Philippines	4,470	685	9
Samoa	12	0	<1
Singapore	0	0	0
Solomon Islands	0	0	0
South Korea	6,541	4,790	7
Thailand	4,515	1,531	5
Timor-leste	0	0	0
Tonga	0	0	0
Tuvalu	0	0	0
Vanuatu	0	0	0
Viet Nam	17,333	0	53
Total	**522,891**	**75,540**	**1,639**

Europe

Country/Territory	Total installed capacity including pumped storage (MW)	Pumped (MW)	Generation (TWh)
Albania	2,390	0	5
Andorra	45	0	<1
Austria	14,747	5,596	41
Belarus	97	0	<1
Belgium	1,427	1,307	1
Bosnia and Herzegovina	2,187	440	5
Bulgaria	3,129	1,404	5
Croatia	2,155	281	7
Cyprus	0	0	0
Czechia	2,281	1,172	4
Denmark	7	0	<1
Estonia	4	0	<1
Faroe Islands	39	0	<1
Finland	3,263	0	16
France	25,494	5,837	63
Germany	10,883	6,199	24
Gibraltar	0	0	0
Greece	3,421	699	6
Greenland	91	0	<1
Hungary	58	0	<1
Iceland	2,086	0	14
Ireland	508	292	1
Italy	22,593	7,685	47
Kosovo	92	0	6
Latvia	1,588	0	3
Liechtenstein	35	0	<1
Lithuania	1,028	900	1
Luxembourg	1,330	1,296	1
Macedonia	644	0	1
Malta	0	0	0
Moldova	76	0	<1
Monaco	0	0	0
Montenegro	649	0	2
Netherlands	38	0	<1
Norway	33,391	1,439	144
Poland	2,385	1,780	3
Portugal	7,199	2,827	13
Romania	6,313	92	17
San Marino	0	0	0
Serbia	3,133	642	12
Slovakia	2,522	1,017	4
Slovenia	1,301	180	5
Spain	20,425	6,117	32
Sweden	16,478	99	71
Switzerland	16,842	3,029	39
Turkey	31,497	0	55
Ukraine	6,317	1,887	2
United Kingdom	4,713	2,833	7
Total	**254,901**	**55,050**	**689**

South America

Country/Territory	Total installed capacity including pumped storage (MW)	Pumped (MW)	Generation (TWh)
Argentina	11,345	974	25
Bolivia	736	0	3
Brazil	109,446	20	341
Chile	6,812	0	17
Colombia	11,945	0	58
Ecuador	5,107	0	25
French Guiana (France)	119	0	<1
Guyana	3	0	0
Paraguay	8,810	0	46
Peru	5,340	0	31
Suriname	180	0	1
Uruguay	1,538	0	4
Venezuela	15,393	0	61
Total	**176,773**	**994**	**614**

North and Central America

Country/Territory	Total installed capacity including pumped storage (MW)	Pumped (MW)	Generation (TWh)
Anguilla	0	0	0
Antigua and Barbuda	0	0	0
Aruba	0	0	0
Bahamas	0	0	0
Barbados	0	0	0
Belize	55	0	<1
Bermuda	0	0	0
Canada	82,300	177	377
Cayman Islands	0	0	0
Costa Rica	2,379	0	9
Cuba	65		<1
Dominica	7		<1
Dominican Republic	623		1
El Salvador	573		2
Grenada	0	0	0
Guadeloupe	11		<1
Guatemala	1,516		6
Haiti	78		0
Honduras	849		4
Jamaica	30		<1
Martinique	0	0	0
Mexico	12,614		34
Montserrat	0	0	0
Nicaragua	157		0
Panama	1,754	0	8
Puerto Rico	98	0	<1
Saint Bartholemy	0	0	0
Saint Kitts And Nevis	0	0	0
Saint Lucia	0	0	0
Saint Pierre And Miquelon	0	0	0
Saint Vincent And The Grenadines	6		<1
Trinidad And Tobago	0	0	0
Turks And Caicos Islands	0	0	0
United States	101,943	21,912	260
Virgin Islands, British	0	0	0
Virgin Islands, U.S.	0	0	0
Total	**205,058**	**22,089**	**702**

World

	Total installed capacity including pumped storage (MW)	Pumped (MW)	Generation (TWh)
Total	**1,360,405**	**164,761**	**4,252**

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