ENGLISH Magazine of ANDRITZ Hydro // Asia Special / 3-2020

ANDRITZ

ASIA IN SHORT

Asia in this issue covers Central Asia, East Asia, South Asia, Southeast Asia, and Oceania.

POPULATION:
4.138 billions

54% of the world's total

COUNTRIES:
(incl. dependent territories)
63

Australia forming a **whole own continent**

4 countries among the **top 10 richest** of the world (GDP PPP per capita)

LANGUAGES:
about 2,300 +

TOTAL LAND AREA:
51,113,505 km²

about **34%** of earth's total land area

ANDRITZ
50 + locations
5,780 employees

ANDRITZ HYDRO
20+ locations
1,760 employees

thereof **4** manufacturing locations

Booming region – Ambitious targets – Huge hydropower potential

Dear Business Friends,

Asia is currently a hydropower hotspot– especially in Southeast Asia. Over the last five years, more than 60 GW of new hydropower capacity was commissioned, driven by rapid population growth and industrial development.

Adding to this growth trend is the addition of substantially more variable output energy resources, like wind and solar, requiring the development of grid-balancing pumped storage projects throughout the region. In addition to aging hydropower assets and new operations and maintenance requirements, environmental regulations also offer ample opportunities for modernization, rehabilitation and digitalization.

Sustainable and clean hydropower still represents a huge unexploited potential, too. The technically feasible regional hydropower potential is enormous and far more than the entire current domestic power requirement.

For decades, ANDRITZ has been active in the region and long ago became a market leader. Local set-ups in Australia, China, India, Indonesia, Kazakhstan, Lao PDR, Malaysia, Myanmar, New Zealand, Pakistan, the Philippines, and Vietnam reinforce ANDRITZ's regional presence. With the first turbines to the region supplied more than a century ago, nearly 3,000 turbines with a total output of about 100,000 MW have been supplied and installed by ANDRITZ in this region to date.

ANDRITZ offers top-notch technology – combined with long years of experience and extraordinary expertise – to provide high-quality equipment and environmentally-friendly solutions. Simultaneously ensuring long-lasting optimized operations, best return on investment and the preservation of nature are ANDRITZ's core values. We're prepared to support all countries in this booming region of the world on its way to better economic welfare based on renewable energy from sustainable hydro resources.

Alexander Schwab
Senior Vice President
ANDRITZ HYDRO GmbH

CON

SPECIAL TOPIC

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COUNTRY REPORTS

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BEST ECO
PERSPECT

India is a robust country with an area of 3.29 million km² and a population of close to 1.4 billion people. It is currently the second most populous country after China and the population is projected to grow by about 1.4% in 2020. Projections also show that India might be the most populous country in the world by 2024.

India is both a regional and international economic power. However, from a GDP growth of about 6.4% in 2018, India has shown signs of recession. Currently, India's growth is pegged at a relatively slow rate of 5.6% while forecast GDP by various multilateral agencies points to a figure of 5.1% for 2020.

India has over two thousand ethnic groups living within its boundaries. Importantly, more than 50% of India's current population is below the age of 25 and over 65% of the population is below the age of 35. With this young population, India's dependency ratio should be a little over 0.4, which means that it will be one of the most efficient and productive nations in the coming years.

THE HYDRO MARKET OUTLOOK

The government of India made some amendments to the existing hydro policy in 2019. Namely, four major issues were addressed, including a Hydro Purchase Obligation limited to specific conditions, categorization of all hydro projects as renewable energy, rationalizing of hydro energy tariffs (incentives and tax rebates), and budgetary support for the cost of enabling infrastructure and flood moderation components.

To assist further development of the whole hydropower sector and create a robust business environment, the government set a target to raise the renewable energy capacity to 227 GW by 2022. As of October 2019, a total of 48 GW of renewable energy capacity had been installed in the country since March 2014.

Small hydro could contribute about 5 GW to the potential 227 GW of renewable energy capacity. The small hydro potential in India currently is 15,384 MW of which only 4,604 MW have been installed. Some 116 projects aggregating 553 MW are currently under construction.

Considerable growth is expected in Jammu and Kashmir, while the state of Himachal Pradesh has introduced changes in its state hydropower policy to attract developers with better co-ordination between Ministry of New and Renewable Energy and State Nodal agencies. It is also expected that projects in North Eastern states will be given due attention for geopolitical reasons. Currently, 1,662 MW of installed capacity is owned by private developers known as Independent Power Producers.

NOMIC IVES

FUTURE OUTLOOK

With recent developments in Jammu and Kashmir, the government of India is looking to speed up strategically important hydropower projects in the state. These hydro projects, located mainly in the Chenab Valley, will be developed expeditiously due to geopolitical issues bearing from the existing Indus Water Treaty between India and Pakistan. Further, China's One-Belt-One-Road policy has propelled the government to prioritize implementation of large projects like Ratle (850 MW), Dulhasti (390 MW), Kwar (600 MW) and Kiru (624 MW).

In Arunachal Pradesh, a hydropower potential-rich state with an untapped hydro potential of 50,328 MW, state-owned National Hydropower Corporation's (NHPC) Dibang HEP (2,880 MW) witnessed some movement with recent Ministry of Environment, Forest & Climate Change clearance. In the southern states of Tamil Nadu and Karnataka, life extension initiatives for various aged hydro plants, which have an average lifespan of 55 years, are expected. Many are in dire need of renovation and modernization.

With the increase in variable renewable energy capacity, growth in hydro pumped storage schemes (PSPs) is also expected. Projects like Turga (1,000 MW), Lugu Pahar (1,500 MW), Kundah, which has already been tendered (500 MW), and a few larger-sized projects are expected to come up within the next few years.

Teesta-VI (600 MW) in Sikkim, which was previously being developed by an independent power producer, was finally resuscitated through NCLT and NHPC has taken over the project, but the funding is still open.

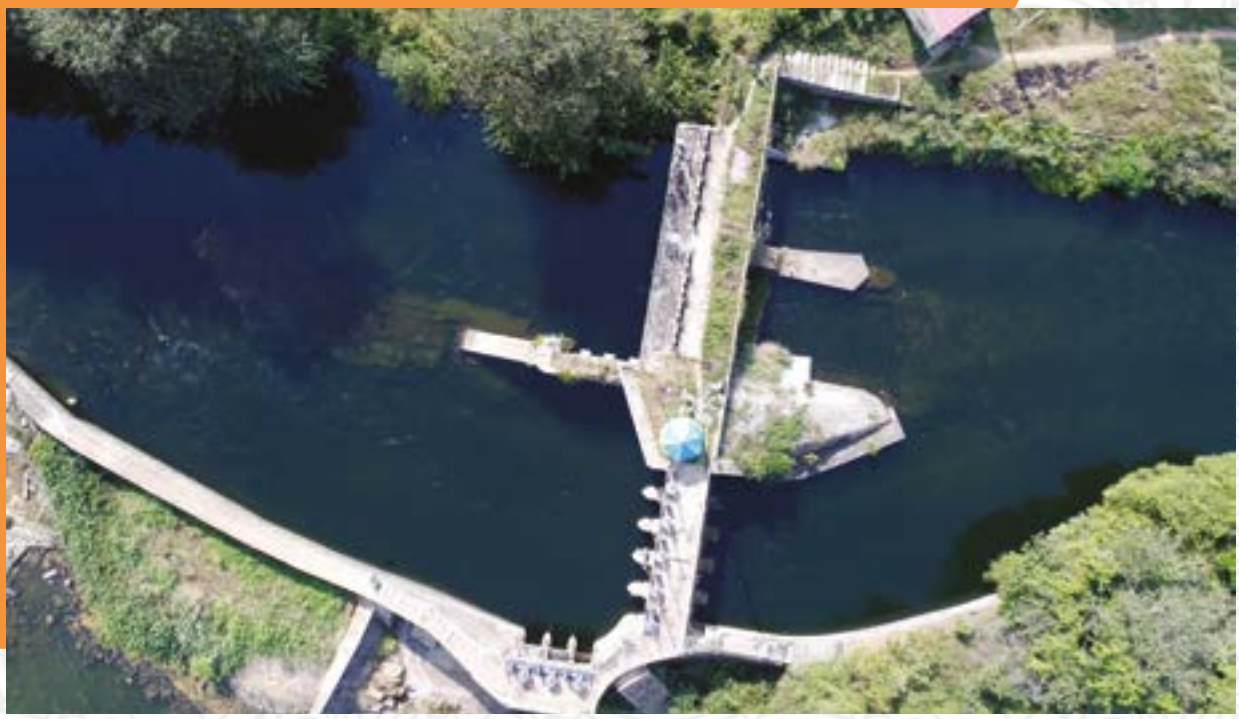
With the amendments to the hydro policy rolled out in 2019, a slew of projects are expected to come up for development by mid-2020.

ANDRITZ HYDRO IN INDIA

ANDRITZ has been a leading player in the hydropower electro-mechanical sector in India and has supplied and installed equipment

→

Shivasamudram, Kaveri River, 42 MW; Commissioned in 1902, it is one of the oldest hydropower plants in Asia.



In a first for the company, ANDRITZ Hydro was given the Star Performer Award in export excellence by the Engineering Export Promotion Council of India. This award was bestowed upon ANDRITZ Hydro at a national level based on its impressive exports in the 2017-2018 financial year. This achievement adds further weight to the company's commitment to "Make-in-India"

Teesta Low Dam Stage III, Teesta River, 132 MW

with over 18,000 MW capacity since the early 19th century. ANDRITZ is proudly associated with prestigious projects like Karcham Wangtoo (1,000 MW) and Teesta III (1,200 MW). Both projects were commissioned on time and have added substantial new capacity to the national grid. Additionally, ANDRITZ has been involved in service and rehabilitation of existing projects and small hydro projects.

With two well-established and state-of-the-art manufacturing sites, a new corporate office in New Delhi and an employee base of over 850 trained and qualified engineers, ANDRITZ Hydro in India is poised to be one of the largest units of the whole ANDRITZ GROUP outside Europe. ANDRITZ India is now aligned to address future market demand not only in India but across the whole South East Asia region.

In 2018, ANDRITZ further extended its portfolio by introducing its presence to the penstock and gates (PG) business for hydropower plants and irrigation projects. The company has also executed operation and maintenance (O&M) for hydropower plants and high capacity engineered pumps. Receiving the O&M contract for the Teesta III hydropower project in 2018, ANDRITZ further received contracts to maintain and service lift irrigation schemes

Tiloth, Bagrathi River, 90 MW

Teesta Stage III, Teesta River, 1,200 MW

Vertical generator test bench in ANDRITZ's manufacturing facility in Bhopal

in the states of Andhra Pradesh, Arunachal Pradesh and Telangana.

While continuing its dominance in the service and rehabilitation segment in India's hydropower sector, ANDRITZ was recently awarded a contract from state owned Tamil Nadu Power Generation Company to renovate, modernize and uprate the Moyar hydroelectric project. The project, located in the Nilgiri Hills in western Tamil Nadu, has three units of 12 MW. Each unit will be uprated to 14 MW.

