international hydropower association

2015 HYDROPOWER STATUS REPORT

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Methodology

Statistics are compiled by IHA using data from publicly published sources, IHA members, government representatives, industry sources and media monitoring. The data is regularly tracked, stored and updated to account for new information as it is received. Data verification exercises are an ongoing process, leading to corrections as and when needed.

IHA's database houses data for all sizes of hydropower, in all locations and of all types. In the past, hydropower has often been reported as a combined number for 'pure' and pumped-storage hydropower. IHA is continually working to separate out these numbers in spite of combined reporting from official reporting entities.

For hydropower generation, statistics are a combination of official government reports and IHA estimates based on capacity factor.

Corrections

The global additions in 2014 reflect a downwards adjustment of 3 GW to the added capacity which was noted in the *2015 Key Trends in Hydropower* briefing.

FOREWORD

It is my pleasure to introduce the ***2015 Hydropower Status Report***: an insight into recent hydropower development and sector trends around the world.

37.4 GW

of new installed capacity in 2014 (including pumped storage)

1,036 GW

global hydropower capacity

We publish this report at a time of significant hydropower development, with 37.4 GW of new installed capacity in 2014 (including 1.5 GW of pumped storage) bringing the global total to 1,036 GW. The landmark 2015 World Hydropower Congress saw a strengthening interaction between all participants in the sector, and a commitment to make hydropower a win-win for our society, environment and economy in our climate-constrained future.

The picture that emerges from our global monitoring is quite dynamic. Across Asia, the policy environment is shifting to support hydropower (provided it meets acceptable sustainability criteria) to meet the demands of growing economies, and more players are becoming involved. In Africa, though deployment remains low, we are seeing increased co-operation at a regional level, and a growing consensus on hydropower's importance to the continent's energy future.

In South America, where virtually every country has hydropower development in the pipeline, water storage is becoming increasingly important in the debate. And in the mature markets of Europe and North America, drivers include greater interconnections and a growing role for hydropower as a facilitator of the changing energy mix.

As we move forward, we can only manage this progress if we stay well connected. It is through the sharing of knowledge that we can empower decision-makers to become more transparent and predictable, and enable project developers to achieve the best outcomes.

The International Hydropower Association's database of the world's hydropower stations and companies has grown in maturity, and is now a fantastic asset to monitor the sector. We have built it in a truly collaborative effort with regulators, ministries and electricity associations, as well as the world's station owners and operators, to serve as a valuable resource.

It is this database that sits beneath the report you are reading, while contributions from our vibrant community of members and partners throughout the world bring additional insight. Our regional overviews and country profiles have been reviewed by IHA champions throughout the world.

As we enter a new phase of work and build towards the 2017 World Hydropower Congress, we look forward to providing a range of new tools, briefings and insights.

We would like to extend our gratitude to everyone who has contributed to producing the *2015 Hydropower Status Report*, and we would be pleased to hear your comments on how we might develop this document in the future.

Richard Taylor
(Chief Executive)

EXECUTIVE SUMMARY

In 2014, hydropower development continued its strong growth trend. Globally, the drivers for this include a general increase in demand not just for electricity, but also for particular qualities such as reliable, local, clean and affordable power.

DURING 2014

- An estimated 36 GW of hydropower capacity (not including pumped storage) was put into operation, bringing the world's total installed capacity to 1,036 GW.
- An additional 1.46 GW of pumped storage capacity came online, with significant capacity was under construction or in the planning stages, bringing the world's total pumped storage capacity to 142 GW.
- Total hydropower generation for the year is estimated at 3,900 TWh.
- China once again dominated the market for new development, adding 21.85 GW of new capacity within its borders.
- Other countries leading in new deployments include Brazil (3.31 GW), Canada (1.72 GW), Turkey (1.35 GW), Russia (1.22 GW) and India (1.20 GW).

Key trends and noteworthy developments

Increasing regional development

In 2014, Norway's role as a green battery for Europe stepped forward with the announcement of plans for a direct submarine transmission line with the UK, adding to the planned Norway–Germany and existing Norway–Denmark links. Iceland is also pursuing a 1,000 km submarine link to export hydropower to the UK.

In eastern Africa, Kenya and Ethiopia are progressing work on the implementation of a 1,000 km high-voltage transmission line, which will further enable a regional approach to hydropower development. Nepal and Bhutan are also pursuing hub strategies, where India is investing in hydropower in return for a portion of the produced power.

Shake-up in manufacturing

In 2014, General Electric signalled a move which would see it re-enter the world of hydropower turbine manufacturing by making a bid to acquire Alstom, one of the major manufacturers of hydropower turbine equipment. While the bid has met with some resistance within France and is still under review by the European Commission, this marks a period of uncertainty in the make-up of the global hydropower industry.

Chinese manufacturers, particularly Harbin and Dongfang, continue to gather market share worldwide. There is also a resurgence of equipment suppliers in Japan, particularly in relation to variable-speed technology.

Renewables synergies

The world's largest solar–hydro hybrid station was connected to the grid in 2014. China's Longyangxia station – a 320 MW solar park linked up to a 1,280 MW hydropower station – is expected to last 25 years and deliver 498 GWh/y of solar PV, complementing the output of the existing hydropower peaking station.

Costa Rica announced in 2015 that it had operated on 100 per cent renewable electricity for 75 days, mainly using hydropower. On a smaller scale, El Hierro in the Canary Islands commissioned an ~11 MW wind–hydro hybrid project, bringing the island significantly closer to becoming 100 per cent renewable and energy self-sufficient.

More activity in mature markets

In 2014, the United States announced a new price premium for hydropower when added to existing non-powered reservoirs. The US also extended its production tax credit, which provides incentives for hydropower technology manufacturing. In Canada, new greenfield projects continue to be developed, including Romaine 2 (640 MW) and Forrest Kerr (195 MW), both completed in 2015, and the 695 MW Keeyask project is now under construction.

In Europe, pumped storage continues to be a focus, with new facilities totalling 8,600 MW in the planning and construction stages, although this development continues to be compromised by market uncertainty. Developments in variable-speed technology are expected to be a key component of this new capacity.

Rethinking approaches to private sector development

We have long been aware of an increasing role for the private sector in hydropower, and the evidence continues to mount in support of this trend. For example, there are some 19 GW of hydro projects moving forward in Bhutan, India and Nepal. Many of these projects are being realised under the independent power producer model, and based on long-term power purchase agreements.

In the case of Bhutan and Nepal, these include cross-border trade with India. Within India, a few developers are currently considering the business model of operating as merchant plants, and there is also some interest in captive plants, with industrial partners seeking long-term reliability and price stability.

Offshore hydro steps forward

In late 2014, the UK government included the long-studied Swansea Bay tidal lagoon scheme in its National Infrastructure Plan. New investors have been secured and contract negotiations begun, indicating a greater likelihood that the 320 MW project will move forward. If built, it would become the largest tidal project in the world, ahead of South Korea's Sihwa Lake (254 MW) and France's La Rance (240 MW) stations.

Contracts were also awarded in 2014 for the supply of turbines at the MeyGen tidal stream project (398 MW) off the coast of Scotland, which will be the largest tidal array project worldwide.

New sources of finance and investment

While the past few years have seen a shift towards more private sector investment in hydropower, 2014 brought further new approaches and sources of funding. This includes the announcement of the New Investment Bank, funded by the BRICS countries (Brazil, Russia, India, China and South Africa). Several key countries have now also signed on to the China-led Asian Infrastructure Investment Bank, which has signalled its intent to include hydropower in its investment portfolio.

On the private sector side, green bonds are on the rise, while new vehicles such as the IFC's InfraVentures are offering early stage risk capital for hydropower financing.

Hydropower providing climate services

While it has long been the case that hydropower can offer a range of services, we are seeing increasing awareness of its potential to offer climate services, especially projects which include storage.

In addition to providing a carbon offset when developed in place of fossil fuel technology, we see a greater recognition of hydropower's ability to provide flood protection and mitigate drought impacts in the face of increasingly frequent extreme hydrological events.

In parallel, financial institutions are seeking more assurances of hydropower's climate resilience before lending, highlighting the need for more robust analysis at the basin and individual station levels.

GLOBAL TRENDS IN BRIEF

North and Central America

- 3,081 MW added in 2014, of which 1,995 MW was in Canada and 760 MW in Mexico.
- New government incentives introduced in the USA to add hydropower to existing reservoirs.
- Costa Rica operated on 100% renewable energy for 75 days, powered largely by hydropower.
- The 1,800 km SIEPAC transmission line reaching from Guatemala to Panama was completed in October 2014.

Read more on pages 26–31

South America

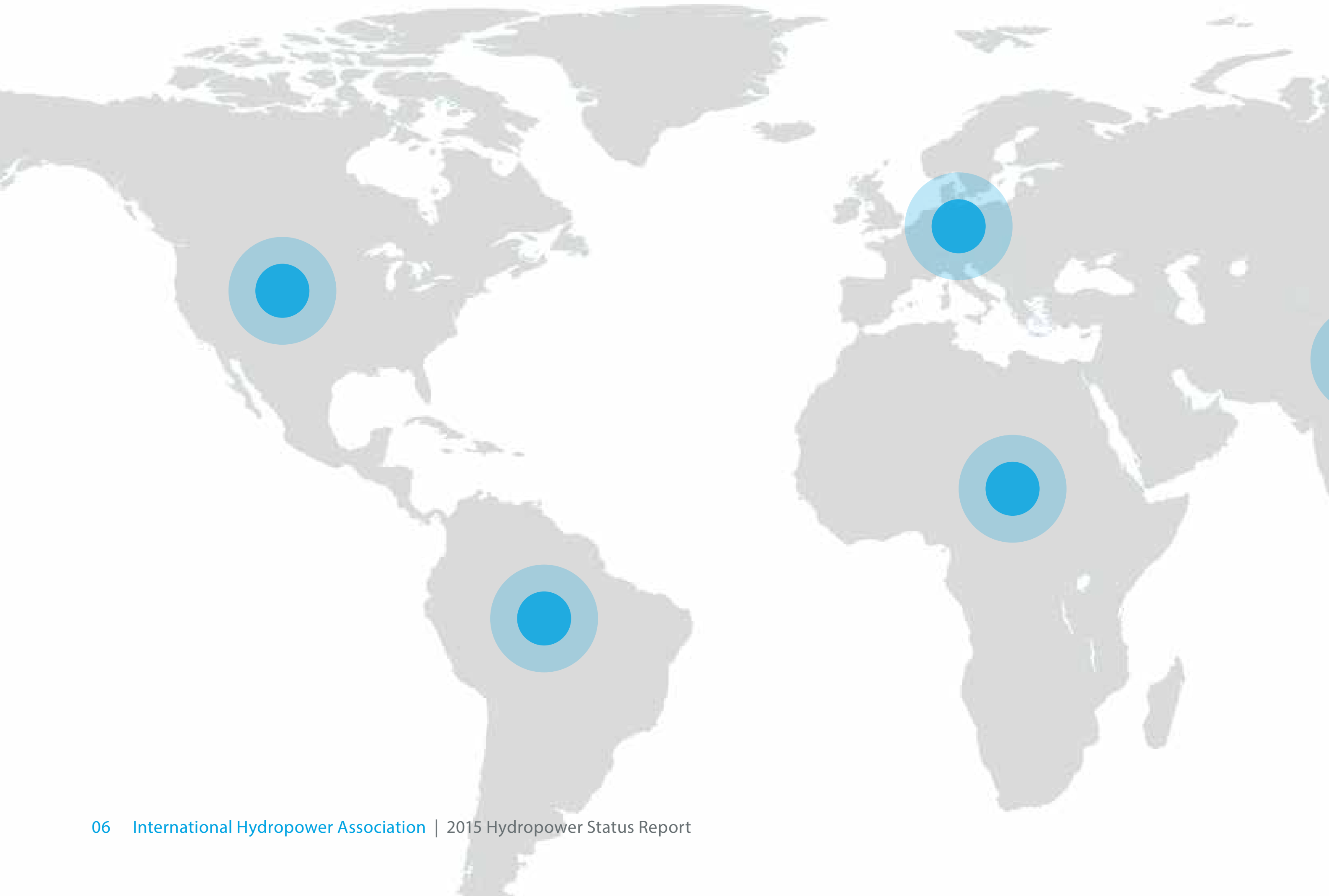
- 4,979 MW added in 2014.
- 3,312 MW commissioned in Brazil, despite severe drought affecting generation in the south.
- 875 MW commissioned in Colombia, including the 820 MW Sogamoso project, which will meet about 8% of the country's electricity demand.
- Development continuing on the lower Caroni cascade in Venezuela, with the commissioning the 'Manuel Piar' project (2,300 MW) expected in early 2016.

Read more on pages 32–37

Africa

- 128 MW added in 2014.
- Very low deployment, despite significant untapped potential and major needs for electricity and water services.
- Ethiopia completed construction of the 1,870 MW Gilgel Gibe III in 2015, and is well into construction of the Grand Renaissance project, which will bring a further 6,000 MW to the region in the coming years.
- Burundi, Rwanda and Tanzania signed an agreement to build the 80 MW Rusumo Falls hydropower plant, with output shared equally between the three countries.

Read more on pages 38–45



Europe

- 405 MW added in 2014.
- Pumped storage remains a focus of activity, with 8,600 MW planned or under construction, including 2,500 MW expected in the Swiss Alps by 2017.
- In 2015, Norway and the UK announced agreement for the world's longest submarine high–voltage cable (730 km, 1.4 GW), allowing the UK to import Norwegian hydropower.
- In preparation for the 2015 climate summit in Paris, the EU committed to a 40% reduction in GHG emissions by 2030 compared with 1990, complemented by a 27% target for renewables.

Read more on pages 46–53

South and Central Asia

- 4,073 MW added in 2014.
- The policy environment is shifting in support of more hydropower in India, with the government considering market incentives and encouraging private sector investment.
- Regional interconnection projects could drive further optimisation of hydropower, with the CASA-1000 transmission project linking Pakistan, Tajikistan, Kyrgyzstan and Afghanistan.
- Russia added 1,168 MW of new capacity to the mix and completed the restoration of the 6,400 MW Sayano-Shushenskaya station.
- Turkey commissioned 1,352 MW as part of its push to rapidly exploit its hydropower potential by the year 2023.

Read more on pages 54–61

East Asia and Pacific

- 24,724 MW added in 2014, 90% of which is in China.
- China leads global hydropower development, with 21,850 MW installed in 2014, including the final 4,620 MW of the 13,860 MW Xiluodu project – the third-largest hydropower plant in the world.
- Malaysia commissioned 836 MW in the state of Sarawak, including the final two 300 MW turbines at Bakun (2,400 MW) and the first of four 236 MW turbines at Murum (944 MW), while also announcing plans to begin construction on the 1,285 MW Baleh project in 2016.
- Cambodia commissioned 707 MW, and all three projects are CDM-accredited. Lao PDR (308 MW) and Vietnam (281 MW) were also active in 2014.

Read more on pages 62–67

"The picture that emerges is quite dynamic, with Asia leading in terms of new development. Regional considerations and opportunities for power export are an important driver for projects everywhere in the world."

FUTURE ENERGY MIX: RENEWABLE SYSTEMS

Hydropower has been a mainstream renewable energy technology for decades, and currently represents about 16 per cent of global electricity generation. However, while hydropower has been a steady constant in the energy supply scene, the energy mix as a whole is undergoing rapid and dramatic change.

In part due to a drive for cleaner, renewable energy, as well as energy security concerns and resource constraints, the energy mix is evolving. While fossil fuels still hold a dominant position globally, the role of renewable energies – including hydropower, solar, wind, geothermal and biomass – is increasing. Renewables, including hydropower, now supply 22.8 per cent of the electricity mix.

As the energy mix continues to evolve, operators face new challenges in maintaining system stability. Chief among these challenges is the variability of some forms of renewable energy – namely solar and wind power. While solar and wind resources are abundant, their availability is not always predictable. In traditional energy systems, demand follows a relatively predictable pattern, and generation is planned and delivered to meet that demand. In systems with wind and solar power, supply is less predictable and therefore requires greater reserve power capacity.

While critics contend that this is a flaw of renewable systems that necessarily must limit renewables penetration, evidence shows otherwise. Energy storage and strategic use of a mix of renewable energy technologies, and taking advantage of connections between systems across a range of geographies, can enable ever greater penetrations of renewable energy.

Energy storage, in particular, is often cited as the primary means by which electricity systems will be able to absorb ever greater amounts of variable renewable energy. Hydropower has a unique and powerful role to play in this regard. Hydropower reservoirs, including those for pumped hydro, are used for storing energy at multiple time horizons, ranging from minutes up to several years. Hydropower currently provides 99 per cent of the world's electricity storage for grid systems.

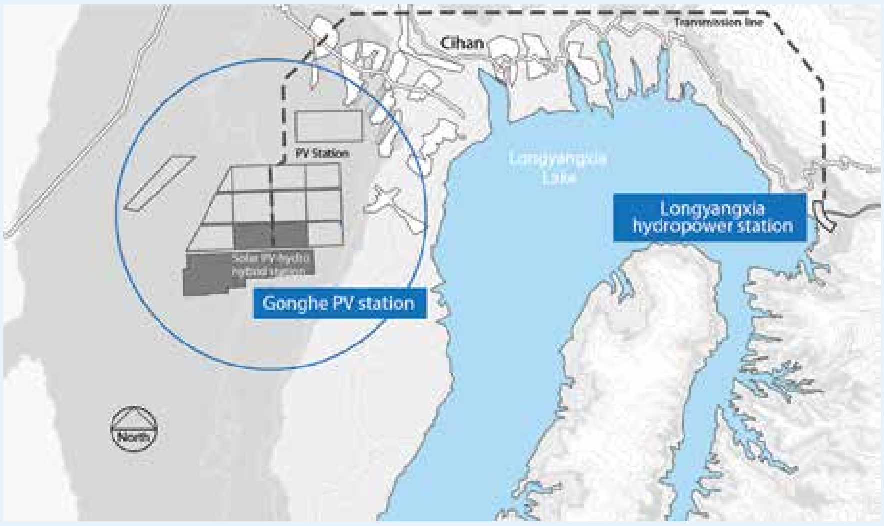
In fact, evidence continues to mount in support of the concept of renewable energy systems. The International Hydropower Association has gathered case studies demonstrating how and where synergies between renewables can work. These range from project-specific hybrids, to 100 per cent renewable systems.

16%

of global electricity generation comes from hydropower

CASE STUDY

FUTURE ENERGY MIX: RENEWABLE SYSTEMS
LONGYANGXIA SOLAR PV–HYDRO HYBRID STATION



In December 2013, after only nine months of construction, the Gonghe PV solar park was commissioned and connected to the power grid via the nearby Longyangxia hydropower plant on the Yellow River. This marks the first commercial operation of a large-scale solar PV–hydro hybrid system.

The hydropower station was originally designed and commissioned in 1992 as the first load-peaking and frequency-regulating power plant for the north-western power grid. It employs quick–response turbines, which smooths the output curve of the PV power, caused by natural fluctuations in sunlight due to cloud cover and time of day. By smoothing the power curve, the hybrid-connection allows for the exploitation of an intermittent energy source to provide good-quality, safe and reliable power to the grid.

The Longyangxia solar–hybrid power station is located in the arid north-west of China, in an area with vast solar resources. The reservoir supports a 1,280 MW power station, with four 320 MW turbines. Since 1999, a unified policy for the regulation of the Yellow River was adopted, and the Longyangxia reservoir is one of the main elements of this as one of the first cascaded projects on the main reach of the upper part of the Yellow River, it controls downstream releases to reservoirs lower on the river, providing those projects with a stable and reliable supply of water.

The Longyangxia PV plant has a capacity of 320 MW and covers a 9 km^2 area. It is connected directly to one of the turbine units by a 330 kV transmission line. As one of the largest solar PV stations in the world, without the balancing power of the Longyangxia hydro turbine, this could pose a serious problem for the stability of the grid. While the use of small amounts of intermittent power has little effect on grid operations, larger penetration of variable power can affect the grid's ability to operate as required.

Developing a joint hydro/PV operation control system, effectively allowing the PV plant to act as Longyangxia's fifth turbine, allows for almost immediate compensation between hydropower and PV generation. In essence, the active power output of the PV plant is adjusted using the hydropower turbine to achieve a smooth and stable output curve. As a whole, this increases the efficiency of both plants, and requires less spinning reserve capacity in the grid itself, further increasing the efficiency of the grid.

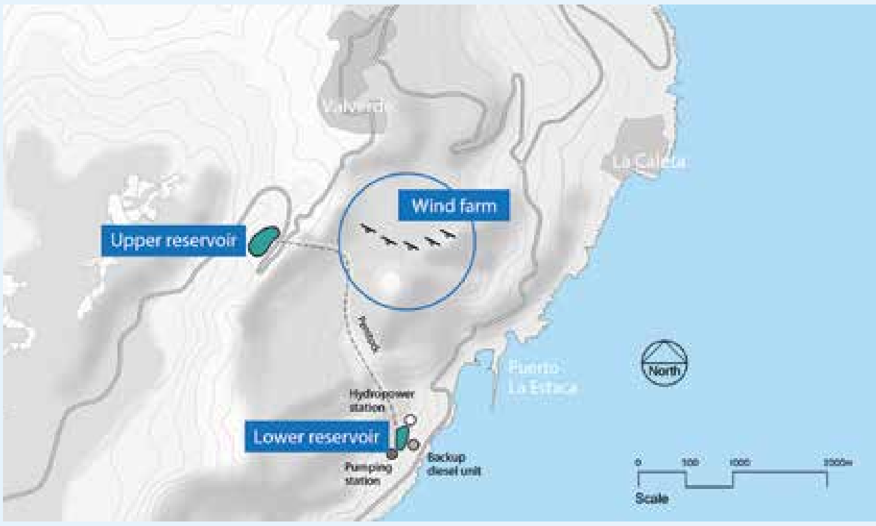
The addition of the solar park also increases the operation efficiency of the hydropower plant. Qinghai province is dry, and water is a scarce resource, so the Longyangxia reservoir only releases water with caution. With the addition of the solar project, the hydropower station has been able to increase its annual capacity utilisation and economic efficiency.

Already one of the largest PV power plants in the world, the construction of phase 2 of the solar power plant, which will bring the capacity to 530 MW, was commenced in August 2014, and is scheduled to come online in late 2015.

Large-scale centralised PV power is still in its infancy, and the Longyangxia coupling of PV and hydropower is the first of its kind and provides a valuable example for future hybrid systems linking variable renewables and hydropower.

CASE STUDY

FUTURE ENERGY MIX: RENEWABLE SYSTEMS
EL HIERRO – RENEWABLE ENERGY FOR REMOTE ISLAND SYSTEMS



El Hierro is the westernmost of Spain's Canary Islands, located in the Atlantic Ocean. It is a small volcanic island (278 km^2), with a population of about 11,000. The island was declared a UNESCO Biosphere Reserve in 2000 due to its rare flora and fauna.

