2020

Hydropower Status Report

Sector trends and insights

iha

international hydropower association

Contents

Main cover image: The 900 MW Nant de Drance pumped storage hydropower plant, in Switzerland, under construction, credit: Alpiq. Turbine image: Francis runner close up, credit: Gilkes.

About IHA

The Gries run-of-river hydropower plant, under construction in Germany. Credit: Verbund.

iha
international hydropower association

The International Hydropower Association (IHA) represents organisations and individuals committed to the responsible and sustainable development and operation of hydropower.

Since IHA was founded almost 25 years ago the hydropower sector has more than doubled in size from 625 GW in 1995 to over 1,300 GW today. IHA's membership operates over 450 GW of current capacity.

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, sustainable 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 also ensures global decarbonisation goals remain within reach, while complementing variable renewables through its flexibility and storage.

Find out more: hydropower.org

Foreword

Hydropower is an essential service now and in the future. This report shows how, despite slowed capacity growth, hydropower generation increased by 2.5 per cent in 2019, and it continues to be the world's largest source of renewable electricity with multiple non-power benefits.

During the Covid-19 crisis, hydropower has kept the lights on in homes, businesses and hospitals. Its flexibility was best demonstrated in perhaps the largest electricity experiment the world has even seen in April 2020, when India's hydropower sector restored electricity to tens of millions of households following a 31 GW fall in demand for a lights-out Covid-19 vigil. Once the current health emergency is under control, policy makers will need to be bold and move quickly with massive stimulus packages to ensure a full recovery. We need to make sure that we 'build back better'.

There is now more than 1,300 GW of installed hydropower capacity globally. According to the International Renewable Energy Agency (IRENA)'s Global Renewables Outlook 2020, this figure will need to grow by around 60 per cent by 2050 to help limit the rise in global temperature to well below 2 degrees Celsius above pre-industrial levels. Such growth would help generate some 600,000 skilled jobs over the coming decade according to IRENA and would require an estimated investment of US$1.7 trillion.

Additional capacity does not only have to come through building new hydropower projects:

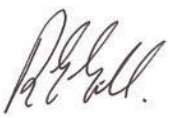
- With some 600 GW of existing capacity older than 30 years, significant opportunities exist to upgrade and modernise the world's hydropower fleet;
- There are also tens of thousands of non-powered dams and it is vital we tap these unused resources;
- Pumped storage capacity should more than double and this growth is vital to support variable renewable energy.

Policy makers and planners need to initiate new projects now, due to the longer planning cycles for hydropower construction. This report highlights where the needs and opportunities are the greatest.

For the energy sector as a whole, the Covid-19 crisis has caused unprecedented volatility and uncertainty. Electricity demand and prices have plunged by up to 20 per cent in some markets. The sector is undergoing a huge involuntary transformation which can be shaped for a more sustainable future. Nonetheless this report highlights the relative stability, resilience and reliability of the hydropower sector.

The crisis has again showed that preventing an emergency is far better than responding to one. The events of the past few months must be a catalyst for stronger climate action, including greater development of sustainable hydropower.

However, for this to happen, hydropower's contribution in maintaining system reliability has to be properly recognised, incentivised by policy makers and appropriately valued by the market. This report highlights the tools, trends and topics to inform good policy and investments for governments, financial institutions and companies. We hope you find it useful and we stand ready to assist you in the energy transition.



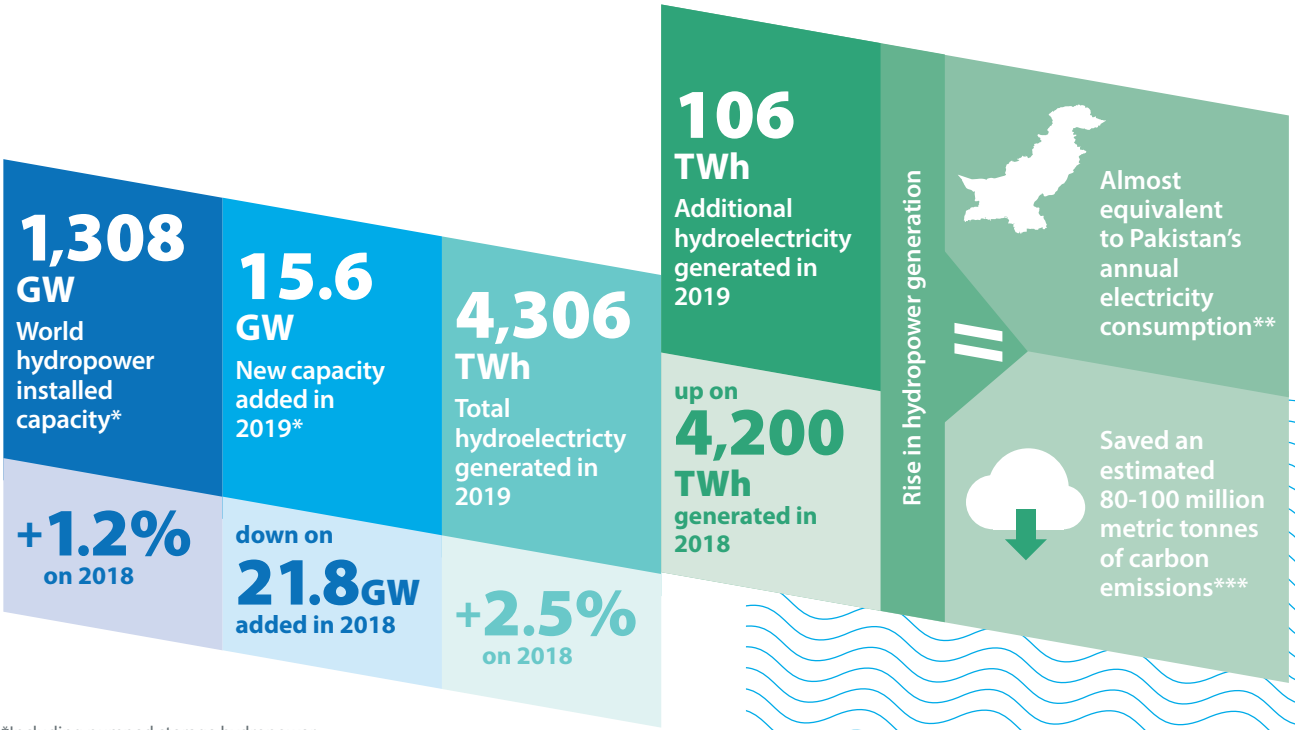
Roger Gill
IHA President

Executive Summary

Now in its seventh edition, the 2020 Hydropower Status Report is published at a time of great global uncertainty caused by the Covid-19 pandemic. Although the crisis has not affected hydropower to the extent witnessed in the oil and gas markets, the impact on the sector has been far from insignificant.

This report, compiled by IHA and its team of researchers and analysts, finds that:

- Covid-19 has underlined the hydropower sector's resilience and its critical role in delivering clean, reliable and affordable energy, especially at times of crisis.
- A bold and ambitious green recovery plan involving significant investment in sustainable hydropower and other renewables will be needed as part of the policy response.
- Clean electricity generation from hydropower achieved a record 4,306 terawatt hours (TWh) in 2019, the single greatest contribution from a renewable energy source in history.
- Projects totalling 15.6 GW in capacity were put into operation in 2019, although this was down on the amount added in 2018.
- Total global hydropower installed capacity reached 1,308 gigawatts (GW) in 2019. This represents a rise of 1.2 per cent, down on the five-year annual average of 2.1 per cent and well below an estimated 2.0 per cent annual growth required to meet Paris Agreement targets.
- Fifty countries added hydropower capacity in 2019. Those with the highest individual increases in installed capacity were Brazil (4.92 GW), China (4.17 GW) and Laos (1.89 GW).
- India overtook Japan as the fifth largest world hydropower producer with its total installed capacity now standing at over 50 GW.
- The 11,233 MW Belo Monte project in Brazil became fully operational in 2019, while other major projects include the 1,285 MW Xayaburi project in Laos, followed by the 990 MW Wunonglong and 920 MW Dahuaqiao projects in China.
- There was a decrease in the growth of pumped storage hydropower installed capacity in 2019 due to project delays in China. However, growing interest in new pumped storage projects has been observed across the world.



*Including pumped storage hydropower.
**Approximate based on Pakistan's total electricity consumption of 110 TWh in 2018 (IEA).
***IHA calculation if additional 106 TWh on 2018 had been generated instead by coal.

Covid-19 and hydropower

The Covid-19 pandemic will reset society and the economy. There will be significant new approaches to global governance, economic development, energy systems, and environmental and social sustainability.

While this is a time of great uncertainty, it is vitally important that economic stimulus packages not only maximise the short-term benefits of infrastructure investment, but also accelerate the transition towards cleaner and lower-carbon technologies such as hydropower.

Immediate impacts on hydropower

The Covid-19 crisis is causing an upheaval in energy markets and hydropower is not immune to these developments.

Between late March and early April 2020, IHA conducted a rapid survey of its members to find out how the coronavirus pandemic is affecting hydropower. Fifty respondents took part of which 60 per cent were heads of organisation or senior management. The survey, together with wider analysis conducted by IHA, shows the sector has been affected by the coronavirus in a variety of ways.

"Operations are digitalised and have been for about 10 years, so all stations can be operated remotely."
survey respondent

"Essential employees are still working to maintain the power supply to all customers."
survey respondent

Widespread uncertainty and liquidity shortages have put financing and refinancing of some hydropower projects at risk. Greenfield development and critical modernisation projects have also been halted due to supply chain disruptions. In addition, proposed or existing government programmes aimed at supporting the sector have been postponed.

While operations have been less affected due to the high level of automation found in modern facilities, significant falls in electricity demand and prices has had an impact. In some markets both demand and prices have contracted by up to 20 per cent and remain extremely volatile. It must be noted however that those projects covered by long-term power purchase agreements have remained largely insulated from these impacts.

All these developments have contributed to falling confidence across the hydropower sector. IHA's survey showed a more than a 20 per cent drop in confidence by survey respondents (from 77 per cent in 2018's survey, to 56 per cent in March/April 2020) on the question of whether their organisation's hydropower revenues would grow over the next 1-3 years.

In the first quarter of 2020, during the height of the Covid-19 crisis, China's Three Gorges and Gezhouba power plants generated 20.16 TWh of electricity, up 3.7 per cent from a year earlier, setting a new record and providing power to Hubei province and other regions. These handheld signs show "Go Three Gorges! Go Wuhan!" to express support from the control room of Three Gorges power plant. Credit: CTG.

Hydropower's role in responding to the crisis

Covid-19 has demonstrated the resilience, reliability and flexibility of hydropower at a time of global crisis. Due to successfully implementing business continuity plans, hydropower operators have helped 'keep the lights on' for essential sectors of the economy.

The need to ensure sufficient capacity at all times, with higher shares of variable renewable energy (VRE), has highlighted the operational challenges faced by grid operators in maintaining stability. Hydropower's flexibility was best demonstrated in India on 5 April 2020 when the country's operators restored electricity to tens of millions of households following a huge plunge in demand; this came after Prime Minister Narendra Modi called on Indians to switch off their lights for a Covid-19 vigil, leading to an unprecedented 31 GW of load variability over a nine-minute period.

In addition to continuing to provide energy and water services to local communities, there have also been inspiring stories emerging from IHA's members from across the globe. Hydropower utilities and manufacturers have been securing energy, providing relief to customers, donating medical supplies and offering support to vulnerable groups.

Photo: Engineers at the Itaipu hydropower plant, between Brazil and Paraguay, continue maintenance operations while applying strict new Covid-19 health and safety guidelines. Credit: Itaipu Binacional

Hydropower and the global recovery

As the world's single largest source of renewable electricity with unique storage and flexibility services to support the integration of variable renewables, hydropower can play an integral role in the recovery effort and the clean energy transition.

Hydropower projects can safely supply clean water for agriculture, homes and business, and help to mitigate the impacts of extreme weather events such as floods and drought. These projects can also provide vital transportation infrastructure, investment in community services and leisure and recreation.

To maximise the contribution hydropower can make to the world economy, policy-makers should recognise the urgency for a bold and ambitious green recovery plan as part of the global response to Covid-19, involving significant new investment by public and private sectors.

In its recently released Global Renewables Outlook, IRENA stated that an additional 850 GW of newly installed hydropower capacity, requiring investment of up to US$ 1.7 trillion, is needed by 2050 to support the targets of the Paris Agreement. This added capacity would also generate some 600,000 skilled jobs over the coming decade.

This means promoting greenfield and upgrade projects to help stimulate the economy, and increasing the ambition of renewable energy and decarbonisation targets. Necessary support may include fast-tracking planning approvals, introducing tax relief or low-interest loans where needed to ensure viable projects can commence, extending deadlines for existing government programmes, and properly compensating hydropower's flexibility services.

Toward this effort, IHA is building coalitions and engaging decision-makers to help ensure that sustainable and responsibly managed hydropower – constructed and operated in accordance with international good practices – is recognised as indispensable for our energy, water and climate needs.

Visit Hydropower.org for further updates on IHA's recommendations for policy-makers.

Regional news in brief

North and Central America

In the United States, total hydropower capacity, including pumped storage, remained at 103 GW in 2019. While most recent growth comes from small projects, there is still 50 GW of untapped hydropower potential, including 30 GW of pumped storage.

In Canada, hydropower remains the dominant source of electricity supply, representing 61 per cent of total electricity generation and 55 per cent of total installed generation capacity.

Mexico emphasised the need for public energy generation, and an increase in hydropower installed capacity by modernising existing assets.

In the Caribbean, which has some of the highest electricity charges in the world, countries are aiming to increase renewable energy sources (hydropower, wind and solar) to decrease dependence on fossil fuel imports for electricity.

South America

Brazil surpassed China as the largest single contributor of added capacity in 2019 with 4,919 MW. This was mainly attributed to the completion of the 11,233 MW Belo Monte hydropower plant.

The insurance company of the Ituango hydropower plant in Colombia concluded that a major incident in April 2018 is within the policy coverage. While the claim's value is still to be determined, it is expected to be one of the largest claims in the history of engineering.

The region is moving to a diversified renewable electricity mix, especially in the Southern Cone countries, which have rapidly increased capacity from wind projects.

The development of long distance high-voltage interconnections is top of the agenda to strengthen energy security in the Andean subregion.

Africa

Hydropower remains the main renewable resource in Africa with over 37 GW of installed capacity. It has the highest untapped potential in the world, with only 11 per cent utilised.

In 2019, 906 MW of hydropower capacity was put into operation across the continent. Over the last ten years, capacity has grown at an average annual rate of 4.4 per cent.

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.

As 60 per cent of the hydropower installed capacity in the region is over 20 years old, modernisation efforts are key to improving access to clean and reliable energy.

With electricity demand expected to triple by 2040, one of the regional priorities is to improve and increase the transmission and distribution assets.

Europe

The carbon-intensity of Europe's power mix continues to fall, with declining coal generation in 2019 and rising output from wind, solar and gas, reflecting a year-on-year trend.

Last year hydropower capacity remained relatively stable across the continent, while annual production varied in different regions depending on seasonal weather.

Hydropower featured in several policy and planning updates released in 2019, including investment guidance published as part of the EU Taxonomy for sustainable finance.

Utility companies continued to invest in their hydropower fleets in Europe, under new and ongoing modernisation programmes.

Pumped storage remains high on the agenda, with increasing focus on the need for flexible grid services, including storage, to support a renewable energy mix.

Hydropower potential in the Balkans faces environmental opposition, particularly where proposed schemes are in sensitive and protected areas.

South and Central Asia

Over the past five years, annual hydropower capacity growth has averaged 2 per cent, in line with the global average.

In 2019, just over 2.3 GW of hydropower capacity went into operation, including both greenfield and modernisation projects.

The largest project commissioned last year was the 720 MW Mangdechu project in Bhutan, funded by the Indian government. The run-of-river project will supply electricity to the domestic market, and any surplus will be exported to India.

The Indian government announced a raft of measures to support hydropower development, including declaring that large hydropower (>25 MW) is officially a renewable energy source. This move will enable new, large projects to benefit from the non-solar Renewable Purchase Obligation, which mandates that regional utilities purchase a portion of their electricity from hydropower.

East Asia and Pacific

With 4.17 GW of new capacity added, China is still the regional leader in hydropower development. Pumped storage capacity grew by 300 MW in 2019, with a temporary pause on new pumped storage projects.

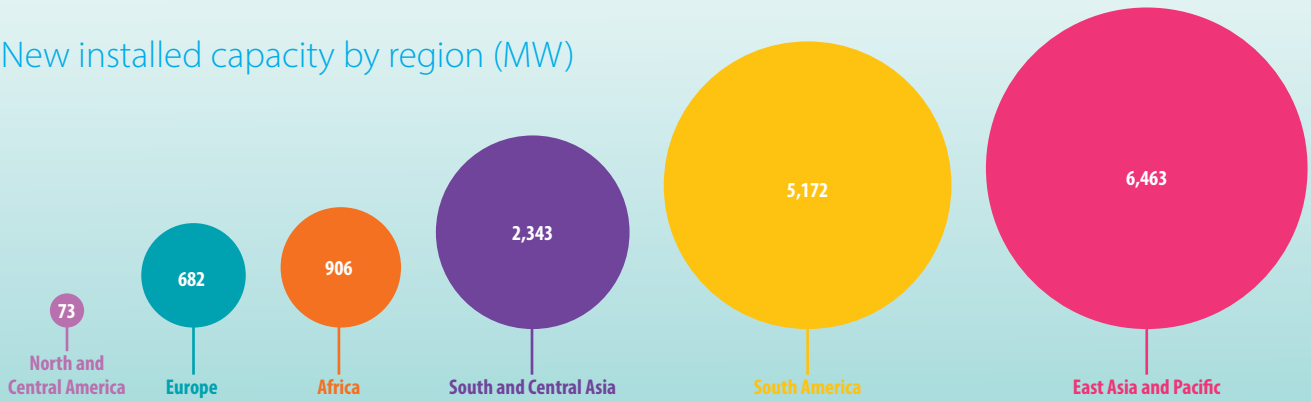
Laos was second-highest in new added capacity. This includes the 1,295 MW Xayaburi and 270 MW Nam Ngiep 1 projects, which will export power to Thailand. In addition, the 260 MW Don Sahong project will export power to Cambodia.