The company has received a total of seven contracts for manufacturing, supplying and commissioning penstocks and gates for projects in Nepal and India. Very challenging commissioning schedules for all the projects mean the experience and expertise on hand are vital to allow ANDRITZ to meet client deadlines.

ANDRITZ Hydro India not only caters to the Asia market but has also exported equipment and generators to over 28 countries, including North America.

While it is pertinent to mention that there have not been many new large projects up for development recently, ANDRITZ is well prepared to contribute to the country's hydropower sector and support the nation's ambitious renewable energy targets.

GENERAL FACTS

Population: **1.353 billion**
Access to electricity: **92.6%**
Installed hydro capacity: **> 45,217 MW**
Hydropower under construction: **10,500 MW**
Share of generation from hydropower: **11%**
Hydro generation per year: **140,000 GWh**
Technically feasible hydro generation potential per year: **660,000 GWh**

ANDRITZ Hydro in the country:
Total installed / rehabilitated units: **633**
Total installed / rehabilitated capacity: **18,076 MW**
Location: **New Delhi, Bhopal, Prithla**
contact-hydro.in@andritz.com

AUTHOR
De Neelav Samrat

Baglihar, Chenab River, 450 MW

MOVING ON THE RIGHT TRACK

With an annual GDP growth of about 6.3% in 2018, Nepal is one of the fastest growing economies in the world, though still one of the least developed. Political uncertainty and a difficult market have slowed foreign investment. Additional challenges to Nepal's growth include its geographic location, power shortages, and underdeveloped infrastructure.

Nepal's recent progress in hydropower construction is phenonenal when compared with the previous century of hydropwer development, which achieved less than 1,200 MW in total. Conversely, it is expected that around 3,000 MW of hydroelectricity is to be added to the grid over the next three years.

Nepal has a large economically feasible hydropower potential of 44,000 MW, however the vast majority has yet to be harnessed. To address this, the Government of Nepal has come up with a roadmap to produce 15,000 MW of electricity within 15 years*.

ANDRITZ HYDRO IN NEPAL

ANDRITZ has been a significant contributor to the Nepalese hydropower sector for many years. Over the last three decades almost 1,200 MW of electricity generation capacity has been commissioned or is in development. For example, ANDRITZ is the electro-mechanical and recently also the hydro-mechanical contractor of Nepal's national priority project Upper Tamakoshi (456 MW), the largest hydropower plant funded solely by the Nepalese. This is in addition to 33 other projects all around the country. ANDRITZ is also now actively involved in hydro-mechanical works in Nepal and secured four contracts in 2019 alone.

Kalanga Cluster Projects: Located in the Bhajang District, one of the most remote parts of Nepal, the Kalanga cluster projects include Upper Kalanga Gad (38.46 MW), Kalanga Gad (15.34 MW) and Upper Sanigad (10.7 MW). In 2017, ANDRITZ signed a contract with Kalanga Group

Installation team Upper Tamakoshi

NEPAL

Tamakoshi River in the Nepalese Himalayas

of Companies, a well-known independent power producer in Nepal and the developer of these projects. The scope includes the supply of three vertical, four-jet Pelton turbines for Upper Kalanga Gad, two horizontal Francis turbines for Kalanga Gad, and two horizontal Pelton turbines for Upper Sanigad. The scope also includes the entire electro-mechanical equipmment as well as erection and commissioning.

Likhu Cluster Projects: Likhu 1 (77 MW), Likhu 2 (54 MW) and Likhu A (29 MW) are three cluster projects on the Likhu River at Ramechhap District developed by a single client, MV Dugar Group. ANDRITZ signed a contract in December 2018 for the delivery of three vertical, five-jet Pelton turbines for Likhu 1, three vertical Francis turbines for Likhu 2, and three horizontal Francis turbines for Likhu A. The contract included the entire electro- and hydro-mechanical scope, as well as erection and commissioning.

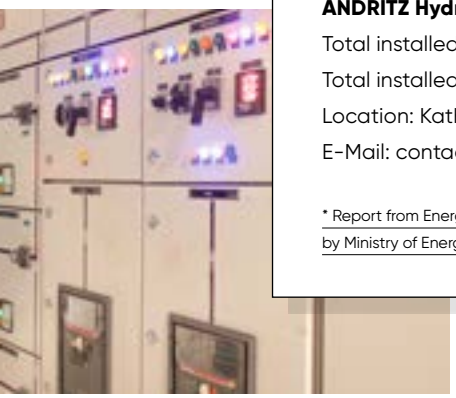
Nilgiri Cluster Projects: In December 2019, ANDRITZ signed the hydro-mechanical contract for the Nilgiri cluster projects in Myagdi District. The cluster comprises Nilgiri Khola I (38 MW) and Nilgiri Khola II (71 MW) and is developed by the well-regarded Nilgiri Khola Hydropower Company Limited. The contract includes design, engineering, fabrication and installation of the penstock (service contract) and supply of manholes and bifurcations (supply contract).

GENERAL FACTS

Population: **28,087 million**
Access to electricity: **95.5%**
Installed hydro capacity: **1,074 MW**
Hydropower under construction: **2,647 MW**
Share of generation from hydropower: **100%**
Hydro generation per year: **4,476 GWh**
Technically feasible hydro generation potential per year: **300,000 GWh**

ANDRITZ Hydro in the country:
Total installed / rehabilitated units: **74**
Total installed / rehabilitated capacity: **1,200 MW**
Location: Kathmandu
E-Mail: contact-hydro.np@andritz.com

* Report from Energy White Paper 2018 published by Ministry of Energy, Water Resources and Irrigation.



Automation systems Upper Tamakoshi

AUTHOR

Dhakal Aashish
Kunwar Roshni

LAND OF GREAT CONTRASTS

Pakistan has a semi-industrialized economy based largely on agriculture and a growing services sector. With one of the world's largest and fastest-growing middle classes, Pakistan is ranked among the emerging and growth-leading economies.

Over the last several years, the macroeconomy has stabilized. However, to attract foreign investment and support further economic growth, additional economic reform and development of the energy sector is necessary.

Pakistan's energy mix is split among fossil fuels (69%), hydropower (21%) and other renewables and nuclear power (10%). In April 2019, Pakistan declared to have 30% of its energy capacity coming from renewable sources by 2030. The International Hydropower Association states that Pakistan has a technically feasible hydropower potential of about 60,000 MW.

During 2018, three long-delayed mega hydropower projects were successfully completed and commissioned. With a cumulative generation capacity of 2,487 MW, the projects include the commissioning of the 108 MW Golen Gol hydropower project, the 1,410 MW Tarbela fourth extension, and the 969 MW Neelum Jhelum hydropower projects.

In 2018, close to 22 GW of new renewable hydroelectric capacity was put into operation worldwide. By commissioning additional capacity collectively reaching 2,487 MW, Pakistan is positioned as the world's number 3 in hydropower installation ranking. Following only China (8,540 MW) and Brazil (3,866 MW), Pakistan's hydropower is making a significant contribution to a clean and sustainable future.

Pakistan ranked as the world's No. 3 in hydropower installation

ANDRITZ HYDRO IN PAKISTAN

ANDRITZ has been active in Pakistan for more than 75 years, supplying equipment and complex project execution. Across Pakistan to date, more than 71 units with a total capacity of 4,723 MW have been installed and/or rehabilitated by ANDRITZ. Among the long list of important projects for ANDRITZ are Allai Khwar with 121 MW and Duber Khwar with 130 MW. Both of these projects, which have been completed and handed over to the customer, are outstanding signature projects representing the first high head Pelton units in Pakistan.

New Bong Escape (84 MW): This project, the first private large hydropower station in Pakistan, features four Kaplan Bulb turbines each rated at 21 MW.

Golen Gol (108 MW): Three Pelton units of 36 MW each, have been commissioned successfully, the last from June

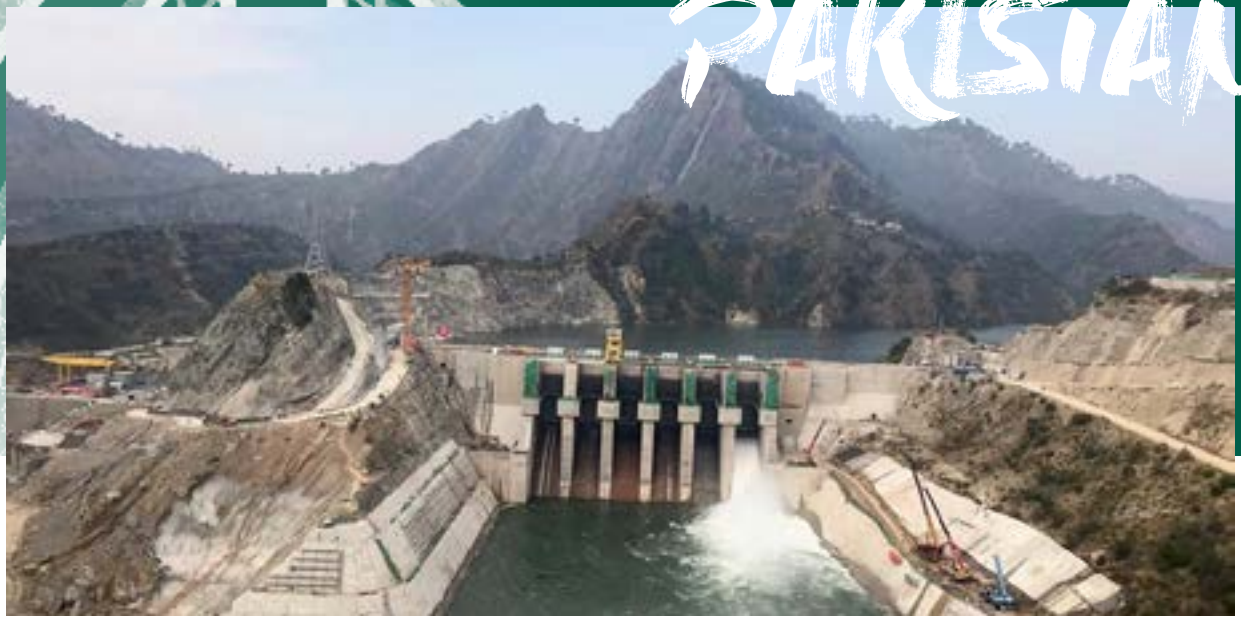
GENERAL FACTS

Population: **212 million**
Access to electricity: **70.8%**
Installed hydro capacity: **9,500 MW**
Hydropower under construction: **4,675 MW**
Share of generation from hydropower: **21%**
Hydro generation per year: **28,562 GWh**
Technically feasible hydro generation potential per year: **204,000 GWh**

ANDRITZ Hydro in the country:
Total installed / rehabilitated units: **71**
Total installed / rehabilitated capacity: **4,723 MW**

Successful model test for the largest Pelton turbines in Pakistan. Suki Kinari, Kunhar River, 840 MW

PAKISTAN



Gulpur, Poonch River, 102 MW

to October 2019. The ANDRITZ installation team recovered the timetable even though the project was delayed by civil works and heavy floods.