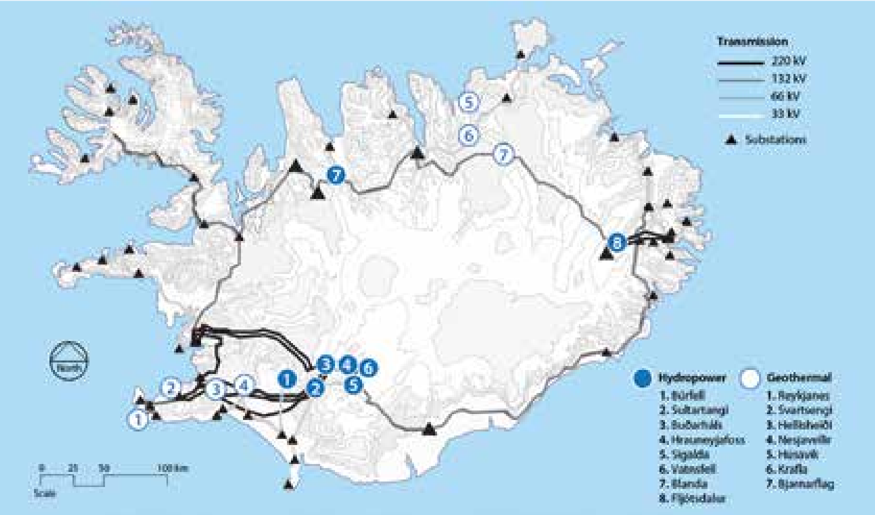
Prior to the implementation of a renewable energy system, the island relied upon imported diesel to produce 45 GWh/year via nine diesel units (13.36 MW total) located in the Llanos Blancos power station with a peak production of 7 MW. The annual diesel consumption was 40,000 barrels, with emissions of 18,700 tonnes of carbon dioxide, 100 tonnes of sulphur dioxide and 400 tonnes of nitrogen oxides.

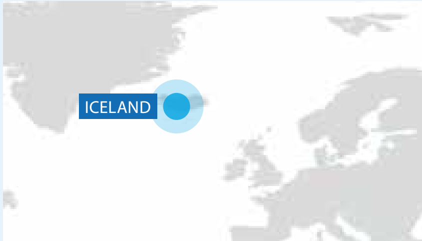
In an effort to remove El Hierro's reliance on diesel, the role of the principal generator has been transferred to a wind power plant of five 2.3 MW turbines – total power 11.5 MW. This is backed up by a pumped-storage hydropower system comprising an upper reservoir of 500,000 m^3 at an elevation of 715 m situated in a volcanic caldera, and a lower man-made reservoir of 226,000 m^3 at an elevation of 54.5 m. In generation mode the station's four 2.83 MW Pelton turbines (total 11.32 MW) operate under a gross head of about 655 m at a flow rate of 2 m^3/s. In pumping mode, the two 1,500 kW and fourteen 500 kW pump sets provide a pumping capacity of up to 10 MW.

In addition to providing electricity to the domestic and commercial sectors, the wind/hydro system also powers the island's three desalination plants linked to the lower reservoir. With this link, the El Hierro case not only provides a compelling example of how water storage supports energy security based on renewables, but also an example of the water–energy nexus in practice. The diesel units remain in an operational condition to act as a backup. The plant was commissioned in 2014, and it has been claimed that hundreds of islands globally could use the same model.

CASE STUDY

FUTURE ENERGY MIX: RENEWABLE SYSTEMS
ICELAND – 100 PER CENT RENEWABLES AT A NATIONAL SCALE





Clean energy systems are possible not only at the station level, but also at much broader levels including at national scales. With the country's extensive natural resources, Iceland's electricity system is almost 100 per cent renewable. There are tremendous hydropower resources from its numerous glaciers and plentiful rainfall, and abundant geothermal resources due to its location on a major geological rift at the juncture of the Eurasian and North American plates where the North Atlantic Ocean meets the Arctic Ocean. In addition, Iceland benefits from strong wind resources, and in 2012 it became the hundredth country in the world to install wind power.

Iceland's electricity system was 71 per cent hydropower, 28.9 per cent geothermal and 0.04 per cent wind in 2014. Thermal sources supplied 0.01 per cent of the electricity in 2014 and are reserved for remote islands not connected to the grid, and emergency backup. In 2013/14, 3.2 MW of wind capacity was installed to study the opportunity for incorporating additional renewables into Iceland's system.

Beyond electricity, Iceland's heating system is also 100 per cent renewable, with plans to transition the transport sector by 2050.

Iceland achieved its renewable and self-sufficient status through a planned transition from fossil-fuel dependency to renewable energy. Over the past half century, the country has embarked on a strategic initiative to reduce its reliance on imported fossil fuels, especially oil, and to focus instead on the development of domestic resources.

Iceland has 665 MW of installed geothermal capacity and 1,986 MW of hydropower capacity, including its most recent development, the 95 MW Búðarháls station which entered commercial operation in 2014. Hydropower supplies peaking and baseload power for the Icelandic system, with geothermal providing baseload power. Iceland built its first hydropower station in 1904, but full-scale development of hydropower as a strategy began in the 1970s, with geothermal development beginning in 1982. Various geothermal and hydropower projects are in the planning stage or under construction, with the Theistareykir 45–90 MW geothermal plant currently under construction, and the 100 MW Búrfell hydropower expansion expected to enter construction phase at the end of 2015.

As part of its strategy, Iceland has at the same time attracted power-intensive industry to its low-cost, renewable energy system. Hydropower and industrial facilities were constructed simultaneously, and this contributed to an increase in GDP of over 6 per cent, 4,800 direct and indirect jobs, and some of the lowest electricity tariffs for consumers and industry globally.

Households in Iceland consume only 10 per cent of the country's electricity. The remainder is used as an engine for economic growth – including renewable electricity for heavy industry, agriculture (greenhouses), food processing (fish), and, increasingly, activities such as hosting data centres. This demonstrates that 100 per cent renewable electricity is not just for small, isolated systems, or for providing a minimum level of access to electricity – renewables can and do supply sufficient reliable electricity for industry and economic growth.

Looking forward, Iceland is also aiming to export its clean energy to customers seeking clean, reliable and affordable energy supplies. A proposed 1,000 km direct submarine cable link is being explored to share Iceland's excess capacity with the United Kingdom.

THE WATER–ENERGY NEXUS: HYDROPOWER AND WATER CONSUMPTION

The water–energy nexus has become a key issue for the hydropower sector. The nexus, as it is often referred to, is the relationship between the impact on water caused by the provision of energy, and also the energy needed to collect, clean, store and supply water. The nexus considers not only the relationship between these two sectors, but also approaches to understanding and managing them in an integrated, systemic way.

All energy technologies require water – for cooling processes for thermal generation, as irrigation for biofuel crops, as an aid to extract fuels, and in the case of hydropower, as the fuel itself. For this reason, hydropower sits at the heart of the nexus – not only using water for fuel, but also making it available for other uses. Hydropower provides an important water management function in addition to generating energy – from providing a means to make water available in times of scarcity, to absorbing flows during times of excess.

One of the key emerging issues within the nexus is the difference between water use and consumption. An energy technology's water use, sometimes referred to as its water footprint, is the amount of water that is used in order to produce a unit of energy. The water used as fuel for generating hydroelectricity is returned to the water course and remains available for other purposes. The issue of consumptive use of water, on the other hand, examines how much water is consumed and is, therefore, no longer available. For hydropower, evaporative losses are increasingly considered to be consumptive losses.

However, most watercourses already lost water through evaporation prior to the introduction of a reservoir – and so a net approach is the only way to accurately assess the evaporative losses of a reservoir. A net evaporation evaluation takes into account the pre-existing characteristics of the site by factoring out the natural evapotranspiration of plants in the flooded area and the evaporation of pre-existing water bodies, both of which occur naturally in any landscape.

Furthermore, reservoirs typically make water available to the system that was previously not available when needed. Wet seasons and dry seasons lead to an uneven hydrograph, with too much water for part of the year and not enough in other parts of the year. Through the strategic use of a reservoir, hydropower facilities are able to smooth the annual variations in runoff – conserving excess water in the reservoir during high-flow periods for use during times when natural inflows are insufficient. This implies a credit may be needed in any true assessment of hydropower's water footprint – recognising the value of making water available when it is most needed.

And finally, hydropower reservoirs are typically built for multiple purposes, and electricity generation is often not the primary purpose. Other purposes include irrigation, flood control, navigation and drinking water supply. Any evaporative net loss of water from a reservoir should be allocated among all the main uses of the reservoir rather than being attributed to only one of a reservoir's multiple purposes.

Evaluation framework for energy impacts on water (W4EF)

The W4EF project is organised under the auspices of the World Water Council and is led by EDF. The project aims to provide a framework for assessing the energy sector's impacts on water, developing approaches and methodologies that are applicable across all energy sector technologies.

Assessing the relations between an energy activity and its water environment requires more than simple volume estimations. Taking into account both quantity and quality of usages, the W4EF relates these figures to the local situation and calculates indicators estimating several kinds of interactions. Flexibility is a key factor for providing any user with a common set of coherent and simple indicators helping to produce a first estimation of the risks an energy activity may be facing in regards to its water environment.

The main objective of the W4EF initiative is to provide all energy sectors with a common terminology and assessment method to evaluate the relations between energy production and water.

Multipurpose water uses of hydropower reservoirs

The multipurpose water uses of hydropower reservoirs project (hereafter referred to as the Multipurpose Project) was led by EDF as part of its collaboration with the World Water Council and resulted from the 6th World Water Forum in 2012.

Many of the water reservoirs in the world are dedicated to several purposes. The Multipurpose Project introduces a framework to analyse reservoirs where hydropower is one of the main functions, and is a key driver for the project's development. The framework recognises that reservoir purposes can conflict at times, but are often complementary.

The Multipurpose Project is based on the principles of 'Shared vision, shared resource, shared responsibilities, shared rights and risks, and shared costs and benefits'. These principles drive the 'SHARE' concept: sustainability approach for all users, higher efficiency and equity among sectors, adaptability for all solutions, river basin perspectives for all, and engaging all stakeholders.

The framework addresses several topics: tools to avoid or minimise tensions among users, governance issues for all stages, and financial/economic models to develop and operate such multipurpose reservoirs. It discusses good practices in multipurpose reservoir design, development and implementation, and includes twelve case studies from around the world highlighting at least one aspect of the SHARE concept.

While not a direct aim of the Multipurpose Project, the work highlights that any use of water or loss of water in a multipurpose reservoir is a shared responsibility among all the users of the reservoir, not just the hydropower operator.

WHAT NEXT?

The issue of water consumption and hydropower is one that requires further examination, understanding and communication. Over the past three years, the International Hydropower Association has supported two initiatives, described in this section, that seek to address some of the issues associated with the water–energy nexus.

HYDROPOWER AND CLIMATE CHANGE

In December 2015, representatives from across the world will gather in Paris for the 21st Conference of Parties (COP21), where climate change negotiations will take place under the umbrella of the UN Framework Convention on Climate Change (UNFCCC).

COP21, will be the culmination of two years of intensive negotiations and is expected to produce a legally binding international treaty focused on preventing irreversible climate change. Specifically, the agreement, if reached, will aim to limit the Earth's temperature rise to no more than 2°C by limiting the atmospheric concentration of CO_2 to 450 parts per million.

The energy supply sector is the largest emitter of greenhouse gases (GHG) globally, and is already under increased pressure to decarbonise. However, depending on the outcome of COP21, the sector may be required to do substantially more. In light of this, it is useful to understand hydropower's relationship to climate change in terms of contributions, uncertainties, risks, opportunities and strategies.

The International Hydropower Association considers hydropower and climate change through four lenses: mitigation, GHG footprint, resilience, and adaptation services. As a renewable energy, hydropower is a mitigation strategy against climate change. But there is also a need to understand, predict and, where necessary, mitigate the potential GHG footprint of hydropower at specific sites.

Furthermore, as the climate changes, these major infrastructure investments must ensure climate resilience is built into both new and existing projects, while also considering the role of hydropower reservoirs in helping societies to adapt.

Climate change mitigation – offsetting the GHG impact of providing electricity

As the energy sector accounts for 35 per cent of global emissions, the options for slowing climate change will continue to be heavily focused on this sector. Decarbonising the electricity system is possible by improving energy efficiency of the system and through increased use of renewable energies in place of fossil fuel generation, that is, offsetting the use of fossil fuels with cleaner technologies.

It is here that hydropower has a two-pronged role to play: it is both a renewable energy that can directly offset fossil fuel use when it is deployed in place of fossil fuel generation, and it is also an energy storage technology that enable a greater penetration of more variable forms of renewable energy such as wind and solar power.

This is why, as the world's leading renewable energy technology in terms of both installed capacity (1,036 GW) and total generation (3,900 TWh/year) in 2014, hydropower is recognised as a clean, renewable, low-carbon energy technology. It is recognised as a tool for mitigating climate change by offsetting the use of fossil fuels.

Hydropower's generally low emissions of 28 g CO_2e/kWh – the median value as reported by the International Panel on Climate Change – are significantly lower than other electricity generation technologies, with mean values ranging from 490 g CO_2e/kWh for gas-fired generation up to 820 g CO_2e/kWh for coal-fired generation.

Given the current uncertainties around the GHG impact of a specific reservoir, the UNFCCC has produced an interim methodology for ascribing emissions, based on the reservoir area and the capacity of the hydropower station. This 'power density' approach creates three categories and allocates an emissions profile to each of the three categories allowed by the Clean Development Mechanism (CDM):

Power density per reservoir area	UNFCCC allocated emissions for use in calculating offsets
≥10 Watts per m^2	0 g CO_2e/kWh
4-10 Watts per m^2	90 g CO_2e/kWh
<4 Watts per m^2	not effective in offsetting carbon emissions

In the absence of a more refined methodology, these rates of emissions from hydropower are used for calculating the GHG offset that hydroelectricity provides. While it is clear that hydropower gains credit from this, it is also apparent that some power density approach largely over-ascribes emissions from hydropower, in relation to the average emissions of the power system it is feeding into.

Upon closer examination, all storage hydropower projects would be considered poor performers using the above methodology, when in fact most have very low emissions profiles. This highlights the need for better tools to estimate the GHG impact of a specific reservoir based on its actual characteristics (see GHG footprint section p.16).

In a world impacted by climate change, water storage reservoirs will be fundamental to adaptation, where storage capability will enable better planning for and response to increased floods and droughts (see climate adaptation subsection p.18). This, coupled with the need to provide energy storage (see below), will mean that more storage reservoirs will be developed in the future.

Hydropower as energy storage – enabling variable renewables

In addition to being the world's largest supply of renewable electricity, the unique characteristics of storage hydropower (i.e. hydropower with a reservoir, including, but not limited to, pumped-storage hydropower) make it well suited to enabling the increased penetration of other more variable renewable energy technologies, specifically wind and solar power.

Hydropower reservoirs already play a significant role in providing energy storage to the grid, which helps to smooth the fluctuating relationship between supply and demand. Estimates indicate that hydropower today represents approximately 99 per cent of the world's electricity storage capacity. It is widely recognised that as the penetration of all renewables increases, especially variable renewables such as wind and solar, there will be a greater need for more energy storage capability to smooth increased fluctuations and firm up supply of the electricity system.

Specifically, when water is pumped into a reservoir or stored through natural inflows, it can be released at any time that it is needed by the grid system. So when the wind stops blowing or the sun's energy is interrupted by cloud and rain, stored energy in the form of reservoir water can be released to compensate for the loss of electricity in the system.

Similarly, when there is excess wind or solar power in the system, the excess can be used to power pumps to store this renewable energy for later use. Hydropower operations can also provide ancillary services that support grid stability by stabilising voltage and frequency.

Hydropower's role as facilitating technology is expected to increase as more energy storage is needed as part of the global shift towards increased use of renewable energy.

GHG footprint – understanding and managing hydropower's impact

While hydropower is recognised as a clean energy technology and standard methodologies exist for allocating offsets, there are some sites where reservoirs may have a negative impact on the GHG regime. As the pressure to mitigate climate change increases, so does the need to quantify all human activity in terms of GHG impact. As part of this, the hydropower sector must also quantify its own footprint and take appropriate measures to mitigate or offset impacts where necessary.

Hydropower's GHG footprint arises from two aspects: the GHG impact of physical materials, manufacturing of equipment, and construction processes; and GHG fluxes from reservoirs. The GHG emissions associated with the construction and materials needed to build a hydropower station typically represent about 1-2 g for each kWh of electricity generated. As for the reservoir, the Intergovernmental Panel on Climate Change, based on a review of specific site assessments of 120 reservoirs, currently reports the median value for hydropower's GHG footprint worldwide is 28 g of CO_2 equivalent to each kWh (28 gCO_2e/kWh).

Much work has been done in recent years on quantifying the impact of the creation of a specific reservoir on the GHG balance. Studies have clearly shown that all freshwater systems transport and emit GHG due to the decomposition of organic material. This means that rivers, lakes and reservoirs can emit carbon dioxide (CO_2) and methane (CH_4), or they can also act as sinks, absorbing CO_2 from the atmosphere.

The amount emitted is a function of the local natural environment, climate conditions, and human activity in the area. The source of these GHGs can be the natural carbon cycle at the site, specific conditions in the water of the reservoir (i.e. stratified, anoxic zones), and upstream unrelated human activities, such as sewage outflow, agricultural runoff, and industrial effluent.

Separating these elements in terms of quantifying the GHG impact of a reservoir on the pre-existing condition is a challenge, but these factors can have an impact on the GHG profile of a reservoir. As such, when assessing the footprint of hydropower, it is important to consider this pre-existing GHG regime, as well as other human activities not related to the reservoir itself.

Such an analysis of the net emissions of a reservoir will subtract the pre-existing emissions from the river or lake system, as well as the impact of unrelated anthropogenic activities in the catchment area. However, undertaking extensive measurements of the net emissions of a reservoir is a time-consuming exercise and cost-prohibitive in all but the most well-funded locations.

To address the need to assess hydropower's GHG footprint at each reservoir site, work is being undertaken to develop methodologies and tools to assist with predicting the net GHG impact of a reservoir using input parameters normally available through rigorous environmental and social impact studies.

Launched in 2006, the UNESCO/IHA GHG Status of Freshwater Reservoirs project aims to develop a preliminary screening tool for the hydropower sector and its stakeholders to assess the likely net GHG impact of a reservoir. This information can also be used to assess options for mitigating this impact, whether through an altered project design or operational regime, or through activities in the catchment area to reduce unrelated anthropogenic sources of GHG emissions.

Furthermore, as most of the world's reservoirs are not primarily built for hydropower, it is important to not over-ascribe GHG impacts to one sector or user of the reservoir. Allocating the GHG footprint to the multiple services of the reservoir will give a truer reflection of the GHG impact of hydropower and other reservoir services.

The UNESCO/IHA GHG Status of Freshwater Reservoirs project has recently completed the development of a prototype tool to screen for net GHG emissions. The tool, called G-res, is now undergoing a peer review process prior to its finalisation, which is planned for May 2016. If you would like to contribute to the peer review process, please contact **hd@hydropower.org**

Planning for the future – incorporating resilience into project siting, design and operations

Even with efforts to reduce emissions, it is clear that the world's climate is changing. Alongside actions to measure hydropower's potential contribution to climate change and mitigation strategies favouring low-carbon energy, it is now also incumbent on the global community to adapt to the changing climate and prepare for its potential impacts.

Climate resilience calls for the development of systems and structures that are inherently capable of absorbing change, and even potentially capable of utilising climate change to become more efficient. Actions for climate resilience are those that seek to both understand and respond to risk by reducing vulnerability, or by increasing adaptive capacity to climate change.

Future climate conditions are uncertain, especially at the local, site-specific level. Governments, developers, investors and other stakeholders involved in hydropower will need to make decisions that can withstand a range of conditions related to a degree of uncertainty.

Hydropower systems are characterised by their longevity, and are traditionally designed on the basis of historical hydrological data. However, under climate change, the past is no longer an exact indication of the future, particularly with respect to precipitation patterns. Two general approaches to planning and investment are emerging in light of this uncertainty:

1. Traditional, top-down decision-making calls for selecting a climate and demand scenario and an associated climate model upon which to base a project's design.
2. A bottom-up approach, referred to as 'decision-making under uncertainty' (DMU), tests a preferred design against a range of scenarios to determine if the investment is sound under many or all scenarios. DMU is intended to support projects that make sense in any climate scenario for a given location, or even in the absence of climate change.

Climate change is expected to bring about more intense extreme events, such as floods and droughts, as well as to shift demand patterns – for example, earlier hotter summers may drive an increased need for electric cooling earlier in the year. Planning hydropower systems from a long-term, climate-resilient perspective should include the aim to ensure that future generations inherit institutions and infrastructure that will not be compromised by climate change.

Climate-resilient infrastructure must therefore address two key concerns: safety in the face of more extreme weather events, and continued or enhanced productivity in light of changing precipitation and demand patterns. In order to be climate resilient, hydropower, as major infrastructure, must be built or modified to withstand increased occurrences of extreme events. Assets must also be able to cope with a changing pattern of floods and droughts, with equipment that is able to handle the range of conditions that will likely be placed on the infrastructure.

Furthermore, climate change brings opportunities as well as threats, and truly resilient infrastructure may be able to capitalise on this by taking on new roles and providing new services in response.

Uncertainty is a common theme running through analysis and decision-making with respect to climate resilience. While there is no one recommended approach to climate change, the hydropower sector is responding. Lenders and regulators are increasingly aware of, and reviewing requirements for, climate resilience in any project with which they participate. Responses from hydropower operators have taken many forms: establishing special climate change task forces, investing in enhanced monitoring of hydrological characteristics, reviewing dam safety, updating emergency planning and response procedures, revising storage operations rules, building in contingency and flexibility into operations, partnering with academia and meteorological agencies for climate modelling and hydrological forecasting, and conducting new analyses for generation and investment planning.

Adaptation – water storage infrastructure's role in helping societies adapt to climate change

While climate resilience looks at how hydropower infrastructure can withstand climate change and respond to the threats and opportunities posed by it, climate change adaptation takes a broader view beyond infrastructure to the societal level.

Water management is a central component of climate change adaptation. As mentioned previously, storage hydropower can serve multiple purposes including provision of clean, renewable electricity; energy storage and ancillary services in support of the changing energy mix; and flood management and drought mitigation services – which will be increasingly important under conditions of climate change.

When planned properly, a hydropower reservoir can store excess inflows during flood season, and release it when needed during the dry season. This mitigates impacts of floods and droughts. Incorporating these services often requires reassessing design criteria for new and existing hydropower assets to incorporate structural measures, such as physical capacity to store and discharge water, and re-consideration of operational measures, including reservoir drawdown prior to flood season and/or restricted generation during times of drought.

Managing excess water and delivering highly valued water requires good understanding at the levels of policy, implementation and operation. Developing water management infrastructure to serve multiple purposes is more complex than undertaking than single-purpose projects. Further complicating matters, current market and policy incentives are misaligned with the needs of climate adaptation.

While there is a great need for more water storage to facilitate climate adaptation, one of the key challenges is determining who can and who should pay for these services. Climate adaptation is often considered a public good which societies expect public funds to cover. This is inherently at odds with a private sector approach to hydropower development.

Often, incentives – including the UNFCCC's CDM programme – have the effect of discouraging development of storage reservoirs, which is contrary to the needs of society in a climate-constrained world. There is already a requirement for more water storage capacity worldwide, and climate change adds another dimension to this need. There is a strong need for policy-makers to consider the adaptation side of climate change, even revisiting policies that were intended to be 'climate-friendly'.