Retrofitting floating solar on hydropower is gaining momentum across South East Asia, with new projects in Indonesia, Vietnam, Thailand, and Cambodia.

Cambodia will not pursue new hydropower development on the mainstream Mekong River, but is still studying the potential for development on tributaries.

In Australia, the state of Tasmania announced a 200 per cent renewable generation target for 2040 and aims to become a net exporter of renewable energy to the rest of the country.

New installed capacity by region (MW)



2019 generation and capacity statistics

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.

Record generation

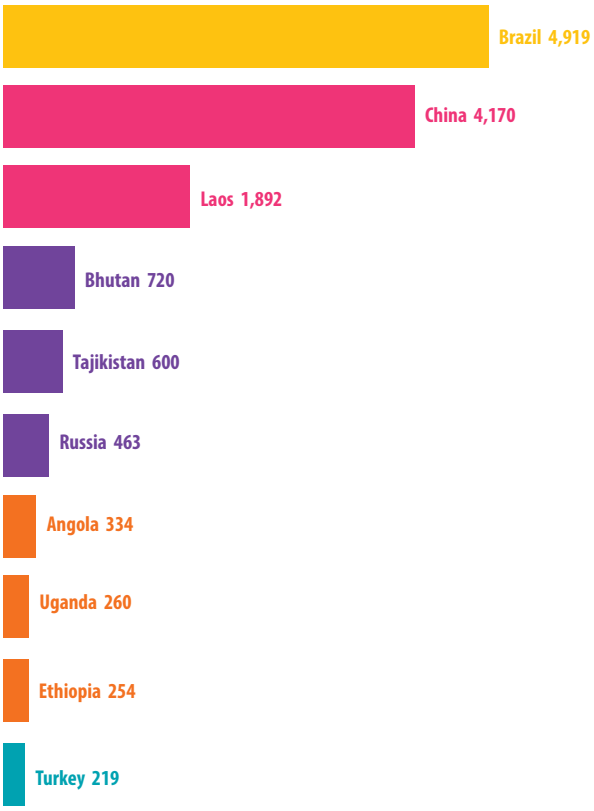
Hydropower generated a record 4,305 TWh of clean electricity worldwide, surpassing the 4,200 TWh recorded for 2018 in last year's Hydropower Status Report. This came after projects totalling 15.6 GW in capacity were put into operation, increasing total global hydropower installed capacity to 1,308 GW in 2019.

Fifty countries added hydropower capacity in 2019. The countries with the highest individual increases in installed capacity were Brazil (4.92 GW), China (4.17 GW) and Laos (1.89 GW).

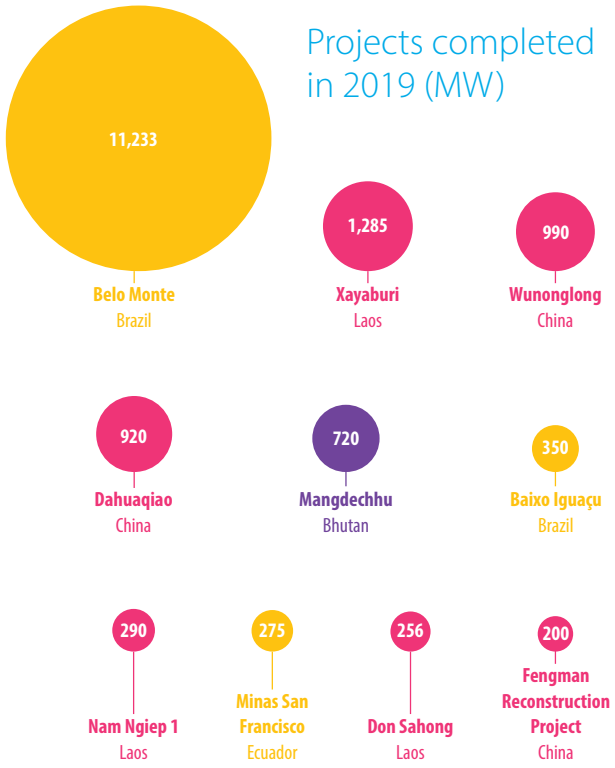
With the installation of its 18th turbine, the 11,233 MW Belo Monte project in Brazil became fully operational in 2019, while other major projects include Xayaburi in Laos (1,285 MW), Wunonglong in China (990 MW), Mangdechhu in Bhutan (720 MW).

During 2019, India overtook Japan as the fifth largest world hydropower superpower with its total installed capacity now standing at 50.07 GW.

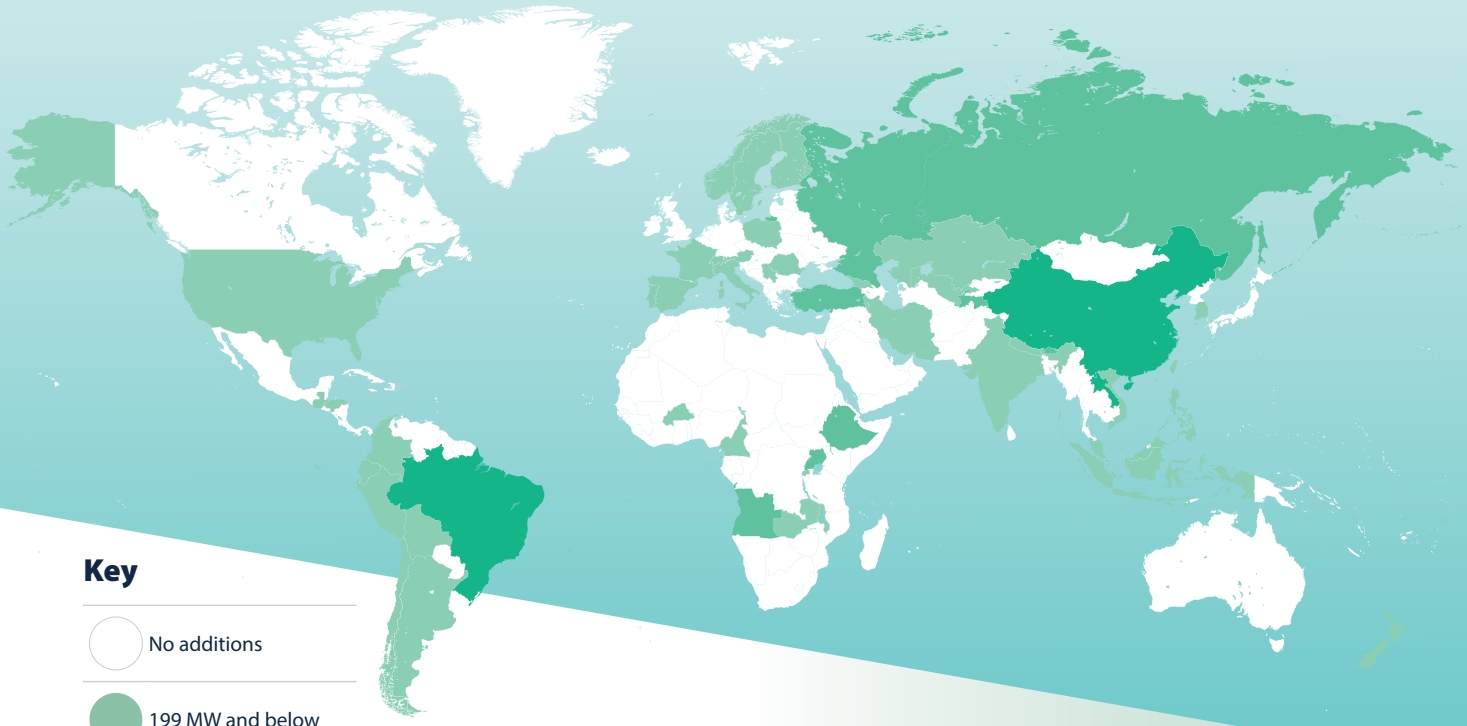
Top 10 countries by new installed capacity (MW)



Projects completed in 2019 (MW)



Where was capacity added in 2019?



Key

- No additions
- 199 MW and below
- 200 MW to 1,999 MW
- 2,000 MW to 9,999 MW

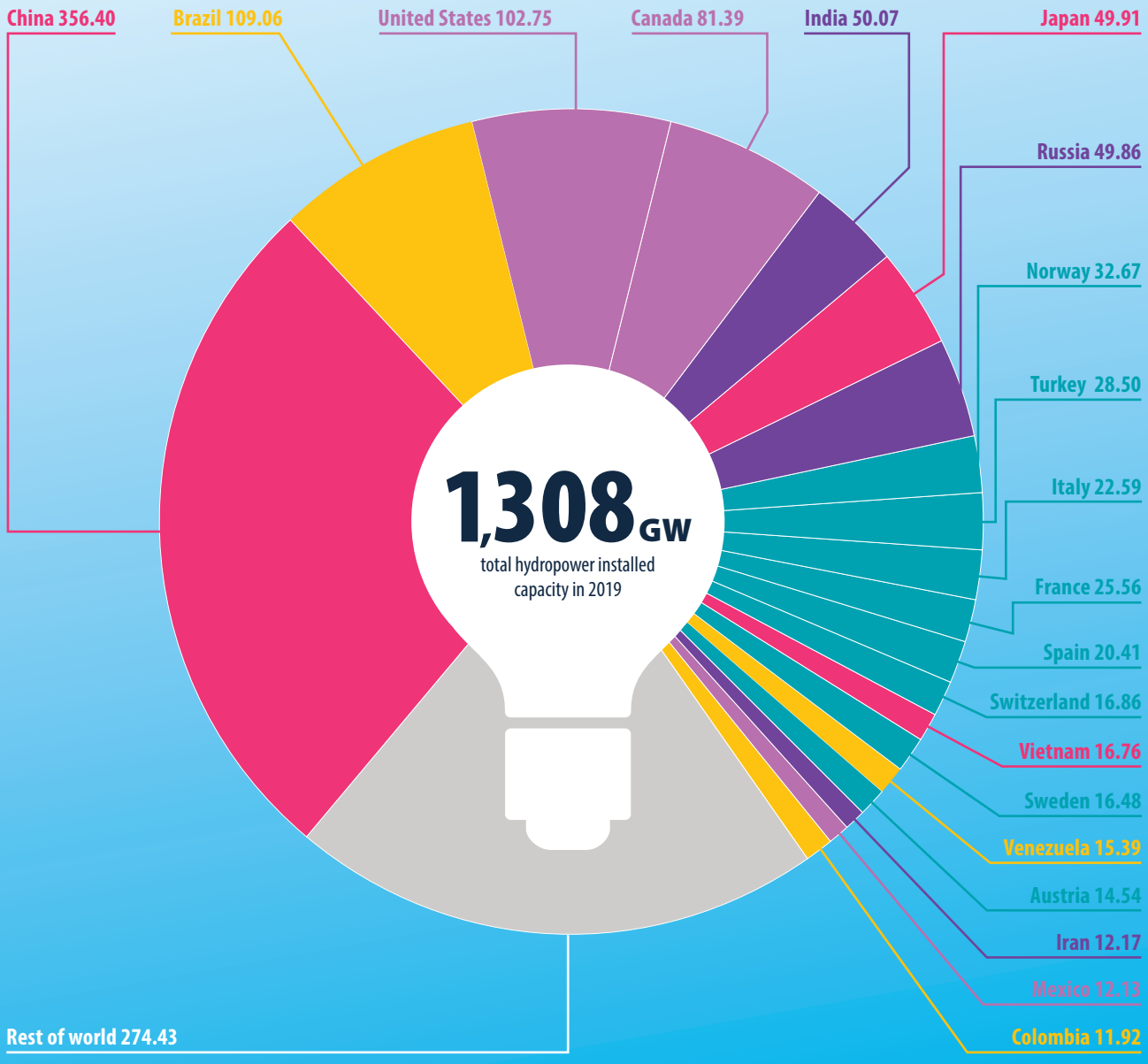
Ranking	Country/Territory	Capacity added (MW)
1	Brazil	4919
2	China	4170
3	Laos	1892
4	Bhutan	720
5	Tajikistan	600
6	Russia	463
7	Angola	334
8	Uganda	260
9	Ethiopia	254
10	Turkey	219
11	Nepal	176
12	India	154
13	Iran	150
14	Indonesia	144
15	Norway	134
16	Italy	95

Ranking	Country/Territory	Capacity added (MW)
17	Colombia	81
18	Malaysia	80
19	Vietnam	80
20	Bolivia	77
21	Philippines	71
22	Guatemala	58
23	Georgia	50
24	Serbia	49
25	Cameroon	45
26	Chile	38
27	Spain	38
28	Peru	33
29	Austria	29
30	Portugal	24
31	Argentina	22
32	France	21

Ranking	Country/Territory	Capacity added (MW)
33	Kazakhstan	20
34	Sweden	18
35	South Korea	18
36	Finland	14
37	Switzerland	13
38	Poland	13
39	Romania	12
40	Uzbekistan	11
41	Malawi	8.2
42	New Zealand	8
43	United States	7.6
44	Honduras	7.6
45	Burkina Faso	2.6
46	Chinese Taipei (China)	2.2
47	Ecuador	1.65
48	Rwanda	1.38

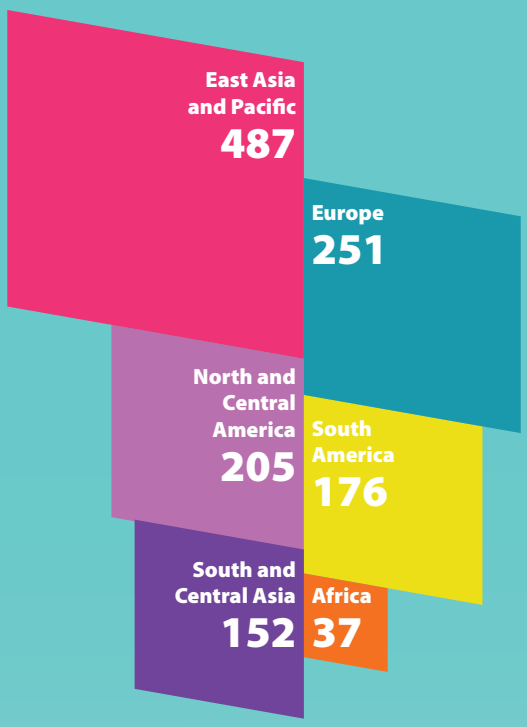
Figures above 10 MW rounded to nearest MW.

Global hydropower installed capacity

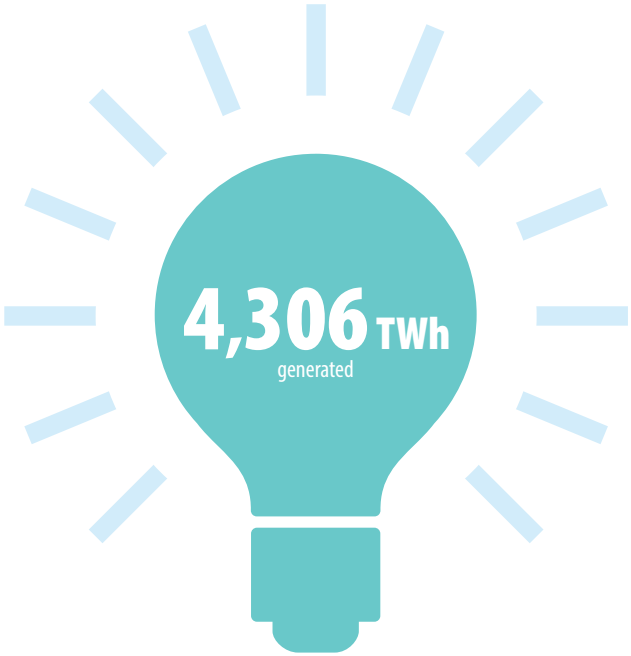


Hydropower installed capacity (GW) of top 20 hydropower producers and the rest of the world, including pumped storage (2019)

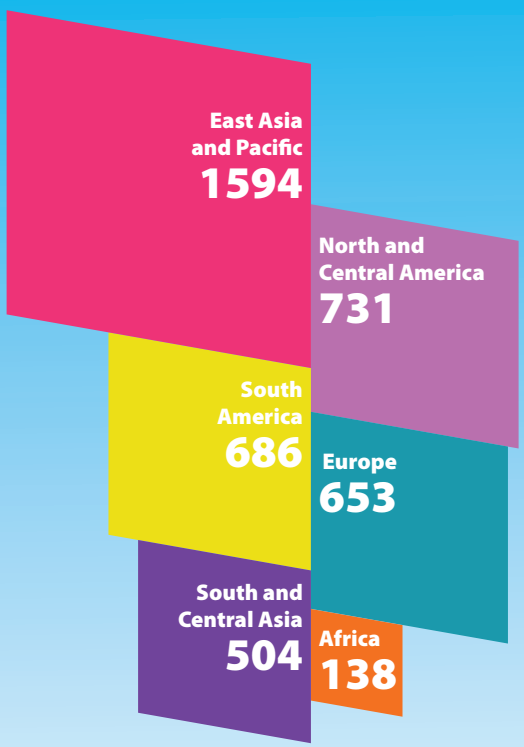
Hydropower capacity by region (GW)



East Asia and the Pacific, thanks to the vast contribution of Chinese hydropower, remains the largest hydropower producing region by installed capacity at 487 GW. Africa, by contrast, with its large untapped hydropower potential has the smallest installed capacity at 37 GW.