Gulpur (102 MW): Gulpur is currently in the final installation phase with more than 350 local ANDRITZ erection specialists working to install two Kaplan units of 51 MW each. Commercial operation should commence in 2020.

Suki Kinari (840 MW): ANDRITZ was awarded a contract to supply four 210 MW Pelton units for this project, which will be the largest Pelton turbines in the country.

Tarbela Dam (6,298 MW): Tarbela Dam is an earth-filled dam along the Indus River and the largest of its kind in the world. It is also the largest dam by structural volume. Completed in 1976 and designed for irrigation as well as flood control, the generation of hydroelectric power is the dam's primary function. ANDRITZ was the OEM for all units except the earliest units, #1 – #4. The company has also been awarded several projects at Tarbela, including modernizing, refurbishing and delivering electro-mechanical equipment, the world's largest penstocks as listed in the Guiness Book of World Records, and gates. The existing powerhouse consists of 14 units (10 × 175 MW, 4 × 432 MW). The installed capacity of 4,888 MW will be increased to 6,298 MW after completion of the planned fifth extension.

AUTHOR
Iftikar Ahmad

Golen Gol, Golen Gol River, 108 MW

Allai Khwar, Allai Khwar River, 121 MW

Qian Wei, Minjiang River, 9 × 55.6 MW

Er Tan, Yalong River, 6 × 550 MW

China is the world's most populous country with around 1.4 billion individuals in 2018. And, with an average growth rate above 6%, it has one of the fastest-growing economies. Indeed, measured on a purchasing power parity (PPP) basis, since 2014 China has been regarded as the world's largest economy and it became the world's largest exporter in 2010. China is a major global power.

The technically feasible hydropower potential of China is some 2,720 TWh per year (541.6 GW), about 17% of the global total. To date, about 45% has been developed. Total installed hydropower capacity is 352.26 GW, generating about 1,233 TWh in 2018.

Under government plans to increase renewable energy capacity to a 15% share by 2020 and 30% by 2050, the installed hydropower base is expected to reach about 660 GW by 2050. This will include numerous hydropower projects, both conventional as well as pumped storage. Many such projects are already under construction or are in the planning phase for development in the near future.

In 2018, about 8.5 GW hydropower capacity was added to China's total, more than in any other country of the world.

ANDRITZ HYDRO IN CHINA

ANDRITZ Hydro China is headquartered in Beijing with two further manufacturing workshops in Chengdu and Foshan. Dedicated to the supply and other services for hydropower equipment and covering all types of turbines, generators, main inlet valves, governors, excitation-protection-control and electrical power systems, ANDRITZ Hydro China supplies not only locally but also across Southeast Asia and other international markets. Recent stand out projects from ANDRITZ Hydro China are the San José plant in Colombia and Suki Kinari in Pakistan.

历史 HISTORY

Ren Zonghai, Dadu River, 2 × 123 MW

Tian Huangping pumped storage plant, Zhejiang Province, 6 × 306 MW

With the objective of maintaining and securing a leading position in the important region of Asia, ANDRITZ – in co-operation with several reputable Chinese EPC companies, such as China Gezhouba Group, Sinohydro and others – has been exploring opportunities emerging from the "One Belt One Road" initiavite, such as the China-Pakistan economic corridor.

Da A Guo: ANDRITZ was awarded a contract by Yajiang JinTong Hydroelectric Development Co Ltd. for the supply, installation, and commissioning of two 130 MW Pelton units. The first and second units began commercial operations in August 2018 and September 2019, respectively. Both units have run well since. Warrantees expire in September 2020.

Zhen An: In 2018, ANDRITZ received an order from Shaanxi Zhen An Pumped Storage Co. Ltd., in Shaanxi Province. A subsidiary of State Grid Corporation of China (SGCC), the order is for the supply of four 350 MW reversible pump turbines and motor generators, including auxiliary equipment. With a total installed hydropower capacity of 1,400 MW, Zhen An will be the first pumped storage power station in northwest China.

The four 350 MW reversible pump-turbine units will operate at a head of 440 m. The first will be put into commercial operation in 2023 and all units will be operational in 2024. After completion, Zhen An will be used for peak power and frequency regulation, and as a synchronous condenser. In addition, it will serve as emergency standby reserve and black-start capacity for the Shaanxi power grid.

Feng Ning II: In 2017, ANDRITZ received a contract from the state-owned Chinese energy utility Feng Ning Pump Storage Co. Ltd., State Grid Xinyuan Co. Ltd., to supply two variable speed pumped storage units for the new Feng Ning II pumped storage power plant in Hebei Province. The scope of supply includes two asynchronous motor generator units with variable speed and a nominal capacity of 330 MVA in generator mode and 345 MVA in pump mode. Additionally, the AC-excitation, governor, as well as protection and computer control systems will be supplied. Completion of the project is scheduled for the end of 2023.

Feng Ning II will be the world's largest pumped storage power plant, equipped with 12 × 300 MW pump turbine units in one cavern. ANDRITZ has several pumped storage power plant references in China, including Shi San Ling, Tian Huangping, Tong Bai, Lang Ya Shan and others. For ANDRITZ, this order represents the return of rapid growth in the Chinese pumped storage market.

GENERAL FACTS

Population: **1.392 billion**
Access to electricity: **100%**
Installed hydro capacity: **352,260 MW**
Hydropower under construction: **42,000 MW**
Share of generation from hydropower: **17.6%**
Hydro generation per year: **1,232,900 GWh**
Technically feasible hydro generation potential per year: **2,720,000 GWh**

ANDRITZ Hydro in the country:
Total installed / rehabilitated units: **524**
Total installed / rehabilitated capacity: **37,916 MW**
Location: **Beijing, Chengdu, Foshan**
E-Mail: **contact-hydro.cn@andritz.com**

Tong Bai pumped storage plant, Zhejiang Province, 4 × 300 MW

Qian Wei: ANDRITZ supplied the automation control system for Qian Wei ports, shipping channel and hydropower station in Sichuan Province. Qian Wei is a navigation junction project designed for 1,000 tonne-class ships.

With a total installed capacity of about 500 MW (nine Bulb units with 55.6 MW each), the station is located in the lower reaches of the main stream of Minjiang River in Leshan and forms the third step of a river cascade. Its functions include port operation, channel management and power generation. The upper station is the Dong Fengyan navigation and power generation project, the lower station is the Long Xikou navigation and power generation project. The dam is about 57 km away from Le Shan City and about 144 km from Cheng Du City.

Contract scope for ANDRITZ comprises the design, manufacturing, delivery and commissioning of the complete SCADA, local control units, auxiliary control and metering systems. The first unit of the project is scheduled to be in commercial operation by the first quarter of 2020 and the entire project will be finished by the end of 2020.

Yang Fanggou: In May 2019, ANDRITZ signed a contract for supply of the automation control system for Ya-lung River Yang Fanggou hydropower station. Yang Fanggou is part of a

Tian Wanhe, hydropower complex, Sichuan Province

With 22,500 MW, Three Gorges on the Yangtze River is the largest hydropower plant of the world to date.

hydro-engineering complex whose primary task is electricity generation.

With a total installed capacity of about 1,500 MW (four units of 375 MW each), Yang Fanggou is located in the middle of the Ya-lung River in the Tibetan Autonomous County of Mu Li, Liang Shan Autonomous Prefecture, Sichuan Province. It is the sixth level of the seven level-development of the middle Ya-lung River. It is about 235 km away from Xi Chang City.

The contractual scope for ANDRITZ consists of the design, manufacture, delivery and commissioning of the complete SCADA, local control and auxiliary control systems. Yang Fanggou Hydropower Station is scheduled to start production in November 2021. The project will be finished by the end of 2022.

Tian Wanhe (TWH): In early 2019, a frame-service agreement was signed for runner repair, spare parts supply and technical service that ensures long-term cooperation between ANDRITZ Hydro China and Sichuan Chuantou Tian Wanhe Developing Company, operators of a project comprised of three Pelton hydropower plants: Ren Zonghai (2004) 2 × 120 MW, Jin Wo (2004) 2 × 140 MW, Da Fa (2004) 2 × 120 MW.

In July 2019, ANDRITZ signed a contract for the supply of one unit (for Da Fa unit #2, six nozzles) for a rehabilitation experimental program. Supply will be completed within the first quarter of 2020. This will be the first real-world application of the cut needle tip technology. Perhaps more importantly, the success of Da Fa unit #2 nozzle rehab could have a significant impact on future market potential.

AUTHOR

Xue Yuan

Repair of Pelton runner for Jin Wo, Sichuan Province, 2 × 40 MW, at ANDRITZ Hydro local manufacturing facility

SPECIAL TOPIC

Pumped Sto
STABILITY AN

Pumped storage significantly contributes to a clean energy future as the most proven, reliable and cost-efficient technology for bulk energy storage existing to date. Pumped storage hydropower plants balance grid fluctuations through their high operational flexibility, allowing the integration of intermittent renewable power on a grand scale with low risks and low operating costs.

BENEFITS

Benefits of Pumped Storage:

- Best-proven, low-risk energy storage technology
- Balancing volatile renewable energy generation with demand
- Managing grid bottlenecks
- Supporting grid stability by virtue of a quick response to changing demand or sudden outages
- Contributing to grid stability by increasing grid inertia and providing black start capability
- Very long facility lifetime
- Water resource management

Today, more than 160 GW of pumped storage capacity is installed throughout the world. About 1.9 GW was added worldwide in 2018, whereas about 75 GW are in the pipeline, either in planning or under construction.

In South, East, Southeast and Central Asia – as well as Oceania, the region covered in this edition – 74 GW of pumped storage are currently installed, with China and Japan leading with 30 GW and 27.6 GW, respectively. In 2018, 1.5 GW were added in the region, solely in China, which benefits from specific tariff mechanisms and where pumped storage continues to be a priority in the country's energy transition.

Feasibility studies show interesting potential for off-river (closed-loop) pumped storage in Australia and other arid regions. Australia has several projects in planning development.

Many countries have readjusted their energy policies in order to follow the Paris Climate Agreement, boosting power generation from renewable resources, which in turn triggers an increasing need for energy storage. As the leading technology for energy storage services, pumped storage not only balances variable power production, but also serves as a back-up with its firm capacity, ensuring grid stability while reducing the risk of blackouts. For small and islanded grids especially, pumped storage is an ideal partner to gain independence from fossil fuels.

Pumped storage could continue to be an essential contribution to a clean sustainable energy future. Pumped storage could also be more than just a back-up for intermittent renewable energy resources and additional grid services. With its operational flexibility, pumped storage offers a wide spectrum of benefits and plays a vital role within local and regional water and energy programs. However, for further development and growth, adaption of appropriate market structures and regulatory frameworks is vital.

orage in Asia
ND BALANCE

Pumped storage could also be more than just a back-up for intermittent renewable energy resources. It offers a wide spectrum of benefits and plays a vital role within local and regional water and energy programs.