WHAT NEXT?

While climate change brings risks as well as opportunities, more work is needed to optimise hydropower in the face of climate change. From building a better understanding of the GHG footprint of reservoirs, to encouraging the better definition of climate-resilient development, to supporting the role of hydropower in helping societies mitigate and adapt to climate change, IHA is working with the hydropower sector and other stakeholders to improve knowledge and understanding on the topic.

SUSTAINABILITY: PROJECT ASSESSMENTS IN 2014/15

The Hydropower Sustainability Assessment Protocol, launched in 2011, is a framework for assessing project sustainability across a range of social, environmental, technical and economic considerations. It was developed by a multi-stakeholder community of governments, commercial and development banks, social and environmental NGOs, and industry.

During 2014, the protocol has been applied widely, with increased uptake in developing and middle-income countries. It has now been used in all regions of the globe.

The period has also seen a diversification of users, from industry-leading companies to other hydropower stakeholders such as financial, governmental and non-governmental organisations.

As the managing body of the protocol, the International Hydropower Association (IHA) supports the governance and management structures for the protocol. It also leads training courses for companies, banks and accredited assessors.

Recent protocol applications

There were eleven official project assessments between January 2014 and mid-2015. Notably, this included the first two applications of the protocol's early stage tool, which focuses on preliminary screening of potential projects from a sustainability perspective.

Most assessments have been implemented through sustainability partnerships, in which IHA works with a company to provide training and support, followed by the first assessment.

The model has proved successful in simplifying initial engagement with the tool and will continue to be important for introducing new projects and users to the protocol. Sustainability partners now comprise all types of developers, and extend beyond IHA's membership to governments, civil society and financial institutions.

The ability to demonstrate how the protocol works through published assessments has also built the tool's integrity and value, and has driven further interest. The assessment of the Kabeli-A project (37.6 MW) in Nepal was a particularly important landmark, being the first published assessment from a developing country.

Looking forward, the sustainability partnership model will continue to evolve. While it will continue to be a means for a growing body of developers and owners to engage with the protocol, it will also become a means of evaluating projects for finance and regulatory approval, and provide a framework for management system and internal sustainability capacity-building.

SUSTAINABILITY: PROJECT ASSESSMENTS IN 2014/15 CONTINUED

Projects

The protocol continues to enjoy strong support from third parties, and the contribution of SECO and Norad are gratefully acknowledged. SECO is coordinating a project which focuses on the early stage tool and providing support around protocol communication, while the Norad project focuses on driving protocol uptake in developing economies.

IHA is also working closely with the World Bank Group in driving protocol uptake through direct projects, including assessments and capacity-building workshops.

Training

There have been 38 training workshops run to date, twelve of which took place between January 2014 and June 2015. Training has taken place across the spectrum of development agendas and in all regions in the world.

The training materials have expanded from week-long courses run by IHA to a fully flexible set of materials that is adaptable to the needs of each user. These materials are continually updated and expanded.

Besides providing training for sustainability partners before assessments, IHA provides support for introductory workshops for the full range of stakeholders now engaging with the protocol.

PUBLICATIONS

Numerous organisations now refer to the protocol in their own literature. A library of references is available at www.hydrosustainability.org/references and summarised here:

- Citi: Hydropower sector brief
- Government of Germany: Compliance with environmental and social standards for large dam projects
- E.ON: The Hydropower Sustainability Assessment Protocol in practice – a utility's perspective
- ICPDR: Sustainable Hydropower Development in the Danube Basin: Guiding Principles
- IIED: A review of social and environmental safeguards for large dam projects
- IIED: The business case for bilateral support to improve sustainability of private sector hydropower
- OECD: Common Approaches
- Standard Chartered Position Statement: Dams and Hydropower
- WWF: Everything you need to know about the UN Watercourses Convention

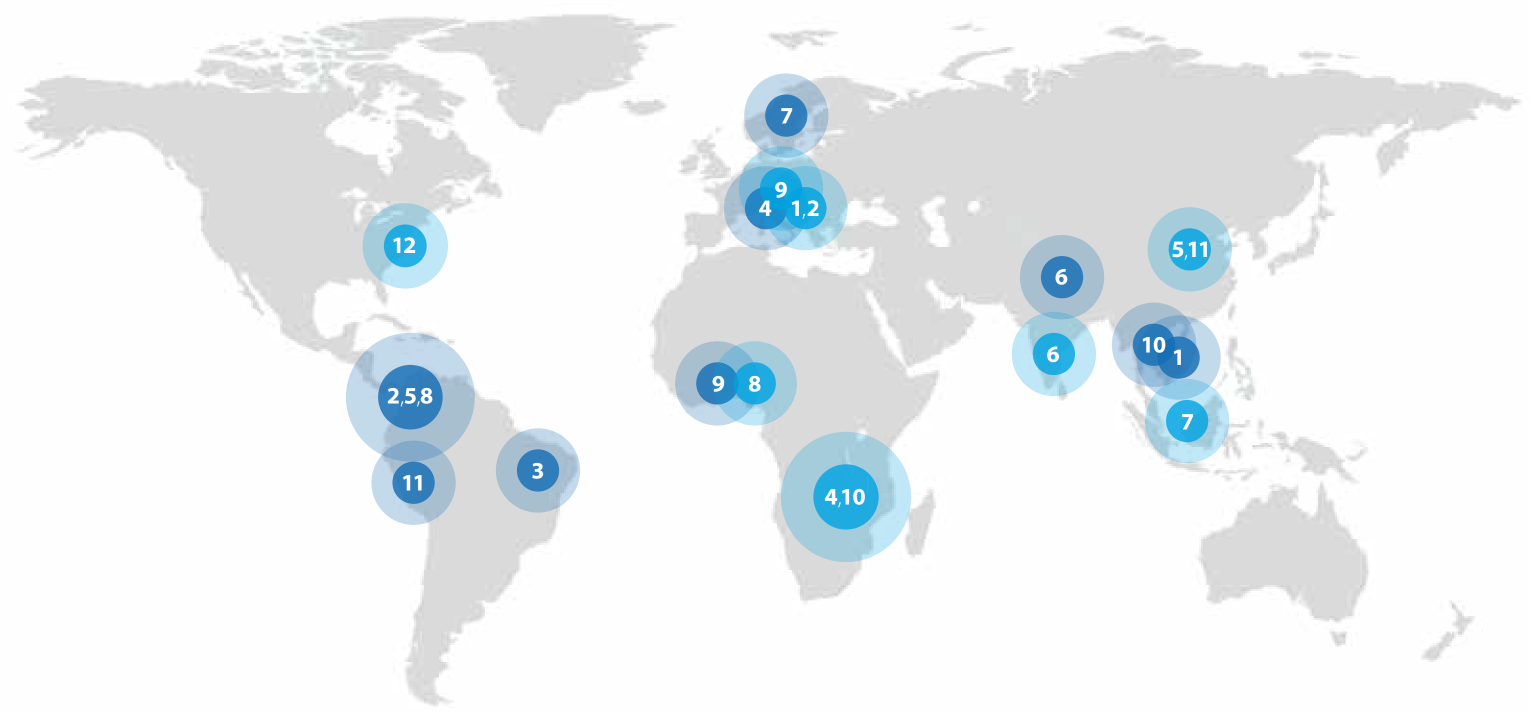
SUSTAINABILITY: PROJECT ASSESSMENTS IN 2014/15 CONTINUED

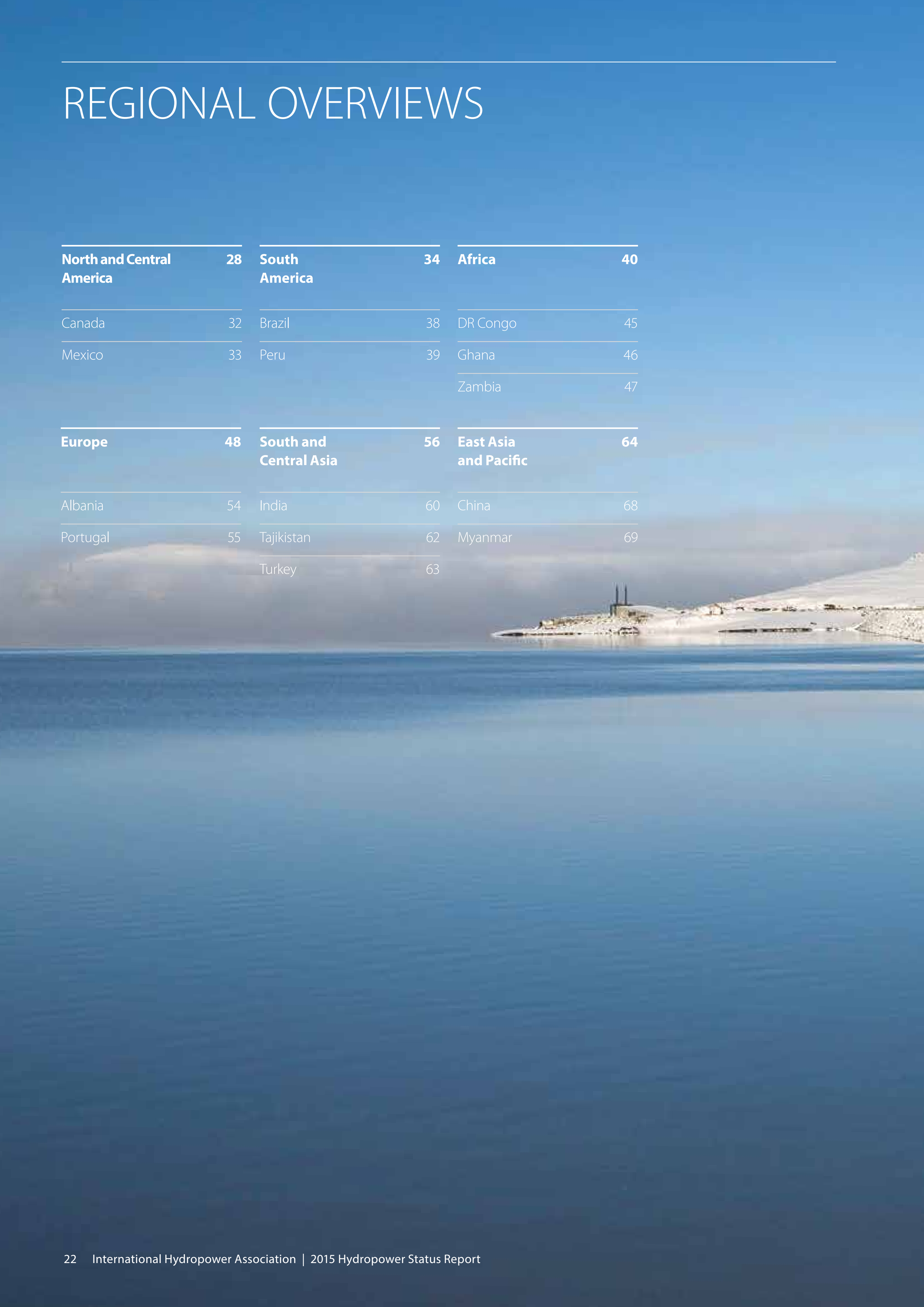
Assessments

	Developer	Country	Stage	Date
1	EVN/TSHPCo	**Vietnam**	Implementation	Jan-14
2	Isagen	**Colombia**	Preparation	Mar-14
3	SAE	**Brazil**	Implementation	Apr-14
4	HEP	**Croatia**	Early Stage	Jun-14
5	Isagen	**Colombia**	Operation	Jun-14
6	Kabeli Energy	**Nepal**	Preparation	Sep-14
7	E.ON	**Sweden**	Preparation	Nov-14
8	EPM	**Colombia**	Preparation	Nov-14
9	Ministry of Power	**Ghana**	Early Stage	Apr-15
10	China Three Gorges	**Laos**	Operation	Apr-15
11	Odebrecht	**Peru**	Implementation	Jun-15

Training

	Host Organisation	Location	Date
1	Program Sava	**Zagreb, Croatia**	Feb-14
2	HIEP	**Zagreb, Croatia**	May-14
3	Kabeli-A	**Kathmandu, Nepal**	Jun-14
4	WWF	**Lusaka, Zambia**	Jun-14
5	China Three Gorges	**Beijing, China**	Aug-14
6	Jindal Power	**Delhi, India**	Aug-14
7	Sarawak Energy	**Kuching, Malaysia**	Dec-14
8	Ministry of Power	**Accra, Ghana**	Jan-15
9	TIWAG	**Innsbruck, Austria**	Jan-15
10	ZAMDU-WWF	**Zambia**	Apr-15
11	World Hydropower Congress	**Beijing, China**	May-15
12	World Bank	**Washington DC**	Jun-15





REGIONAL OVERVIEWS

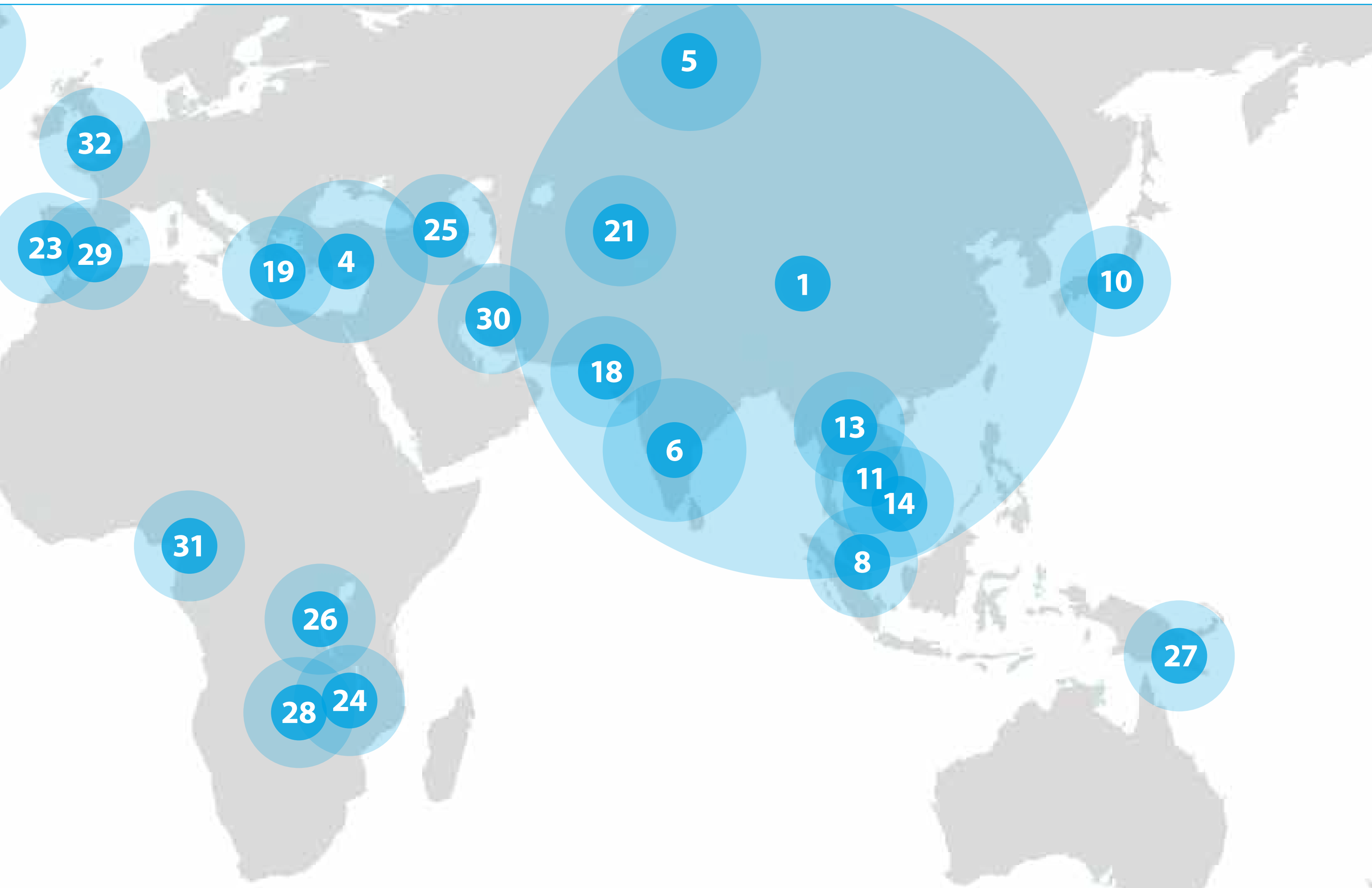
WHERE HAS NEW HYDROPOWER CAPACITY BEEN ADDED IN 2014?

NEW INSTALLED CAPACITY BY COUNTRY

Rank	Country	Capacity added
1	China	21,250 MW + 600 MW pumped storage
2	Brazil	3,312 MW
3	Canada	1,995 MW
4	Turkey	1,352 MW
5	Russia	1,058 MW + 160 MW pumped storage
6	India	1,195 MW

Rank	Country	Capacity added
7	Colombia	875 MW
8	Malaysia	836 MW
9	Mexico	760 MW
10	Japan	34 MW + 690 MW pumped storage
11	Cambodia	707 MW
12	Chile	316 MW

Rank	Country	Capacity added
13	Laos	308 MW
14	Vietnam	281 MW
15	Venezuela	257 MW
16	USA	212 MW
17	Peru	199 MW
18	Pakistan	178 MW

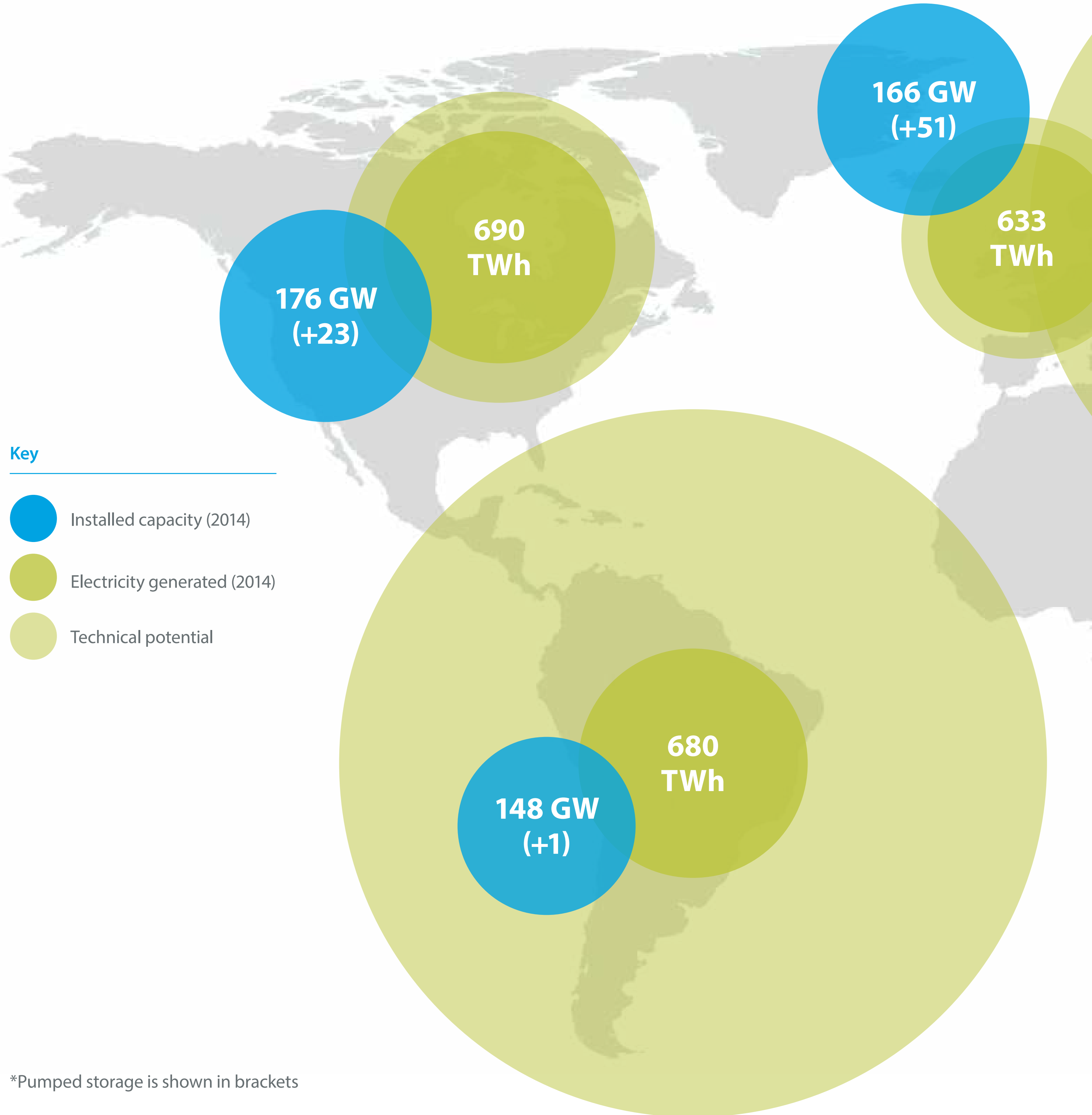


Rank	Country	Capacity added
19	Greece	160 MW
20	Panama	154 MW
21	Kyrgyzstan	120 MW
22	Iceland	95 MW
23	Portugal	81 MW
24	Malawi	64 MW

Rank	Country	Capacity added
25	Azerbaijan	53 MW
26	Rwanda	34 MW
27	Papua New Guinea	18 MW
28	Zambia	14 MW
29	Spain	11 MW pumped storage
30	Iran	10 MW