Hydropower generation by region (TWh)



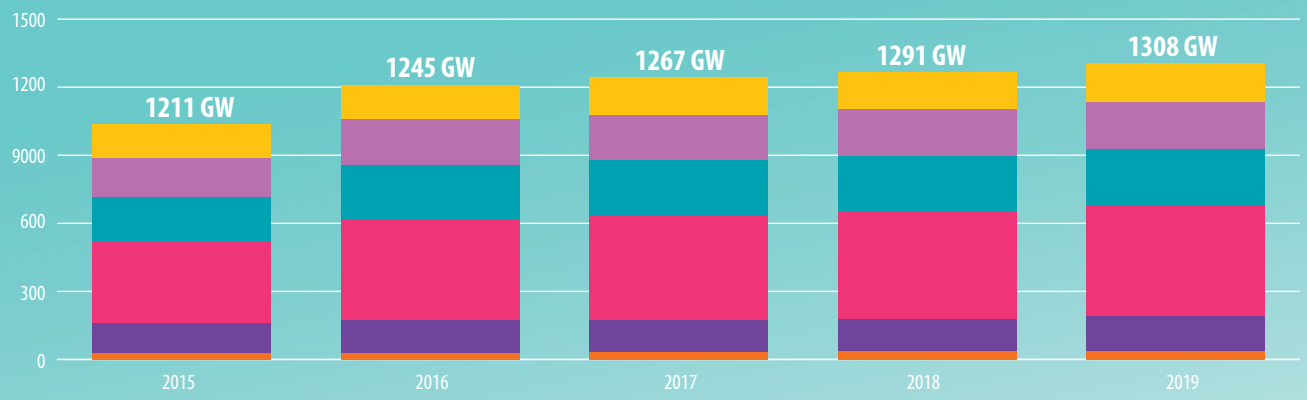
Hydropower growth in context

In order to limit the global temperature rise to below 2°C above pre-industrial levels, IRENA in its 'Transforming Energy Scenario' suggests global hydropower capacity would need to increase by 25 per cent by 2030, and by 60 per cent by 2050. This equates to around 850 GW in additional installed capacity over the next 30 years – roughly the same as adding the European Union's entire power system capacity.

To reach the 2050 target, the yearly average growth in hydropower capacity would need to reach an estimated 2.0 per cent a year on average.

In the five years between 2015 and 2019, the average year-on-year growth in installed capacity was 2.1 per cent. In 2019, the growth rate was 1.2 per cent. Annual growth in installed capacity can however vary considerably depending on when major hydropower projects, which take years to develop, become operational. Notwithstanding, this underlines the need for investment in hydropower to increase significantly over the next decade and more.

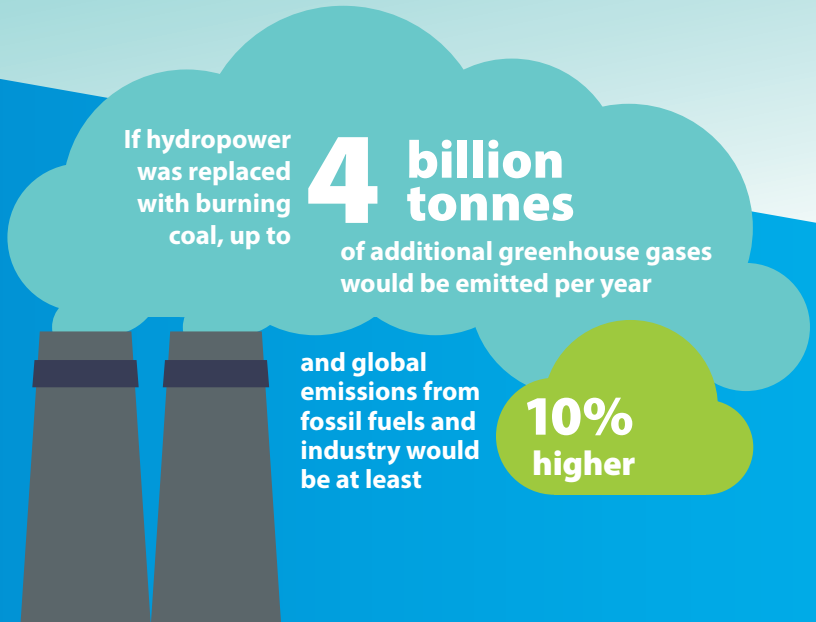
Hydropower installed capacity growth, 2015-2019



Emissions and pollution avoided

If hydropower was replaced with burning coal for electricity generation, analysis by IHA suggests that around 3.5 to 4.0 billion metric tonnes of additional greenhouse gases would be emitted annually, and global emissions from fossil fuels and industry would be around 10 per cent higher.

In addition, using hydropower instead of coal avoids the production of around 150 million tonnes of air polluting particulates, 60 million tonnes of sulphur dioxide, and 8 million tonnes of nitrogen oxide – avoiding many health, environment and climate impacts.



Pumped storage hydropower: the world's water battery

Energy storage in the form of pumped storage hydropower (PSH), the world's 'water battery', is a proven technology that has continuously evolved to suit the needs of changing power systems. PSH currently accounts for over 94 per cent of installed global energy storage capacity, and over 96 per cent of energy stored in grid scale applications.

Crucially, pumped storage helps to accommodate the intermittency and seasonality of variable renewable energy (VRE) sources such as wind and solar. The flexibility it can provide through its storage and ancillary grid services, is increasingly important in ensuring power supply meets demand across multiple timescales.

Enhanced by the latest technological advancements, PSH also provides flexibility through system inertia, frequency control, voltage regulation, storage and reserve power with rapid mode changes, and black-start capability. All of these are vital to support the ever-growing proportion of VRE in grid systems. PSH particularly excels at its long discharge duration and high-power capacity that will be crucial in avoiding VRE curtailment, reducing transmission congestion, and reducing overall costs and emissions in the power sector.

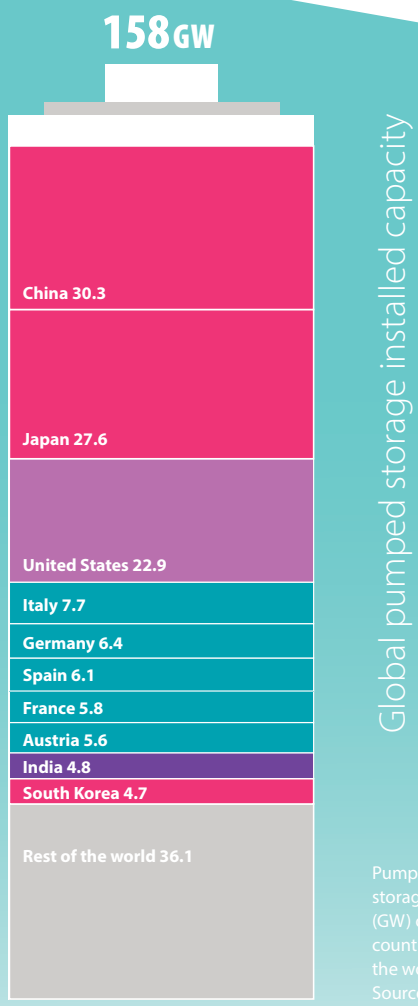
Furthermore, PSH enjoys several distinct advantages over other forms of energy storage due to its long asset life, low lifetime cost and independence from raw material availability.

Multiple studies have identified vast potential for PSH sites worldwide and there is growing research on retrofitting PSH at disused mines, underground caverns, non-powered dams and conventional hydro plants, representing vast untapped PSH potential. As a result of a resurgence of interest in PSH around the world, it is estimated that global PSH capacity will grow by 78 GW by 2030, considerably more than other forms of energy storage technologies.

However, market regulations and policy frameworks do not yet incentivise this technology. The flexibility and storage services provided by PSH are not appropriately valued. As a result, the lack of a strong business case has hindered private sector investment in PSH development, as is evidenced in the low rate of growth in pumped storage globally in 2019. Only 304 MW of new pumped storage capacity was added last year, as some projects in China missed their deadlines.

IHA is actively responding to this given the growing interest in the need for energy storage, and is promoting exchange of knowledge and experience, to help understand and shape the role of pumped storage hydropower in future power systems.

For more in-depth analysis, please read IHA's working paper, The World's Water Battery: Pumped Hydropower Storage and the Clean Energy Transition.



Pumped hydropower storage capacity (GW) of top 10 countries and rest of the world in 2019. Source: IHA 2019.

Sector news and insights

Clean energy systems

World Hydropower Congress delivers priorities for action

Investment in hydropower will deliver reliable, affordable and sustainable clean energy systems. The true value of hydropower is however not well recognised. This was the conclusion of delegates attending the World Hydropower Congress in Paris in May 2019. The biennial event attracted 750 attendees from over 70 countries and delivered a range of priorities for action for the sector covering policies on clean energy systems and modernisation, sustainability and strategic planning, and climate change and resilience.

Hydropower group initiated at IRENA General Assembly

The government of Switzerland together with IHA, the World Bank and Norway co-organised a ministerial plenary session on hydropower at the 9th General Assembly in January 2020. This resulted in a proposal from Switzerland to establish an IRENA Hydropower Group to steward the cause of hydropower in IRENA. More than 40 member countries supported the initiative. The group will aim to provide a global platform for dialogue, cooperation and coordinated action between the hydropower sector, policy-makers and other stakeholders in addressing opportunities and challenges in hydropower development.

Renewables-plus-storage model can beat coal and gas

Research indicates that solar and wind energy combined with storage are cheaper alternatives to fossil fuels. According to a report by Australia's national science research agency (CSIRO) and the Australian Energy Market Operator (AEMO), variable renewable technologies combined with storage are among the cheapest forms of low carbon options that can already beat coal, gas and nuclear. The report also indicated that pumped storage hydropower has a distinct competitive advantage in longer duration storage applications" and "pumped hydro is one technology which likely benefits from the increased competitiveness of wind and solar PV generation which creates demand for system balancing technologies".

Seasonal pumped storage to address energy and water challenges

The first global assessment of seasonal pumped hydropower storage (SPHS) potential suggests it could gain a more prominent role in providing long-term, low-cost energy storage, according to International Institute for Applied Systems Analysis. Given the vast untapped and cheap potential of SPHS, it will soon play an important role in storing energy and water on a yearly basis, according to the authors. The study identified more than 1,000 suitable locations worldwide and the associated unit costs for energy and water storage services. The results suggested that SPHS costs vary from 0.007 to 0.2 USD per m^3 of water stored, 1.8 to 50 USD per MWh of energy stored and 370 to 600 USD per kW of installed power generation.

Expanding transmission lines reduces power system costs

The transition to low-carbon electricity can be achieved at a lower cost by using hydropower reservoirs for energy storage, suggests research by the MIT Center for Energy and Environmental Policy Research. The study shows that two-way power flows between the U.S. Northeast and Quebec can help reduce overall power system costs, decrease dependence on natural gas, and lowering the need for carbon capture and sequestration in a decarbonised electricity system. The authors estimate that the addition of 4 GW of new transmission between New England and Quebec would lower the costs of a zero-carbon electricity system in these regions by 17-28 per cent.

Gulling, Germany.
Credit: Wien Energie.

Finance and modernisation

Annual global investment in hydropower tops US$50 billion

Global investment in hydropower in 2018 topped US$50 billion according to the International Energy Agency (IEA)'s World Energy Investment 2019 report. While at similar levels to previous years, it is still well short of the estimated US$100 billion a year required to help meet the energy-related components of the IEA's Sustainable Development Scenario. Under this scenario, which is compatible with the objectives of the Paris Agreement, around an additional 800 GW of hydropower capacity would need to be commissioned by 2040.

Hydropower green bond standard closer to becoming reality

To date, hydropower's involvement in the green bond market has been held back by a lack of clarity over appropriate climate-related and broader sustainability eligibility criteria. In 2019, the Climate Bonds Initiative published a consultation on their proposed green bond hydropower eligibility criteria, which recommends the use of tools developed by IHA such as the G-res Tool and Hydropower Sustainability ESG Gap Analysis Tool. While still under development, the hydropower sector is hopeful that the criteria will be ready for market use later this year.

World-first approach to remunerating flexibility services

Considered a world-first approach to managing the stability of the electricity system, five companies including a pumped hydropower storage operator were awarded contracts in the UK to provide flexibility services such as inertia and reactive power. The six-year contract awarded by the National Grid Electricity System Operator will see one of the four turbines at Drax's 440 MW Cruachan pumped storage station no longer generate power; instead the turbine will be used solely to provide flexibility services needed to support the system.

Nant de Drance, Switzerland. Credit: Alpiq.

European initiative to deliver new hydropower research agenda

A new three-year project to develop a research and innovation agenda and technology roadmap for the hydropower sector was launched in February 2019. The multi-partner Hydropower Europe initiative – led by the International Commission on Large Dams (ICOLD) and supported by IHA – aims to agree common research priorities for hydropower in Europe. It will guide funding authorities such as the European Commission to prioritise support aimed at helping the sector adapt to a constantly evolving energy system.

XFLEX HYDRO initiative to demonstrate hydropower's flexibility

The European Commission launched an €18 million initiative – Hydropower Extending Power System Flexibility (XFLEX HYDRO). The project is being delivered by a consortium of 19 partners including utilities, manufacturers, universities and consultancies and is led by École polytechnique fédérale de Lausanne (EPFL). XFLEX HYDRO will last four years and demonstrations are planned at seven sites in Europe, covering pumped storage, reservoir storage and run-of-river hydro. Innovative technologies include smart digital controls, enhanced variable- and fixed-speed turbines, as well as a battery hybrid.

Sector news and insights

Climate and freshwater

UN Water report highlights role of hydropower

Exploring the theme of 'Water and Climate Change', UN Water's report on World Water Day 2020 highlighted that hydropower forms an essential part of the solution to climate change. "Hydropower will continue playing a role in climate change mitigation and adaptation of the energy sector", the World Water Development Report stated, acknowledging the need for low-carbon renewable energy. The UN agency recognised multipurpose hydropower reservoirs contribute to flow regulation, flood control and availability of water for irrigation. To maximise their role in mitigating climate change, hydropower projects need to be developed and operated sustainably, taking into account biodiversity, river ecology and hydrology, sediment transport, local livelihoods, and greenhouse gas emissions, it noted.

New guidance to strengthen climate resilience

The United Nations climate conference (COP25) in Madrid brought special attention to climate resilience and adaptation, highlighting the need for capacity building to prepare for climate change. Aiming to ensure the long-term operational viability of new and existing assets, IHA launched the Hydropower Sector Climate Resilience Guide in May 2019 to provide good practice guidance on how to incorporate climate resilience measures into project planning, design and operations. This guide positions hydropower ahead of other renewable energies in their adaptation to climate change.

Hydropower sector leaders adopt zero carbon target

As governments around the world set a target of 2050 for their economies to become carbon neutral, leading hydropower operators and manufacturers including GE, Landsvirkjun and Voith agreed their own ambitious timetables to become zero carbon. Targets range between 2020 and 2025 for operations to become carbon neutral using a range of measures to reduce, prevent and sequester emissions, including using energy efficiency, self-generation and carbon credit schemes.

Businesses source hydropower to limit emissions

Technological giant Microsoft is among the forward-thinking businesses pledging to become carbon neutral by sourcing clean energy from local hydropower sources for its headquarters in Washington, USA. Similar moves were observed in energy intensive industries such as the aluminium smelting sector. China Hongqiao Group, the world's largest aluminium producer, is moving two million tonnes of annual production from Shandong to Southwest China's Yunnan province to take advantage of clean hydropower. Russia's Rusal, owned by En+ Group, has also taken steps to close its coal-powered smelters and invest in hydropower smelters.

Rural electrification intake, Africa.
Credit: Gilkes

Kota 2, a mini run-of-river scheme in northern Sarawak. Credit: Sarawak Energy.

Sustainability assessments

Assessment tools aligned with World Bank and IFC

The Hydropower Sustainability Tools were enhanced in May 2020 to better align with ESG requirements set by IFIs. Use of the tools will mean hydropower developers better understand how their project can achieve the performance standards required by major investment banks. The assessment tools comprise the Hydropower Sustainability Assessment Protocol (HSAP), which is used to assess projects against 26 environmental, social and governance performance areas, and the Hydropower Sustainability ESG Gap Analysis Tool, which identifies gaps against good practice. The tools offer a scoring framework specific to hydropower, and cover topics such as climate change and hydrological resource.

New guidance on indigenous peoples' consent

Projects which achieve the Free, Prior and Informed Consent (FPIC) of affected Indigenous Peoples will now be recognised as meeting international good practice in sustainable hydropower development, according to updated language in the Hydropower Sustainability Tools. FPIC is a principle recognised in the UN Declaration on the Rights of Indigenous Peoples and is a condition of performance standards issued by the World Bank and International Finance Corporation. The Hydropower Sustainability Assessment Council, a multi-stakeholder group of social and environmental NGOs, industry, government and financial institutions, released the guidance to give increased confidence to local communities, industry and investors that hydropower projects can be successfully developed while respecting Indigenous Peoples' lands, rights and culture.