ANDRITZ HYDRO'S HISTORY OF PUMPED STORAGE TECHNOLOGY IN ASIA

Since the very beginnings of pumped storage technology, ANDRITZ has continued to provide groundbreaking technology. Having delivered about 500 pumped storage units with a total capacity of about 40,000 MW worldwide, the company has been involved in many major projects around the globe. Highlights include Vianden in Luxembourg, the largest pumped storage plant in Europe, and Goldisthal, the largest in Germany and the first with variable speed outside Japan. Northfield and Castaic in the USA, Edolo in Italy, Malta-Reisseck in Austria, Drakensberg in South Africa and Aldeávila in Spain are other key ANDRITZ references.

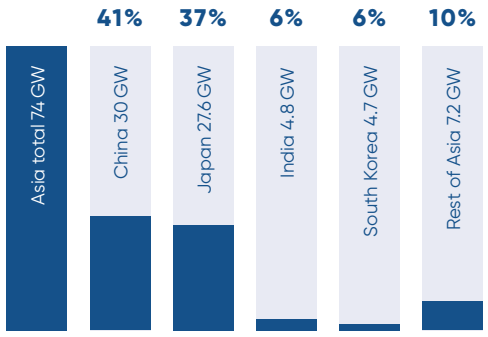
In Asia, ANDRITZ was the supplier for several pumped storage plants, such as Tianhuangping,Shi San Ling, Lang Ya Shan, and Tongbai in China. Currently, the company is executing a contract for two asynchronous generating units for Feng Ning II in China, which will become the largest pumped storage plant in the world when completed.

Pumped storage is a proven, highly efficient and low-risk technology. It benefits from long asset lifetimes and demonstrates lower operating costs than any other bulk power storage technology currently available. By successfully integrating intermittent renewable generation resources into the grid, pumped storage hydro can thus contribute significantly to a clean energy future.

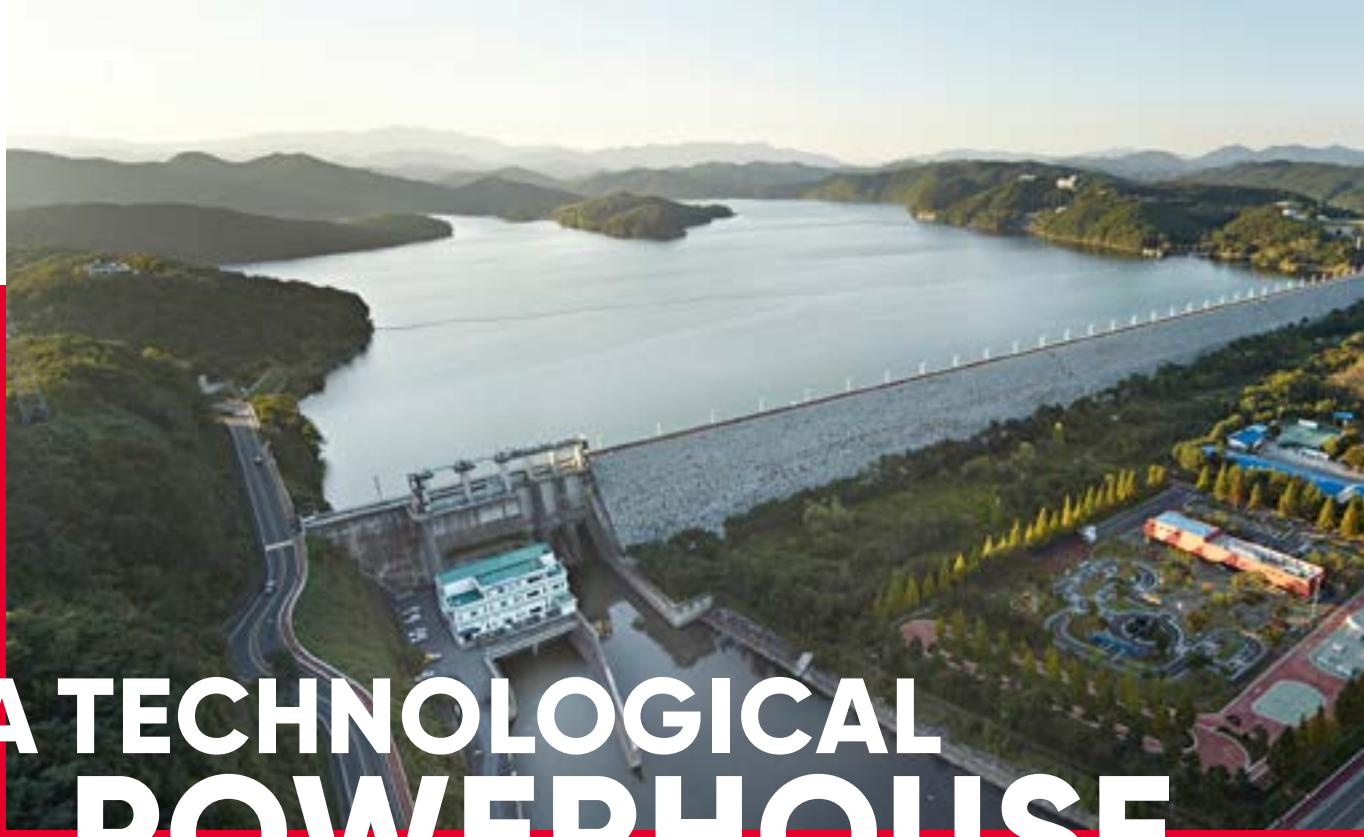
STATISTICS

TOTAL INSTALLED PUMPED STORAGE CAPACITY IN 2018

WORLDWIDE, TOTAL 160 GW
THEREOF 74 GW IN ASIA



AUTHOR
Marie-Antoinette Sailer



A TECHNOLOGICAL POWERHOUSE

South Korea is a highly developed country with a globally connected, high-tech society. It is one of the world's most innovative countries and a global leader in many technology and innovation-driven fields.

Although the Korean peninsula has a few rivers flowing west and south, which seem advantageous to hydropower generation, there are significant challenges. There are high seasonal variations in the weather and most of the rainfall occurs in the summer. Installed hydropower capacity is about 6,489 MW and annual hydropower generation is some 7,273 GWh as of 2018. The hydropower fleet comprises 1,789 MW of pure hydropower and a further 4,700 MW of pumped storage.

Today, as the potential for conventional hydropower generation is almost fully exploited, Korea is focusing on additional hydro resources, such as tidal energy power generation. South Korea has already built the largest tidal power plant in the world at Sihwa Lake. This tidal lake power plant has a total capacity of 254 MW with an annual power generation of 543 GWh. It is managed and operated by K-water, a government agency that develops and manages water resources and water supply facilities in Korea. It is still a lighthouse project for ocean energy exploitation worldwide.

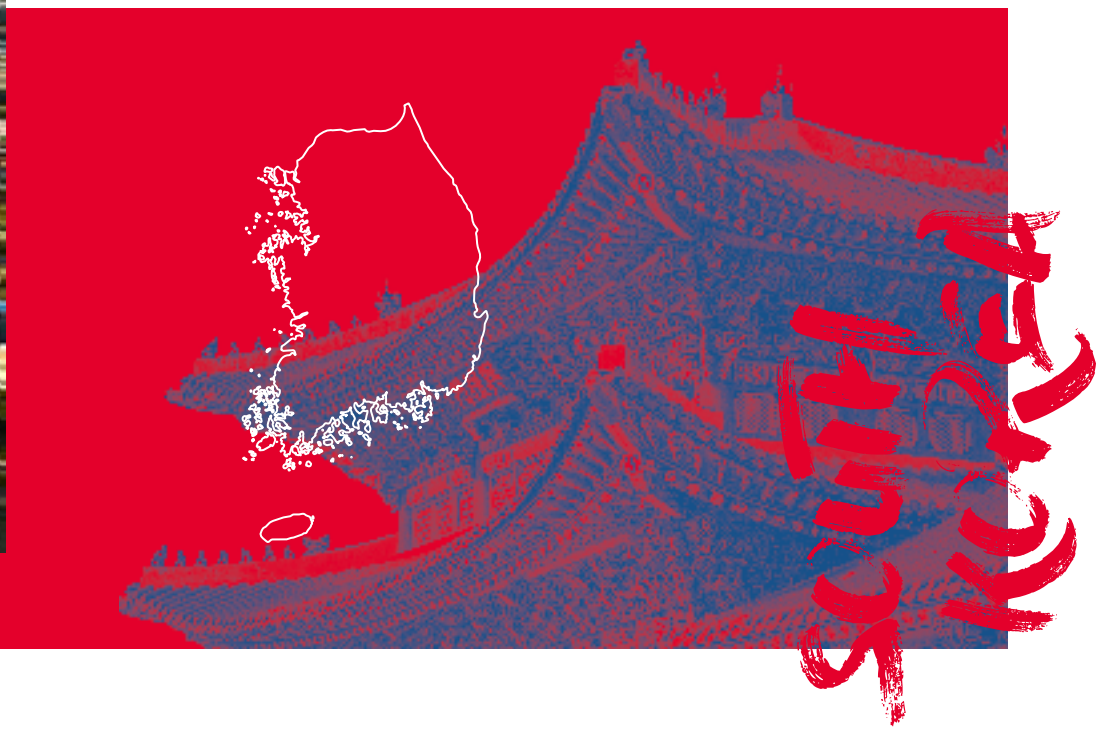
GENERAL FACTS

Population: **51.6 million**
Access to electricity: **100%**
Installed hydro capacity: **6,489 MW** incl. PSPP
Share of generation from hydropower: **1.3%**
Hydro generation per year: **7,273 GWh**
Technically feasible hydro generation potential per year: **26,389 GWh**

ANDRITZ Hydro:
Total installed / rehabilitated units: **40**
Total installed / rehabilitated capacity: **1,000 MW**
Location: **Seoul**
E-Mail: **contact-hydro.kr@andritz.com**

Sihwa tidal power plant, Sihwa Lake Dam

Namgang, Namgang River, 18 MW



Another technology to be promoted is pumped storage. For the new pumped storage power plants, KHNP has selected three areas for development: Youngdong (500 MW), Hongcheon (600 MW) and Pocheon (750 MW). According to Korean government plans, KHNP will progress construction and completion is due in 2031.

Many hydropower plants in the country were built about 40 to 50 years ago and are in need of modernization work in order to improve their performance, efficiency and output. This requirement represents an interesting business opportunity.

Sihwa has a total output of 254 MW and is therefore the largest tidal power plant in the world, having an annual power generation of 543 GWh.

ANDRITZ HYDRO IN SOUTH KOREA

First equipment deliveries to South Korea had already taken place in the early 1930s, although there was a break due to the political and economic situation. Nonetheless, in total, ANDRITZ has delivered and/or rehabilitated about 40 units with a total installed capacity of more than 1,000 MW to South Korea. The largest of these projects are Cheongsong (2 × 306 MW) and Sihwa (10 × 25.4 MW). Since the beginning of this millennium, ANDRITZ has also won some important orders in the South Korean market.

Andong (90 MW): K-water awarded ANDRITZ with a refurbishment contract for the hydropower plant. Two turbine-generator sets, each with an output of 45 MW, were completed in mid-2019. In September 2019, the opening ceremony of the power plant was celebrated in the presence of K-water's CEO.