Rank	Country	Capacity added
31	Cameroon	5 MW
32	United Kingdom	4 MW

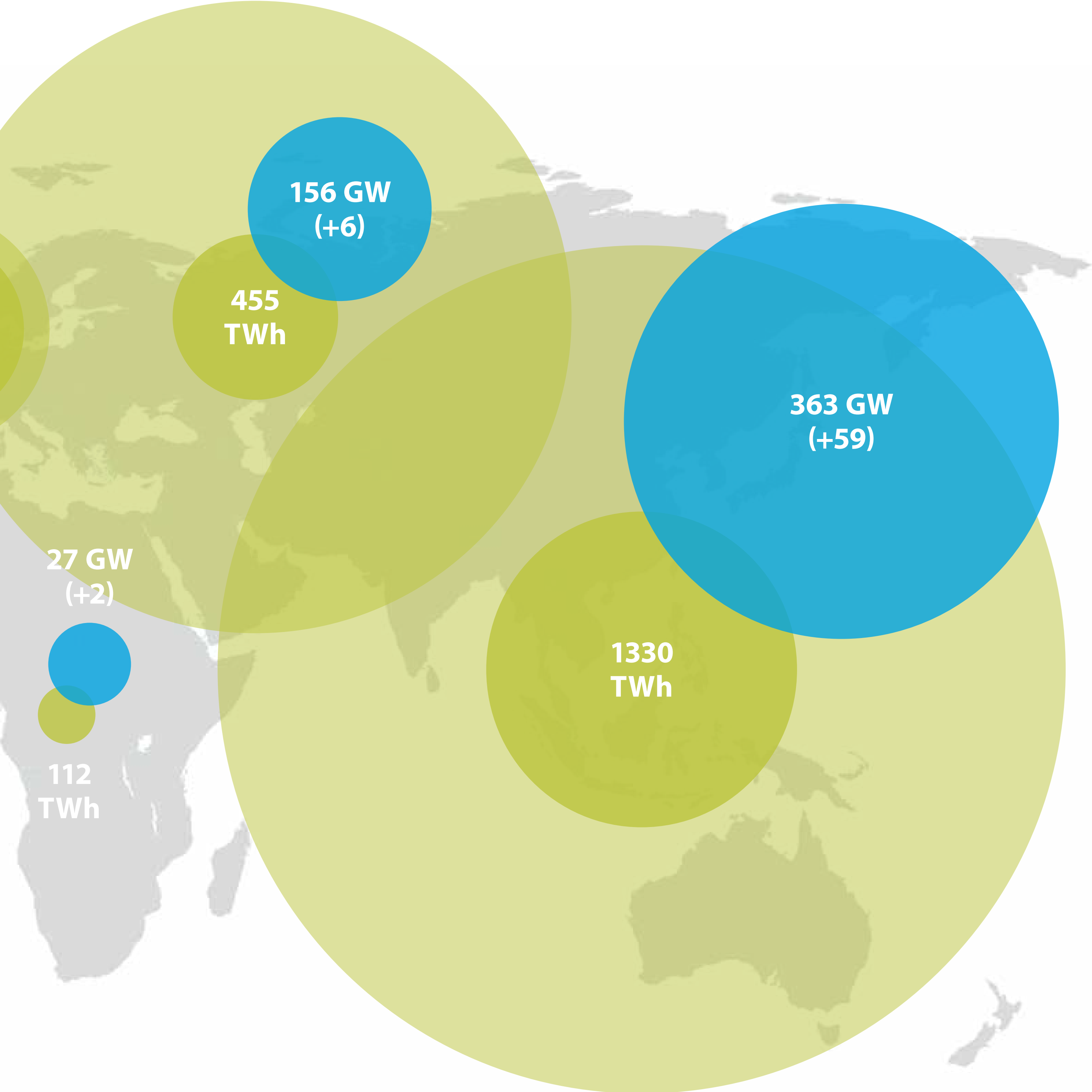
GLOBAL HYDROPOWER TECHNICAL POTENTIAL, GENERATION AND INSTALLED CAPACITY BY REGION*



Key

- Installed capacity (2014)
- Electricity generated (2014)
- Technical potential

*Pumped storage is shown in brackets


156 GW
(+6)
455
TWh
363 GW
(+59)
27 GW
(+2)
112
TWh
1330
TWh

NORTH AND CENTRAL AMERICA **REGION MAP**

Map shows countries in the region with total installed capacity above 200 MW, excluding pumped storage

TOP SIX COUNTRIES BY INSTALLED HYDROPOWER CAPACITY (MW)* **OTHERS:** 2,002 | **TOTAL:** 175,388

1	2	3	4	5	6
UNITED STATES 79,270	CANADA 77,558	MEXICO 12,410	COSTA RICA 1,750	PANAMA 1,622	GUATEMALA 991

NORTH AND CENTRAL AMERICA
CAPACITY BY COUNTRY

Rank	Country	Installed hydropower capacity (MW)*
1	**United States**	79,270
2	**Canada**	77,558
3	**Mexico**	12,410
4	**Costa Rica**	1,750
5	**Panama**	1,622
6	**Guatemala**	991
7	**Honduras**	558
8	**Dominican Republic**	543
9	**El Salvador**	472
10	**Nicaragua**	106
11	**Puerto Rico**	100
12	**Cuba**	64
13	**Haiti**	61
14	**Belize**	53
15	**Jamaica**	23
16	**Guadeloupe**	10
17	**Saint Vincent and the Grenadines**	7
18	**Dominica**	6

* excludes pumped storage

NORTH AND CENTRAL AMERICA **OVERVIEW**

Although hydropower is already a highly developed sector in Canada and the United States, both countries are continuing to see growth and innovation. Meanwhile, improved electricity infrastructure in Central America is driving sustainable hydropower development across the region.

The US and Canada are world leaders in hydropower. Both have very large installed hydropower capacities, at 79.6 GW and 77.6 GW respectively (not including pumped storage). In Canada, hydropower generates around 63 per cent of total electricity, while the US figure is only 6 per cent, due to the latter's far larger population and greater demand for electricity.

Going forward, Canada's strategy will include further large deployments, with 4,000 MW worth of projects currently entering the construction phase. By contrast, development in the US will now primarily take the form of unit additions and upgrades to existing facilities, alongside the construction of new powerhouses at dams and water infrastructure originally built for other purposes.

Indeed, most of the US's new capacity in 2014 came from small projects and upgrades to existing sites. Notable additions include 122 MW at the Wanapum Dam (1,040 MW) in Washington, as part of an ongoing renovation project; 25.2 MW at Lake Livingston, Texas, previously a non-powered dam; and the ongoing addition by American Municipal Power of 313 MW of new hydro capacity at four sites on the Ohio river.

Bringing hydropower technology to non-powered dams has recently been incentivised by the federal government. In early 2014, President Obama signed a pair of bills which both streamline the approval process for small hydropower facilities at existing water infrastructure. The Hydropower Regulatory Efficiency Act increases the capacity of hydropower plants eligible for a licensing exemption from 5 to 10 MW in locations with existing water infrastructure or in locations with natural hydropower potential, such as waterfalls.

There are currently 331 proposed projects registered with the Federal Energy Regulatory Commission (FERC) in the US, which would amount to 4,370 MW of installed capacity. Of this total, 407 MW is now in the construction phase, while a further 315 MW have received FERC's authorisation. Two pumped storage projects were also authorised in 2014, marking the end of a two-decade hiatus in such approvals.

Despite slowed growth, hydropower remains by far the largest source of renewable energy in the US, occupying almost half the share of electricity generated by renewables in 2014. The US also continues to import Canadian hydropower. Net imports totalled 62.5 million MWh in 2013, amounting to 1.5 per cent of total electricity consumption in the US that year.

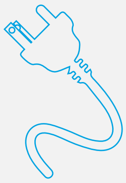
The integration of electricity infrastructure and markets is also improving across Central America. The Central American Electrical Interconnection System (SIEPAC), a 1,800 km transmission line which reaches from Guatemala to Panama, saw its final segment, connecting Costa Rica and Panama, completed in October 2014. This network enhances regional energy security by significantly increasing the power transfer capacity and opening up the regional electricity market by allowing for the purchase and sale of power regardless of geographical location. SIEPAC countries can therefore meet domestic power demand with electricity imports, rather than turning to expensive thermal fuels. Over time it is expected that SIEPAC will connect with the large demand centres of Colombia and Mexico.

The transmission line is currently underutilised, but is nevertheless driving a number of new hydropower projects across Central America. Its commissioning coincides with that of the 305.5 MW Reventazón station in Costa Rica. This five-year project, which is the second largest infrastructure development in the region after the Panama Canal, is expected to begin supplying electricity to the grid in early 2016, before Costa Rica's dry season begins.

Meanwhile, Panama added 154 MW of installed capacity in 2014, including commissioning of the El Alto (72 MW), Monte Lirio (51.65 MW) and San Andres (12.8 MW) stations. All of these will benefit from the new SIEPAC transmission system, which is serving as the key means by which their power can be brought to market.

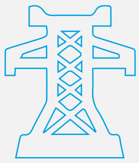
The region also saw a new record set in early 2015 as Costa Rica used only renewables to power the country for 75 days. Hydropower, which usually accounts for around 80 per cent of the country's electricity mix, was a crucial factor in this success. Geothermal energy and some wind power made up the remainder of the mix. Heavy rainfall led to record levels of electricity generation at Costa Rica's four largest hydropower stations in early 2015, which enabled the country to achieve this milestone.

POLICIES



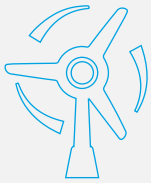
Canada

The Program of Energy Research and Development (PERD) supports research and development for hydropower. The feed-in tariff programme in Ontario includes 40-year contracts for hydro plants, with specific incentives for projects featuring aboriginal and community participation.



Mexico

Grid interconnection contract for renewable energy supports small hydropower installations, requiring utilities to prioritise renewable sources and providing discounts of 50 to 70 per cent for transmission costs.



United States

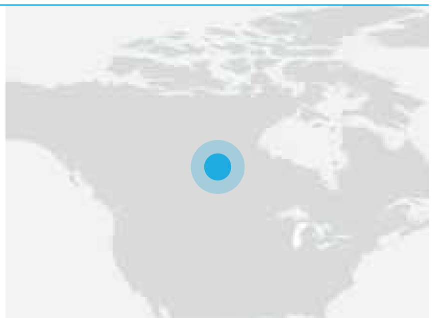
The Wind and Water Power Program funds research and development on materials and manufacturing techniques to improve performance and lower costs of conventional hydropower. It also supports the development of marine and hydrokinetic technologies.

HYDROPOWER TARGETS

Country	Target
Canada	1.5 GW by 2025 in Ontario
USA	Renewable Portfolio Standards (RPS) are state policies that establish a minimum required percentage of renewable power for electricity generation. There are currently 38 states with RPS policies in place, all of which include hydropower as an eligible technology.

NORTH AND CENTRAL AMERICA

CANADA



Canada is the third largest generator of hydropower in the world, despite a much smaller population than other hydro giants such as China and Brazil. With an installed capacity of 77.6 GW, hydropower currently accounts for 63 per cent of the country's power mix.

There is the technical potential to add another 160 GW, without even taking into account pumped storage, refurbishments, or the addition of new powerhouses to existing dams. Current projects entering the construction phase will contribute 4,000 MW to installed capacity, while an additional 7,000 MW worth of projects are in the provisional or early planning stage.

While the resources for hydropower development are distributed fairly evenly across the country, current levels of deployment are concentrated in certain provinces. Having already deployed 38,400 MW, Québec is the largest hydropower generator in the country. Other major producers include British Columbia (13,800 MW), Ontario (8,500 MW), Newfoundland and Labrador (6,800 MW), and Manitoba (5,000 MW). Hydropower amounts to over 90 per cent of the electricity mix in all of these provinces, except in Ontario, where there is a considerable nuclear deployment.

US states, particularly those close to the border, are increasingly choosing to import Canadian hydropower to meet their goals for a cleaner energy mix. Net exports to the US currently total around 60 million MWh per year. Nonetheless, Canadian hydropower amounts to less than 1 per cent of overall electricity consumption in the US, suggesting that there is significant capacity for growth driven by the rising demand for clean energy in the US.

2014 saw Canada install 1,955 MW of new hydropower capacity. Major additions included the commissioning of the Romaine 2 station (640 MW) in Québec; completion of the Romaine 1 (270 MW) is expected in early 2016.

The Mica Creek facility in British Columbia also installed its fifth unit last year, bringing a further 520 MW into the mix. This project has benefitted from a close collaboration with the Secwepemc First Nation. Maintaining a 65 per cent First Nations employment target, the Mica Construction Camp project contributed more than CAD 2 million to the local economy.

More recently, the Lower Mattagami project (438 MW) was completed in early 2015. This four-station complex, Northern Ontario's largest hydropower project in 50 years, was the result of a partnership between Ontario Power Generation and the Moose Cree First Nation.

Indeed, many projects in Canada are now firmly rooted in collaboration between developers and First Nation communities, and the Canadian hydropower sector has become a world leader in aboriginal relations. The Keeyask station (695 MW) in Manitoba, the first project in Canada to apply the Hydropower Sustainability Assessment Protocol, has been developed in partnership with four aboriginal Cree Nations. These communities have participated actively in project design and governance, while vital conservation efforts have depended on local and traditional knowledge to protect aquatic species such as the sturgeon.

POPULATION
35,160,000

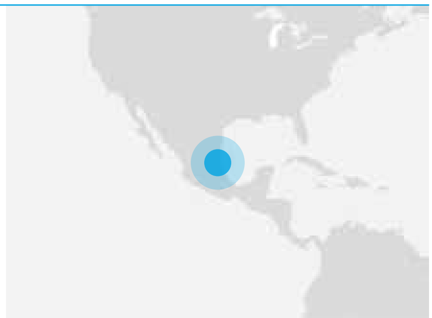
AREA
9,093,500 km²

GDP
USD 1,827 bn

INSTALLED HYDROPOWER CAPACITY
77,558 MW
HYDROPOWER
177 MW
PUMPED STORAGE

NORTH AND CENTRAL AMERICA

MEXICO



Mexico currently has 12,410 MW of installed hydropower capacity, accounting for roughly 20 per cent of its domestic hydropower potential (53,000 MW). In 2014, hydropower accounted for 14 per cent of total electricity generation in Mexico. The country has ambitious targets for new development of renewables, and has recently reformed its energy marketto encourage increased private sector involvement.

Despite its rich endowment of natural resources, water volumes are unevenly distributed throughout the country. Northern and central Mexico comprise around half of the land area and almost 60 per cent of the population, but just 10 per cent of the national water resources.

Consequently, hydropower supply is concentrated in the west and south-west of the country, in river basins that drain into the Pacific. The Rio Grijalva Basin in the south-west houses three of the five largest hydropower projects in the country: Chicoasen (2,400 MW), Malpaso (1,080 MW) and Angostura (900 MW). Further north, the Rio Grande de Santiago supplies three further large dams: Aguamilpa (960 MW), El Cajón (750 MW) and La Yesca (750 MW), the latter commissioned in 2014.

Mexico is the ninth largest oil producer in the world and is home to the world's 16th largest power market in terms of installed generation capacity. The state-owned Comisión Federal de Electricidad (CFE) has enjoyed an 80-year monopoly over the national power grid, and still owns and operates almost 90 per cent of the country's hydropower stations.

Recent energy reforms ratified in late 2014 aim to open up the previously restricted electricity market, making it easier for private companies to build and operate power plants. While many approach these reforms as a means to reverse the decline in oil production to exploit domestic shale deposits, legislation also requires CFE to prioritise the purchase of "clean energies… [that] reduce polluting emissions" before other sources.

The reforms also lifted restrictions on the private ownership of hydropower stations greater than 30 MW in capacity, significantly increasing the feasible potential for future hydropower development. Other new policies that drive low-carbon energy supply technologies include Mexico's General Law for Climate Change, which establishes targets of 35 per cent electricity generation from renewables by 2024 and 50 per cent by 2050. The law also introduced a clean energy certification system similar to the successful system adopted in California.

Mexico's Secretariat of Energy expects an increase in power generation capacity of roughly 20 GW by 2025, of which approximately 5 GW will come from hydropower. Much of the new development will happen in the southern states of Chiapas, Veracruz, Oaxaca, and Guerrero. Projects that have been identified by CFE that are currently under development include La Parota (900 MW), Ixtayutla (530 MW) and Paso de la Reina (540 MW).

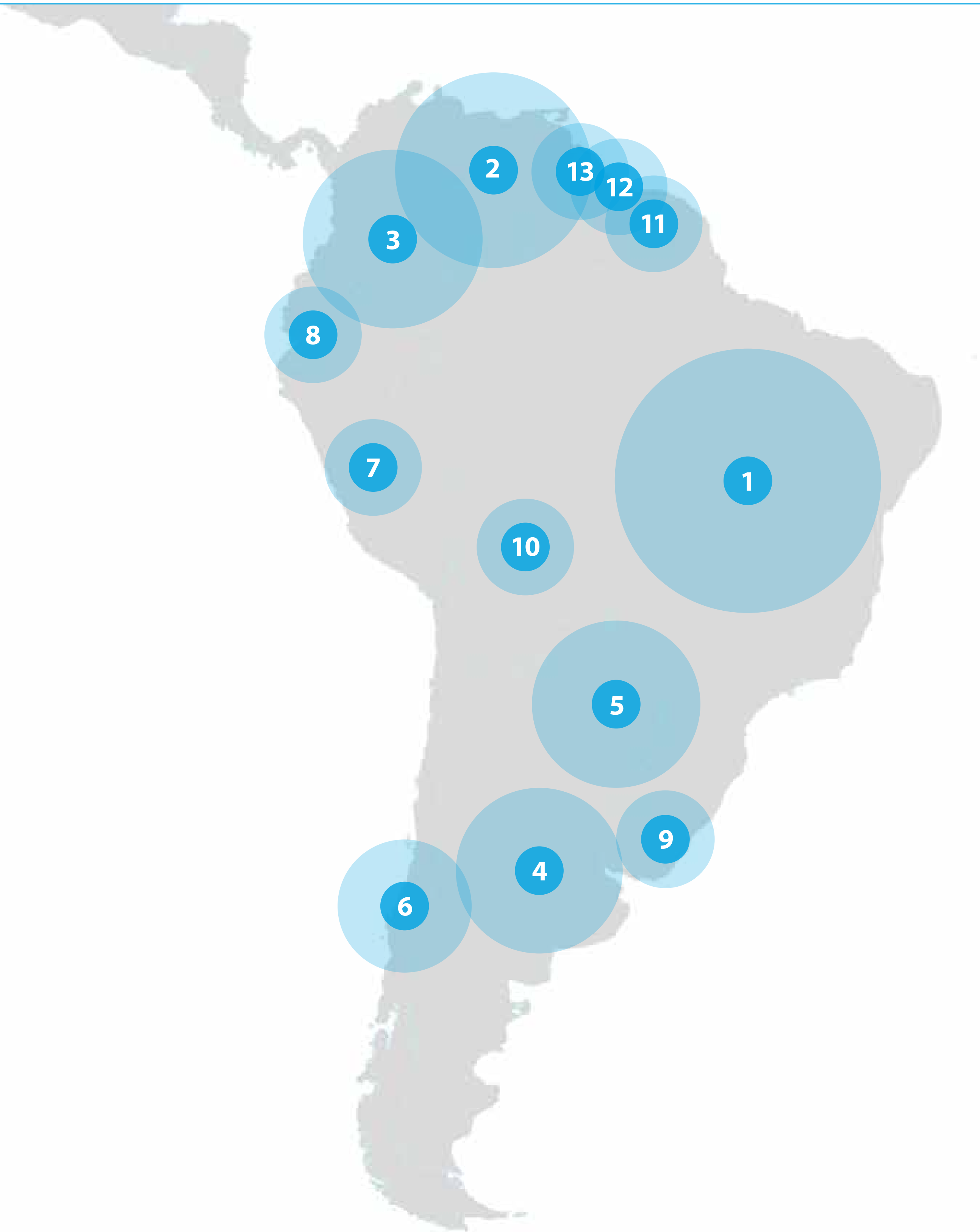
POPULATION
119,700,000

AREA
238,533 km^2

GDP
USD 1,295 bn

INSTALLED HYDROPOWER CAPACITY
12,410 MW

SOUTH AMERICA
REGION MAP



TOP SIX COUNTRIES BY INSTALLED HYDROPOWER CAPACITY (MW)* **OTHERS:** 8,378 | **TOTAL:** 147,860

1	2	3	4	5	6
BRAZIL	VENEZUELA	COLOMBIA	ARGENTINA	PARAGUAY	CHILE
89,306	15,136	10,793	9,079	8,810	6,358

SOUTH AMERICA
CAPACITY BY COUNTRY

Rank	Country	Installed hydropower capacity (MW)*
1	**Brazil**	89,306
2	**Venezuela**	15,136
3	**Colombia**	10,793
4	**Argentina**	9,079
5	**Paraguay**	8,810
6	**Chile**	6,358
7	**Peru**	3,820
8	**Ecuador**	2,237
9	**Uruguay**	1,538
10	**Bolivia**	494
11	**Suriname**	189
12	**French Guiana**	119
13	**Guyana**	1

* excludes pumped storage

"Altogether there are over 800 approved projects across the continent, estimated to be worth more than USD 200 billion."

SOUTH AMERICA
OVERVIEW

Overall, the South American region gained almost 5 GW of new hydropower capacity in 2014. While most of this was concentrated in Brazil, there were also additions in Chile, Colombia, Peru and Venezuela.

Every country in South America, with the exception of Suriname, has approved hydropower projects in the pipeline. Altogether there are over 800 approved projects across the continent, estimated to be worth more than USD 200 billion. The hydropower potential in the region as a whole is estimated to be around 580 GW, of which about a quarter has been exploited so far.

Hydropower currently accounts for approximately half the installed electricity generation capacity in the region. This significant proportion, large by global standards, is mainly a result of favourable historical economics, advanced energy planning, and established legislation regarding new project development.

Colombia completed its 820 MW Sogamoso project after six years of construction work. All three turbines came online in 2014. The project is now the fourth-largest hydropower station in the country and will provide around 8.3 per cent of the domestic electricity supply. Colombia also commissioned the 55 MW Cucuana power plant in the Tolima department. Certified as a UN clean development mechanism project, this station will provide much needed power to the region while regulating local water resources. The plant has effectively become the focal point for the river-basin-wide approach to water and environmental management in the region.

Chile connected the 316 MW Angostura project to the grid in 2014. The country's largest new plant in the last ten years, Angostura will meet about 3 per cent of the country's total electricity demand. Angostura is expected to become one of the essential contributors to the intra-national interconnection system, a north–south 2000 km transmission system that serves over 90 per cent of the population. Chile expects a further twelve hydropower plants to come online within the next five years, with a total installed capacity of around 1 GW.

In January 2014, the Ecuadorian Ministry for Electricity and Renewable Energy announced its Institutional Strategic Plan for 2014-17. The plan includes the ambitious target of generating 90 per cent of its electricity from renewable sources by 2017, while adding a further 2 GW of hydropower to reach a total 4.2 installed capacity by 2022. Although no new hydropower stations were commissioned in 2014, eight are expected to come online in 2015. The 65 MW Munduruku Dam, the first of these stations to be completed, was connected to the grid in January 2015. Another project nearing completion is the Toachi Pilaton complex (254 MW), which will consist of three power stations, the Alluriquin (204 MW), Sarapullo (48.9 MW) and Toachi Foot Dam (1.4 MW). These stations, and others in the pipeline, represent an important step towards improving Ecuador's domestic energy security while reducing the reliance on fossil fuels. Many projects in Ecuador are being financed and built by Chinese companies.

China is now a major investor in Ecuador, and the financing of hydropower stations has become a hallmark of co-operation between the two countries. The two largest stations under construction, Coca Codo Sinclair (1,500 MW) and the Sopladora (487 MW), have both received finance from the China Exim Bank.

Hydropower already provides the bulk of Venezuela's electricity, where the majority of hydropower stations are located on the Caroní River in the east of the country. The state electricity firm Corpoelec commissioned the 514 MW Fabricio Ojeda hydropower plant in late 2014. This station will help to secure the electricity supply in the area, which has recently suffered blackouts due to drought and ageing transmission infrastructure. With the support of Dongfang Electric Corporation, Venezuela also began the renovation of its Guri plant (10,235 MW), which will boost the station's capacity by a further 795 MW.

Cross-boundary interconnections, whether in the form of a power pool or bilateral agreement, are important drivers for hydropower development. Large projects often depend on these infrastructure networks for their success. The Initiative for the Integration of Regional Infrastructure in South America (IIRSA) aims to construct an interconnected network of transport, telecommunications, and power links throughout the continent. The initiative, which was founded in 2000, includes the twelve South American countries that form the Union of South American Nations as members. A few of the initiative's projects are now nearing completion and have started generating power. These include hydropower plants in the Amazon basin such as the Santo Antônio (3,568 MW) and Jirau (3,750) plants, both in Brazil.