Sustainability assessment fund launched

IHA launched the Hydropower Sustainability ESG Assessment Fund to award 1 million Swiss Francs (USD 1.02m) to 40 hydropower projects between 2020 and 2024. Financed by the Swiss government, the fund will aid hydropower project developers and operators to benchmark and raise their social and environmental performance. Successful recipients will receive a grant to part-finance the cost of commissioning an independent project assessment.

Emissions reporting tool endorsed by IPCC and EU

The Intergovernmental Panel on Climate Change (IPCC) demonstrated its confidence in the science underpinning the G-res Tool, which was developed by IHA and the UNESCO Chair in Global Environmental Change, for reporting greenhouse gas emissions from reservoirs. The IPCC refined its Guidelines for National Greenhouse Gas Inventories in 2019, including freshwater reservoir emissions derived from the G-res Tool's estimations for methane and carbon dioxide. In addition, the EU's Technical Expert Group on Sustainable Finance recommended the G-res Tool as a methodology to assess the carbon footprint of hydropower facilities.

An Indigenous Peoples prayer ceremony at Nepal's UT-1 hydropower project

Hydropower sustainability

Hydropower Sustainability Tools

Hydropower, as with any major infrastructure development, will inevitably bring change to a landscape. The challenge is how to make sure that change is responsibly managed and sustainable.

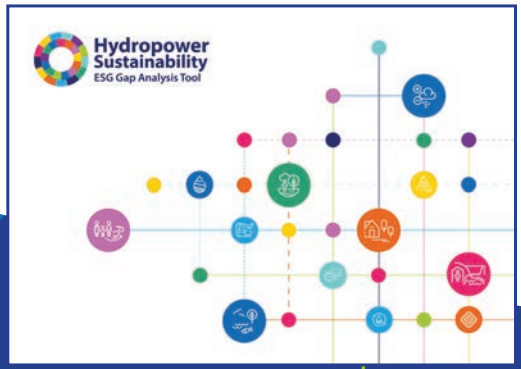
After two decades of multi-stakeholder consultation and governance, IHA and a broad coalition of partners from all sectors have developed a suite of tools to assess and improve the sustainability of hydropower projects.

The Hydropower Sustainability Tools define international good and best practice in hydropower development. They provide a common language for governments, civil society, financial institutions and industry to discuss and evaluate environmental, social and governance (ESG) performance.

The tools comprise the Hydropower Sustainability Guidelines on Good International Industry Practice (HGIIP) as well as two assessment tools: an Assessment Protocol (HSAP), to measure performance above and below defined good practice, and an ESG Gap Analysis Tool (HESG), for checking gaps against good practice and delivering a gap management plan.

The tools are governed by the Hydropower Sustainability Assessment Council, whose more than 100 members include representatives of social and environmental NGOs, intergovernmental organisations, development banks, governments and hydropower companies and contractors.

As the management body for the tools, IHA's sustainability division oversees and provides capacity building, training and accreditation for independent assessors in the use of the tools. It ensures the tools continue to be relevant for the sector and aligned with standards developed by the World Bank, the International Finance Corporation and the Equator Principles group of banks.



Teesta V, India.
Credit: NHPC Limited

India

Teesta-V

The Teesta-V hydropower station, located in Sikkim, in northern India, was rated as an example of international good practice in hydropower sustainability in 2019. The 510 MW power station, owned and operated by NHPC Limited, was reviewed by a team of accredited assessors using the HSAP. The assessment, the first of its kind in India, was conducted between January and June and involved two visits to the project area as well as numerous stakeholder interviews.

According to the assessment, Teesta-V met or exceeded international good practice across all 20 performance criteria. The station is part of a cascade of hydropower projects along the Teesta River. Commissioned in 2008 as the first large-scale power station in Sikkim, it was built to supply power to Sikkim's Energy and Power Department, and other state-owned distribution companies in India's eastern region.

Costa Rica

Reventazón

Reventazón Hydropower Plant in Costa Rica was awarded the 2019 IHA Blue Planet Prize in recognition of its excellence in sustainable hydropower development. Reventazón is the largest hydropower project in Central America with 305.5 MW of installed capacity. The recipient was the Instituto Costarricense de Electricidad, Costa Rica's national electricity company, which built, owns and operates Reventazón.

Reventazón was the first station to be assessed in Central America using the HSAP. The assessment was conducted by a team of independent accredited assessors with financial and technical support from the World Bank Group. This involved 90 interviews with relevant stakeholders and a review of over 470 related project documents.

Reventazon, Costa Rica.
Credit: World Bank - Mario Lacayo.

North and Central America

Overview

Hurricane, USA. Credit: Gilkes.

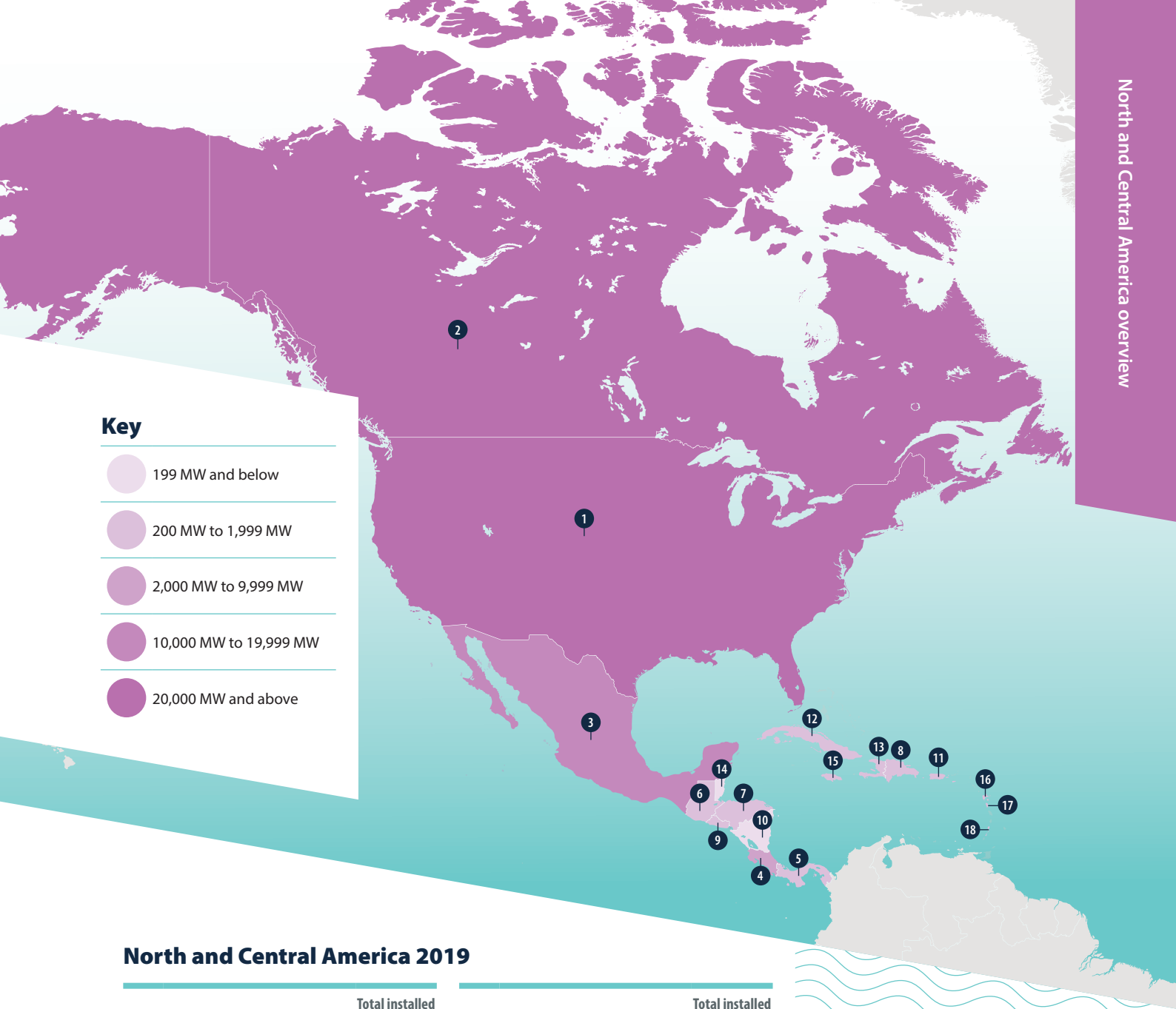
Historically, Central America's power supply has been predominantly served by hydropower, but this has fluctuated over the years. Hydropower now represents 40 per cent of the installed capacity and approximately 50 per cent of the electricity generation in the region. The Central America Electrical Interconnexion (SIEPAC) facilitates renewables in the region and the exchange of electricity between countries to strengthen their energy security.

In the Caribbean, consumers pay some of the highest electricity charges in the world, largely due to the predominance of fossil-based generation and dependence on fossil fuel imports. Hydropower represents only 6 per cent of the electricity generation. In recent years hurricanes Irma and Maria caused major damage to electricity infrastructure in many countries, exacerbating the lack of access to electricity. Countries are aiming to increase renewables through mechanisms such as national plans to develop new projects in the Dominican Republic, modernising existing hydropower facilities in Haiti, and privatising the electricity sector to attract investment in Puerto Rico.

In the United States, total hydropower capacity, including pumped storage, remained at 103 GW in 2019. While most recent hydropower growth comes from small projects, the Department of Energy estimates there is nearly 50 GW of untapped hydropower potential; including 30 GW of pumped storage and 5 GW of development at non-powered dams. The existing hydropower fleet continues to play a critical role, providing carbon-free flexibility and reliability as fossil fuels are replaced with intermittent renewables. Most States are setting carbon-free goals over the next 30 years and relying on hydropower to help achieve these.

In Canada, hydropower remains the dominant source of electricity supply, representing 61 per cent of total electricity generation and 55 per cent of total installed generation capacity in 2019. Since 2005, renewable electricity production has grown more from hydropower (growth of 40,000 GWh) than from wind and solar combined (30,000 GWh). Renewable electricity (water, wind, solar, biomass and geothermal) represented approximately 68 per cent of Canada's total electricity production in 2019.

Factors including the near-completion of several new major green-field hydropower projects and the regulated phase-out of coal-fired electricity are driving continued growth in hydroelectricity production and installed capacity. It is forecast that hydroelectricity production will have grown by a further 9 per cent by 2030 from 2019 levels, representing 62 per cent of total electricity generation in that year.



North and Central America 2019

Rank	Country	Total installed capacity (MW)
1	United States	103,000
2	Canada	82,000
3	Mexico	12,126
4	Costa Rica	2,343
5	Panama	1,786
6	Guatemala	1,559
7	Honduras	713
8	Dominican Republic	616
9	El Salvador	575

Rank	Country	Total installed capacity (MW)
10	Nicaragua	157
11	Puerto Rico	100
12	Cuba	68
13	Haiti	60
14	Belize	55
15	Jamaica	30
16	Guadeloupe	11
17	Dominica	7
18	Saint Vincent and The Grenadines	7

Including pumped storage

North and Central America
Developments

The Mexican government has emphasised the need for public energy generation and an increase in hydropower installed capacity through the upgrade of existing assets. CFE, the state-owned company, will focus on the modernisation of 18 existing hydropower plants, as well as the development of 14 new ones. There is strong opposition to new developments but Chicoasen II will resume construction after it was stalled in 2018.

Guatemala commissioned the Renace IV, which will add the last 58 MW of the 301 MW Renace Hydroelectric Complex.

The Dominican Republic has considerably increased wind and solar installed capacity as well as new hydropower projects of less than 5 MW aimed at bringing renewable electricity to rural communities.

In Haiti, the government promises to continue efforts to repair and modernise all the hydropower stations after rehabilitating the 54 MW Péligre plant, the country's main asset for both water and energy supply.

In Puerto Rico, due to privatisation, the Cooperativa Hidroeléctrica de la Montaña is taking the lead to reactivate the 15 MW Dos Bocas and 25 MW Caonillas hydropower plants, both over 70 years old. Dos Bocas is operating with 6 MW while Caonillas is not operational, due to the loss of capacity because of sedimentation.

In 2019, both the sale and purchase of electricity through the SIEPAC increased to 12.9 per cent and 13.5 per cent respectively. Guatemala was the largest seller, representing 58 per cent of the market and El Salvador the largest purchaser representing 68 per cent. The SIEPAC continues to expand however the Covid-19 crisis is affecting the regional market and limiting the transactions.

As at January 2020, the United States had issued three licenses for 2 GW of new pumped storage projects and another 22 GW had received preliminary permits. Although demand for storage is increasing, the primary obstacle for deployment of additional pumped storage hydropower is obtaining long term financing to cover high up-front capital costs. The Department of Energy Water Power Technologies Office continues to see record funding levels for hydropower research and development, including US$70 million for marine energy and US$35 million for conventional hydropower.

Generation by hydropower
731 TWh

Total installed capacity*
205 GW
*including pumped storage

Capacity added in 2019
73 MW

Pumped storage installed capacity
23 GW

Pumped storage capacity added in 2019
00 MW

Hurricane, USA.
Credit: Gilkes.

Top 3 countries by capacity added in 2019

1st	Guatemala	58 MW
2nd	Honduras	7.6 MW
3rd	United States	7.6 MW

In Canada, the most significant green-field hydropower projects have a total installed capacity of almost 3,000 MW and include: Site C in British Columbia (1,100 MW, in-service by 2025); Muskrat Falls in Newfoundland and Labrador (824 MW, in service by 2020); Keeyask in Manitoba (695 MW, in service in 2020); and La Romaine Complex Unit 4 in Quebec (245 MW in service in 2021).

Pumped storage hydro projects in development in Canada include five with a total installed capacity of up to 2,400 MW: TC Energy Pumped Storage Project (1,000 MW) and Marmora Pumped Storage Facility (400 MW) in Ontario; Brazeau Pumped Storage Hydro (300 – 900 MW) and Canyon Creek Project (75 MW) in Alberta; and Moon Lake Pumped Storage Hydro Project (25 MW) in British Columbia.

Several new transmission projects that would interconnect provinces with surplus hydroelectricity to those phasing out coal-fired electricity generation (and to territories seeking cleaner alternatives to diesel fuel in remote areas), continue to be studied. Additional transmission capacity to enable imports and exports to the United States is also under development and/or construction.

South America

Overview

Uhe ilha Solteira, Brazil.
Credit: CTG

South America saw the fastest hydropower growth rate after the East Asia and Pacific region in 2019 with close to 5,172 MW of capacity added. In this year, Brazil surpassed China with 4,919 MW of added capacity. This was mainly attributed to the completion of the 11,233 MW Belo Monte hydropower plant.

Brazil's government has included four hydropower plants among the projects that will receive support as part of the country's new energy investment programme, following the change in government in 2019. These four hydropower plants are the 650 MW Bem Querer, 430 MW Tabajara, 140 MW Castanheira, and the 118 MW Telemaco Borba projects. Unfortunately, the Bem Querer and Tabajara sites are in the Amazon region where opposition groups claim adverse effects in conservation areas and indigenous lands. Due to the Covid-19 crisis, the government has suspended energy generation and transmission auctions. The state-owned planning company, EPE, will evaluate when to resume these.

The region is moving to a diversified renewable electricity mix. Countries like Colombia, Venezuela and Ecuador in the Andean subregion have installed hydropower capacity exceeding two-thirds of the electricity share. However, the increased climate variability associated with ENSO events in this area is challenging the strong reliance on hydropower.

Chile and Argentina are also moving away from fossil fuel generation with large untapped renewable energy resources of hydropower, wind, solar and geothermal. Chile currently has almost 16 GW and Argentina almost 33 GW of hydropower potential. With an ambitious goal of producing 60 per cent of its electricity from renewable energy resources by 2035, Chile has achieved installed capacity of 10.8 per cent from solar and 8.6 per cent from wind in its national electricity grid. Argentina has achieved 1.1 per cent from solar and 4 per cent from wind. In Argentina and Chile 33 per cent and 28 per cent respectively of installed capacity is from hydropower.

In Paraguay, the 2040 national energy policy is aimed at harnessing the country's renewable resources for the country's social and industrial economic development. Similarly, Uruguay is looking to exploit their renewable resources further to increase energy security and decarbonise other sectors of the economy.

South America 2019

Rank	Country	Total installed capacity (MW)
1	Brazil	109,058
2	Venezuela	15,393
3	Colombia	11,918
4	Argentina	11,310
5	Paraguay	8,810
6	Chile	6,739
7	Peru	5,396
8	Ecuador	5,074
9	Uruguay	1,538
10	Bolivia	735
11	Suriname	190
12	French Guiana	119
13	Guyana	0.5

Including pumped storage

South America
Developments

In Brazil, Jair Bolsonaro inaugurated the 11,233 MW Belo Monte hydropower plant, which will provide electricity to 60 million people. It is the largest in Brazil (excluding Itaipu Binational), the fourth largest in the world, and a source of national pride as the development and construction was undertaken by Brazilian companies.

In May 2019, Iberdrola inaugurated the 350 MW Baixo Iguaçu hydropower plant. The plant will provide electricity to one million people in the state of Parana.

In Colombia in September 2019, the insurance company Mapfre concluded that the incident at the Ituango hydropower plant in 2018, when heavy rainfall and landslides caused damage, are within its policy coverage. This allows up to US$2,556 million of infrastructure and equipment damage, plus US$628 million in lost profits. The claim's value is still to be determined but it will be one of the largest claims in the history of engineering. The project is still in construction, and expected to start operating in 2021, with an additional estimated cost of US$1 billion. It will support 17 per cent of the country's electricity demand.