Namgang (18 MW): In 2016, ANDRITZ contracted with K-water for the refurbishment of the entire hydropower plant. The existing units 2 × 7 MW were changed to 2 × 9 MW.

Hwacheon (27 MW): KHNP awarded the rehabilitation work for unit #4 of the Hwacheon hydropower plant to ANDRITZ. One turbine-generator set with an output of 27 MW is to be modernized by mid-2021.

Sihwa (254 MW): In 2005, ANDRITZ received a contract from Daewoo Engineering & Construction Co., Ltd. for the electro-mechanical equipment of the Sihwa tidal power plant, located at the Sihwa Lake Dam. The scope of supply comprised the design of 10 Bulb turbine-generator units and their ancillaries, delivery of core components for turbines and generators, the automation system, supervision of the site installation and commissioning.

AUTHOR

Kim Minchan

Sihwa tidal power plant, Sihwa Lake Dam

ENERGIZING THOUSANDS OF ISLANDS

Indonesia is Southeast Asia's most populous country and the largest economy in Southeast Asia. More than seventeen thousand islands form the world's largest island country. With an electrification ratio of 98.10%, Indonesia still needs to provide power to millions of people living in very isolated areas.

Unit hall Hasang, North Sumatra, 3 × 13.73 MW

Indonesia's power generation mix is dominated by coal, oil and natural gas, but it has an astounding technically feasible hydropower potential of some 225,000 GWh. So far, only about 8.15% of this potential has been developed. Indonesia has a total installed hydropower capacity of about 5,742 MW, representing about 7.6% of the national total.

In order to tap its vast potential while combating climate change, Indonesia has set a target to increase renewable energy's market share to 23% by 2025. Hydropower is expected to become the biggest contributor to this target, indicating interesting hydropower project development and investment opportunities.

ANDRITZ HYDRO IN INDONESIA

ANDRITZ has been an active contributor to Indonesia's hydropower development for more than 100 years. The first hydropower plant built by ANDRITZ in Indonesia was Bangoen Purba back in 1910. Malabar and Mendalan followed in 1930.

To date, ANDRITZ has contributed to the development of about 128 units with a

Lake Toba near Asahan 3, North Sumatra, 2 × 87 MW

INDONESIA

Hasang, North Sumatra, 3 × 13.73 MW

combined capacity of 3,099 MW. This represents a market share of more than 60%. Responding to the positive hydro-market outlook and in readiness to provide client support, ANDRITZ established a local entity, PT ANDRITZ Hydro, back in 1996.

Large hydropower plants owned by Indonesia's state-owned utility PT Perusahaan Listrik Negara (PLN) Persero that are currently under construction, such as Peusangan 1 & 2 and Asahan 3, illustrate ANDRITZ's success in Indonesia. Its strong national presence is also revealed by the comprehensive assessment, rehabilitation, implementation and upgrade projects at several running and significant hydropower installations, such as Cirata, Besai, and Renun.

With more than 10 decades of experience in the execution of hydropower projects in Indonesia, ANDRITZ is continuously capturing opportunities for further improvement. PT ANDRITZ Hydro has successfully established a dedicated engineering team for the design and supervision of the installation and commissioning of automation products, electrical power systems, penstocks and gates. ANDRITZ's Indonesian team also provides services for projects both locally and in more than 35 other countries.

Cikaengan 2: In December 2016, ANDRITZ was awarded a contract from PT Cikaengan Tirta Energi, a subsidiary of Nippon Koei Co. Ltd., Japan, for the design, supply, and installation of generating equipment, gates and penstock works. Cikaengan 2 is the first hydropower plant ever built by Nippon Koei Co. Ltd.

Hasang: In December 2016, ANDRITZ signed a contract with Posco Engineering Co., Ltd., Korea, and PT. Pen Indonesia for offshore equipment supply and construction services with a capacity of 3 × 13.73 MW.

GENERAL FACTS

Population: **267.6 million**
Access to electricity: **98,10%**
Installed hydro capacity: **5,742 MW**
Hydropower under construction: **1,059 MW**
Share of generation from hydropower: **7.6%**
Hydro generation per year: **21,637 GWh**
Technically feasible hydro generation potential per year: **225,000 GWh**

ANDRITZ Hydro:
Total installed / rehabilitated units: **128**
Total installed / rehabilitated capacity: **3,099 MW**
Location: **Jakarta**
E-Mail: **contact-hydro.id@andritz.com**

Penstock Cikaengan 2, West Jawa, 2 × 3.65 MW

Cikaengan 2, West Jawa, 2 × 3.65 MW

Cikandang: In January 2019, ANDRITZ signed another contract with PT. Republika Mandiri Energi for the design, manufacture, supply and supervision of installation and commissioning of electro-mechanical equipment with a capacity of 3 × 2 MW.

Asahan 3: In September 2019, ANDRITZ signed a contract with PT PLN (Persero) for metal works for Asahan 3, located at Asahan Regency in North Sumatra, with a capacity of 2 × 87 MW. This project is jointly financed by the Japan International Corporation Agency (JICA) and the Government of Indonesia.

Furthermore, ANDRITZ has received some large rehabilitation orders in the recent past, such as Cirata (8 × 125 MW), Musi (3 × 74 MW), Asahan-1 (2 × 90 MW), Besai (3 × 38 MW), Renun (2 × 42 MW), Wampu (3 × 15 MW), Kedung Ombo (2 × 22.5 MW), and an operation and maintenance contract for Cianten (2 × 1.0 MW) and Cianten 1B (2 × 3.35 MW).

Cirata: In September 2018, PT Pembangkitan Jawa Bali (PJB) awarded ANDRITZ the fourth stator refurbishment contract for Cirata, located in West Java. Engineered success and dedication on the previous refurbishment works encouraged PJB to contract ANDRITZ Hydro for execution of the universal stator concept.

ANDRITZ designed and implemented the concept that allows the refurbished stators to be interchangeable between all eight units of the hydropower plant. This cuts service outages and significantly increases plant availability. The works and installation of the new stator were completed in September 2019.

In an October 2018 awards ceremony, PLN honored PJB for Cirata unit #7 (refurbished and commissioned by ANDRITZ in 2015) and Cirata unit #8 (commissioned by ANDRITZ in 1998) with awards for best "Equivalent Forced Outage Rate (EFOR)" and best "Equivalent Availability Factor (EAF)", respectively.

Cirata is situated on the Citarum River in West Java, 100 km southeast of Jakarta and comprises Cirata I (1988) and Cirata II (1998) with a total installed capacity of 8 × 126 MW. It plays an important role in stabilizing the grid in the Java-Bali interconnected system, operating with frequent starts-stops and acting as a fluctuating top load bearer.

AUTHOR
Edo Ronaldo

Cirata, West Java, 8 × 126 MW

ANDRITZ HYDRO INDONESIA TAKES HOME TWO CUSTOMER SATISFACTION AWARDS IN 2018

ANDRITZ's success in Indonesia was recognized by PT. Pembangkitan Jawa-Bali (PJB) and Mrica Plant Unit (UP Mrica) of PT. Indonesia Power (IP) with the awards of "Best Equipment Supplier" and "Best Vendor for Electrical Control", respectively.

PJB and IP are subsidiaries of PLN, operating all PLN-owned hydropower plants in Java with a total generating capacity of over 2.5 GW.

ANDRITZ executed the third refurbishment contract for the PJB-owned Cirata hydropower plant's universal stator concept, which was successfully commissioned in September 2018.

In August 2018, ANDRITZ also designed, manufactured, installed and commissioned a new excitation HIPASE-E system for Kedungombo, which is operated by IP under UP Mrica.

It is also noteworthy that PJB Cirata Unit received two of PLN's most valued awards: "Best Equivalent Forced Outage Rate (EFOR)" for Cirata HPP Unit #7, which was refurbished under the universal stator concept by ANDRITZ in 2015, and "Best Equivalent Availability Factor (EAF)" for Cirata HPP Unit 8, commissioned by ANDRITZ in 1998.

RENEWABLE ENERGY

Malaysia is a multi-sector economy targeting high-income status by taking steps to accelerate the country's economic growth and improve attractiveness for investments. The measures are targeting high technology industries, such as biotechnology, and services. Malaysia is well-developed with 100% access to electricity. The share of hydro in the electricity generation mix is about 18%, but only 20% of the total hydro generation potential has been developed to date.

Renewable energy is key to meet the environmental goal of reducing CO_2 emissions by 45% by 2030 (compared to 2005 levels). To encourage private sector participation in the development of Malaysia's renewable energy market, a revised Feed-in Tariff (FiT) scheme was introduced under the Renewable Energy Act 2011. Spearheaded by the Sustainable Energy Development Authority (or SEDA) various projects could be implemented using standardised Renewable Energy Power Purchase Agreements (RePPAs) and established FiT rates that vary according to the type of technology.

ANDRITZ HYDRO IN MALAYSIA

Since 2009 ANDRITZ has maintained an office in the Malaysian capital Kuala Lumpur, but the company's history in the country goes back to the early 1960s. So far, ANDRITZ has delivered 26 units with a total installed capacity of more than 1,200 MW to Malaysia.

Special highlights among ANDRITZ 's key references for successfully executed projects include Ulu Jelai HEPP (382 MW, turnkey delivery including hydromechanical equipment), Chenderoh HEPP (30 MW, refurbishment and modernization), Sultan Ismail Petra Pergau HEPP (664 MW, mechanical equipment), Sultan Yusof Jor HEPP (100 MW, mechanical equipment), and the small hydropower plants Hulu Terengganu (15.7 MW), and Bintang (7.7 MW).

With the successful execution of these projects, ANDRITZ again emphasizes its competence for the Malaysian hydropower market and proves its readiness for future challenges.

Bintang: The Bintang hydroelectric power plant was among the first mini-hydro projects awarded and implemented under SEDA's FiT scheme. Situated in the Selama region in the state of Perak, it is designed

GENERAL FACTS

Population: **31.5 million**
Access to electricity: **100%**
Installed hydro capacity: **6,095 MW**
Hydropower under construction: **156 MW**
Share of generation from hydropower: **16.2%**
Hydro generation: **26,597 GWh**
Technically feasible hydro generation potential per year: **123,000 GWh**

ANDRITZ Hydro:
Total installed / rehabilitated units: **26**
Total installed / rehabilitated capacity: **1,200 MW**
Location: **Kuala Lumpur**
E-Mail: **contact-hydro.my@andritz.com**

Tembat Station, Hulu Terengganu hydroelectric project, Sg. Tembat Tributary, 2 × 7.5 MW

Bintang, Sg. Bintang and Sg. Perak, 2 × 3.85 MW

Y IS KEY

as the upper plant of two power stations within the Kerian hydroelectric scheme. The outflow from Bintang's tailrace is transferred to the lower power station via a direct penstock.

ANDRITZ was awarded the contract by Emrail Sdn. Bhd., for the complete electro-mechanical "from water-to-wire" package, including design, engineering, manufacture, delivery, installation, and commissioning of two 3.85 MW horizontal Pelton turbine units. Upon successful completion and commissioning in March 2019, the Bintang hydroelectric power station was connected to Tenaga Nasional Berhad's grid and entered commercial operation at full capacity.