SOUTH AMERICA: OVERVIEW CONTINUED

IIRSA supports binational dam projects such as the La Yacyretá (3,200 MW) project between Argentina and Paraguay, completed in 2011. Other binational projects in the pipeline include the Garabi Panambi complex (2,200 MW) on the border of Argentina and Brazil and the Corpus Christi project (2,880 MW), which will be shared between Argentina and Paraguay. Both these stations are in the pre-implementation stages and are waiting for the necessary approvals.

POLICIES

Chile

Currently utilities with more than 200 MW capacity will be required to generate 20 per cent of electricity from renewables by 2025. The Invest Chile Programme finances small hydropower projects and currently subsidises pre-investment studies for renewables.

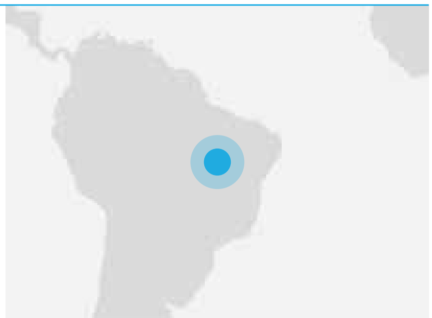
Ecuador

2013–16 feed-in tariffs for hydropower, USD 7.81/kWh for <10 MW capacity, USD 6.86/kWh for 10–30 MW capacity, and USD 6.51/kWh for 30–50 MW capacity, all contracts awarded for a period of 15 years.

HYDROPOWER TARGETS

Country	Target
Argentina	60 MW small-scale hydropower by 2016
Brazil	7.8 GW small-scale hydropower by 2021
Ecuador	2,500 MW hydropower and accounting for 93 per cent of total generation by 2017

SOUTH AMERICA
BRAZIL



Brazil is one of the largest generators of hydropower in the world, second only to China in terms of total installed capacity. In 2014, Brazil brought 3.3 GW of new capacity online, and the country's current ten-year plan for energy expansion states that installed hydropower capacity will reach 117 GW by 2023. Hydropower usually amounts to around 70-80 per cent of the country's electricity generation in any given year; however, this share has recently declined due to drought in several regions.

Brazil's large hydropower potential is concentrated in the Amazon River basin in the north, while demand for electricity is highest in the population clusters along the south-eastern coast. Considering the vast distances involved, this disparity has presented significant challenges in terms of electricity transmission and distribution infrastructure.

The last year has seen notable advances in these areas. The Rio Madeira Transmission System, comprising the longest power lines in the world at 2,375 km, was finally completed in August 2014. The 6,300 MW, 600 kV high-voltage direct current lines bring electricity from the Santo Antônio (3,568 MW) and Jirau (3,750 MW) facilities in the Amazon basin to the demand centres in the country's south-east. Both plants deployed new turbines in 2014, together installing an additional 589 MW.

In the middle of 2014, a contract was awarded to a consortium of developers, including the State Grid, Eletronorte, and Furnas, to construct the 2,092 km transmission lines which will similarly connect the Belo Monte project (11,233 MW) with the urban south-east. The USD 26 billion Belo Monte plant is expected to be complete by 2019.

As Brazil continues to endure an exceptionally dry period in the south-eastern region, low water levels led to the temporary deactivation of several hydropower facilities in early 2015. Since the last period of drought in 2001, the Brazilian government has chosen to deploy an increasing number of natural gas power stations to improve the system's resilience to climate change. Fossil fuels now amount to around one-fifth of Brazil's power mix, up from 6 per cent in 2001.

Other solutions and innovative projects are also emerging. For example, the introduction of floating solar panels to hydropower reservoirs is currently under discussion, with pilots in preparation at two state-owned dams: Sobradinho (1,050 MW) and Balbina (250 MW). These projects demonstrate a novel synergy between hydropower and solar energy: the floating panels reduce water loss while the reservoir water boosts photovoltaic efficiency by keeping the solar units cool.

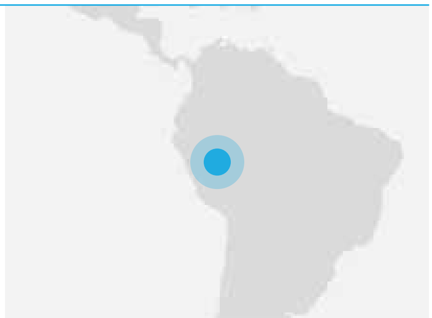
POPULATION
202,033,670

AREA
8,515,767 km^2

GDP
USD 2,244 bn

INSTALLED HYDROPOWER CAPACITY
89,306 MW

SOUTH AMERICA
PERU



Peru is the third-largest country in South America, after Brazil and Argentina. Its diverse terrain includes an arid coastline, high-altitude Andean mountains, and tropical rainforest in the Amazon basin.

Many of the Amazon River's most important tributaries originate in the Peruvian Andes, such as the fast-flowing Marañón – identified as a major 'energy artery' by the government, with over 20 projects currently in the planning stage. The total hydropower potential in Peru is estimated to be approximately 70 GW, of which only 3.8 GW have been tapped so far.

2014 saw considerable progress on the planned Marañón developments. The government granted final and definitive concessions for both the Veracruz (730 MW) and Chadin 2 (600 MW) projects to respective developers Enersis and AC Energia, a subsidiary of Odebrecht. Other recent developments include completion of the Huanza project, which brought 92 MW of installed capacity online in September 2014. The USD 1.2 billion Chaglla plant (406 MW), currently undergoing the Hydropower Sustainability Protocol Assessment, is expected to commence operations in 2016.

While sustained economic growth in Peru averaged over 6 per cent per annum in the last decade, extreme poverty and a lack of access to modern water and energy services continue to present considerable challenges, particularly in remote areas. Sustainable hydropower projects are nonetheless contributing to wider social and economic development, bringing jobs, investment, and improved infrastructure to rural areas. For example, two new hydropower facilities (totalling 27 MW), currently under construction in the Monzón valley, are expected to bring benefits and further opportunities to the local economy, following a recent government-led coca eradication programme.

According to the International Renewable Energy Agency (IRENA), demand for electricity is expected to grow at an average rate of 8.8 per cent per annum until 2017, necessitating investment of more than USD 5 billion in electricity generation and infrastructure by 2016. These investments will contribute a further 4,300 MW to the country's power mix, including 1,400 MW of installed hydropower capacity.

Last year, Peru finalised its National Energy Plan 2014 – 2025, which calls for the electricity mix to include 60 per cent renewables by 2025 (54 per cent hydropower and 6 per cent other renewables). Both large- and small-scale hydropower projects will form part of the country's strategy to meet this pledge. Since 2010, the government has signed power purchase agreements (PPAs) for no less than 44 small hydropower plants (less than 20 MW each) amounting to a total 391 MW of installed capacity. In order to ensure the participation of renewables in the future energy mix, the government has announced it will promote an auction to buy 1,200 MW of firm energy from new hydropower plants.

Peru has also become a regional leader in renewable energy auctions, promoting biomass, wind, solar and small hydropower projects. The first two auctions, held in 2009 and 2011, awarded 281 MW of small hydropower contracts to developers. The results of the third auction were announced in December 2013, and included the awarding of 16 hydropower projects which will contribute 1,278 GWh per year upon their completion.

POPULATION
30,380,000

AREA
1,280,000 km²

GDP
USD 202 bn

INSTALLED HYDROPOWER CAPACITY
3,820 MW

AFRICA
REGION MAP

Map shows countries in the region with total installed capacity above 200 MW, excluding pumped storage

TOP SIX COUNTRIES BY INSTALLED HYDROPOWER CAPACITY (MW)* **OTHERS:** 13,102 | **TOTAL:** 27,029

1	2	3	4	5	6
EGYPT	DR CONGO	SUDAN	MOZAMBIQUE	ETHIOPIA	NIGERIA
2,800	2,472	2,250	2,187	2,178	2,04

AFRICA
COUNTRY RANKINGS

Rank	Country	Installed hydropower capacity (MW)*
1	**Egypt**	2,800
2	**DR Congo**	2,472
3	**Sudan**	2,250
4	**Mozambique**	2,187
5	**Ethiopia**	2,178
6	**Nigeria**	2,040
7	**Zambia**	1,895
8	**Ghana**	1,602
9	**Morocco**	1,306
10	**Kenya**	812
11	**Angola**	760
12	**Zimbabwe**	750
13	**Cameroon**	736
14	**Uganda**	706
15	**South Africa**	661
16	**Cote D'ivoire**	604
17	**Tanzania**	562
18	**Malawi**	364
19	**Namibia**	341
20	**Algeria**	228
21	**Republic of the Congo**	209
22	**Gabon**	170
23	**Madagascar**	164
24	**Mali**	157
25	**Guinea**	128
26	**Equatorial Guinea**	127
27	**Réunion**	121
28	**Rwanda**	99
29	**Mauritania**	97
30	**Lesotho**	80

Rank	Country	Installed hydropower capacity (MW)
31	**Tunisia**	66
32	**Togo**	65
33=	**Mauritius**	60
33=	**Swaziland**	60
35=	**Burundi**	54
35=	**Sierra Leone**	54
37	**Burkina Faso**	32
38	**Central African Republic**	25
39	**São Tomé and Príncipe**	4
40=	**Benin**	1
40=	**Comoros**	1

* excludes pumped storage

AFRICA
OVERVIEW

Although 14 per cent of the world's population lives in Africa, the continent's energy use amounts to only 4 per cent of the global total. The region is richly endowed with energy resources, including around 10 per cent of the world's total hydropower potential, but access to electricity remains limited and unevenly distributed: only 290 million out of 915 million people currently have access to electricity in sub-Saharan Africa. Even those who are connected to national grids are often faced with unreliable supply, and must therefore rely on expensive diesel generators for backup.

Ensuring the availability of affordable and reliable energy is essential to the continued and sustainable development of a region that has seen rapid economic growth in the recent past. While many governments are tackling the obstacles which have deterred investment in the domestic energy supply, the lack of essential power infrastructure still presents a substantial barrier to social and economic development.

Furthermore, political instability, lack of finance, small market size, and weak inter- and intra- national transmission connections have all held back the further development of hydropower resources. As a result, less than 10 per cent of Africa's considerable hydropower potential has been tapped so far. The continent's total installed capacity is only 27 GW, 70 per cent of which is concentrated in just nine countries: DR Congo, Egypt, Mozambique, Morocco, Ethiopia, Nigeria, Ghana, Sudan, and Zambia.

In order to meet the continent's rapidly growing demand for energy, African governments have collectively recognised the need to take regional planning and integration more seriously. An example of the increased push in this direction is the Programme for Infrastructure Development in Africa (PIDA). Led by the African Union and African Development Bank, this programme includes regional projects to boost energy trade within power pools and between power pools. The ultimate aim is to create a pan-African electricity grid by integrating the existing eastern, western, southern and central African power pools.

Major developments include Ethiopia's Gilgel Gibe III (1,870 MW). Construction of the complex dam was completed in mid-2015. The first two of its ten 187 MW turbines come online in 2015 and the remaining eight will follow in 2016. The station will export power to neighbours Kenya, Sudan and Djibouti. Meanwhile, construction has started on a 1,000 km transmission connection between Ethiopia and Kenya. This project is centred around the 6,000 MW Grand Renaissance Dam, situated on the Ethiopian side of the border with Sudan.

Other big projects currently in development include the Ingwa III (4,800 MW) complex in DR Congo, which will export a large portion of its power to South Africa, the Zambian and Zimbabwean Batoka Gorge (2,400 MW) project, and the 1,500 MW Mphanda Nkuwa and 1,200 MW Cahora Bassa North Bank expansion projects in Mozambique.

In Uganda, two major hydro projects are under construction: Karuma (600 MW) and Isimba (180 MW), both of which are expected to be fully commissioned by 2018. Plans are also advanced on the next set of projects, namely Ayago (600 MW) and Oriang (400 MW).

2014 also saw the energy ministers of Burundi, Rwanda and Tanzania sign an agreement to build the Rusumo Falls hydropower plant (80 MW) on the Kagera river, along the Rwanda–Tanzania border. Output from the station will be shared equally between all three countries. Supported by the World Bank, the station is expected to come online in 2018.

Smaller, domestic, and privately funded projects were also completed in the past year. As part of Rwanda's commitment to increase domestic energy production, the country commissioned Nyabarongo I (28 MW), a run-of-river power station on the River Mwogo, in October 2014. Although the project is relatively small, Nyabarongo I is now the largest hydropower plant in Rwanda, and will significantly increase the country's installed capacity, which totalled 110 MW at the end of 2013. Rwanda also commissioned the Rukarara II (2.2 MW) and Giciye (4 MW) stations last year.

In Malawi, ESCOM commissioned phase two of its Kapichira power station. The last of three cascaded hydropower stations on the Shire River, this development doubled the cascade's capacity by 64 MW to 128 MW. The engineering work was completed by the China Gezhouba Group.

POLICIES

Ghana
Feed-in tariffs for hydropower, GHS 53.6223/kWh for <10 MW capacity and 53.884 kWh for 10–100 MW capacity, both for ten-year agreements. Rates are reviewed every two years.

Kenya
Feed-in tariffs for hydropower units up to 10 MW in capacity, standard rate of USD 0.0825/kWh.

Mauritius
Feed-in tariffs for small hydropower units, including rate of MUR 10/kWh for 10–50 kW capacity, all for a period of 15 years.

Nigeria
Multi-Year Tariff Order 2 establishes regulated prices for hydropower plants up to 30 MW capacity until 2017, including rates of NGN 29.643/MWh in 2015 and 32.006 NGN/MWh in 2016.

Rwanda
Renewable energy feed-in tariff available for hydropower units from 50 kW to 10 MW.

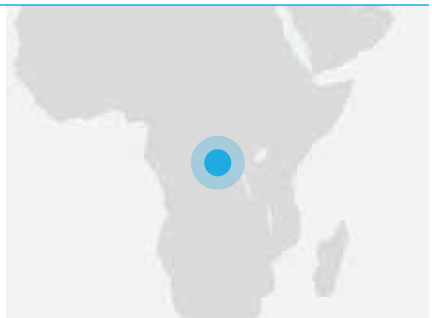
Uganda
Global Energy Transfer Feed-in Tariff (GET FIT) Programme comprises additional payments per kWh beyond the regulated feed-in tariff levels for hydropower projects between 1 and 20 MW capacity.

South Africa
Renewable Energy Independent Power Producer Programme (REIPPP) includes support for small hydropower plants. Ceiling tariffs are established by auction; winning bidders sign power purchase agreements guaranteed for 20 years.

HYDROPOWER TARGETS

Country	Target
Burundi	212 MW (no date)
Egypt	2.8 GW by 2020
Ethiopia	22 GW by 2030
Kenya	794 MW by 2016, 5 per cent of total capacity by 2031
Morocco	2 GW (14 per cent of total capacity) by 2031
Mozambique	2 GW (no date)
Nigeria	2 GW small-scale hydropower by 2025
Rwanda	340 MW by 2017
	42 MW small-scale hydropower by 2015
Sudan	63 MW by 2031
Uganda	1.2 GW by 2017
	85 MW small-scale hydropower by 2017

AFRICA
DEMOCRATIC REPUBLIC OF THE CONGO



The Democratic Republic of the Congo (DRC) holds the potential to light up a significant portion of Africa. The Congo River, the continent's largest by volume and its most powerful, passes through ten countries before emptying into the Atlantic Ocean. At 150 km from its mouth in DRC, the river holds its greatest hydropower potential at the site of Inga Falls.

The river currently plays host to 40 hydropower projects, nine of which are in DRC, including the country's two largest: Inga I (354 MW) and Inga II (1,424 MW), although they are both currently producing at well below capacity due to insufficient maintenance and lack of funding for refurbishment.

Built in the wake of independence, the two Inga projects were completed in the 1970s and 1980s respectively. While they make up the majority of DRC's total installed capacity (2,472 MW), significant additional capacity is planned as part of the Grand Inga project. If fully developed, Grand Inga would become the largest hydropower project in the world at 40 GW, and could generate twice as much as the Three Gorges dam in China. With an estimated generation cost of USD 0.03 per kWh, it would also be one of the most affordable sources of energy in Africa and could theoretically provide 40 per cent of Africa's electricity needs.

Grand Inga was originally envisioned in the 1950s, but has faced significant barriers to progress – the plans have been revised several times to lessen the local impact of the project and to increase the likelihood of attracting sufficient finance in today's investment climate. Today, the Inga site plans include a total of eight power stations, two of which are completed (Inga I and II). However, ongoing political instability in DRC, as well as the substantial investment required, has made further progress difficult.

A key hurdle to development has been the need for a firm market for the electricity generated; despite rates of electrification of only 9 per cent, DRC does not have sufficient domestic demand to justify development on such a large scale. However, power can be exported over long-distance transmission lines to South Africa, Egypt and Nigeria, provided appropriate agreements and market structures are in place.

The next phase of Grand Inga to be developed is the Inga III project. In late 2013 and 2014, the African Development Bank and the World Bank announced a combined USD 106.5 million of funding initiatives to help establish the Grand Inga Development Authority and to prepare for competitive tendering of the Inga III and other medium-size projects.

In addition, in 2014, South Africa ratified an agreement with DRC to purchase over half of the output of Inga III (roughly equivalent to dedicating 2,500 MW of a planned 4,800 MW to South Africa) as well as subsequent phases, significantly strengthening the bankability of the project. The remainder of the electricity would be sold to national power company Société Nationale d'Electricité for consumers in Kinshasa and the surrounding areas, as well as to the mining sector in the southern province of Katanga. Construction of Inga III is now expected to begin in 2017, with completion slated for 2020.

Furthermore, DRC has an additional 2,020 MW of capacity in the planning and construction phases, largely financed by the mining sector, as well as an ongoing rehabilitation of Inga I and Inga II, expected to be completed in 2015.

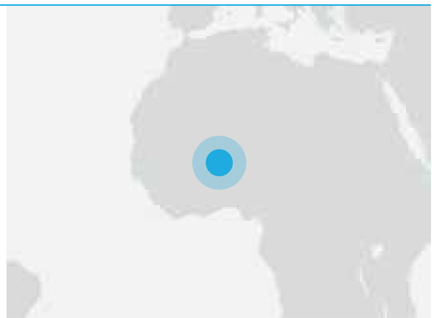
POPULATION
79,400,000

AREA
2,267,100 km²

GDP
USD 32.7 bn

INSTALLED HYDROPOWER CAPACITY
2,472 MW

AFRICA
GHANA



As the Ghanaian government aims to nearly double the country's installed power capacity to 5 GW by 2016, hydropower is expected to play an important role in new development. A number of potential sites have been identified for hydropower projects of a range of sizes.

Ghana's total installed capacity currently stands at 2,936 MW, just over half of which is provided by hydropower (1,580 MW). This contribution is accounted for by just three stations, all located in the Volta River basin: Akosombo (1,020 MW), Kpong (160 MW) and Bui (400 MW).

Ghana also exports power to Togo, Benin, Burkina Faso and Côte d'Ivoire. It currently supplies over 60 per cent of the power consumed in Togo and Benin. The average commercial and industrial tariffs in Ghana are, since the new announcement in early 2014, far higher than those in South Africa, Nigeria, Ethiopia, Libya, Kenya and Namibia.

The vision for regional development across west Africa is driving new activity in Ghana. The country is a member of the West African Power Pool (WAPP), which integrates the national power systems of the region into a unified regional electricity market.

The WAPP masterplan outlined in 2011 places the development of new hydropower capacity at the heart of the region's vision. It includes five potential projects in Ghana, which are undergoing feasibility studies led by the Volta River Authority (VRA), and the country's ministry of energy and petroleum (MoEP): Juale (87 MW), Pwalugu (48 MW), Daboya (43 MW), Hemang (93 MW) and Kulpawn (36 MW).

Development of smaller-scale hydroelectric projects in Ghana has, until recently, been challenging due to the lack of a regulatory and legal framework for renewable energy and scant economic incentives to attract investors.

In 2011, the Ghanaian government took steps to improve this situation with the introduction of the Renewable Energy Law Act 832, encouraging private sector investment in renewable energy. Furthermore, the National Energy Policy, introduced in 2010, aims to improve the fiscal and regulatory framework and incentivise development of small hydropower. There are numerous potential sites with capacities ranging from ten to a few hundred kilowatts.

These actions to encourage hydropower development are intended to meet the growing electricity demand, which rises 10 per cent every year. Ghana's hydropower potential has been estimated at 2,480 MW (ECREEE, 2012).

In 2014, the International Hydropower Association (IHA) signed a funding agreement with the State Secretariat for Economic Affairs of Switzerland (SECO) to promote sustainability from the early stage of hydropower developments in less developed countries. Part of the funding has been used to assess the sustainability of six potential sites identified for development in northern Ghana using the early stage tool of the Hydropower Sustainability Assessment Protocol, of which IHA is the management entity.

The early stage tool is used to assess potential hydropower projects against a comprehensive range of social, environmental, technical and economic considerations. It provides guidance on project selection and the core issues to be addressed where decisions are made to proceed with project development. Key stakeholders in hydropower development in Ghana received training on the use of the protocol in January 2015. Preliminary site visits took place in late 2014 and early 2015, and the assessments were performed in March 2015. Significantly, it is the first application of the protocol in Africa.

POPULATION
24,970,000

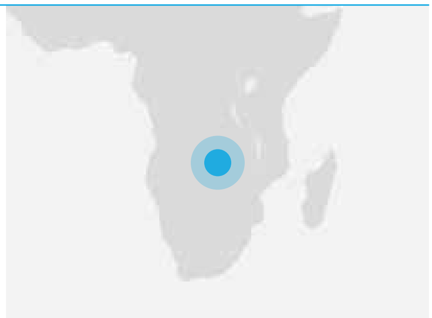
AREA
238,533 km^2

GDP
USD 39.2 bn

INSTALLED HYDROPOWER CAPACITY
1,602 MW

AFRICA

ZAMBIA



The Zambezi River is the major hydropower resource in southern Africa. Zambia's territory occupies a larger area of the river basin, at 41 per cent, than any of the other seven riparian nations. With the completion of the upgraded Lunzua station (14.8 MW) in November 2014, Zambia reached 2,271 MW of installed hydropower capacity, which represents 94 per cent of the nation's total energy mix.

Sustained economic growth in Zambia has meant that the need for clean and renewable energy is more critical than ever. With an electrification rate of only 25 per cent and demand for electricity continuing to rise at a rate of between 150 and 200 MW each year, the development of more than 6,000 MW of untapped hydropower resources remains a priority for the country.

Climate variability has also posed new challenges for the sector in Zambia. In March 2015, a prolonged period of drought resulted in lower water levels at the Kariba Dam, a binational facility managed in co-operation with Zimbabwe. Generational capacity was estimated to have decreased temporarily by around 300 MW, prompting power rationing as an interim solution.

Another area of development has been in the proposed upgrades to existing infrastructure. Preeminent in this regard, the Kariba Dam Rehabilitation Project was launched last year. Essential to the facility's continued safe operation, over the next ten years this USD 294 million scheme will reshape the pool under the dam to limit erosion and refurbish the spillways to improve operations and structural stability.