As part of the Peruvian government's commitment to become self-sufficient in energy by 2040, several hydropower plants are expected to enter into operation in the coming years. In 2019, the 84 MW Callahuanca hydropower plant restarted operations after two years of rehabilitation following damage caused by landslides in 2017. Also, two new hydropower plants, El Carmen (8.4 MW) and 8 de Agosto (19 MW) entered into operation.

Bolivia's President inaugurated in June the 69 MW San Jose II, the second plant of the 124 MW San Jose Complex. This is a step closer to achieving enough reserves to cover the country's electricity demand and to begin exporting electricity to its neighbours. Negotiations to export electricity to Argentina are in progress. The next project in the pipeline is the 147 MW Banda Azul hydropower plant. ENDE Corani, the state-owned company, is looking for financiers for the US$300 million investment, with the aim of launching the call to construct it during 2020.

Generation by hydropower
684 TWh

Total installed capacity*
177 GW
*including pumped storage

Capacity added in 2019
5,011 MW

Pumped storage installed capacity
1 GW

Pumped storage capacity added in 2019
0 MW

Uhe Jupia, Brazil.
Credit: CTG

Top 5 countries by capacity added in 2019

1st	Brazil	4,919.18 MW
2nd	Colombia	80.61 MW
3rd	Bolivia	76.84 MW
4th	Chile	38.22 MW
5th	Peru	33.27 MW

In 2019, the 1,890 MW Salto Grande Hydropower Complex between Argentina and Uruguay began a programme of modernisation with the aim of enhancing electricity production, efficiency and security. The 30-year programme will include renovating electrical and electro-mechanical equipment as well as civil infrastructure.

In Venezuela, several failures in the electricity system caused a shut-down of public infrastructure, leaving millions of people across the country without electricity. While these outages were allegedly caused by cyber-attacks, it highlights the importance of system maintenance and the need to complete rehabilitation of hydropower plants.

More recently, the development of long distance high-voltage interconnections between Ecuador and Peru financed by the IDB is currently stalled due to the Covid-19 crisis. The Ecuadorian government will use the funds to alleviate the health emergency crisis instead.

Europe

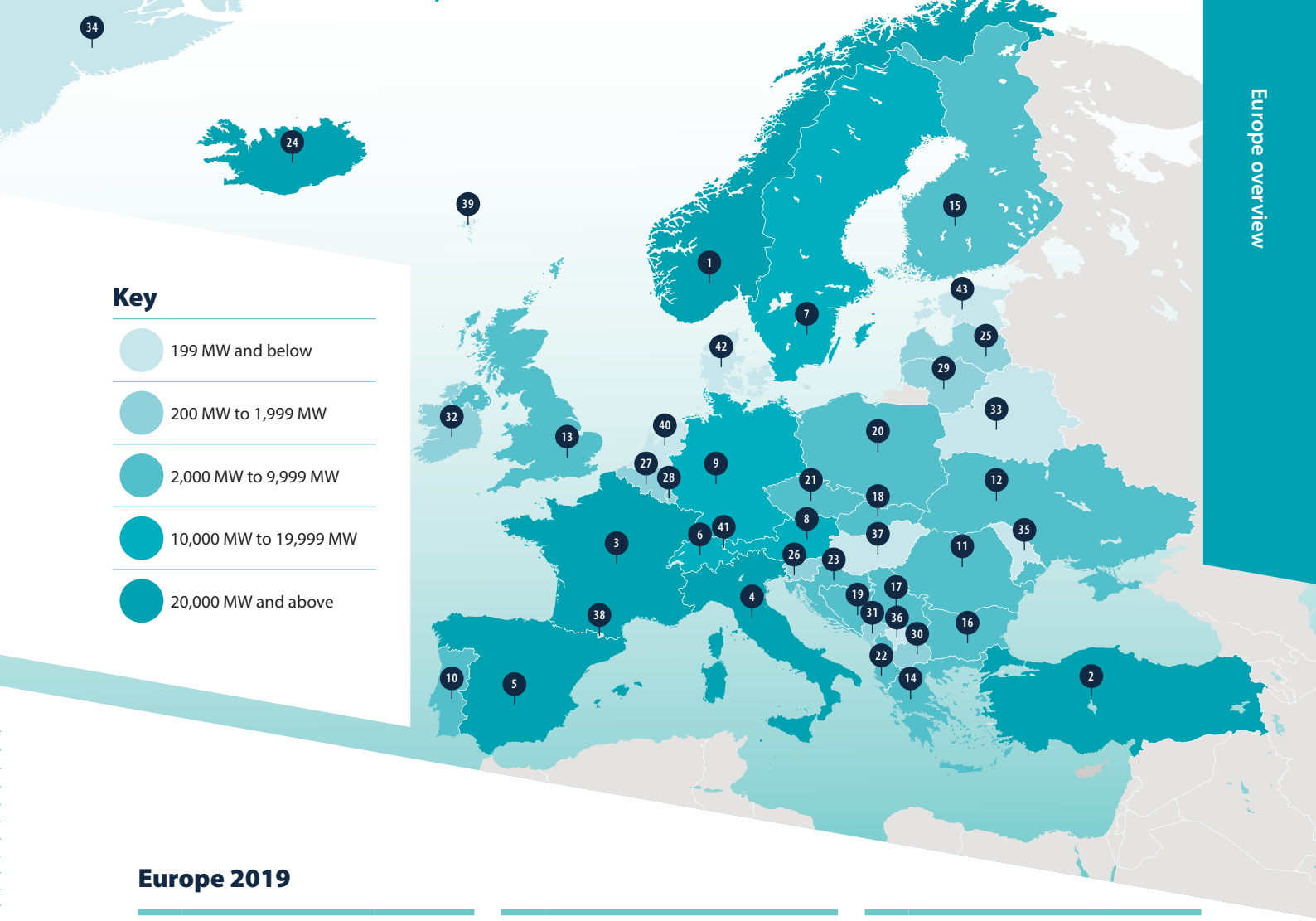
Overview

Nant de Drance, Switzerland. Credit: Alpiq.

Europe is steadily moving towards a cleaner energy mix. Trends show the power industry is reducing its carbon intensity each year; with coal generation declining across the European Union (EU-28), and contributions from wind, solar and gas increasing. Latest estimates of electricity generated in 2019 show the balance was 40 per cent from all fossil fuels (15 per cent coal), 35 per cent from renewables and 25 per cent nuclear. In capacity terms, well over 20 GW of wind and solar was added for another year running, far exceeding other sources. Looking ahead, decarbonisation looks set to continue at pace, with the EU targeting 32 per cent of all final energy consumption to come from renewables by 2030, and further policy proposals under a new Green Deal. The outlook suggests Europe will increasingly rely on hydropower's renewable and dispatchable generation as an essential source of supply.

Over the last five years hydropower has grown by around 10 GW (5 per cent) across the continent, beyond the EU-28. Annual generation has been variable in different regions, with drier weather reducing output in southern countries over recent years. As an established sector in Europe, many of the main sites have already been developed, and in 2019 capacity remained relatively stable. However, there are a number of projects in the pipeline, and greenfield growth is expected around the fringes of the EU bloc. New pumped hydropower storage is another focus area, as well as modernisations or even expansions of existing sites. Small-scale hydropower has also been identified for development, though faces environmental opposition in many countries.

Hydropower featured in regional planning and policy updates released last year. For example, 12 proposed pumped storage projects were included in the European Commission's recently updated list of cross-border Projects of Common Interest (PCIs). Recommendations were also published as part of the EU Taxonomy for sustainable finance, in the form of guidance and eligibility criteria for investments into sectors. These support green growth and align with the EU's net zero 2050 target, including hydropower. Furthermore, the Commission launched research and innovation initiatives focusing on hydropower's potential, including Hydropower Europe, XFLEX HYDRO (Hydropower Extending Power System Flexibility), and Hydroflex, which kicked-off in 2018.



Europe 2019

Rank	Country	Total installed capacity (MW)
1	Norway	32,671
2	Turkey	28,503
3	France	25,557
4	Italy	22,593
5	Spain	20,414
6	Switzerland	16,863
7	Sweden	16,478
8	Austria	14,545
9	Germany	11,022
10	Portugal	7,193
11	Romania	6,313
12	Ukraine	6,229
13	United Kingdom	4,712
14	Greece	3,400
15	Finland	3,257

Rank	Country	Total installed capacity (MW)
16	Bulgaria	3,129
17	Serbia	3,098
18	Slovakia	2,522
19	Bosnia and Herzegovina	2,513
20	Poland	2,385
21	Czech Republic	2,268
22	Albania	2,193
23	Croatia	2,141
24	Iceland	2,086
25	Latvia	1,576
26	Slovenia	1,524
27	Belgium	1,427
28	Luxembourg	1,330
29	Lithuania	1,016
30	Macedonia	674

Rank	Country	Total installed capacity (MW)
31	Montenegro	658
32	Ireland	529
33	Belarus	97
34	Greenland	91
35	Moldova	76
36	Kosovo	92
37	Hungary	56
38	Andorra	45
39	Faroe Islands	39
40	Netherlands	38
41	Liechtenstein	35
42	Denmark	9
43	Estonia	8

Including pumped storage

Europe
Developments

Industry and governments have continued to invest in the hydropower sector. In Scandinavia, Norway's hydropower capacity grew by 134 MW as a series of new small-scale projects opened in 2019. These include the 23 MW Nye Verma site in Rauma and others such as Nye Suvdøla, Holen, Søråni, and Vassenden. Sweden's state-owned utility reported 200 GWh in efficiency improvements achieved last year for its hydro fleet and plans to add 600 MW from upgrades by 2023.

In the UK, refurbishment of the Ffestiniog pumped storage plant is moving ahead, with further pumped hydro planned in the UK as well as in Ireland. Last year milestones were reached in building the North Sea Link and NordLink, projects to interconnect Norway to the UK and Germany respectively to enable trading of renewable electricity. Further north, plans were approved in Iceland to build a new hydro plant in the remote Strandir region, on Ófeigsfjörður fjord.

On the continental mainland, a new 240 MW Pelton turbine was inaugurated at La Coche pumped storage station in France, replacing old units and increasing the site's capacity by 20 per cent. Just over the border in Switzerland, construction of the 900 MW Nant de Drance pumped storage plant achieved first water fill, while 18 MW Murkraftwerk was commissioned in Austria alongside other small plants. There are plans to expand pumped storage in central Europe including Austria, and further east, for example in the Baltic states.

Modernising stations is currently the main focus in the Czech Republic, which has developed about 60 per cent of its domestic hydro potential; as has neighbouring Slovakia. In Italy, a deal was signed to install digital upgrades at 33 hydropower plants across the country.

Spain's national grid, REE, recorded only 38 MW of growth in total hydropower capacity in 2019. Similarly no major additions were made in Portugal, but the 880 MW Gouvaes pumped storage plant is planned to boost capacity and forms part of the Tamega Hydroelectric Complex under construction. Projected growth in renewables over the next decade will mean both countries will increasingly need hydro both for its generation and flexibility services including storage.

Generation by hydropower

653 TWh

Total installed capacity*

251 GW

*including pumped storage

Capacity added in 2019

682 MW

Pumped storage installed capacity

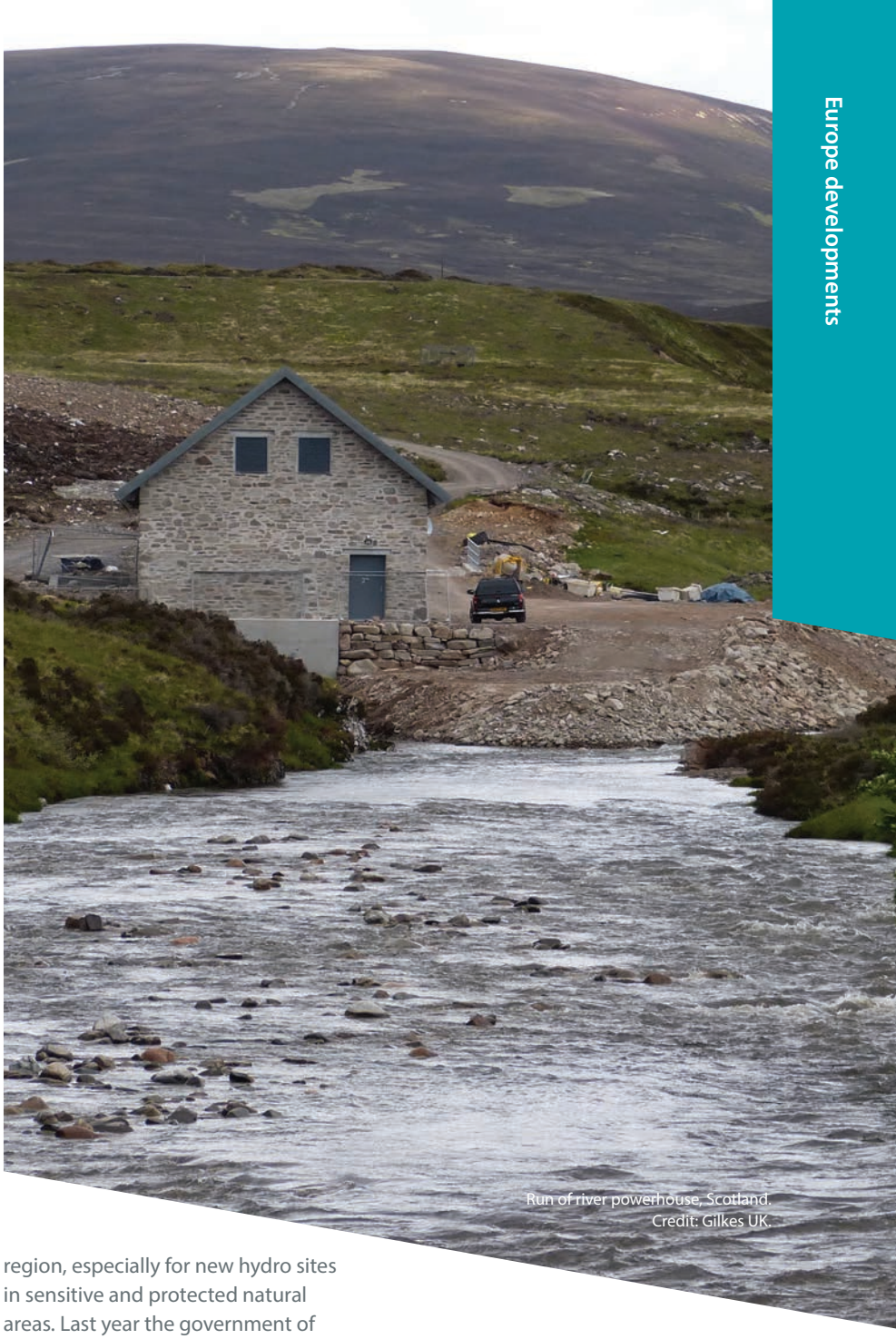
55 GW

Pumped storage capacity added in 2019

4 MW

Top 5 countries by capacity added in 2019

1st	Turkey	219 MW
2nd	Norway	134 MW
3rd	Italy	95 MW
4th	Serbia	49 MW
5th	Spain	38 MW



Run of river powerhouse, Scotland. Credit: Gilkes UK.

In recent years south eastern Europe has gained attention for its significant hydropower potential, with sites identified for development right across the Balkans. Last year a concession and prequalification process was launched in North Macedonia for the proposed 333 MW Cebren hydropower project, seen to be key for the country's energy future., Modernisation programmes are also proceeding, such as the 240 MW Sestrimo project in Bulgaria and 1,056 MW Djerdap and 96 MW (planned 125 MW) Zvornik in Serbia, among others.

Environmental concerns are however affecting hydro development in the region, especially for new hydro sites in sensitive and protected natural areas. Last year the government of Montenegro halted new concession grants for small hydropower, and in Bosnia-Herzegovina an environmental permit was cancelled for the planned 93 MW Buk Bijela project on the river Drina. But other projects still retain broad consensus, and despite set-backs the governments continue to recognise the multiple benefits hydro provides.

Finally, in Turkey hydropower capacity rose by 145 MW and stood at 31 per cent of total national capacity at the end of 2019. Among several ongoing constructions, the Ilisu Dam achieved a milestone last year with the first water fill into its huge reservoir. Upon completion, its 1,200 MW hydropower plant will be the fourth largest in the country.

Africa

Overview

Sindila, Uganda.
Credit: Metier.

With energy demand growing twice as fast as the global average, Africa has the opportunity to be the first continent to develop its economy using renewable and efficient energy. Despite being home to 17 per cent of the world's population, it accounts for just 4 per cent of global power. Access to electricity reached 54 per cent of the population in 2018, dropping to 45 per cent in the Sub-Saharan region.

From 2020 to 2050, most of the world's population growth is predicted to take place in Africa; 1.2 billion of the 1.9 billion increase expected globally. In particular, the West African power pool (WAPP) region will represent one-third of the continent's total population by 2070, with over 1.5 billion people.

Hydropower remains the main renewable resource in Africa with over 37 GW of installed capacity. It accounts for 15 per cent of the total electricity share in the region. This is predicted to increase to more than 23 per cent by 2040, following moves towards universal access and low-carbon energy transition.