AUTHOR
Himanshu Sharma

Ulu Jelai, Sg. Bertam, Sg. Telom, and Sg. Lemoi diverted to Susu Reservoir, 382 MW

Ulu Jelai, Sg. Bertam, Sg. Telom, and Sg. Lemoi diverted to Susu Reservoir, 382 MW

AN ECONOMIC BEHEMOTH IN THE MAKING

Bangladesh's GDP growth is forecasted to hit 8% by 2020, putting it well ahead of many other Asian countries, including India. Currently massively underdeveloped but propelled by a robust manufacturing sector and enormous boom in infrastructure, Bangladesh has set a target to become a developed nation by 2041. This ambitious target coincides with the platinum jubilee of the nation's independence.

HYDROPOWER IN BANGLADESH

Due to its geography and topography, Bangladesh is not endowed with much hydropower potential and current energy development has focused on thermal projects. To face future energy demands from industry, Bangladesh is looking to expand hydropower capacity. The country is in talks with the Himalayan nations of Nepal and Bhutan to tap their hydropower with a transmission corridor through India, for example.

Kaptai Lake near Karnafuli, Kaptai Dam, 6 × 48 MW

Domestically, currently only 50% of potential hydropower capacity has been tapped in Bangladesh's predominately flat terrain. in order to see more hydropower development, a detailed hydropower potential map is still required, which must be mandated by the government of Bangladesh.

ANDRITZ HYDRO IN BANGLADESH

Bangladesh has a single large hydro project, Kaptai Karnafuli, featuring six 48 MW units. ANDRITZ is the OEM supplier for three of these units. Currently, the company is undertaking the renovation and modernization of units #1 and #2, a contract which was awarded to ANDRITZ via a competitive international bid process. Commissioning of the project is expected by the end of 2020. ANDRITZ has also established an office in the capital, Dhaka, for better client service and access to market.

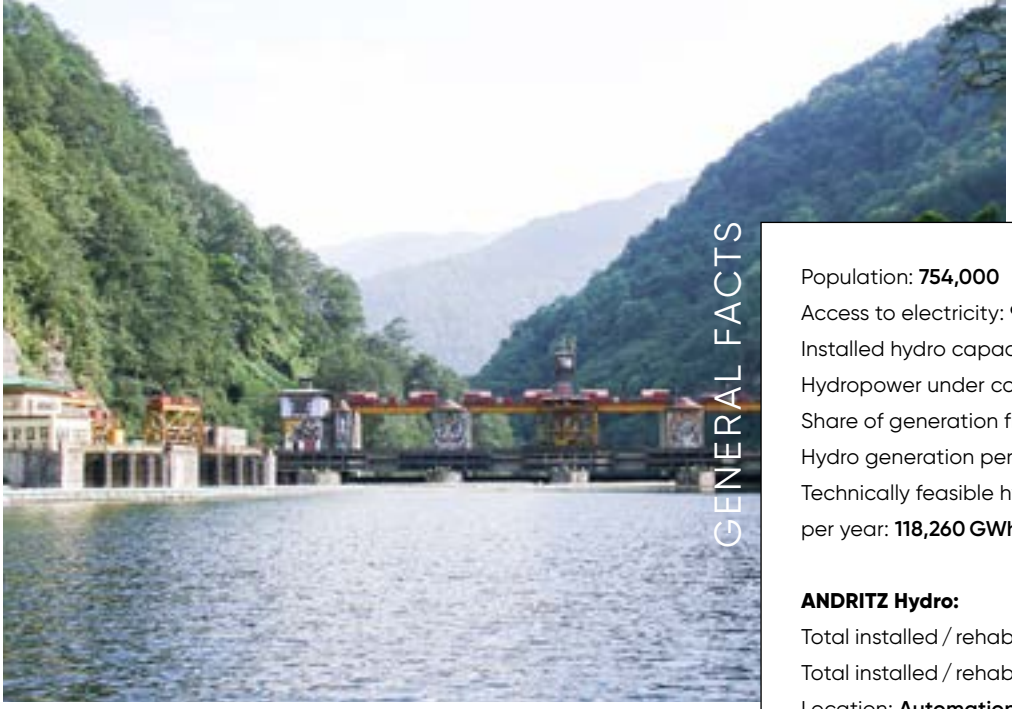
ANDRITZ Hydro has supplied more than 15 turbo generator units to Bangladesh with ratings ranging from 30 to 45 MVA. Aftersales services for these units are being facilitated through the company's major regional location in neighboring India.

AUTHOR
De Neelav Samrat

GENERAL FACTS

Population: **161 million**
Access to electricity: **88%**
Installed hydro capacity: **230 MW**
Share of generation from hydropower: **1.7%**
Hydro generation per year: **982 GWh**
Technically feasible hydro generation potential per year: **1,500 GWh**

ANDRITZ Hydro:
Total installed / rehabilitated units: **3**
Total installed / rehabilitated capacity: **130 MW**
Location: **Dhaka**
E-Mail: **contact-hydro.in@andritz.com**



Chhukha hydropower station, Wangchhu River (Raidak), south-west Bhutan, 4 × 84 MW; Location of Bhutan Automation workshop

GENERAL FACTS

Population: **754,000**
Access to electricity: **97%**
Installed hydro capacity: **1,615 MW**
Hydropower under construction: **3,058 MW**
Share of generation from hydropower: **100%**
Hydro generation per year: **6,960 GWh**
Technically feasible hydro generation potential per year: **118,260 GWh**

ANDRITZ Hydro:
Total installed / rehabilitated units: **22**
Total installed / rehabilitated capacity: **2,282 MW**
Location: **Automation workshop in Chhukha**
E-Mail: **contact-hydro.in@andritz.com**

SMALL COUNTRY HIGH POTENTIAL

Bhutan's small and less developed economy, is based largely on hydropower, agriculture, and forestry. Its largest export – hydropower to India – has been a key driver for sustainable growth and Bhutan has an impressive annual hydropower potential of 118,260 GWh. It is currently building 12 new hydropower dams with a combined capacity of 10,000 MW, as agreed with India in 2008.

ANDRITZ HYDRO IN BHUTAN

For better efficiency and cost-effectiveness, in 1997 Druk Green Power Corp (DGPC) formed a joint venture with ANDRITZ Hydro Private Limited, India, Inc. – Bhutan Automation & Engineering Ltd – to build additional hydropower capacity. A modern facility for the manufacture and integration of automation systems for hydropower plants was also established. This facility specializes in the manufacture and delivery of state-of-the-art automation systems, as well as secondary equipment for power and industrial applications. A Technical Assistance Agreement was also signed between the joint venture partners to use ANDRITZ's advanced automation systems technology.

Kuricchu: A SCADA system for the 60 MW Kurichhu hydropower plant was identified as a pilot project and in December 2019, re-commissioning of the first unit was completed after a control and automation systems upgrade. This was a milestone in the history of hydropower in Bhutan. In addition to core equipment, the design, engineering, manufacturing, installation, and commissioning of the upgrade works are being executed by ANDRITZ. The contract for replacement of the existing SCADA system including unit, dam, common auxiliary and switchyard controls, as well as governor and excitation systems, was awarded in September 2018. Completion is scheduled for the end of April 2020.

Establishing Bhutan Automation not only helps develop in-house capacity, it also reduces dependency on external OEMs. ANDRITZ is also exploring other opportunities in Bhutan to increase its portfolio base.

AUTHOR
Vibhor Gupta

HyBaTec
GOING NEW WAYS

The modern energy market presents many challenges for power companies. Factors such as market liberalization, volatile energy prices, base- and peak-load demands, volatility of wind and solar energy production, and new consumption behaviors all affect the energy supply and demand balance.

These challenges are also infecting each and every hydropower plant, regardless of whether it is a plant that has been operating for decades or it was just commissioned. In today's market, responsiveness and flexibility of generation assets are becoming increasingly important economic factors.

HyBaTec is a hybrid energy solution that addresses these modern market challenges. Combining a hydro turbine generator unit with a battery, the system can be applied to "greenfield" applications, as well as retrofitted to existing facilities. The system as supplied currently covers battery capacities from 100 kWh up to 10 MWh. Compared with a conventional hydro application, and depending on the size of the battery, the operational range can be extended up to +/- 25%. This can even be achieved while reducing the mechanical stress impinging on the units. Due to sophisticated interactions between the generation unit and the battery, faster response times and very flexible operational profiles become available without the restrictions that may result from electrical, mechanical or hydraulic limitations.

HYBATEC FLEXIBILITY WITH THREE DIFFERENT OPERATIONAL MODES

The HyBaTec system is available in three separate operational modes: Lifetime, Grid, and Storage.

In Lifetime mode, the system stabilizes and balances fast and short-term grid frequency demands using the battery element. Movements of the mechanical parts, and therefore the mechanical stresses on the unit, will be reduced. This in turn ensures that the operational lifetime of the unit is dramatically extended.

At the same time, maintenance costs are also reduced significantly. Typically, for use in Lifetime mode, the battery will be dimensioned to about 2.5% of the generation capacity of the installed unit.

In the Grid operational mode, operators are able to explore new opportunities to participate in both primary and secondary energy markets. Grid mode provides a defined amount of energy over a limited period of time, allowing operators to participate in short-term capacity markets, peaking power markets and other emerging bidding opportunities. For operation in Grid mode the battery will typically be dimensioned to about 5-20% of the installed unit capacity.

HyBaTec – an integrated hybrid solution able to improve and expand your business case with a range of benefits.

In Storage mode, the system is able to shift energy over the day (base load to peak load; no demand to demand). This offers optimization possibilities for the whole unit/power plant during the design phase. For use in Storage mode, the battery would typically be dimensioned to about 15-25% of the installed unit capacity and have a storage capacity of two to four hours of full plant output.

In addition to these dedicated applications, HyBaTec is able to provide additional benefits such as black start capability, meeting self-consumption demand, virtual inertia, and virtual storage reservoir.

The HyBaTec batteries will be installed in a standard shipping container, integrated into the electrical power plant as well as the control system to optimize revenue from the system.

BENEFITS OF HYBATEC

Hyrid Battery Technology

- Extended energy storage
- New market opportunities
- Fast implementation
- Increased lifetime of mechanical components
- Reduced O&M costs
- Fast response times
- Flexible power
- High operational flexibility

AUTHOR
Jens Päutz

The HyBaTec-Concept: Modern hydrid solution for hydropower

GOOD PROSPECTS FOR GREEN ENERGY

With its rapidly growing economy, the Philippines was ranked third in 2019 among the best countries to invest in. Over the last five years, annual GDP growth hit up to 6.8%.*

With more than 70 plants in operation, the Philippines has a total installed hydropower capacity of about 3,701 MW. That represents about 16% of the national total. Of this, around 566 MW are run-of-river and 3,135 MW are dam-type plants, including one 728 MW pumped storage complex. Only about 24 plants (34%) have a capacity larger than 10 MW, but they provide around 96% of the total hydropower generation. The estimated technical and economic hydropower potential is about 20,334 GWh per year, 17% of which has already been exploited. About 275 MW of the existing hydro capacity comprises units more than 40 years old.