Energy policy has also progressed in Zambia with the aim of enabling both public and private investors to contribute more effectively to the renewable energy sector. The Renewable Energy Feed-In Tariff (REFIT) policy is the result of in-depth consultation between USAID's Trade Hub for Southern Africa and the Zambian government. It will enable the government to purchase renewable energy at predetermined costs, reducing price volatility and attracting significant private sector investment to hydropower schemes.

In the last decade, gains to installed capacity have been achieved primarily through upgrades and extensions to existing infrastructure. However, in the next five years, these are set to be more than matched by new projects, with the Zambian government predicting an increase of 1,172 MW by 2019.

ZESCO's Itezhi Tezhi project (120 MW) is due to be completed later in 2015, while Lunsemfwa Hydro Power Company concluded feasibility studies for its Muchinga facility (200 MW) in November 2014. Copperbelt Energy also began feasibility studies in 2014 to develop a major hydropower station on the Luapula River (800 MW). Looking forward, efforts to implement the USD 2 billion Lower Kafue Gorge project (750 MW) are at the energy performance certificate procurement stage, with construction expected to start in the first half of 2016.

The private sector is also active in project development. The Kalungwishi hydroelectric project has reached advanced preparatory levels. This 247 MW, USD 700 million project on the Kalungwishi river is being implemented by the Lunzua Power Authority.

Another key development in the pipeline is the Batoka Gorge project, for which the feasibility study and environmental and social impact assessments are already under way. A major run-of-river scheme managed by the Zambezi River Authority, the USD 2.5 billion project is expected to bring 2,400 MW of installed capacity to Zambia and Zimbabwe to meet the sharply rising demand for energy in the region.

Moving forward, Zambia, like the majority of the countries in Southern African Development Community, will need to address the sub-economical electricity tariffs which have been a contributory factor to low private sector investment in new hydropower projects.

POPULATION
14,540,000

AREA
752,618 km²

GDP
USD 26.8 bn

INSTALLED HYDROPOWER CAPACITY
1,895 MW

EUROPE
REGION MAP

Map shows countries in the region with total installed capacity above 200 MW, excluding pumped storage

TOP SIX COUNTRIES BY INSTALLED HYDROPOWER CAPACITY (MW)*					**OTHERS:** 61,231 | **TOTAL:** 166,054
1	**2**	**3**	**4**	**5**	**6**
NORWAY	FRANCE	SWEDEN	ITALY	SWITZERLAND	SPAIN
28,718	18,382	16,315	14,325	13,790	13,293

EUROPE
CAPACITY BY COUNTRY

Rank	Country	Installed hydropower capacity (MW)*
1	**Norway**	28,718
2	**France**	18,382
3	**Sweden**	16,315
4	**Italy**	14,325
5	**Switzerland**	13,790
6	**Spain**	13,293
7	**Austria**	7,968
8	**Romania**	6,456
9	**Ukraine**	5,470
10	**Portugal**	4,455
11	**Germany**	4,452
12	**Finland**	3,198
13	**Greece**	2,697
14	**Georgia**	2,640
15	**Bulgaria**	2,265
16	**Serbia**	2,221
17	**Bosnia and Herzegovina**	2,156
18	**Iceland**	1,986
19	**Croatia**	1,848
20	**United Kingdom**	1,690
21	**Slovakia**	1,606
22	**Latvia**	1,576
23	**Albania**	1,527
24	**Armenia**	1,249
25	**Azerbaijan**	1,116
26	**Slovenia**	1,074
27	**Czech Republic**	1,065
28	**Montenegro**	658
29	**Poland**	569
30	**Macedonia**	538

Rank	Country	Installed hydropower capacity (MW)
31	**Ireland**	237
32	**Belgium**	120
33	**Lithuania**	116
34	**Moldova**	76
35	**Hungary**	56
36	**Andorra**	45
37	**Faroe Islands**	39
38	**Netherlands**	37
39	**Luxembourg**	34
40	**Greenland**	20
41	**Belarus**	13
42	**Denmark**	9
43	**Estonia**	8

* excludes pumped storage

EUROPE
OVERVIEW

Hydropower remains the major renewable generation technology in Europe today, representing 10 per cent of the continent's electricity generation with a total installed capacity of 166 GW conventional hydropower and 50 GW pumped storage.

A recent macroeconomic study of hydropower in Europe, conducted by DNV GL on behalf of 21 hydropower companies, outlined the direct and indirect benefits of hydropower in the 28 EU member states, alongside Norway, Switzerland and Turkey. The study calculated the total value creation of hydropower in Europe to be around EUR 38 billion per year, similar to the current GDP of Slovenia. This figure is projected to grow to around EUR 75 to 90 billion by 2030.

The report identified that the hydropower sector in Europe supports around 120,000 jobs (full time equivalent), each bringing an average annual value of around EUR 650,000 to the European economy. Hydropower also stood out from other renewables in terms of public revenues in Europe – the sector's EUR 15 billion in annual tax revenues far exceeds the limited subsidies granted to small hydropower projects.

Hydropower will continue to play an important role in the European economy. The highest growth rates are expected in the fast-developing countries of eastern Europe, where significant hydropower potential remains unexploited. Western and northern Europe already have highly developed hydropower markets; development there is primarily focused on refurbishing, upgrading or converting existing infrastructure, as well as new pumped storage developments.

POLICIES

Armenia
Feed-in tariffs for small hydropower stations guaranteed for 15 years, rates differentiated by type, including AMD 21.168/kWh for natural water streams in 2015.

Austria
Tax incentives and feed-in tariffs for small hydropower, for example maximum 10 per cent of the investment for up to 10 MW capacity, up to EUR 400/kWh.

Belarus
Law on Renewable Energy Sources (2011) includes feed-in tariff for hydropower plants at rate of USD 1.3/kWh for first ten years, then USD 0.85/kWh for next ten years.

Bosnia and Herzegovina
Feed-in tariffs and power purchase agreements for hydropower plants up to 10 MW capacity in the Republika Srpska.

Bulgaria
Energy from Renewable Sources Act 2011 includes feed-in tariff for hydropower plants up to 10 MW capacity at rate of BGN 93.69 – 236.92/MWh.

Estonia
Electricity Market Act 2007 includes feed-in tariff for hydropower with premium at EUR 0.0537/kWh.

Finland
Tax subsidies for small hydropower (below 1 MVA).

France
Feed-in tariff for hydropower at rate of EUR 0.0607/kWh, plus bonuses for small installations and regular production during winter, contracts of 20 years.

2014 saw electricity consumption in Europe decline for the sixth consecutive year, after it peaked in 2008. The global financial crisis of 2008 is a major factor in this decrease, in addition to energy efficiency improvements, reductions in energy intensity, and the influence of mild summer and winter seasons.

In many parts of the world, power infrastructure is typically driven by increasing populations and energy demand. By contrast, hydropower development in Europe is spurred by policy. In preparation for the 2015 climate summit in Paris (COP21), the European Commission adopted a set of objectives relating to energy and climate policy. The EU and its member states committed to a 40 per cent reduction in greenhouse gas emissions by 2030, compared to 1990 levels. This is complemented by a 27 per cent target for renewable energy sources.

The projected increased future penetration of centralised wind and solar PV electricity generation is expected to position hydropower as a load balancing and energy storing technology. Advances in water turbine technology, particularly adjustable turbines and variable-speed pumps, provide a greater range and efficiency of operation, and will further enable hydropower to deliver even more finely tuned load balancing grid services. This technology is already being used in France, which announced plans to upgrade its Le Cheylas pumped-storage project, first commissioned in 1979, from fixed to variable-speed turbines.

POLICIES

Germany
Renewable Energy Sources Act (EEG) includes targets for 35 per cent renewables by 2020, and 50 per cent by 2030, and feed-in tariff at different rates including EUR 0.042/kWh for up to 50 MW capacity, all for 20 years with tariffs decreasing by one per cent each year.

Greece
Feed-in tariff for hydropower units up to 15 MW capacity, rate at EUR 73/MWh in mainland grid and EUR 84.6/MWh in islands not connected to main grid.

Ireland
Feed-in tariff for hydropower units of less than 5 MW capacity at rate of EUR 0.07/kWh, and for wave and tidal power at EUR 22/kWh.

Italy
Feed-in tariff for hydro streams up to 250 kW capacity, tenders for hydropower above 10 MW capacity.

Lithuania
Feed-in tariffs for hydropower, LTL 0.27/kWh for <10 kW capacity, LTL 0.24/kWh for 10 kW–1 MW capacity, and LTL 0.22/kWh for > 1 MW capacity, all granted for period of 12 years.

Luxembourg
Feed-in tariffs for hydropower plants up to 6 MW, including rate of EUR 85/MWh for 1–6 MW capacity, reduced by 0.25 per cent each year, guaranteed for a period of 15 years.

Macedonia
Feed-in tariffs for hydropower units up to 10 MW capacity.

Austria also commissioned a new pumped-storage project, the 430 MW Reisseck II in Carinthia, in early 2015. The plant uses the existing reservoirs of two nearby pumped-storage projects and effectively links the three hydraulic systems together. Several other new pumped-storage projects totalling 4.9 GW are in the pipeline, including the Swiss stations Linthal (1,000 MW), slated to come online later this year, and Nant de Drance (924 MW), as well as Venda Nova (800 MW) in Portugal.

Europe brought 405 MW of new hydropower capacity online in 2014. Azerbaijan successfully commissioned two power plants in the Nakhchivan Autonomous Republic: Arpachay 1 (20.5 MW) and Arpachay 2 (1.4 MW). This area was previously plagued by energy shortages, but with these two stations now online, most of the local electricity demand can be met using domestic resources. A 36 MW hydropower plant is also currently under construction in the region, which increases the possibility of Nakhchivan exporting electricity to neighbouring Turkey or Iran in the future. Azerbaijian also connected the 31.8 MW Tahtakopru station to the grid.

Greece added to their fleet of hydropower stations, commissioning the 160 MW Ilarionas power plant in early 2014. The station will regulate the flows of the Aliakmon River, which supplies the nearby city of Thessaloniki. In Iceland, the 95 MW Búðarháls station entered commercial operation, bringing the country's total hydropower capacity to 1,980 MW.

POLICIES

Montenegro
Feed-in tariffs for hydropower at EUR 0.104/kWh for plants with annual generation up to 3 GWh, EUR 0.0744/kWh for plants with annual generation between 3 and 15 GWh, and EUR 0.0504/kWh for plants with annual generation above 15 GWh.

Norway
Hydropower plants of less than 5 MW capacity exempt from natural resource and ground rent taxes.

Poland
Obligation for suppliers to purchase certain quota of power from renewable sources, quota set at 14 per cent in 2015, rising to 20 per cent in 2021.

Slovakia
Feed-in tariffs for hydropower in various bands including EUR 105.15/MWh for 500 kW – 1 MW capacity and EUR 97.98MWh for 1–5 MW capacity, all for period of 15 years. Hydro also exempted from electricity excise tax.

Switzerland
Energy Law 2008 includes feed-in tariff for hydropower plants up to 10 MW capacity.

Ukraine
Green Tariff policy includes feed-in tariff for hydropower plants up to 10 MW capacity at rate of EUR 104.7/MWh, until 2030.

United Kingdom
Renewables Obligation (RO) sets renewable quotas on electricity suppliers which rise annually. Feed-in tariff for small scale renewables including hydropower up to 5 MW, for period of 20 years, rate of 11 GBP pence/kWh for 2–5 MW capacity.

The Spanish island of El Hierro, the smallest of the Canary Islands, became the first energy-isolated territory in the world able to power itself entirely from renewable energy sources with the completion of a wind and pumped-storage hybrid station in 2014. The project consists of an 11.5 MW wind farm, two water reservoirs, a pumping unit, generating unit, and a seawater desalination plant. The hydro generator has a capacity rating of 11.3 MW, well in excess of peak demand on the island.

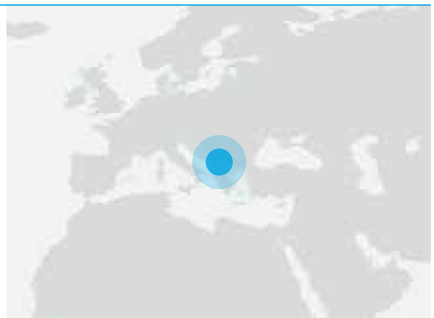
Norway and Sweden have established a joint certificate market with a target of 26 TWh of new renewable energy generation by 2020. Under this technology-neutral incentive scheme, hydropower generation is expected to increase by 10 TWh.

The United Kingdom has made progress in the development of its ocean and tidal hydropower projects. The 320 MW Swansea Bay tidal lagoon project was approved by the country's regulator. Construction should begin by 2016, and the facility's commercial operations are scheduled to commence in 2019.

HYDROPOWER TARGETS

Country	Target
Armenia	377 MW small-scale hydropower by 2020, 397 MW by 2025
Austria	1 GW to be added 2010–20
Belarus	103 MW to be added 2011–15
Bulgaria	522 MW new capacity by 2018
Finland	14.6 GW hydropower by 2020
Italy	42,000 GWh/year from 17.8 GW by 2020
Lithuania	14 MW by 2020
Macedonia	216 GWh/year small-hydropower by 2020
Portugal	400 MW small-scale hydropower by 2020
Spain	13.9 GW by 2020 (2.9 per cent of final energy mix)
	8.8 GW pumped storage by 2020
Switzerland	43 TWh/year by 2035

EUROPE
ALBANIA



Albania is almost totally dependent on hydropower for electricity generation; nearly 100 per cent of the country's domestically produced electricity comes from hydropower.

The mountainous nation is home to eight major river systems. The Drin river, located in northern Albania, is the largest river in the country and hosts three hydropower stations: Fierzë (500 MW), Komani (600 MW) and Vau I Dejës (250 MW). This 1,350 MW cascade represents more than three-quarters of the country's total electricity capacity and 90 per cent of domestic electricity production. The remaining 430 MW of installed capacity is distributed over some 90 stations.

Albania was once a net exporter of electricity, but it has recently been forced to import power due to rising demand and a stagnation of new capacity installations since the transition from a centrally planned economy to an open market in the late 1980s. This has led, as recently as 2011, to power shortages during dry periods, and even blackouts during prolonged droughts.

Energy demand is expected to increase by 60 per cent in 2020, and there is a clear need for Albania to strengthen its energy security. While efforts to develop new thermal, wind and solar capacity are ongoing, hydropower remains the nation's largest energy resource.

Estimates show that only 30 to 35 per cent of Albania's hydropower potential has been developed so far. Delays due to social and environmental concerns have been a deterrent to major projects. Instead, the government has focused on constructing smaller hydropower plants (less than 100 MW capacity) and passing fiscal incentives. For example, investments in renewable energy sources are exempt from customs duties on imported machinery and equipment.

Due to these favourable legal and regulatory frameworks, Albania's hydropower sector remains attractive to foreign and private investors. In 2013, foreign direct investments in privatisations across the domestic hydropower sector made up almost 9 per cent of GDP, and accounted for approximately half of the capacity under construction.

Most of the new capacity installations are aimed at strengthening power supply to the south of the country, and to complete the planned cascade of projects on the Drin River. Ashta (53 MW), commissioned in 2012, was the largest hydropower project to be completed in Albania since the 1990s.

Another major project is the EUR 535 Devoll River cascade, which will consist of two hydropower stations, Banja and Moglicë. With a total installed capacity of 256 MW, these two stations will produce around 729 GWh each year, increasing Albania's electricity production by nearly 17 per cent. Investment for a third plant in the cascade will be considered once these two are completed. Both are expected to begin commercial operation by 2018.

Albania's mid-term goal is to once again become a net importer of electricity by developing its significant hydropower potential. In this way, Albania could increase its influence in the regional energy market while simultaneously bolstering its own energy security. For example, in 2014, Albania and Kosovo signed an agreement to build a 400 kV transmission line linking their energy grids to maximise Albania's hydropower and Kosovo's coal-fired electricity. In July 2015, the EU announced funding for another 400 kV interconnection line between Albania and Macedonia. Albania is also exploring options for an undersea electricity interconnection to export excess power to Italy.

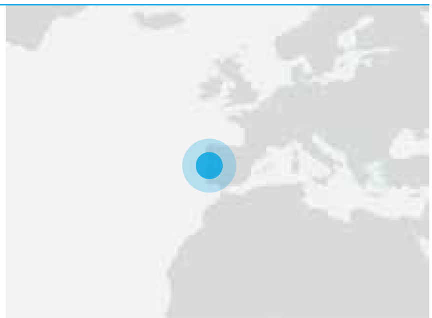
POPULATION
2,800,000

AREA
28,700 km^2

GDP
USD 12.9 bn

INSTALLED HYDROPOWER CAPACITY
1,527 MW

EUROPE
PORTUGAL



With no fossil fuel resources or reserves of its own, Portugal has had to depend on imports to meet its domestic demand for oil and gas. This situation, coupled with European Union targets to cut carbon emissions, has led to substantially increased interest and investment in renewable sources of energy over the last decade. In 2014, renewables accounted for 62 per cent of the country's energy mix in terms of the electricity generated. Hydropower amounted to 31 per cent of the mix, occupying half the total share of renewables.

Portugal's extensive network of hydropower facilities includes an increasingly large share of pumped storage stations, such as the Alqueva I and II facilities. Alqueva II, an extension project, doubled the complex's installed capacity to 512 MW when it was connected to the grid in 2013.

Another pumped storage project, Venda Nova III (756 MW), is currently under construction. This station will include two pump turbines with variable speeds. The facility should come online by the end of 2015, bringing the total installed capacity of Venda Nova up to 1,038 MW. Salamonde II (207 MW) is also currently undergoing an upgrade which should come online in August 2015, bringing the total installed capacity of the Salamonde facility to 250 MW.

Other recent additions to installed capacity include the Baixo Sabor plant (173 MW), which brought its first 30 MW unit online in the first quarter of 2015, and the Ribeiradio – Ermida facility (80.8 MW), which commenced operations in 2014.

In early 2015, construction work began on the three dams which will comprise the Alto Tâmega complex (1,158 MW) in northern Portugal. The project, which is expected to be completed in 2023, will also improve distribution infrastructure linking northern Portugal with the neighbouring region of Galicia in Spain, primarily through upgrades to existing power lines. The Foz Tua station (263 MW) is also under construction now, slated for completion in 2016.

Policy developments in 2014 included a new 0.85 per cent tax on the energy and utility sector's fixed assets. The revenue of around EUR 150 million will go towards the new Fund for Systematic Sustainability of the Energy Sector (FSSSE), which aims to finance social and environmental programmes while reducing the tariff deficit of the electricity system in Portugal.

POPULATION
10,460,000

AREA
92,200 km^2

GDP
USD 227.3 bn

INSTALLED HYDROPOWER CAPACITY
4,455 MW
HYDROPOWER
1,343 MW
PUMPED STORAGE

SOUTH AND CENTRAL ASIA **REGION MAP**

Map shows countries in the region with total installed capacity above 200 MW, excluding pumped storage

TOP SIX COUNTRIES BY INSTALLED HYDROPOWER CAPACITY (MW)* **OTHERS:** 15,790 | **TOTAL:** 155,731

1	2	3	4	5	6
RUSSIA	INDIA	TURKEY	IRAN	PAKISTAN	TAJIKISTAN
49,218	44,799	23,661	10,156	7,264	4,843

SOUTH AND CENTRAL ASIA
CAPACITY BY COUNTRY

Rank	Country	Installed hydropower capacity (MW)*
1	**Russia**	49,108
2	**India**	44,799
3	**Turkey**	23,661
4	**Iran**	10,156
5	**Pakistan**	7,264
6	**Tajikistan**	5,190
7	**Kyrgyzstan**	3,091
8	**Iraq**	2,513
9	**Kazakhstan**	2,260
10	**Uzbekistan**	1,731
11	**Sri Lanka**	1,624
12	**Syria**	1,505
13	**Bhutan**	1,489
14	**Nepal**	706
15	**Afghanistan**	400
16	**Bangladesh**	230
17	**Lebanon**	221
18	**Jordan**	12
19	**Israel**	7
20	**Turkmenistan**	1

* excludes pumped storage

SOUTH AND CENTRAL ASIA **OVERVIEW**

Lack of access to energy is one of the principal challenges facing South and Central Asia. A fast-growing population coupled with high variance in natural resources distribution makes regional trade one of the obvious solutions for the region.

In 2015, the Central Asia – South Asia Electricity Transmission and Trade project (CASA-1000) took an important step forward when the participatory countries approved the master and the power purchase agreements for the project. When completed, the 1,222 km CASA-1000 transmission lines will move high-voltage electricity between exporting countries Kyrgyzstan and Tajikistan, and then from Tajikistan onwards to importers Afghanistan and Pakistan. This enables Tajikistan to adjust to the seasonal variability of its hydropower resources, exporting excess power due to glacial melt in the summer and importing during periods of low flow in the winter.

This outlet for energy trade may also provide the business case for the proposed Rogun project (3,600 MW). Pakistan, in particular, predicts a doubling of energy demand within the next decade. Without such regional agreements, the country would struggle to meet demand for electricity with domestic additions alone. CASA-1000 is a testament to the co-operation among these countries, and marks the first step towards the realisation of a regional electricity market (CASAREM) in South and Central Asia.

Nevertheless, Pakistan commissioned 180 MW of new hydropower capacity in 2014, most notably connecting the Duber Khwar power station (130 MW) to the grid. Pakistan envisions a further 15 GW of hydropower capacity to be installed within the next ten years. Some of the new commercial operations will be delivered by independent power producers (IPPs), or through bilateral co-operation agreements. For example, the Patrind station (147 MW), a run-of-river IPP project slated to come online in 2016, was developed by a Korean construction company, and financed by the World Bank, Asian Development Bank, and the Korea Eximbank.

In addition, the China-Pakistan Economic Corridor, a USD 46 billion bilateral project that aims to build a network of transport, telecommunications and energy infrastructures, includes an agreement for a total of 800 MW new hydropower capacity in two stations and provisions for further IPP-funded hydropower stations.

The Beijing-based Asian Infrastructure Investment Bank (AIIB) has reported USD 50 billion in funding to spur infrastructure growth in developing Asian countries, with projects that include hydropower.

Further to the south-east, regional opportunities for trade are progressing between Nepal, Bhutan, India, Pakistan and Bangladesh – all countries with access to the rich hydropower resources of the Himalayan river systems. Due to its strategic location and regional status as an economic power, India has become a key player in facilitating energy co-operation in the region. Bilateral trade, for example between Bangladesh and Pakistan, often depends on Indian involvement.

Bilateral agreements have progressed between India and Nepal in the past year, as well as between India and Bhutan. The Power Trade Agreement between India and Nepal will throw up new vistas of co-operation in the power sector.

The Pakistan-based South Asian Association for Regional Cooperation (SAARC) Energy Centre is proposing a study of Nepal's 80,000 MW hydropower potential, with a focus on regional development. If developed, the power generated in Nepal could be transported to India, Pakistan and Afghanistan, bringing benefits to and strengthening ties between the four countries.