In the Democratic Republic of Congo, Ethiopia, Lesotho, Malawi, Mozambique and Zambia, hydropower's share in electricity capacity exceeds 75 per cent. The countries with the highest installed capacity are Ethiopia, South Africa, Angola, Egypt, the Democratic Republic of Congo, Zambia, Mozambique and Nigeria, all with over 2 GW. In terms of generation, countries such as Mozambique, Zambia, Ethiopia, Egypt, the Democratic Republic of Congo and Angola generated more than 9 TWh each in 2019.

Africa has the highest percentage of untapped technical hydropower potential in the world, with only 11 per cent utilised. In 2019, 906 MW of hydropower capacity was put into operation across the continent.

Since 2015, significant efforts have been put into improving the socio-economic and energy situation in Africa. The African Union's 2063 Agenda; the Common African Position on the post-2015 Development Agenda; the African Development Bank priority to 'Light up and power Africa'; and the African Union Commission commitment to implementing the Paris Climate Agreement, provide the framework for economic transformation while accelerating renewable energy development.

Although Africa produces just 2 per cent of global energy-related CO2 emissions, climate-related effects are disproportionately higher in the region. This highlights the importance of a diverse power mix and regional interconnection enhancement.

Africa 2019

Rank	Country	Total installed capacity (MW)
1	Ethiopia	4,074
2	South Africa	3,596
3	Angola	3,435
4	Egypt	2,876
5	Democratic Republic of the Congo	2,750
6	Zambia	2,400
7	Mozambique	2,216
8	Nigeria	2,110
9	Sudan	1,923
10	Morocco	1,770
11	Ghana	1,584
12	Zimbabwe	1,076
13	Uganda	1,040
14	Cote D'Ivoire	879
15	Kenya	826
16	Cameroon	792
17	Tanzania	586
18	Malawi	371
19	Guinea	368
20	Namibia	347
21	Gabon	331
22	Algeria	269
23	Congo	218
24	Mali	180
25	Madagascar	164
26	Reunion	134
27	Equatorial Guinea	128
28	Rwanda	111
29	Liberia	93
30	Senegal	81
31	Lesotho	73
32	Tunisia	66
33	Sierra Leone	64
34	Mauritius	60
35	Eswatini	60
36	Burundi	58
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

In the last ten years, hydropower installed capacity has grown at an average annual rate of 4.4 per cent, with 2016 and 2017 the years with the highest growth. Yet in terms of generation, the average annual growth reached only 2.4 per cent. Climate change effects and the ageing of the hydropower fleet, with over 60 per cent of installed capacity over 20 years old, are two of the main drivers for the drop in capacity factors.

In Angola, the Lauca project commissioned one more turbine in 2019, making it the largest hydropower plant in the country with 1,670 MW of installed capacity. The remaining 401 MW is expected to be commissioned in 2020. Lauca (2070 MW) and Caculo Cabaça (2172 MW), once fully operational, will contribute to almost a third of the national target to achieve 9.9 GW of installed capacity by 2025. This is part of the Angola 2025 Energy Plan, launched in 2019, to increase access to electricity to 60 per cent of the population, with 70 per cent of electricity from renewable sources.

With a current electrification rate of 45 per cent, Ethiopia has targeted 100 per cent electrification by 2025 and an increase of 25 GW of installed capacity by 2030, with 22 GW coming from hydropower. In early 2020, Ethiopian Electric Power announced the commissioning of the Genale Dawa III project with a total installed capacity of 254.1 MW. The government's Growth and Transformation Plan (GTP) outlines a 15-year strategy with three five-year phases to transform Ethiopia from a developing country to a middle-income country by 2025.

In Uganda, two storage hydropower projects, Isimba (183.2 MW) and Achwa II (42 MW) were officially commissioned in 2019. Moreover, a total of 35.25 MW of additional capacity was added in 2019 under the Global Energy Transfer for Feed-in-Tariff (GET FiT) Programme: Sindila (5.25 MW), Ndugutu (5.9 MW), Kyambura (7.6 MW) and Siti II (16.5 MW). The total addition of over 260 MW of installed capacity could prompt tariff reduction for large-scale consumers, due to the lower prices expected from Isimba in comparison to Bujagali.

In Cameroon, the Memve'ele project, commissioned in April 2019, has started to produce 45 MW of its total 200 MW and will be fully operational by the end of 2020. Additionally, Rubagabaga (0.28 MW) and Mukungwa

Generation by hydropower

138 TWh

Total installed capacity*

37 GW

*including pumped storage

Capacity added in 2019

906 MW

Pumped storage installed capacity

3 GW

Pumped storage capacity added in 2019

0 MW

Top 5 countries by capacity added in 2019

1st	Angola	334 MW
2nd	Uganda	260.45 MW
3rd	Ethiopia	254.1 MW
4th	Cameroon	45 MW
5th	Malawi	8.2 MW

Lauca, Angola.
Credit: Andritz

II (1.1 MW) hydropower projects in Rwanda; Kasanjiku (0.64 MW) in Zambia; Samendeni (2.6 MW) in Burkina Faso; and Mulanje (8.2 MW) in Malawi, were commissioned in 2019.

With electricity demand expected to triple by 2040, efforts are being made to improve and increase transmission and distribution assets in Africa. 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. Other examples of projects under development are Nigerian-Benin-Togo-Ghana-Cote d'Ivoire Median Transmission Backbone, Egypt-Sudan, Mozambique-Malawi, the Kenya-Tanzania, and Mozambique-Zimbabwe-South Africa.

Average annual hydropower capacity growth over the 2020-2025 period is expected to double, reaching 9.7 per cent. Over 50 hydropower projects are currently under construction, representing more than 15 GW of installed capacity expected to be commissioned by 2025.

In Ethiopia, the Great Ethiopian Renaissance Dam (GERD), expected to reach 6,350 MW, was 70 per cent completed by the end of 2019. Moreover, in Cameroon, the construction of the 420 MW Nachtigal project, the biggest independent hydropower project in Sub-Saharan Africa, started in 2019 and is expected to provide one-third of the country's energy needs. In Angola, the first turbine of Caculo Cabaça (2,172 MW) is expected to be operational in 2024. In Tanzania, the construction of Stiegle's Gorge (2,100 MW) was launched in mid-2019 and Karuma (600 MW), the biggest hydropower project in Uganda, is expected to be commissioned in November 2020.

South and Central Asia

Overview

Mangdechhu, Bhutan.
Credit: MHPA.

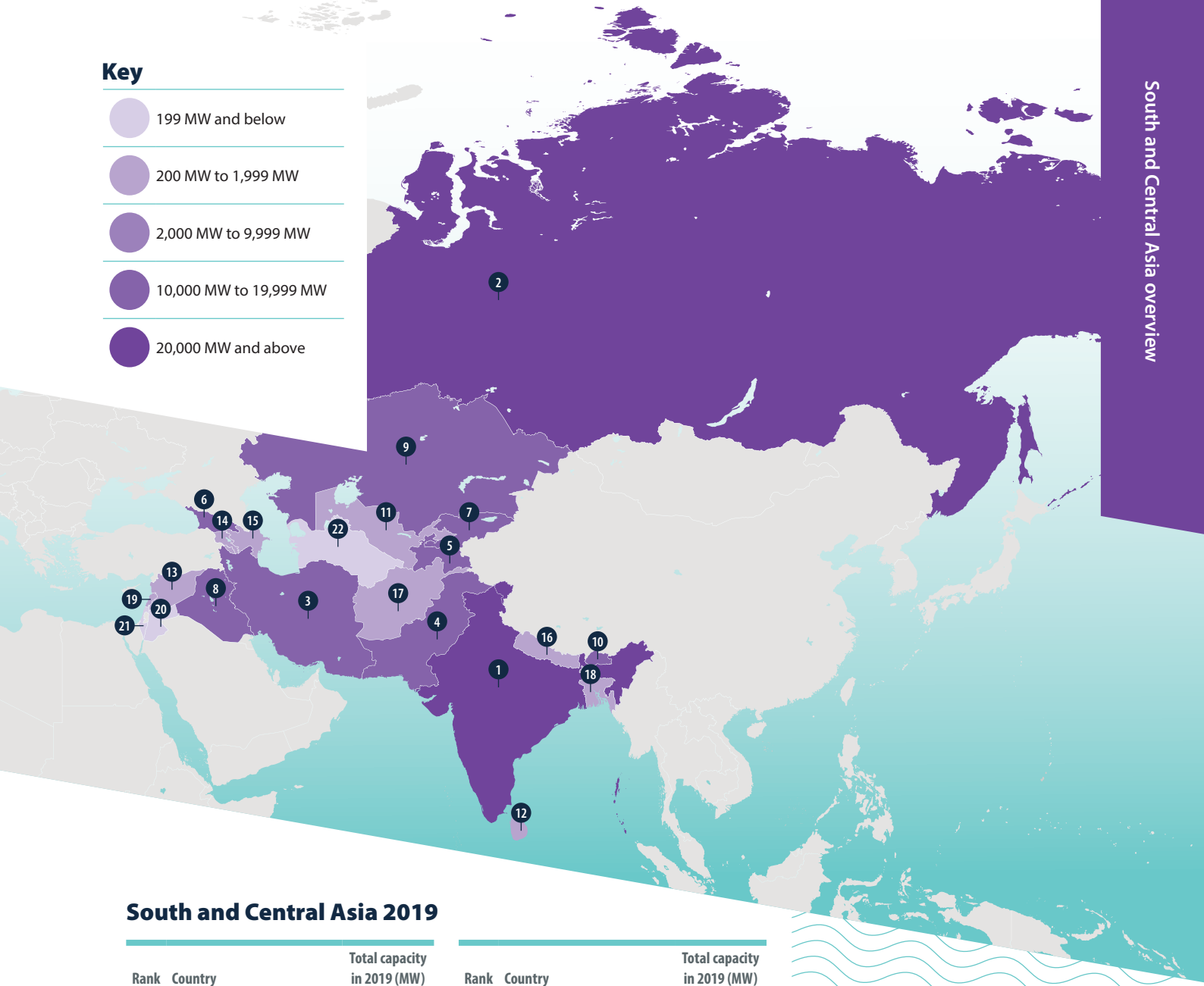
With diverse topography and hydrologic conditions, Central and South Asia's hydropower resources are unevenly distributed. While several arid countries have limited or no hydropower resources, it is the dominant source of electricity in Georgia, the Kyrgyz Republic, Tajikistan, Afghanistan, Nepal and Bhutan. In addition, with a combined installed capacity of 100 GW, hydropower plays an important role in the electricity systems of both Russia and India.

The majority of the region's overall electricity mix is supplied by natural gas, coal and oil, while hydropower contributes approximately 11 per cent of annual generation, the largest renewable source. Over the past five years, annual hydropower capacity growth has averaged 2 per cent in line with the global average. Much of the over 10 GW of capacity added during this period took place in India, Pakistan and Tajikistan.

Looking ahead, hydropower is key to the energy plans of many countries in the region as they seek to address energy poverty and increase access to reliable, affordable and cleaner electricity. This is particularly the case in Pakistan, Nepal, Tajikistan and the Kyrgyz Republic where the immense potential of hydropower has barely been tapped.

Increased regional interconnections and cross-border trading involving hydropower will also become a common feature to alleviate electricity shortages and reduce costs. The CASA-1000 transmission project, set to be completed in the early 2020s, will facilitate the export of hydropower linking Tajikistan, the Kyrgyz Republic, Pakistan and Afghanistan. Meanwhile, India, Nepal and Bhutan continue to augment their already well-established cross-border trading of hydropower.

Finally, with climate change driving greater hydrological variability in the region, implementing measures to build greater climate resilience at hydropower stations is an increasing priority for developers, operators and lenders.



South and Central Asia 2019

Rank	Country	Total capacity in 2019 (MW)
1	India	50,070
2	Russia	49,859
3	Iran	12,169
4	Pakistan	9,827
5	Tajikistan	6,395
6	Georgia	3,271
7	Kyrgyzstan	3,070
8	Iraq	2,753
9	Kazakhstan	2,598
10	Bhutan	2,326
11	Uzbekistan	1,865

Rank	Country	Total capacity in 2019 (MW)
12	Sri Lanka	1,719
13	Syria	1,505
14	Armenia	1,249
15	Azerbaijan	1,131
16	Nepal	1,127
17	Afghanistan	461
18	Bangladesh	230
19	Lebanon	221
20	Jordan	12
21	Israel	7
22	Turkmenistan	1

Including pumped storage

South and Central Asia

Developments

In 2019, just over 2.3 GW of hydropower capacity went into operation across the region, including both greenfield and modernisation projects. This was lower than 2018's figure of 4 GW.

The largest project commissioned last year was the 720 MW Mangdechu project in Bhutan. Funded by the Indian government, the run-of-river project will supply electricity to the domestic market, with any surplus to be exported to India. It is part of the Indian government's Neighbourhood First Policy, through which they are assisting Bhutan to build 10,000 MW of hydropower capacity with concessional finance.

While only 154 MW of capacity was added to the Indian hydropower sector in 2019, a 25 per cent increase in annual generation and the announcement by government of a series of measures to incentivise greater development gave cause for optimism.

With increasing penetrations of wind and solar anticipated in coming years, the government believes it will need a significant increase in power system flexibility to ensure grid stability and avoid power shortages.

Reflecting this, in March 2019 the government declared that large hydropower (>25 MW) is officially a renewable energy source. This move will enable new, large projects to benefit from the non-solar Renewable Purchase Obligation which mandates that regional utilities must purchase a portion of their electricity from hydropower. It will also provide developers with greater access to green bond financing.

Other measures announced include providing developers with flexibility in tariff determination, and grants for the flood moderation components of projects and enabling infrastructure, such as roads and bridges. Taken together, these measures have injected renewed confidence into the sector with nearly 35 GW of capacity either currently under construction or in the development pipeline.

In neighbouring Pakistan, the government-owned utility Water and Power Authority (WAPDA) declared 2019 as an "historic year" having generated 34.7 TWh from its hydropower stations. This represents an annual increase of 22 per cent, and was mainly due to Tarbela 4th Extension (1,410 MW), Neelum Jhelum (969 MW) and Golen Gol (108 MW) becoming fully operational in 2018. WAPDA also announced the start of the construction of the 800 MW Mohmand Dam in 2019, the first large

Generation by hydropower

504 TWh

Total installed capacity*

152 GW

*including pumped storage

Capacity added in 2019

2,343 MW

Pumped storage installed capacity

7.5 GW

Pumped storage capacity added in 2019

0 MW

Top 5 countries by capacity added in 2019

1st	Bhutan	720 MW
2nd	Tajikistan	600 MW
3rd	Russia	462.5 MW
4th	Nepal	175.8 MW
5th	India	154.1 MW

Mangdechhu, Bhutan. Credit: MHPA.

multi-purpose dam to be undertaken in Pakistan since the Tarbela Dam, which started construction in 1968.

Tajikistan recorded the largest capacity addition in Central Asia with the second unit (600 MW) of the 3,600 MW Rogun project entering into operation. Once complete, it will also be the largest hydropower station in the region, but there are growing concerns about the government's ability to service its debt and source funding to construct the remaining four units.

Elsewhere in Central Asia, where the bulk of hydropower capacity was built prior to the collapse of the Soviet Union in 1991, the modernisation of ageing stations remains a priority. Notable stations currently undergoing modernisation include Toktogul (1,200 MW), Uch-Kurgan (180 MW) and Golovnaya (240 MW) in the Kyrgyz Republic. Uzbekistan is focussing on several small hydropower stations. In Kazakhstan, Samruk Energy put three units of the 52-year-old Shardarinsk station back into operation in 2019 with an additional 19.5 MW of capacity. The fourth and final unit is expected to be commissioned in 2020.

In Russia, over 450 MW of capacity was added to the grid, led by the commissioning of RusHydro's 320 MW Nizhne-Bureyskaya project in the Amur region, situated in the far east of the country. In addition to having an expected annual output of 1.67 TWh, the project will help protect the neighbouring residential areas from flooding. In late 2019, RusHydro also announced that solar panels with a combined capacity of 1,275 kW had been commissioned on the surface of the reservoir created by the project. The solar plant is expected to reduce the cost of electricity for the station's own needs, therefore unlocking additional output.

As home to one of the oldest fleets in the world, Russia's hydropower operators continue to make substantial investments in their existing stations. Last year, En+ Group, Russia's second largest hydropower generator announced major upgrades to both the 662 MW Irkutsk and the 6,000 MW Krasnoyarsk hydropower stations as part of their New Energy modernisation programme.