Under the National Renewable Energy Program, the Philippines envisions tripling renewable energy capacity by 2030, requiring an additional 14,900 MW, including 8,700 MW of hydropower. In addition, power transmission system upgrades are also in line. Demand for conventional and pumped storage hydro development is projected to increase, in particular to provide grid stability services.

The Philippines envisions tripling renewable energy capacity by 2030.

About 90 MW of hydropower is currently under construction, some interesting future projects are also planned, including the 100 MW pumped storage plant in Nueva Ecija and the 390 MW project in Ifugao. Numerous pumped storage schemes are also at various stages of development. However, there are also interesting development opportunities for small hydro. Small hydropower plants totaling around 250 MW are already listed as indicative power projects and this does not include all the projects being built.

ANDRITZ HYDRO IN THE PHILIPPINES

From the first delivery of equipment back in 1930 to the recently commissioned small hydropower plant at Catuiran, ANDRITZ has been providing high quality electro-mechanical equipment to the Philippines since the earliest days of national hydropower development. In 2009, when ANDRITZ received some large rehabilitation orders for Ambuklao, Magat, and Pantabangan, an office was established in Manila to support the growing market. Since then, ANDRITZ has been providing technical services, training and spare parts to existing plants, as well as providing technical assistance for developing new ones. In the last five years, ANDRITZ has also received orders for small hydro projects. In total, the company has installed or rehabilitated more than 50 units in the country, with a combined capacity of about 1,600 MW.

Catuiran (8 MW): In 2014, Sta. Clara International Corp. awarded ANDRITZ with a contract for the supply and installation of two horizontal Francis turbines, generators, electrical and mechanical auxiliary systems, including switchyard components. In 2018, it was successfully put into commercial operation providing reliable power to Occidental and Oriental Mindoro and curbing rotational brownouts in these provinces.

Manolo Fortich 1 and 2 (44 MW / 26 MW): In 2014, Hedcor Inc. awarded ANDRITZ the contract for the engineering, design, supply,

Manolo Fortich 1, utilizing rivers Tanaon, Guihean Amusig, Bukidnon, 44 MW

Upper Maladugao,
Maladugao River, Bukidnon, 9 MW

Philippines

installation and commissioning of six small Francis and two small Pelton turbines, including hydraulic governors, synchronous generators, intake valves, and an extensive electrical package with the complete control systems and medium voltage switchgear. Both plants were successfully put into commercial operation in mid- and late 2018, respectively, and generate about 360 GWh annually.

Liangan, Lanao del Norte (11 MW): In 2018, ANDRITZ won the contract award for the supply of a complete electro-mechanical "from water-to-wire" package from Guangxi Hydroelectric Construction Bureau Co. Ltd. Philippines Corp (GHCB).

Upper Maladugao, Bukidnon (9 MW): In 2018; United Holding Power Corporation awarded ANDRITZ a contract for a "from water-to-wire" package with three small Francis units, including installation infrastructure, manpower and commissioning services.

AUTHOR

Mario Barbosa
Albin Königshofer

GENERAL FACTS

Population: **106.6 million**
Access to electricity: **93%**
Installed hydro capacity: **3,701 MW**
Hydropower under construction: **90 MW**
Share of generation from hydropower: **9.4%**
Hydro generation per year: **9,384 GWh**
Technically feasible hydro generation potential per year: **20,334 GWh**

ANDRITZ Hydro:
Total installed / rehabilitated units: **51**
Total installed / rehabilitated capacity: **1,586 MW**
Location: **Manila**
E-Mail: **contact-hydro.ph@andritz.com**

*CEOWORLD Magazine

Liangan, Liangan River,
Lanao del Norte,11 MW

Catuiran, Catuiran River, Oriental Mindoro, 8 MW

SPECIAL TOPIC

Fish-friendly assessment in practice

PROTECTING FISH AND LIVELIHOODS

Modern hydropower developments, either new power plants or refurbishments, face strict regulatory requirements to enhance the survival of migratory fish passing though operating turbines. The earlier the stage at which fish passage studies take place, the better the prospects are for implementing effective strategies for fish survival enhancements.

This makes model-based fish passage analyses ideal for the turbine design phase and increasingly acceptable by operators and authorities. ANDRITZ is advancing simulation technology to rapidly and accurately quantify the intensity and frequency with which fish encounter hazardous flow features and walls during turbine passage (see Figure 1). While the seminal computational method was the product of ground-breaking work in research laboratories, the ANDRITZ advancement consists of streamlining biological performance (a.k.a. fish-friendliness) assessments in the turbine design process. This allows ANDRITZ design teams to develop geometries that maximize fish-friendliness while accounting for on-site needs and even targeting fish species of concern.

These modern tools accompany our projects in all phases, from the general layout of a machine to the definition of its operational management to maximize fish survival. With upgraded biological assessment tools, ANDRITZ offers the possibility to configure a product that not only aims at greater efficiency but also at superior fish-friendliness, by, for instance reducing the likelihood of mortal injury of fish due to collision with runner blades. Thereafter, ANDRITZ can fulfil biological goals. Examples come from the strict fish-related properties required during the design of a Kaplan turbine for the Monsin hydropower plant rehabilitation in Belgium (see Picture 1) and the fish-friendliness enhancement of the Eddersheim power plant in Germany (see Picture 2).

Likewise, these novel tools support the planning of field tests with live fish and sensor devices that record extreme hydraulics though turbines. For instance, ANDRITZ evaluated release scenarios of live fish and sensor samples through a fish-friendly Kaplan machine in order to address questions pertaining to test execution, e.g., where should fish samples be released for collecting representative outcomes, and what should the sample size be (see Figure 2).

Fish ladder, Xayaburi hydropower plant, Lao PDR

Picture 1: Turbine runner for Monsin hydropower plant in Belgium with strictly fish-friendly design

Picture 2: Fish-friendly runner enhancement for the Eddersheim hydropwer plant in Germany.

In addition, while great emphasis is made on fish survival enhancements through design, operational improvements also open doors for a more integrative management of hydropower stations. To that end, the fish-friendly tools assist in bio-hill chart (see Figure 3) calculations, which – in comparison to efficiency hill charts – represent potential survival rates of a target fish species to a specific hydraulic stressor over the entire operating range of the machine. Oil-free hubs are yet another feature embedded in ANDRITZ turbines to reduce the environmental impact of hydropower by eliminating oil pollution.

By combining hydraulic knowledge with biological understanding, ANDRITZ develops fish-friendly solutions to safeguard the viability of fish populations while delivering high-efficiency applied technology for best environmental performance.

Fish-friendliness has also taken precedence in hydro projects in Asia. Developments on the Mekong River are perhaps the most emblematic example of a region in search of a compromise between hydropower and fish protection. The Xayaburi hydropower plant in Lao PDR, equipped with ANDRITZ equipment and successfully commissioned in 2019, features a fish-friendly turbine design with fewer runner blades, thicker leading edges and a lower rotational speed.

By implementing these technologies and developments, a 90% survival rate of the fish passing through a turbine can be ensured. It should also be noted that only about 20% of all migrating fish are affected by the turbine, since the majority of the fish population are protected by other measures, such as fish ladders and bypass passages.

ANDRITZ has a strong conviction that the turbine industry plays a significant role in improving the environmental health of rivers and preserving fish biota, therefore also securing the livelihood of thousands of people living along rivers and lakes throughout Asia.

AUTHOR

Romero-Gomez Pedro de Jesus

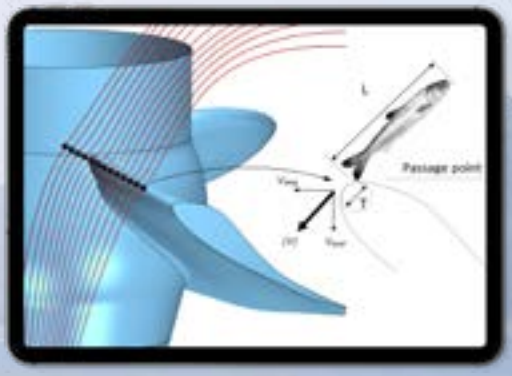


Figure 1: Simulation technology for assessment of fish passing through the turbine

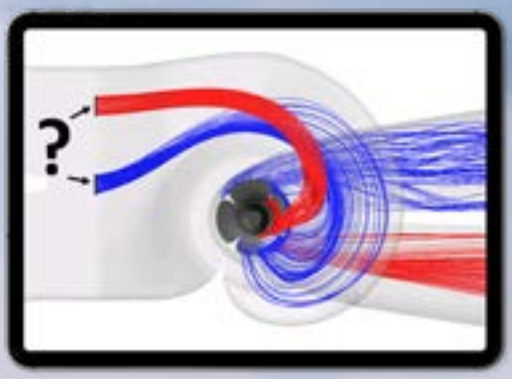


Figure 2: Release scenarios of live fish and sensor samples

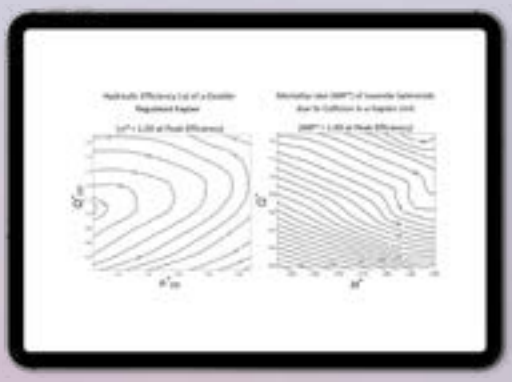


Figure 3: Bio-hill charts representing potential survival rates of fish

ELECTRIFICATION ON THE UPSWING

Myanmar has abundant natural resources attracting potential foreign investments in the energy sector, among others. Land reforms and modernization of the financial sector, as well as transportation and electricity infrastructure, are contributing to the economic opening of the country.

Economic growth also leads to increasing electricity demand and in Myanmar renewables are supported through a policy initiative. Myanmar has a promising hydropower potential, equivalent to 46,000 MW. To date, less than 7% of this potential has been developed. This, combined with a target to achieve 100% electrification by 2030, opens up interesting opportunities for hydropower investment.

ANDRITZ HYDRO IN MYANMAR

After about 40 years of being active in the Myanmar market, in 2013 ANDRITZ established a representative office in the city of Yangon. This local team is actively involved in hydropower development with capacity building and training activities, as well as offering expertise in project development and supply of equipment and services.

Upper Nam Htum: Upper Nam Htum is a small run-of-river hydropower plant which utilizes the discharge of the Nam Htum River with four horizontal Francis turbines, each with an output of 1,020 kW.

Upper Nam Htum is the first hydropower project in Myanmar since the 1980s to use European-sourced electro-mechanical equipment.

ANDRITZ supplied the entire electro-mechanical and hydro-mechanical "from water-to-wire" package for Upper Nam Htum. After successful commissioning, the Final Acceptance Certificate was received in January 2019.