Bhutan's electricity is its main export commodity, which it sells to India, its largest trading partner. About 75 per cent of Bhutan's generated electricity is exported to India as a result of an agreed bilateral export tariff between the two countries. Power accounts for 45 per cent of Bhutan's total exports to India. As Bhutan is almost entirely reliant on hydropower for electricity generation, it imports power from India in the winter when reservoir levels are low. A bilateral agreement was signed in 2009 between the two countries with the goal of developing 10 GW of new capacity by 2020 through intergovernmental and joint ventures.

In early 2015, Bhutan commissioned its fifth hydropower station. The 126 MW run-of-river Dagachhu power station was the result of a joint venture between India's Tata Power and Bhutan's Druk Green Power Corporation. Other plants under construction, in accordance with the bilateral agreement, include the Mangdechhu plant (720 MW) and Punatsangcchu I and II (1,200 MW and 1,020 MW, respectively), which are expected to come online in 2017.

Elsewhere in the region, Russia added 1.1 GW to the mix, increasing its total installed capacity to 47.7 GW. The restoration of the Sayano-Shushenskaya project was completed, returning the plant to its full capacity of 6,400 MW. The country also completed work on the 3,000 MW Boguchanskaya plant, installing the last three of nine 333 MW turbines in 2014, and modernised its existing Zelenchukskaya power plant, adding 140 MW of pumped storage capacity to the Kubanski cascade.

POLICIES

India
2014–19 feed-in tariffs for hydropower in Uttar Pradesh, INR 5.65–6.47/kWh for <5 MW capacity and INR 4.98–5.68kWh for 5–25 MW capacity, both with power purchase agreements for 20 years.

Iran
Renewable Energy Development Fund, tax levied on consumer bills at a rate of IRR 30/kWh, except rural households. Fund goes towards maintenance of rural grids and the development of renewables.

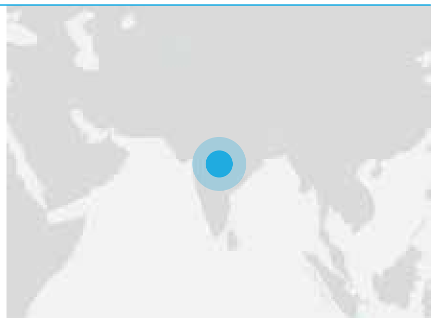
Russia
EBRD loan of EUR 185 million to support modernisation of nine power stations on the Volga-Kama cascade.

Turkey
Renewable Energy Law 2010 includes feed-in tariff for hydropower (all sizes) at rate of USD 0.073/kWh for period of ten years, and renewable producers receive 85 per cent discount on transmission costs for ten years.

HYDROPOWER TARGETS

Country	Target
India	2.1 GW small-scale hydropower to be added 2012–17
Kazakhstan	170 MW new capacity by 2020
Tajikistan	100 MW small-scale hydropower by 2020
Turkey	34 GW by 2023

SOUTH AND CENTRAL ASIA
INDIA



India has the potential to develop a total of around 148 GW of installed hydropower capacity, with resources concentrated in the Himalayan states of Arunachal Pradesh, Sikkim, Uttarakhand, and Himachal Pradesh. So far, however, only a third of these resources have been successfully tapped, while hydropower's share in the country's energy mix has seen a substantial decline since 1966.

Nonetheless, 2014 saw significant developments in governance and policy which have the potential to revitalise the sector in India. Increased international co-operation with neighbours Bhutan, Nepal and Bangladesh has also consolidated India's role as a regional leader in hydropower development.

With a new government elected in May 2014, responsibility for hydropower was brought under the leadership of a single ministry to improve efficiency at the federal level. Since his election, Indian Prime Minister Narendra Modi has made landmark visits to Nepal and Bhutan, cementing the bilateral energy agreements which will hinge on new hydropower deployments in these Himalayan nations. During the prime minister's visit to Nepal in August 2014, a memorandum of understanding was signed to expedite progress on the 5,600 MW Pancheshwar multipurpose project, situated on the Mahakali River which borders both countries.

This partnership was tested by the recent tragedy of the April 2015 earthquakes in Nepal, which caused significant damage to the electricity distribution network in India's northern neighbour. The state-owned Power Grid Corporation of India was instrumental in bringing Nepal's grid back online and is now supporting efforts to rebuild the damaged distribution infrastructure.

The geological disaster in the Himalayan region has also affected the ongoing discussion around the feasibility of hydropower development in the State of Uttarakhand. Environmental and social concerns were first raised following the devastating floods of June 2013, and a temporary hiatus on the construction of new dams in the area was imposed by the Supreme Court soon after.

The environment ministry has recently appointed a panel of eleven experts to assess the cumulative impacts of hydropower projects on the upper reaches of the Ganges river. This new approach demonstrates the increased importance of planning for the sustainable development of an entire river basin, a process which will require both inter-state and international collaboration in the Indian context. Despite these challenges, Uttarakhand's Shrinagar station (330 MW) was able to commission its fourth and final 82.5 MW unit in June 2015.

Other additions to installed capacity in the last year include the Koldam project, an 800 MW run-of-river scheme which commissioned the last of its four units in June 2015, the 412 MW Rampur station which was commissioned in December 2014, and the 520 MW Parbati facility which was commissioned in May 2014. The 240 MW Uri-II plant entered commercial operation in May 2014 and was among several projects to be inaugurated by Prime Minister Modi last year.

Progress has also been made on the 2,880 MW Dibang project, which received social and environmental clearance in October 2014. This multipurpose station will be the country's largest hydropower facility. The project represents a turning point for development in the key region of north-eastern India, where over 93 per cent of the total hydropower potential, largely in the Brahmaputra river basin, is yet to be exploited.

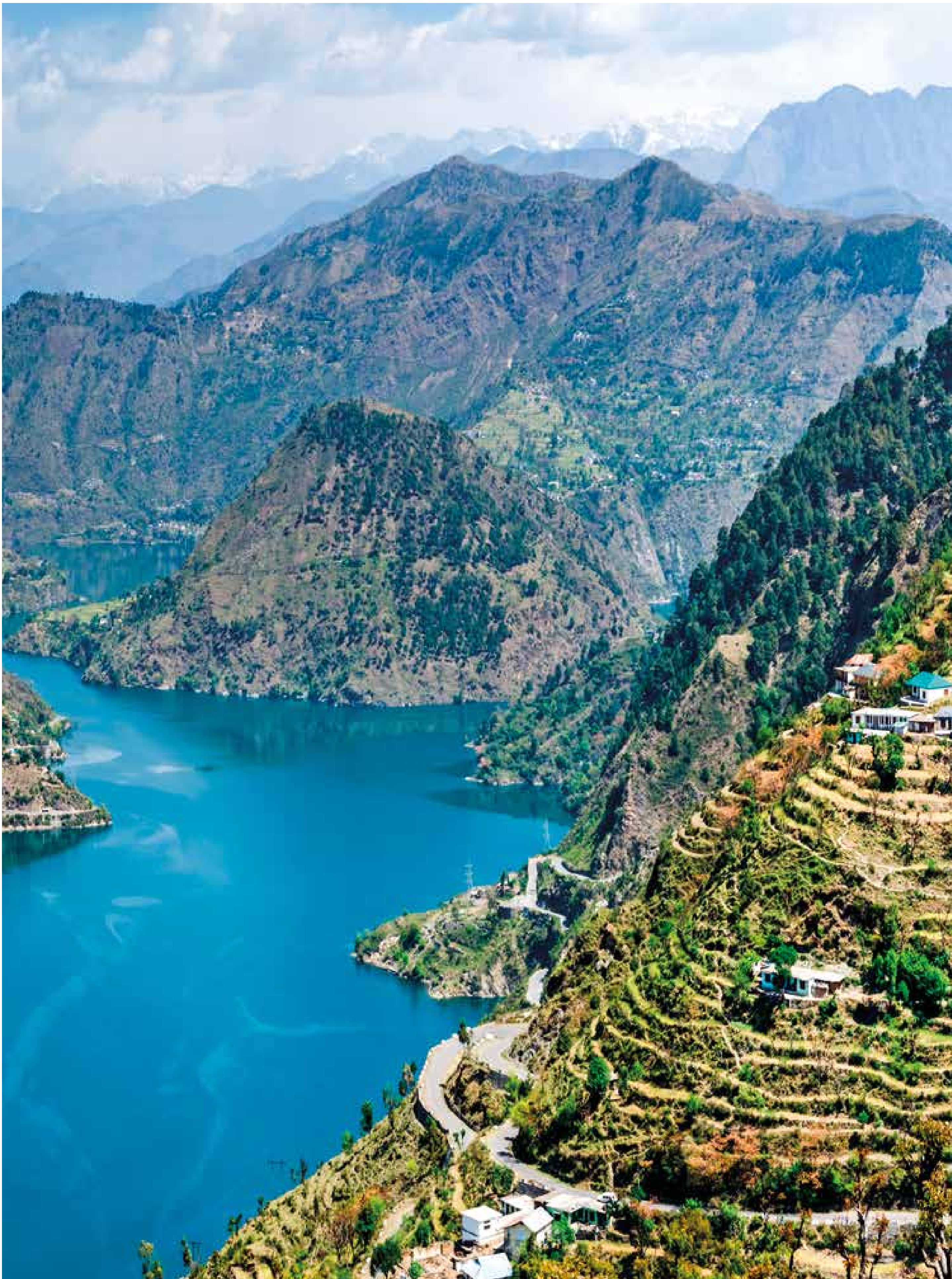
The Indian government is considering reviewing legislation and support schemes, including tariff regulations to promote electricity generation from renewable sources. The government has also taken efficiency measures, such as the streamlining of statutory clearances, and high-level monitoring to avoid delays in the implementation of projects.

POPULATION
1,252,000

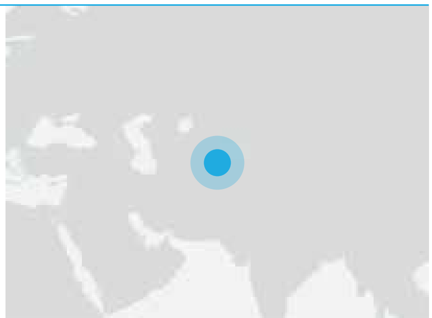
AREA
3,288,000 km²

GDP
USD 1,877 bn

INSTALLED HYDROPOWER CAPACITY
44,800 MW
HYDROPOWER
4,786 MW
PUMPED STORAGE



SOUTH AND CENTRAL ASIA
TAJIKISTAN



Tajikistan is an intriguing country for hydropower activity. With an installed capacity of 5,190 MW, and an estimated hydropower potential of 527 billion kWh per year, there is significant scope for project activity in the coming years.

Hydropower supplies nearly 100 per cent of Tajikistan's electricity, which is used for both domestic supply and export. Recent projects in Tajikistan include full commissioning of Sangtuda 1 (670 MW) in 2009, Sangtuda 2 in 2011 (220 MW), and the planned rehabilitation of the Kairakkum project, which is expected to begin in 2015.

Tajikistan's largest hydropower station is Nurek, with an installed capacity of 3,000 MW. However, the government is seeking finance for the proposed Rogun project, which, if completed, would become Tajikistan's largest hydropower project at 3,600 MW, and would turn Tajikistan into a net exporter of electricity. Rogun would also be the world's tallest dam, at 335 meters.

In 2014, the World Bank completed a feasibility study on Rogun, indicating the project is moving forward. However, financing is still far short of what is needed to break ground, and additional hurdles include regional relations with downstream Uzbekistan, which has expressed opposition to the project.

Tajikistan's hydropower resource experiences highly seasonal variations, leading to excess summer supply and significant shortages during the winter months. This imbalance has set the stage for electricity trade with neighbouring countries. While current exports of excess summer capacity to Afghanistan are conducted on a bilateral basis, the proposed CASA-1000 regional interconnection would link Tajikistan and Kyrgyzstan's hydropower into a regional grid including Kazakhstan, Afghanistan, Uzbekistan and Pakistan.

If realised, the proposed project could spur additional development, moving key projects from the planning stage into construction. Rogun can make a significant contribution, although the project could potentially proceed for bilateral export in the absence of CASA-1000.

Beyond the new capacity in the planning stages, there is significant scope for rehabilitation and modernisation in Tajikistan. Around three-quarters of the country's installed capacity is over 30 years old, and is thus affecting output from the country's existing hydropower facilities. Due to obsolescent assets and a lack of investment, estimates indicate that the effective capacity in Tajikistan is closer to 2,306 MW (compared to an installed capacity of 5,190 MW).

Most significantly, the Nurek project, which was commissioned in 1979 and produces over 70 per cent of Tajikistan's power, is in desperate need of rehabilitation. In 2014, the Asian Development Bank funded the reconstruction of Nurek's switchyard, and the World Bank issued a contract for the techno-economic assessment study for Nurek's rehabilitation.

In addition, the European Bank for Reconstruction and Development is providing concessionary financing for the rehabilitation and upgrade of the Kairakkum hydropower project, which will increase its capacity from 126 to 142 MW. The rehabilitation is focusing on incorporating climate resilience into the project's design and operation, enabling it to also access funding from the Climate Investment Funds (CIF), marking the first use of the CIF for hydropower.

Tajikistan's hydropower potential is ranked eighth in the world, three times higher than the current electricity consumption throughout central Asia. The effective use of these resources will allow the region to be provided with inexpensive and green power.

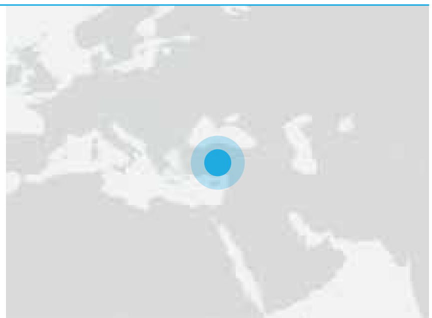
POPULATION
8,200,000

AREA
140,000 km²

GDP
USD 8.5 bn

INSTALLED HYDROPOWER CAPACITY
5,190 MW

SOUTH AND CENTRAL ASIA
TURKEY



Despite recent slowdowns, Turkey remains one of Europe's leading markets for future hydropower development due to a combination of abundant resources, a supportive government, and favourable policy framework.

Sitting at the crossroads of Asia and Europe, Turkey is a high-altitude country with over 25 river basins, including the trans-boundary Tigris and Euphrates rivers. As part of its potential accession to the EU, Turkey has integrated its electricity infrastructure with that of Europe, while at the same time pursuing a strategy of overall energy diversification, including the development of all types of renewable energy. Furthermore, electricity demand in Turkey is forecast to grow by more than 90 per cent over the next ten years, adding to the suite of drivers for hydropower development.

Turkey has ambitious plans for hydropower over the coming decade. The country is aiming to mark its 100 years as a republic in 2023 with a total installed electric power capacity of 100 GW – up from 32 GW in 2002 and 64 GW in 2014 – with 30 per cent of electricity generation coming from renewables. This rate was around 20 per cent in 2014 due to low rainfall.

The country is pushing ahead with its formidable goal to exploit all of its estimated 166,000 GWh/year of economical hydropower potential, which would include an expected total of about 24,000 hydropower plants. To date, roughly 50 per cent of this potential has been tapped, with a further 15 per cent under construction, leaving the country with some way to go in achieving its target. At the end of 2014, Turkey's installed hydropower capacity was 23.6 GW, producing 40,400 GWh/year of electricity.

Turkey has a suite of policies that will support hydropower development, including a 30 per cent target for renewables by 2023, a feed-in-tariff for projects completed by the end of 2015, VAT and customs exemptions, and licence fee exemptions for renewable projects.

In early 2015, the Turkish Government announced it would allocate USD 16 billion to hydro development until 2018 as part of its Tenth Development Plan. In addition, deregulation of the power sector has encouraged private investment, with independent power producers taking on the bulk of new developments. Hydropower development will be further supported by Turkey's interconnections into the European grid and potential for further linkages east into Asia.

In 2003, Turkey liberalised its energy market and embarked on a process of privatising existing assets as well as attracting private sector investment into new projects, although several strategic hydropower facilities will be exempted from the privatisation programme. In recent years, E.ON and Statkraft have made major investments in the country, while China has engaged through a plan to develop hydropower with local companies.

In 2014, Turkey commissioned seven projects (not including micro hydro schemes), adding 688 MW of new capacity, including the Arkun Barajı (245 MW), Kavşak Bendi (190 MW), and Yamanly (88 MW) stations. It is estimated that there is now up to 15 GW of new capacity currently under construction in Turkey, including the Yusufeli (540 MW), Çetin (517 MW), Kığı (180 MW), and Kargı (100 MW) projects.

POPULATION
77,700,000

AREA
783,600 km²

GDP
USD 32.7 bn

INSTALLED HYDROPOWER CAPACITY
23,661 MW

EAST ASIA AND PACIFIC
REGION MAP

Map shows countries in the region with total installed capacity above 200 MW, excluding pumped storage

TOP SIX COUNTRIES BY INSTALLED HYDROPOWER CAPACITY (MW)*					**OTHERS:** 28,872 | **TOTAL:** 383,127
1	**2**	**3**	**4**	**5**	**6**
CHINA 299,250	JAPAN 22,262	VIETNAM 14,181	AUSTRALIA 8,050	INDONESIA 5,258	NEW ZEALAND 5,254

EAST ASIA AND PACIFIC
CAPACITY BY COUNTRY

Rank	Country	Installed hydropower capacity (MW)*
1	China	280,000
2	Japan	22,262
3	Vietnam	14,181
4	Australia	8,050
5	Indonesia	5,258
6	New Zealand	5,254
7	North Korea	5,000
8	Malaysia	4,753
9	Laos	3,569
10	Philippines	3,521
11	Thailand	3,510
12	Myanmar	3,151
13	Chinese Taipei	2,081
14	South Korea	1,747
15	Cambodia	1,184
16	Papua New Guinea	234
17	Fiji	125
18	New Caledonia	78
19	French Polynesia	47
20	Samoa	12
21	United States minor outlying islands	10

* excludes pumped storage

EAST ASIA AND THE PACIFIC
OVERVIEW

East Asia's economy is fast-growing and energy-hungry. The Asian Development Bank estimates that electricity demand in the region will more than double between 2010 and 2035, reaching 16,169 TWh in 2035. In south-east Asia, it is set to almost triple in the same period. China installed 21.85 GW of hydropower capacity in 2014, a larger addition than the rest of the world combined. Excluding China, the region saw some 2.8 GW of new capacity installed, with the majority of these new developments in the Lancang-Mekong river basin. There were also new installations in the Philippines, Malaysia, Japan and Papua New Guinea.

The Lancang-Mekong River originates in the Tibetan Plateau and flows through China, Myanmar, Laos and Thailand, before reaching its delta, which straddles Cambodia and Vietnam. Some 50 million people in the lower basin currently rely directly on the river for their food and livelihoods. The river's immense hydropower potential is estimated to be 23 GW in the upper basin, in China, and 30 GW in the downstream nations.

Laos is home to a vast hydropower potential. Approximately 35 per cent of the Lancang-Mekong's flows originate in the country. Laos is progressing towards its ambition to become the 'battery' of south-east Asia. Despite only commissioning the Nam Sana (14 MW) and Nam Ngiep 3A (44 MW) projects in 2014, a number of stations are expected to come online in 2015: Nam Ngiep 2 (180 MW), Nam Kong 2 (66 MW), and Nam Ou's 2, 5 and 6 units (120 MW, 240 MW, and 180 MW respectively). Laos also completed the first stage of its 1,285 MW Xayaburi project by diverting the river. The project is expected to be completed in 2019. The USD 3.5 billion project is primarily funded by four Thai banks, and 95 per cent of the generated electricity will be exported to Thailand.

In May 2015, Thailand's government approved their new Power Development Plan, which lays out the country's energy and investment strategy up until 2036. For the first time in a Thai development plan, renewable energy and energy efficiency are explicitly mentioned. The goal is to double total installed capacity over the next 20 years. However, much of this growth is reliant on power imports from both Laos and Myanmar. Already, imported hydropower accounts for 7 per cent of Thailand's installed capacity, and this figure is expected to increase to 10–15 per cent by 2025. In addition to the Xayaburi development in Laos, Thailand is involved in two projects across the border in Myanmar: Hatgyi (1,360 MW) and Mong Tong (7,110 MW).

Cambodia's installed hydropower capacity has seen remarkably rapid growth in the past few years. The country was very active in 2014, more than doubling installed capacity to 1.2 GW by commissioning three stations: Russey Chrum Krom (341 MW), Stung Tatay (246 MW), and Stung Atai (120 MW). The Chinese-owned Russey Chrum Krom and Stung Tatay stations, located in the province of Koh Kong, are the largest stations in the country. Over the past 15 years, Chinese companies have invested an estimated USD 1.6 billion to construct six hydropower plants in Cambodia, totalling 928 MW of installed capacity. All of these stations are now operational. Cambodia's electricity supply development plan depends on the successful construction of four more hydropower stations by 2020. Totalling 1,300 MW, these plants are needed to accommodate the projected growth in energy demand.

Vietnam has experienced rapid growth in hydropower, having commissioned some 10 GW of installed capacity since 2004. In 2014, Vietnam brought a further 281 MW online, commissioning the Dak Drinh (125 MW) and Song Bung 4 (156 MW) stations.

These developments mark important steps towards the country's goal of reaching 17 GW of installed capacity by 2020, as laid out in the Power Development Plan for 2011–20.

Elsewhere in south-east Asia, Malaysia added a total 836 MW of new capacity in 2014, all in the state of Sarawak. Two 300 MW turbines were added to the 2,400 MW Bakun power station, marking the project's completion. The first of four 236 MW turbines was added at Murum (944 MW), which is expected to be fully commissioned in 2015, and construction will begin on the Baleh project (1,285 MW) in 2016. Papua New Guinea connected the 18 MW Yonki Toe of the Dam station, which is now the fourth largest hydropower station in the country, after Ramu 1 (75 MW), Ok Menga (57 MW) and Rouna 2 (30 MW).

Like other countries in the region, Indonesia's energy needs are expected to rise in line with the nation's continued economic growth. Due to its current dependence on fossil fuels and the volatile price of oil, Indonesia seeks to capitalise on its alternative natural resources, including hydropower.

The hydropower potential of the archipelago is estimated at 75 GW, with a technically exploitable potential projected at 12.4 GW, focused on the islands of Java, Sumatra and Sulawesi. With the aim to install 35 GW new capacity by 2020, the government is offering added incentives for the development of small hydro in the form of feed-in tariffs for independent power producers. As a result, Iran and Indonesia signed an agreement in early 2015 to build 48 hydropower plants between 1 and 10 MW. Also in the pipeline is the 510 MW Batang Toru project in Sumatra, which is scheduled to commence operations in 2019.

POLICIES

Chinese Taipei
Feed-in tariff for run-of-river hydropower (all sizes) at rate of EUR 0.184/kWh.

Indonesia
Feed-in tariffs for hydropower plants up to 10 MW capacity, IDR 656/kWh for medium voltage and IDR 1,004/kWh for low voltage, power purchase agreements with the state electricity company.

Japan
Feed-in tariffs for hydropower at JPY 35.70/kWh for <200 kW capacity, JPY 30.45/kWh for 200 kW – 1 MW capacity, and JPY 25.20/kWh for 1–3 MW capacity, all for 20 years.