East Asia and Pacific

Overview

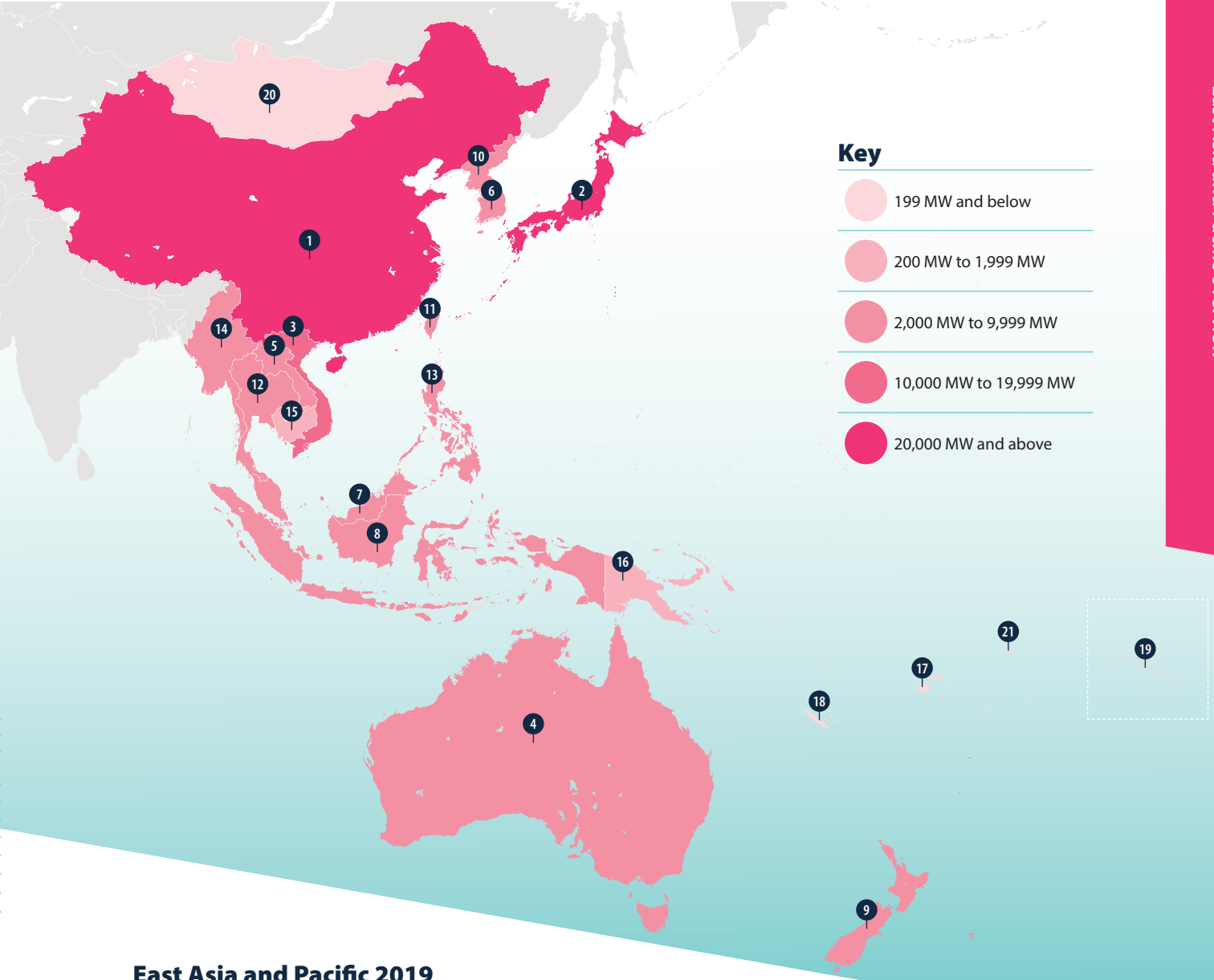
Samoa
Credit: Stantec

Home to 30 per cent of the world's population, East Asia and Pacific is a dynamic region that has experienced rapid economic growth and soaring energy demand in recent years. While China is the region's largest economy, the Association of South East Asian Nations (ASEAN) countries have seen electricity consumption growing at nearly 6 per cent annually since 2000, double the world's average. The International Energy Agency (IEA) estimates that Southeast Asia's rising income and increasing demand for air conditioning will double the region's electricity consumption by 2040.

While governments in the region have been expanding their power sector to meet this demand, the growth of power generation has been dominated by fossil fuels. In 2019, thermal generation accounted for almost 70 per cent in China and 80 per cent in ASEAN countries, where air pollution has become a major public health risk on top of concerns about global warming. The increased demand is of concern for Pacific Island states, which are dependent on imported fuels for power generation and extremely vulnerable to fluctuating energy prices.

Policy makers are, however, scaling-up renewable energy development. Over the past five years, the region has led the world in wind and solar capacity installations. Hydropower output in Southeast Asia has quadrupled since 2000. In 2019, there has been strong momentum for hybrid renewable energy projects as governments encourage deployment of floating solar PV at hydropower facilities This enables hydropower and solar power to work in synergy while also making good use of existing infrastructure. Further plans for cross-border interconnection will also help integrate a greater share of renewable energy into the power system.

Asia Pacific will increasingly be the main battleground in the fight to limit global warming. Yet it remains a formidable challenge to, at the same time, ensure access to "affordable, reliable, sustainable and modern energy for all", as part of low-carbon economic development.



East Asia and Pacific 2019

Rank	Country/Territory	Total installed capacity (MW)
1	China	356,400
2	Japan	49,905
3	Vietnam	16,759
4	Australia	8,790
5	Laos	7,200
6	South Korea	6,508
7	Malaysia	6,174
8	Indonesia	5,886
9	New Zealand	5,354
10	North Korea	5,010
11	Chinese Taipei (China)	4,694

Rank	Country/Territory	Total installed capacity (MW)
12	Thailand	4,510
13	Philippines	4,386
14	Myanmar	3,331
15	Cambodia	1,330
16	Papua New Guinea	234
17	Fiji	125
18	New Caledonia	78
19	French Polynesia	47
20	Mongolia	23
21	Samoa	12

Including pumped storage

East Asia and Pacific

Developments

Despite a slowing rate of new installed capacity in recent years, China is still the regional leader in hydropower development. In 2019, the country commissioned approximately 4.17 GW hydropower installed capacity.

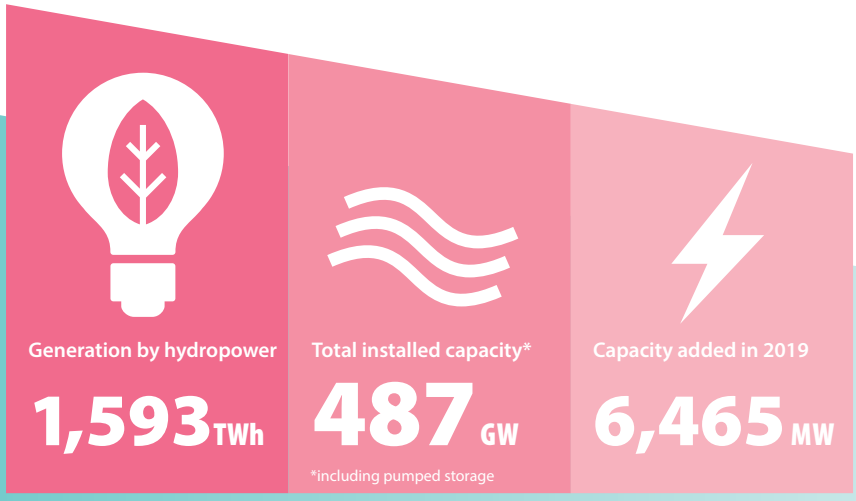
Pumped storage capacity grew by 300 MW in 2019, with a temporary pause on new pumped storage projects. This was due to a lack of progress in electricity market reforms affecting investment returns for energy storage projects, and pressure to reduce electricity prices for consumers. Due to the Covid-19 pandemic though, pumped storage and grid infrastructure projects have been resumed to stimulate economic recovery. Further market reforms and ancillary market development are still required.

Major projects in construction include the 10,200 MW Wudongde project and the 16,000 MW Baihetan project, which are expected to be commissioned in 2021 and 2022. However, the transmission line for Baihetan, originally planned to start construction last year, has not been approved yet.

With new commissions totalling 1.89 GW, Laos was second-highest in new added capacity across the region. The growth includes two major projects; the 1,295 MW Xayaburi run-of-river power station and 270 MW Nam Ngiep 1 project. These will produce electricity for local use as well as export to Thailand. In addition, the new 260 MW Don Sahong project will supply electricity to Cambodia. The Laos government will continue to promote sustainable hydropower with the aim of reducing energy imports, as well as reducing electricity prices.

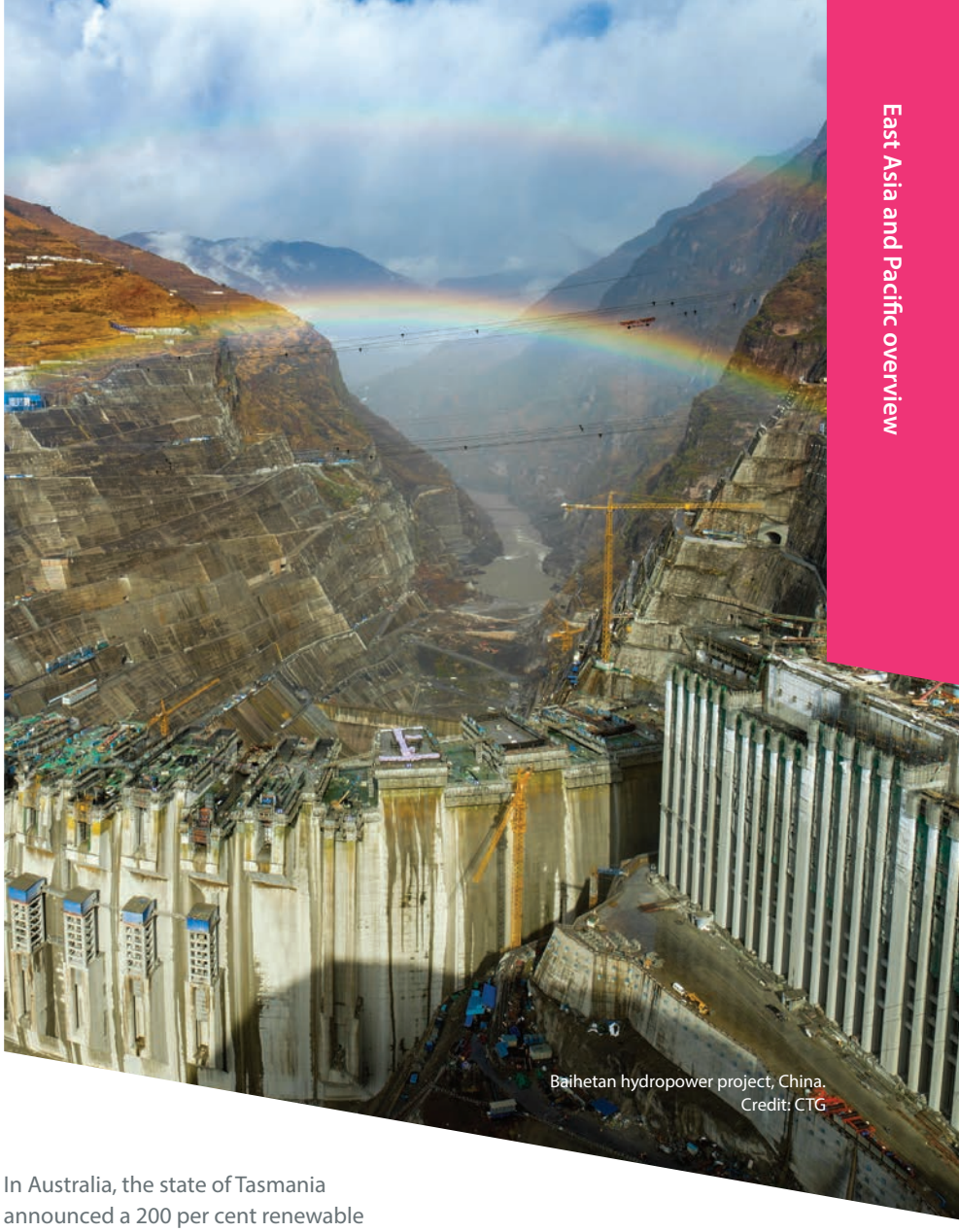
In Indonesia, the 46.6 MW Rajamandala project in Jarkarta was commissioned last year, for Indonesia's state utility PT Perusahaan Listrk Negara (PLN). The government has announced plans to build the country's largest hydro project, the 1,350 MW Mentarang Hydroelectric Power Plant in North Kalimantan in 2020, with total costs of US$2 billion. PLN also signed a power purchase agreement for the 145 MW Cirata floating PV project in West Java.

In Vietnam, the Asian Development Bank (ADB) has provided a US$37 million loan to the Da Mi Hydropower Joint Stock Company, a division of national electric utility Vietnam Electricity (EVN). This is for retrofitting 47 MW of floating solar panels on its hydropower plant. Two pilot auctions for 50-300 MW floating PV



Top 5 countries by capacity added in 2019

1st	China	4,170 MW
2nd	Laos	1,892 MW
3rd	Indonesia	143.5 MW
4th	Malaysia	80 MW
5th	Vietnam	80 MW



Baihetan hydropower project, China. Credit: CTG

on hydropower plants will also be held in 2020 by Vietnam's Ministry of Industry and Trade (MOIT).

The state-run Electricity Generating Authority of Thailand (EGAT) aims to develop 16 floating solar farms with a combined capacity of over 2.7 GW at nine of its hydropower reservoirs by 2037. Thailand is also developing its power transmission network and has agreements to source hydropower from Laos and export to Malaysia, Cambodia and Myanmar.

In Cambodia, the Ministry of Mines and Energy recently announced that the country will not pursue new hydropower development on the mainstream Mekong River. However, the government is still studying the potential for new hydropower development on river tributaries, such as a 190 MW project on the Sekong River in Stung Treng province.

In Australia, the state of Tasmania announced a 200 per cent renewable energy generation target for 2040 and aims to become a net exporter of renewable energy to the rest of the country. Thanks to hydropower, Tasmania is already approaching 100 per cent renewables by 2022. Its government also confirmed its new 'Battery of the Nation' pumped storage projects and the Marinus Link interconnector will play a lead role in the state's economic recovery from Covid-19.

Finally, in 2019, hydropower projects across the Pacific Island states secured funding from international financing institutions. In the Solomon Islands, the 15 MW Tina River Hydropower Project has secured US$240 million from a consortium of development agencies. The project is set to begin construction in early 2020 and will help reduce the country's reliance on imported diesel by nearly 70 per cent. In Vanuatu, an Engineering, Procurement and Construction contract was awarded for the once abandoned 400kW run-of-river Brenwe Hydropower project, with loans provided by the ADB.

Installed capacity and generation 2019

Africa

Country	Total installed capacity including pumped storage (MW)	Pumped (MW)	Generation (TWh)
Algeria	269	-	0.09
Angola	3,435	-	9.03
Benin	33	-	0.06
Botswana	-	-	-
Burkina Faso	34	-	0.11
Burundi	57	-	0.22
Cote dIvoire	879	-	2.31
Cameroon	792	-	5.34
Cape Verde	-	-	-
Central African Republic	19	-	0.15
Chad	-	-	-
Comoros	1	-	-
Congo	218	-	1.07
Democratic Republic of the Congo	2,750	-	9.15
Djibouti	-	-	-
Egypt	2,876	-	12.09
Equatorial Guinea	128	-	0.12
Eritrea	-	-	-
Eswatini	60	-	0.16
Ethiopia	4,074	-	13.56
Gabon	331	-	1.74
Gambia	-	-	-
Ghana	1,584	-	7.44
Guinea	368	-	1.29
Guinea-bissau	-	-	-
Kenya	826	-	3.47
Lesotho	73	-	0.50
Liberia	93	-	0.53
Libya	-	-	-
Madagascar	164	-	0.72
Malawi	371	-	1.30
Maldives	-	-	-
Mali	180	-	0.95
Mauritania	48	-	0.21
Mauritius	61	-	0.10
Morocco	1,770	465	1.55
Mozambique	2,216	-	14.17
Namibia	347	-	0.95
Niger	-	-	-
Nigeria	2,110	-	6.10
Reunion (France)	134	-	0.49
Rwanda	111	-	0.45
Sao Tome And Principe	2	-	0.01
Senegal	81	-	0.31
Seychelles	-	-	-
Sierra Leone	64	-	0.18
Somalia	-	-	-
South Africa	3,596	2,912	5.67
South Sudan	-	-	-
Sudan	1,923	-	7.75
Tanzania	586	-	2.31
Togo	49	-	0.09
Tunisia	66	-	0.06
Uganda	1,040	-	4.92
Western Sahara	-	-	-
Yemen	-	-	-
Zambia	2,400	-	13.67
Zimbabwe	1,076	-	7.26
Total	**37,297**	**3,377**	**137.66**

South and Central Asia

Country	Total installed capacity including pumped storage (MW)	Pumped (MW)	Generation (TWh)
Afghanistan	461	-	0.84
Armenia	1,249	-	2.50
Azerbaijan	1,131	-	1.60
Bahrain	-	-	-
Bangladesh	230	-	0.82
Bhutan	2,326	-	8.95
Georgia	3,271	-	8.93
India	50,071	4,786	162.10
Iran	12,169	1,040	28.60
Iraq	2,753	240	3.50
Israel	7	-	0.02
Jordan	12	-	0.05
Kazakhstan	2,580	-	10.92
Kuwait	-	-	-
Kyrgyzstan	3,070	-	13.45
Lebanon	221	-	0.66
Nepal	1,127	-	4.15
Oman	-	-	-
Pakistan	9,827	-	35.28
Qatar	-	-	-
Russia	49,859	1,385	190.29
Saudi Arabia	-	-	-
Sri Lanka	1,719	-	4.52
Syria	1,505	-	1.25
Tajikistan	6,395	-	19.00
Turkmenistan	1	-	-
United Arab Emirates	-	-	-
Uzbekistan	1,865	-	6.50
Total	**151,850**	**7,451**	**503.93**

East Asia and Pacific

Country/Territory	Total installed capacity including pumped storage (MW)	Pumped (MW)	Generation (TWh)
American Samoa (USA)	-	-	-
Australia	8,790	1,340	14.17
Brunei	-	-	-
Cambodia	1,330	-	4.03
China	356,400	30,290	1,302.00
Chinese Taipei (China)	4,694	2,602	8.75
Cook Islands (New Zealand)	-	-	-
Fiji	125	-	0.50
French Polynesia	47	-	0.18
Guam (USA)	-	-	-
Hong Kong (China)	-	-	-
Indonesia	5,886	-	17.03
Japan	49,905	27,637	86.67
Kiribati	-	-	-
Laos	7,200	-	19.33
Macau	-	-	-
Malaysia	6,174	-	15.66
Marshall Islands	-	-	-
Micronesia, Federated States Of	-	-	-
Mongolia	23	-	0.09
Myanmar	3,331	-	11.19
Nauru	-	-	-
New Caledonia (France)	78	-	0.36
New Zealand	5,354	-	25.40
Niue (New Zealand)	-	-	-
North Korea	5,010	-	13.65
Papua New Guinea	234	-	0.80
Philippines	4,385	685	9.50
Samoa	12	-	0.04
Singapore	-	-	-
Solomon Islands	-	-	-
South Korea	6,508	4,700	6.23
Thailand	4,510	1,000	6.31
Timor-leste	-	-	-
Tonga	-	-	-
Tuvalu	-	-	-
Vanuatu	-	-	-
Vietnam	16,759	-	51.98
Total	**486,754**	**68,254**	**1,593.85**

Europe

Country	Total installed capacity including pumped storage (MW)	Pumped (MW)	Generation (TWh)
Albania	2,193	-	5.19
Andorra	45	-	0.12
Austria	14,545	5,596	42.67
Belarus	97	-	0.40
Belgium	1,427	1,307	1.12
Bosnia and Herzegovina	2,513	420	6.00
Bulgaria	3,129	1,404	3.40
Croatia	2,141	293	5.88
Cyprus	-	-	-
Czechia	2,268	1,171	3.15
Denmark	9	-	0.02
Estonia	8	-	0.02
Faroe Islands	39	-	0.11
Finland	3,257	-	12.28
France	25,557	5,837	63.61
Germany	11,022	6,364	27.88
Gibraltar	-	-	-
Greece	3,400	703	4.06
Greenland	91	-	0.40
Hungary	56	-	0.21
Iceland	2,086	-	13.20
Ireland	529	292	1.12
Italy	22,593	7,685	47.98
Kosovo	92	-	0.33
Latvia	1,576	-	2.10
Liechtenstein	35	-	0.12
Lithuania	1,016	900	0.93
Luxembourg	1,330	1,296	0.95
Macedonia	674	-	1.16
Malta	-	-	-
Moldova	76	-	0.22
Monaco	-	-	-
Montenegro	658	-	1.78
Netherlands	38	-	0.06
Norway	32,671	1,439	125.77
Poland	2,385	1,780	2.64
Portugal	7,193	2,820	10.60
Romania	6,313	92	15.82
San Marino	-	-	-
Serbia	3,098	639	9.50
Slovakia	2,522	1,017	4.48
Slovenia	1,524	180	4.56
Spain	20,414	6,117	26.39
Sweden	16,478	99	64.83
Switzerland	16,863	3,029	40.27
Turkey	28,503	-	87.09
Ukraine	6,229	1,563	6.94
United Kingdom	4,712	2,833	7.77
Total	**251,405**	**54,876**	**653.10**

South America

Country	Total installed capacity including pumped storage (MW)	Pumped (MW)	Generation (TWh)
Argentina	11,310	974	36.83
Bolivia	735	-	3.24
Brazil	109,058	30	386.95
Chile	6,739	-	20.79
Colombia	11,917	-	51.54
Ecuador	5,074	-	23.89
French Guiana	119	-	0.44
Guyana	1	-	-
Paraguay	8,810	-	49.34
Peru	5,396	-	31.49
Suriname	189	-	1.36
Uruguay	1,538	-	7.84
Venezuela	15,393	-	72.00
Total	**176,280**	**1,004**	**685.72**

North & Central America

Country	Total installed capacity including pumped storage (MW)	Pumped (MW)	Generation (TWh)
Anguilla	-	-	-
Antigua and Barbuda	-	-	-
Aruba	-	-	-
Bahamas	-	-	-
Barbados	-	-	-
Belize	55	-	0.25
Bermuda	-	-	-
Canada	81,386	177	398.00
Cayman Islands	-	-	-
Costa Rica	2,343	-	7.83
Cuba	68	-	0.06
Dominica	7	-	0.04
Dominican Republic	616	-	1.76
El Salvador	575	-	1.44
Grenada	-	-	-
Guadeloupe	11	-	0.03
Guatemala	1,559	-	5.77
Haiti	60	-	0.13
Honduras	713	-	3.25
Jamaica	30	-	0.16
Martinique	-	-	-
Mexico	12,126	-	30.96
Montserrat	-	-	-
Nicaragua	157	-	0.41
Panama	1,786	-	7.25
Puerto Rico	98	-	0.05
Saint Bartholemy	-	-	-
Saint Kitts And Nevis	-	-	-
Saint Lucia	-	-	-
Saint Pierre And Miquelon	-	-	-
Saint Vincent And The Grenadines	7	-	0.04
Trinidad And Tobago	-	-	-
Turks And Caicos Islands	-	-	-
United States	102,753	22,855	274.00
Virgin Islands, British	-	-	-
Virgin Islands, U.S.	-	-	-
Total	**204,350**	**23,032**	**731.42**

World

	Total installed capacity including pumped storage (MW)	Pumped (MW)	Generation (TWh)
Total	**1,307,935**	**157,994**	**4,306**

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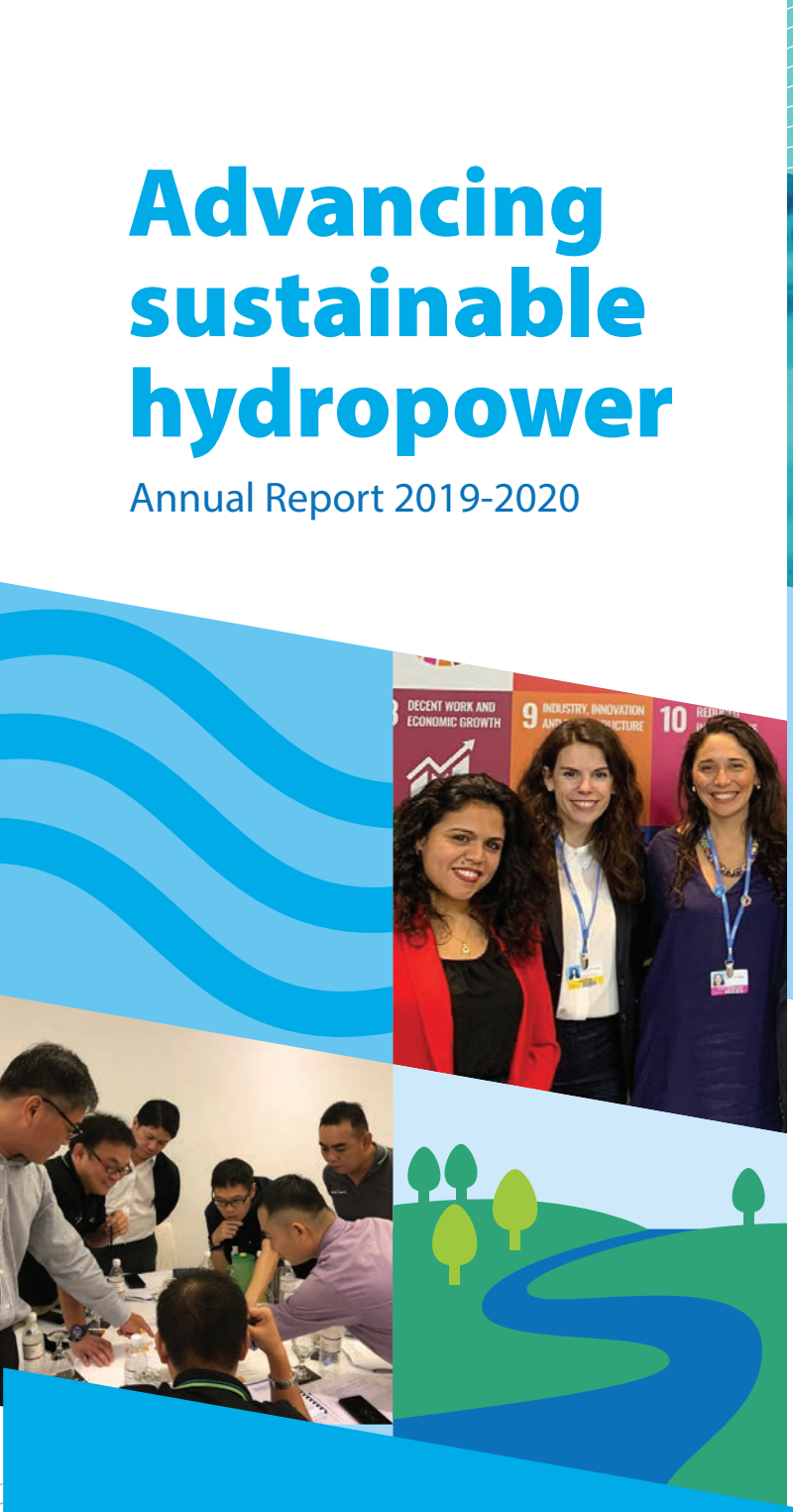

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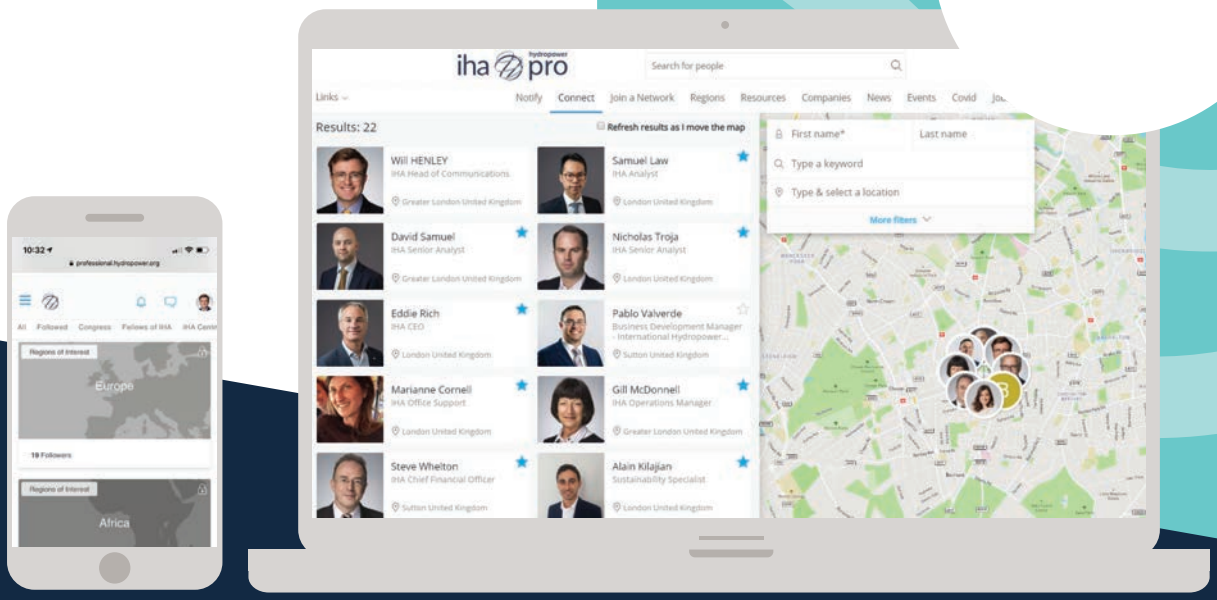

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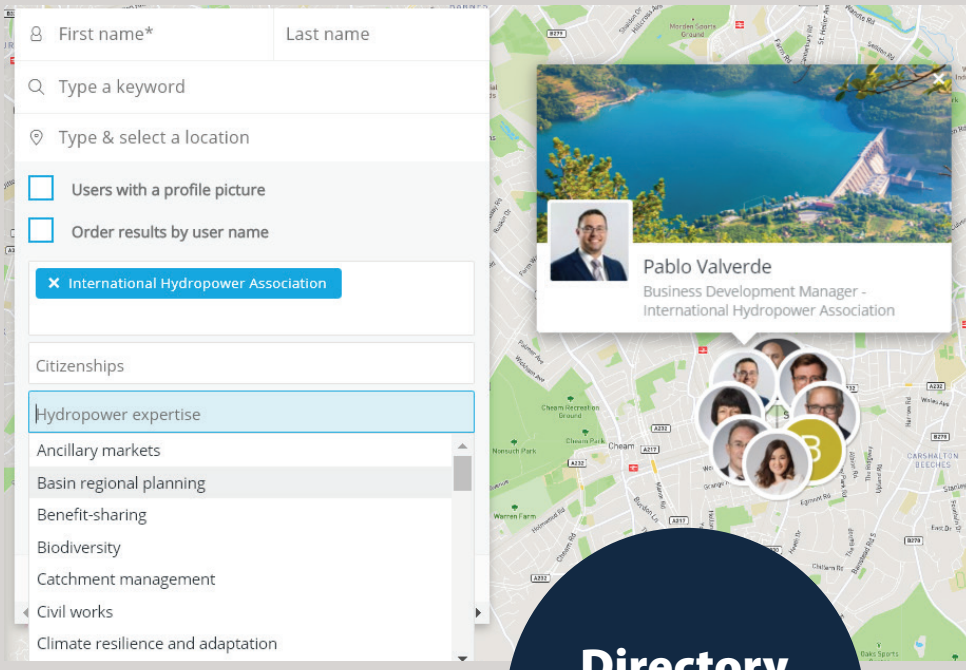

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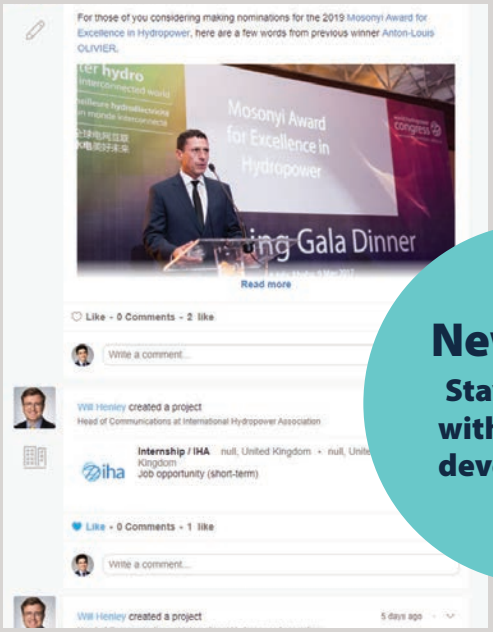

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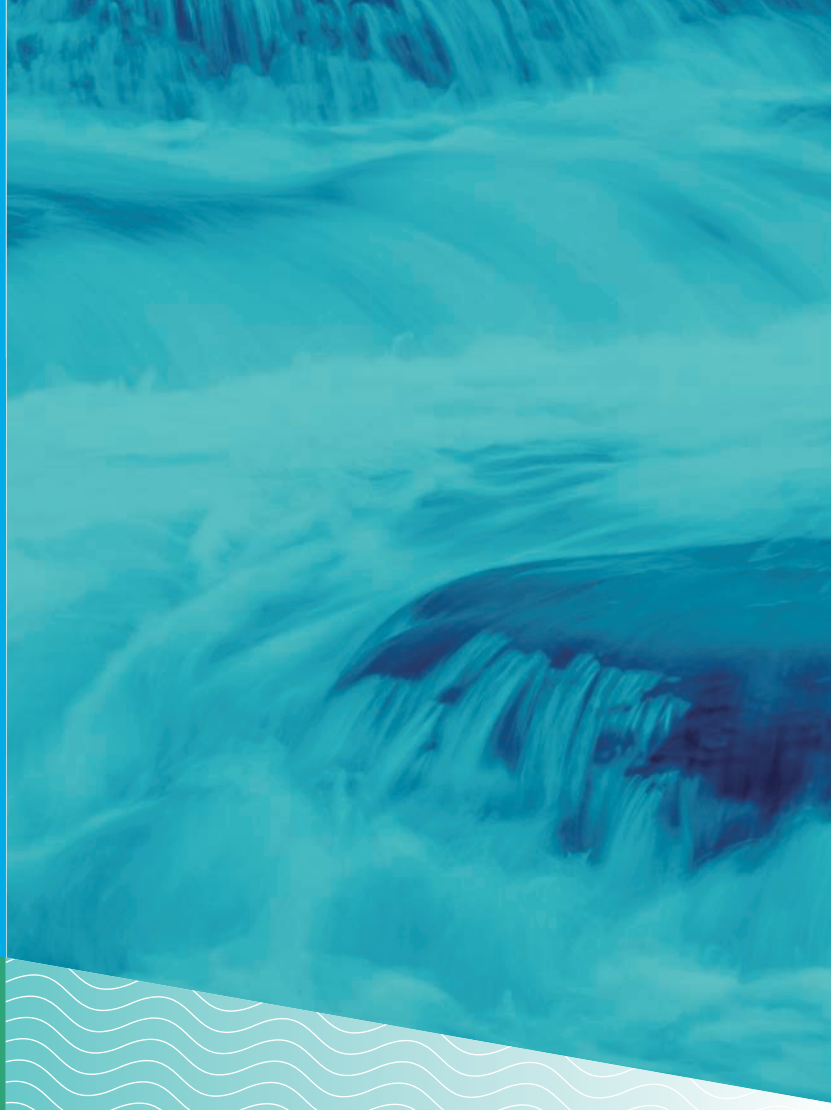

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