Malaysia
Renewable Energy Act 2011 includes feed-in tariff for small hydropower plants for period of 21 years.

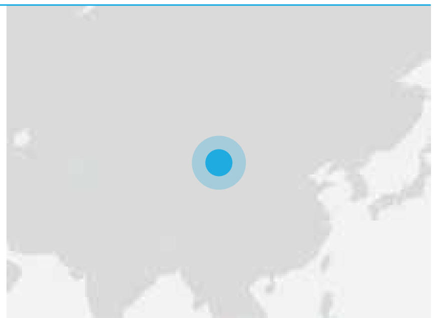
Philippines
Feed-in tariff for run-of-river hydropower at PHP 5.90/kWh for at least twelve years, installation target of 250 MW by 2015.

Thailand
Small hydropower supported by small power producer purchase agreements.

TARGETS

Country	Target
China	260 GW to be added 2012–17
	30 GW pumped storage to be added 2012–17
Chinese Taipei	2,112 MW by 2020, 2,502 MW by 2025
Indonesia	2 GW by 2025
	3 GW pumped storage by 2025
Japan	49 GW by 2020
South Korea	13,016 GWh/year by 2030
	1,926 GWh/year small-scale hydropower by 2030
	6,159 GWh/year ocean power by 2030
Vietnam	19.2 GW by 2020
	1.8 GW pumped storage by 2020, 5.7 GW pumped storage by 2030
Philippines	8,824 MW by 2030
Thailand	5.1 GW by 2021
	2 MW ocean power by 2021

EAST ASIA AND PACIFIC
CHINA



Four years ago, the Chinese government initiated its twelfth five-year plan, a strategy for economic development that recognised and addressed the social, political and environmental dangers of uncontrolled growth. The plan provides goals and direction for the country's national economic development vision. In an effort to reduce its greenhouse gas emissions, while meeting a rising energy demand, China pledged to increase its hydropower capacity to 284 GW and its pumped storage capacity to 41 GW by 2015.

At the end of 2014, China had almost reached this goal a year early. Hydropower capacity totalled 282 GW after 21,250 MW came online in 2014, and a further 600 MW of pumped storage was added to the mix. Approximately 80 per cent of the additional capacity was commissioned in remote areas of the Sichuan and Yunnan provinces, both in the south-west. Overall, China added turbines to more than 35 of its hydropower plants. Notably, 4,260 MW were added at Xiluodu (13,860 MW), 1,600 MW at Xiangjiaba (6,400 MW), and 1,300 MW at Nuozhadu (5850 MW). These plants are now fully commissioned.

Further additions to installed capacity included 2,400 MW at Jinping II, 1,080 MW at Ludila (2,160 MW), and the commissioning of the Hohhot pumped storage plant (600 MW). China has also connected the world's largest solar-hydro hybrid station to the grid; the Longyangxia complex consists of a 320 MW photovoltaic park, fully integrated with a 1,280 MW hydropower peaking station.

The added capacity resulted in China generating over 1 TWh of hydropower in 2014, increasing hydropower's share in the energy mix to 17.3 per cent, up from 16.9 per cent in 2013. However, the development of energy transmission infrastructure linking remote supply centres to coastal areas, where demand is concentrated, lags behind the rapid increase in generational capacity. Coupled with slow local demand growth, this has resulted in power curtailment of both hydropower and wind.

As a result, China announced in January 2015 that it would be investing record amounts in its domestic grid infrastructure. The plan includes project work which will connect the Chinese grid to Russia, Kazakhstan, Mongolia and Pakistan.

China will continue to increase its hydropower capacity, aiming to achieve its ambitious targets of 350 GW hydropower and 70 GW pumped storage by 2020, and 510 GW hydropower and 150 GW pumped storage by 2050.

Projects currently under construction include the Fengning pumped storage station in Hubei province which, once completed, would be the largest pumped storage plant in the world, with an installed capacity of 3,600 MW. Other major stations in the pipeline include Baihetan (16,000 MW) and Wudongde (8,700 MW) – both expected to enter commercial operation in 2020.

Chinese companies are also playing leading roles in developing hydropower beyond China's borders. Deals have recently been secured in south-east Asia, but firms are also increasing their presence in central Asia, Africa, and South America.

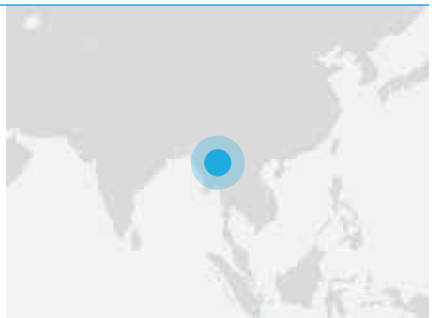
POPULATION
1,355,682,576

AREA
9,326,410 km²

GDP
USD 9,240 bn

INSTALLED HYDROPOWER CAPACITY
280 GW
HYDROPOWER
21.8 GW
PUMPED STORAGE

EAST ASIA AND PACIFIC
MYANMAR



Myanmar has the potential for more than 100 GW of hydropower, of which only 3 GW has been developed so far. The largest potential is to be found in the Kayin, Shan, and Kayah states, where the Salween River is the major hydropower resource.

In the wake of ongoing political reforms and economic liberalisation, Myanmar's strategic position at the crossroads of south and east Asia is leading to increased participation in regional energy cooperation. Nonetheless, with an electrification rate of only 31 per cent and demand growth of 15 per cent per annum, Myanmar faces the familiar challenge of meeting a rapidly increasing domestic energy demand.

To this end, the government finalised its National Electrification Plan in June 2014. With the aim of providing electricity to the entire country by 2030, the plan emphasises hydropower as a long-term energy solution. In the plan's scenario, installed hydropower capacity will almost triple to reach 9,000 MW by 2030.

Currently, hydropower comprises two-thirds of the country's energy mix, with 3,151 MW of installed capacity from 25 operational projects. Another 46 GW of technically feasible potential has been identified so far, and a number of these projects are now under construction or at the advanced planning stage.

New policy and legal frameworks are being put in place to spur development and attract international engagement and investment. With the assistance of the Asian Development Bank, national energy policy has been reformed and the new Electricity Law was passed in October 2014. The new legislation was drafted with the specific aim of encouraging international investment in electricity infrastructure and includes provisions for the issuance and revocation of licences to foreign investors.

There is already evidence of increased international engagement. Toshiba has been contracted to deliver the 308 MW Upper Yeywa hydropower facility via its Chinese subsidiary, Toshiba Hydro Power. The station is expected to enter commercial operation by 2018. Asia World and China's Hanergy Group were granted approval to develop the 1,400 MW Upper Thanlwin project, which will also provide electricity to south-western China.

These partnerships build on previous successes in international collaboration such as the Balu Chaung 3 project, which brought 52 MW of installed capacity into commercial operation in January 2014.

In December 2014, Myanmar received a credit of USD 100 million from the World Bank Group to develop the Irrawaddy River Basin. This will allow for feasibility studies and pioneering assessments which will take account of the effect of hydropower development on the entire river basin.

POPULATION
53,260,000

AREA
676,600 km²

GDP
USD 51.29 bn

INSTALLED HYDROPOWER CAPACITY
3,151 MW

PRIORITIES FOR THE SECTOR: BRIEFING FROM THE WORLD HYDROPOWER CONGRESS

A number of emerging trends, ongoing challenges and opportunities were identified and discussed at the 2015 World Hydropower Congress, organised by IHA. We summarise the strategic, business, practice and research **topics** likely to influence the future of hydropower.

Strategy

Energy scenarios point to a likely doubling of global hydropower capacity by 2050. But a number of economic, political and socio-economic factors can influence this development. For example, policy frameworks and market conditions can enable investment in favour of a more renewable **future energy mix**, although it is clear that investment will not only have to be made in technology, but also in transmission networks and grid services, some of which hydropower can provide.

In addition, energy planners are now encouraged to adopt a **nexus approach** (see p. 12), meaning that the impact of energy production on water resources will influence preferences for technology and project design going forward.

Finally, decision-makers, in particular in developing countries, have to manage a difficult balance between unavoidable **development and sustainability** imperatives.

Solutions to this dilemma emerge that emphasise strategic consideration around the early stage of projects, taking into consideration a basin-wide perspective. However, while conservation objectives can be achieved by limiting river fragmentation at the basin level, planners will have to ensure that alternative solutions provide similar energy output. This of course requires awareness, consultation and formal collaboration at a higher level to encourage **regional development.**

Business

From a business point of view, addressing sustainability and finance is critical to the long-term success of projects, with the former often influencing access to the latter.

This is why the Hydropower Sustainability Assessment Protocol (see p.19) has proved a useful tool to developers and operators looking to benchmark their projects internationally and provide financiers with a way to incorporate **sustainability performance** in their evaluation of projects.

Sustainability in the broad sense covers a range of topics. We often talk about **good corporate governance**. Transparent communication and leadership in this area delivers positive signals to investors, as does the ability to demonstrate **climate resilience** (see p. 17).

Complex hydropower projects with high upfront costs remain intrinsically challenging to finance, because of their evolving risk profile over time. Risk can be managed with good **project and financial structuring**, but it is clear that all actors would benefit from the sharing of experience, knowledge and tools available worldwide.

Practice

From a practitioner point of view, environmental and social aspects remain the most challenging and scrutinised aspects of a project. Among them, **resettlement** has evolved over the last decades, from simple compensation for adverse impacts to ensuring livelihoods for affected communities, and living standards which are equivalent to pre-project conditions, if not improved. Collaboration with public authorities throughout the process is essential.

Another aspect, **sediment management,** is a growing concern which should be addressed during the design phase of a project, but also during basin-wide considerations.

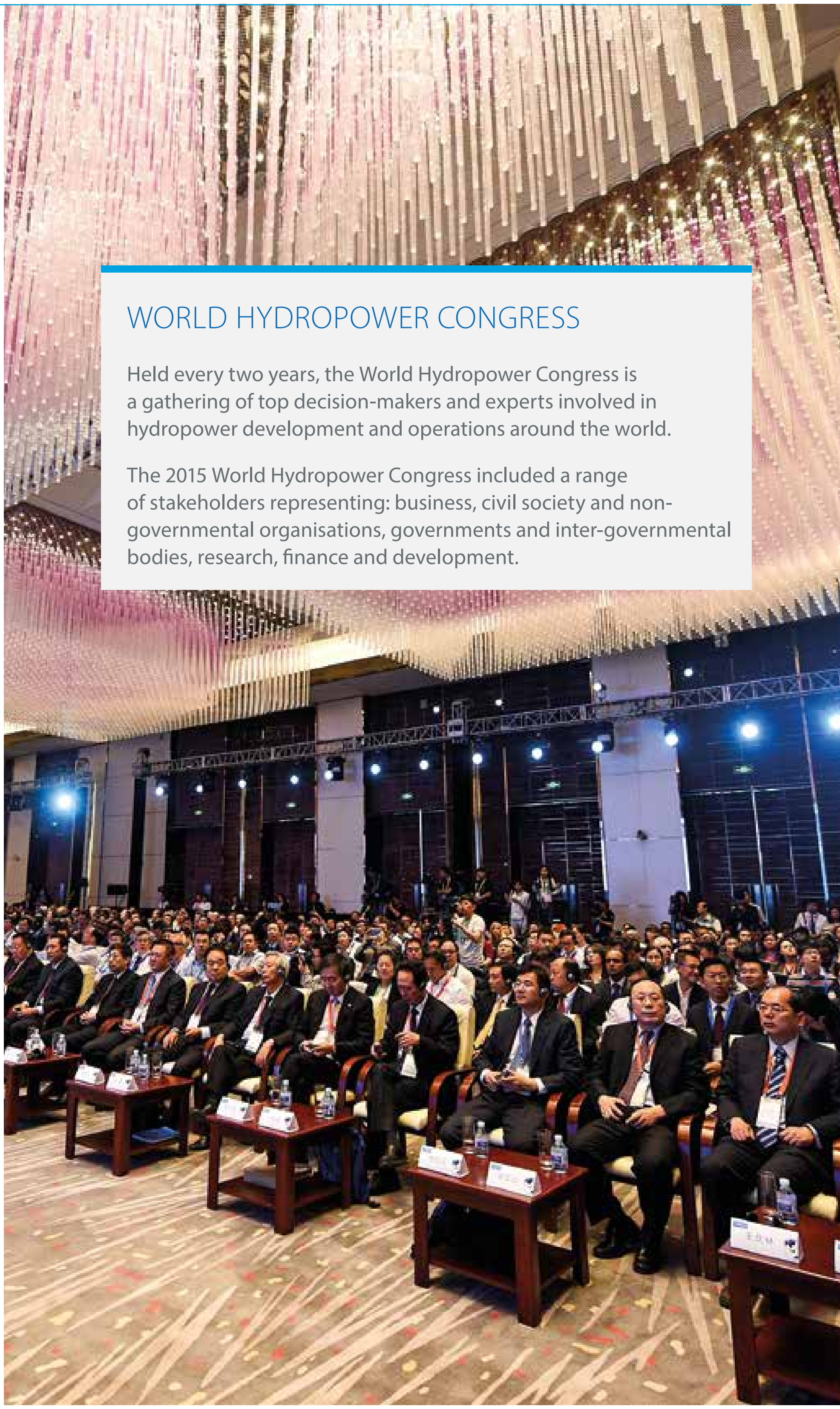
Finally, maintaining high **safety** standards in an increasingly diverse industry will require wide exchange of good practices, particularly with regard to sector-specific matters such as water release, either under normal or abnormal conditions.

It is worth noting that **modernisation** – which will have been carried out in all current installations by 2050 – can be an opportunity to address some of the issues mentioned above, but also adapt to market conditions, changing energy mixes and climate change. Knowing the options available can give a competitive edge to operators.

Research

Because they will affect the perception and development of hydropower, positive and negative impacts need to be better understood, and research results disseminated beyond the sector. In addition to the quantification of greenhouse gas emissions from reservoirs (see p.16), which may determine access to climate-change-related funding, the evaluation of macroeconomic benefits from hydropower will shed light on the value of the investment beyond the provision of electricity.

From an environmental perspective, a better understanding of the concepts of downstream flows and connectivity at the river-basin level, and how it affects aquatic species in particular, will inform project design and planning.



WORLD HYDROPOWER CONGRESS

Held every two years, the World Hydropower Congress is a gathering of top decision-makers and experts involved in hydropower development and operations around the world.

The 2015 World Hydropower Congress included a range of stakeholders representing: business, civil society and non-governmental organisations, governments and inter-governmental bodies, research, finance and development.

WORLD HYDROPOWER INSTALLED CAPACITY AND GENERATION 2014

AFRICA

Country	Total installed capacity excluding pumped storage (MW)	Pumped storage (MW)	Generation (TWh)
Algeria	228	-	0.32
Angola	760	-	2.93
Benin	1	-	-
Botswana	-	-	-
Burkina Faso	32	-	0.10
Burundi	54	-	0.16
Cote dIvoire	604	-	2.49
Cameroon	736	-	4.38
Cape Verde	-	-	-
Central African Republic	25	-	0.14
Chad	-	-	-
Comoros	1	-	-
Congo	209	-	1.06
Democratic Republic of the Congo	2,472	-	7.80
Djibouti	-	-	-
Egypt	2,800	-	13.25
Equatorial Guinea	127	-	0.01
Eritrea	-	-	-
Ethiopia	2,178	-	5.72
Gabon	170	-	0.80
Gambia	-	-	-
Ghana	1,602	-	8.42
Guinea	128	-	0.50
Guinea-bissau	-	-	-
Kenya	812	-	3.41
Lesotho	80	-	0.69
Liberia	-	-	-
Libya	-	-	-
Madagascar	164	-	0.86
Malawi	364	-	2.14
Maldives	-	-	-
Mali	157	-	0.29
Mauritania	97	-	0.12
Mauritius	60	-	0.08
Morocco	1,306	464	2.52
Mozambique	2,187	-	16.67
Namibia	341	-	1.79
Niger	-	-	-
Nigeria	2,040	-	5.90
Reunion	121	-	0.50
Rwanda	99	-	0.18
Sao Tome And Principe	4	-	0.01
Senegal	-	-	-
Seychelles	-	-	-
Sierra Leone	54	-	0.11
Somalia	-	-	-
South Africa	661	1,580	1.04
South Sudan	-	-	-
Sudan	2,250	-	6.31
Swaziland	60	-	0.27
Tanzania	562	-	2.56
Togo	65	-	0.10
Tunisia	66	-	0.05
Uganda	706	-	1.48
Western Sahara	-	-	-
Yemen	-	-	-
Zambia	1,895	-	11.62
Zimbabwe	750	-	5.39
TOTAL	**27,028**	**2,044**	**112**

CENTRAL AND SOUTH ASIA

Country	Total installed capacity excluding pumped storage (MW)	Pumped storage (MW)	Generation (TWh)
Afghanistan	400	-	0.91
Bahrain	-	-	-
Bangladesh	230	-	1.49
Bhutan	1,489	-	7.17
India	44,799	4,786	131.00
Iran	10,156	-	13.34
Iraq	2,513	240	4.40
Israel	7	-	0.03
Jordan	12	-	0.06
Kazakhstan	2,260	-	7.33
Kuwait	-	-	-
Kyrgyzstan	3,091	-	13.81
Lebanon	221	-	0.66
Nepal	706	-	3.34
Oman	-	-	-
Pakistan	7,264	-	31.18
Palestinian Territory, Occupied	-	-	-
Qatar	-	-	-
Russia	49,108	1,360	164.00
Saudi Arabia	-	-	-
Sri Lanka	1,624	-	5.12
Syria	1,505	-	2.77
Tajikistan	5,190	-	16.55
Turkey	23,661	-	39.53
Turkmenistan	1	-	-
United Arab Emirates	-	-	-
Uzbekistan	1,731	-	10.31
TOTAL	**155,968**	**6,386**	**455**

EAST ASIA AND PACIFIC

American Samoa	-	-	-
Australia	8,050	740	20.45
Brunei	-	-	-
Cambodia	1,184	-	1.45
China	280,000	21,800	1,064.34
Chinese Taipei	2,081	2,602	4.19
Cook Islands	-	-	-
Fiji	125	-	0.30
French Polynesia	47	-	0.29
Guam	-	-	-
Hong Kong	-	-	-
Indonesia	5,258	-	13.36
Japan	22,262	27,434	78.01
Kiribati	-	-	-
Laos	3,569	-	12.19
Macau	-	-	-
Malaysia	4,753	-	10.41
Marshall Islands	-	-	-
Micronesia, Federated States Of	-	-	-
Mongolia	-	-	-
Myanmar	3,151	-	5.52
Nauru	-	-	-
New Caledonia	78	-	0.33
New Zealand	5,254	-	22.09
Niue	-	-	-
North Korea	5,000	-	13.14
Papua New Guinea	234	-	0.86
Philippines	3,521	685	9.87
Samoa	12	-	0.05
Singapore	-	-	-
Solomon Islands	-	-	-
South Korea	1,747	4,700	4.13
Thailand	3,510	1,000	11.68
Timor-leste	-	-	-
Tonga	-	-	-
Tuvalu	-	-	-
United States Minor Outlying Islands	-	-	-
Vanuatu	-	-	-
Vietnam	14,181	-	58.39
Wallis And Futuna	-	-	-
TOTAL	**364,017**	**58,961**	**1,330**

EUROPE

Country	Total installed capacity excluding pumped storage (MW)	Pumped storage (MW)	Generation (TWh)
Aland Islands	-	-	-
Albania	1,527	-	4.01
Andorra	45	-	0.10
Armenia	1,249	-	2.74
Austria	7,968	5,108	39.71
Azerbaijan	1,116	-	2.44
Belarus	13	-	0.04
Belgium	120	1,307	1.43
Bosnia and Herzegovina	2,156	458	6.42
Bulgaria	2,265	864	4.87
Croatia	1,848	293	9.07
Cyprus	-	-	-
Czech Republic	1,065	1,147	3.00
Denmark	9	-	0.02
Estonia	8	-	0.03
Faroe Islands	39	-	0.12
Finland	3,198	-	13.22
France	18,382	6,985	67.28
Georgia	2,640	-	7.63
Germany	4,452	6,806	21.64
Gibraltar	-	-	-
Greece	2,697	699	4.57
Greenland	20	-	0.08
Hungary	56	-	0.30
Iceland	1,986	-	12.60
Ireland	237	292	0.94
Italy	14,325	7,555	58.07
Latvia	1,576	-	1.95
Liechtenstein	-	-	-
Lithuania	116	760	1.07
Luxembourg	34	1,100	1.16
Macedonia	538	-	1.19
Malta	-	-	-
Moldova	76	-	0.37
Monaco	-	-	-
Montenegro	658	-	1.96
Netherlands	37	-	0.12
Norway	28,718	1,351	135.56
Poland	569	1,782	11.66
Portugal	4,455	1,343	16.16
Romania	6,456	92	18.57
San Marino	-	-	-
Serbia	2,221	614	10.51
Slovakia	1,606	916	4.44
Slovenia	1,074	180	6.17
Spain	13,293	5,268	40.18
Sweden	16,315	99	63.79
Switzerland	13,790	1,817	37.45
Ukraine	5,470	1,315	11.02
United Kingdom	1,690	2,744	8.71
TOTAL	**166,113**	**50,895**	**633**

NORTH AMERICA

Country	Total installed capacity excluding pumped storage (MW)	Pumped storage (MW)	Generation (TWh)
Anguilla	-	-	-
Antigua and Barbuda	-	-	-
Aruba	-	-	-
Bahamas	-	-	-
Barbados	-	-	-
Belize	53	-	0.21
Bermuda	-	-	-
Canada	77,558	177	375.11
Cayman Islands	-	-	-
Costa Rica	1,750	-	7.21
Cuba	64	-	0.10
Dominica	6	-	0.03
Dominican Republic	543	-	1.43
El Salvador	472	-	1.90
Grenada	-	-	-
Guadeloupe	10	-	-
Guatemala	991	-	3.99
Haiti	61	-	0.15
Honduras	558	-	2.98
Jamaica	23	-	0.12
Martinique	-	-	-
Mexico	12,410	-	31.53
Montserrat	-	-	-
Nicaragua	106	-	0.47
Panama	1,622	-	4.97
Puerto Rico	100	-	0.10
Saint Bartholemy	-	-	-
Saint Kitts And Nevis	-	-	-
Saint Lucia	-	-	-
Saint Pierre And Miquelon	-	-	-
Saint Vincent And The Grenadines	7	-	0.03
Trinidad And Tobago	-	-	-
Turks And Caicos Islands	-	-	-
United States	79,270	22,368	258.75
Virgin Islands, British	-	-	-
Virgin Islands, U.S.	-	-	-
TOTAL	**175,604**	**22,545**	**690**

SOUTH AMERICA

Argentina	9,079	974	29.43
Bolivia	494	-	2.34
Brazil	89,306	-	392.58
Chile	6,358	-	20.61
Colombia	10,793	-	52.00
Ecuador	2,237	-	11.56
French Guiana	119	-	0.73
Guyana	1	-	-
Paraguay	8,810	-	59.43
Peru	3,820	-	23.76
Suriname	189	-	0.73
Uruguay	1,538	-	7.54
Venezuela	15,136	-	78.23
TOTAL	**147,880**	**974**	**680**