With a total capacity of 3.2 MW, Upper Nam Htum is providing electricity to four wards and the villages of Putao and Machanbaw Township, and supporting regional development and tourism.

ANDRITZ is proud to contribute to the development of the remote Putao region and introduce state-of-the-art hydropower technology to Myanmar.

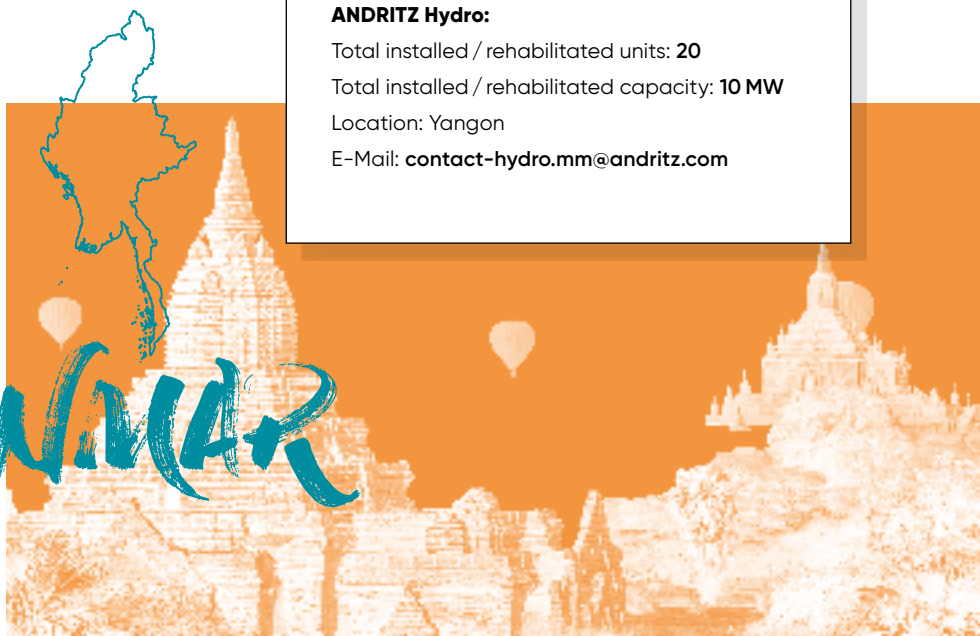
AUTHOR
Ngwe Thein Htike

Upper Nam Htum, Nam Htum River, 3.2 MW

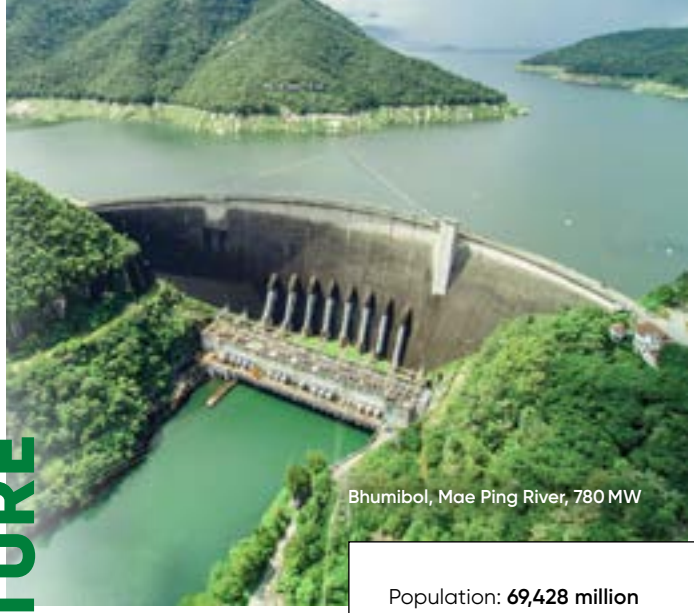
GENERAL FACTS

Population: **53.7 million**
Access to electricity: **69%**
Installed hydro capacity: **3,477 MW**
Hydropower under construction: **1,700 MW**
Share of generation from hydropower: **60%**
Hydro generation per year: **15,802 GWh**
Technically feasible hydro generation potential per year: **46,330 GWh**

ANDRITZ Hydro:
Total installed / rehabilitated units: **20**
Total installed / rehabilitated capacity: **10 MW**
Location: Yangon
E-Mail: **contact-hydro.mm@andritz.com**



PILOTING TO A LOW-CARBON FUTURE



Bhumibol, Mae Ping River, 780 MW

GENERAL FACTS

Population: **69,428 million**
Access to electricity: **100%**
Installed hydro capacity: **3,561 MW** incl. PSPP
Hydropower under construction: **28 MW**
Share of generation from hydropower: **2.5%**
Hydro generation per year: **7,598 GWh** incl. PSPP
Technically feasible hydro generation potential per year: **13,564 GWh**

ANDRITZ Hydro:
Total installed / rehabilitated units: **41**
Total installed / rehabilitated capacity: **1,841 MW**

Considered a newly industrialized country, Thailand's economic growth is due to well-developed infrastructure, economic reform and pro-investment government policies.

Technically feasible annual hydropower potential is 13,564 GWh with 75% already utilized. Installed hydro capacity is about 3,561 MW and 26 plants are owned and operated by Electricity Generating Authority of Thailand (EGAT) with around 70 MW - some 40 small and mini hydro plants - operated by Department of Alternative Energy Development and Efficiency and Provincial Electric Authority.

Under the Power Development Plan, a total installed energy capacity of 73,211 MW is targeted by 2037. Development is focusing on renewables like solar and wind, leading to an increased demand for hydropower to provide grid stability services. If the target is achieved, 11% of the installed capacity by 2037 will come from hydropower too.

ANDRITZ HYDRO IN THAILAND

ANDRITZ has been active in Thailand for more than 50 years. Over this time 41 units with a total capacity of 1,841 MW have been installed or rehabilitated by ANDRITZ, representing about 40% of the country's total installed hydro capacity.

Srinagarind: In 2015, ANDRITZ was awarded the contract for the rehabilitation of three 120 MW Francis units, generators, governors, automation system, associated electro-mechanical equipment, and mechanical auxiliaries, as well as installation, and commissioning. Project completion is expected by July 2020.

Bhumibol: In 2018, the contract for the refurbishment of the generator of unit In 2018, ANDRITZ was awarded the generator refurbishment contract for unit #7, including engineering design, manufacturing and supply, installation, testing and commissioning of a three-phase synchronous generator and all related electro-mechanical auxiliary systems. Project completion is due in July 2020.

Pa Chuk: In 2018, ANDRITZ won the contract for the supply of an electro-mechanical "from water-to-wire" package with two Bulb turbine units (14 MW).

AUTHOR
Mario Barbosa
Albin Königshofer

Contract signing for Pha Chuck, Mae Nam Nan, 14 MW

Srinagarind, Kwai Yai River, 720 MW

Nam Kong 3, Attapeu Province, 54 MW

Though Laos' economy is mainly based on agriculture and farming its economic growth has been amongst the fastest in Asia recently, averaging more than 7% per year. This growth emerged largely from natural resource exports, tourism and hydropower.

Nam Theun1, Nam Kading River, 670 MW

In particular, electricity exports have benefited from high-profile foreign direct investment in the development of hydropower projects.

Laos has an enormous hydropower potential of more than 18,000 MW, excluding the main stream of the Mekong River and up to 27,000 MW with it. Total installed hydro capacity is about 7,213 MW, which produces some 24,204 GWh per year. The government has ambitions to become the "Battery of Southeast Asia" by exploiting its impressive hydropower potential. By 2020-2021, an extra 50 hydropower plants with a total capacity of 5,606 MW will be in service. A total output of 27,024 GWh is anticipated and by 2025, Laos expects to export 14,600 MW to neighboring countries.

ANDRITZ HYDRO IN LAOS

In 2016, ANDRITZ emphasized its long-term presence in the country by establishing a representative office in the capital, Vientiane. ANDRITZ achieved a milestone in 2019 by completing the biggest hydropower station in Laos on schedule. Xayaburi features the world's largest and most powerful oil-free Kaplan runners built to date.

ANDRITZ's expertise and experience reaches from research and development to complete engineering, procurement, and construction for electro-mechanical equipment and projects. ANDRITZ is ready to contribute with state-of-the-art equipment to the development of safe and sustainable hydropower in Laos.

Xekaman 1 (290 MW): In 2013, based on the Lao-Vietnam Bilateral Agreement, ANDRITZ won a contract for the delivery of the complete electro-mechanical equipment for this plant. This came right after the successful completion of Xekaman 3 (250 MW). It was successfully commissioned by end of 2016 with the majority of its output exported to Vietnam.

Xekaman Sanxay (32 MW): Again based on the Lao-Vietnam Bilateral Agreement, in 2015 ANDRITZ secured a contract for electro-mechanical equipment. The main objective was electrical generation and downstream regulation for Xekaman 1. Both units were commissioned in 2018.

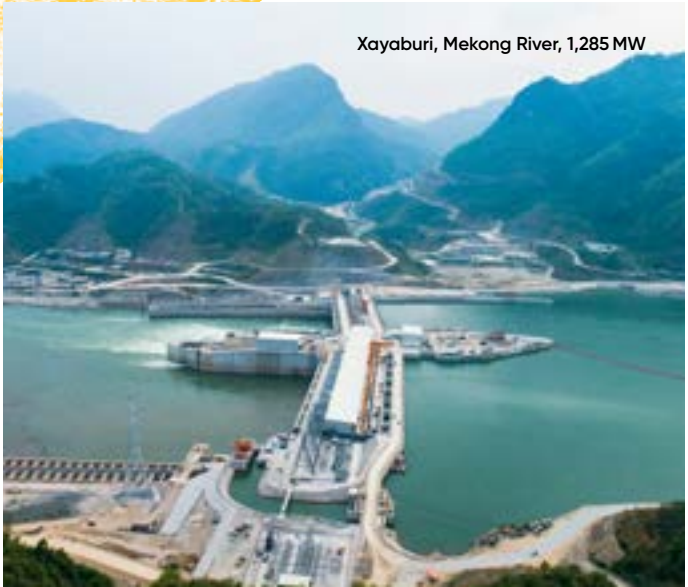
Nam Lik 1 (64.5 MW): POSCO Engineering and Construction Company Ltd. awarded ANDRITZ a contract for the supply, installation, and commissioning of electro-mechanical equipment in 2013. The scope comprised two 32.25 MW Bulb turbines, horizontal generators, mechanical auxiliaries, electric power systems, and gates. Operation began in March 2019.

THE BATTERY OF SOUTHEAST ASIA

Xayaburi (1,285 MW): Ch. Karnchang (Laos) Company Ltd. awarded ANDRITZ the 2012 contract to supply the entire electro-mechanical equipment for this giant project. This included delivery of seven 175 MW Kaplan units for export of electricity to EGAT/Thailand and one 60 MW Kaplan unit to EDL for domestic consumption, as well as two 4 MW CAT turbine units to facilitate upstream fish migration. By October 2019, commercial operations had started and about 7,300 GWh is being produced annually.

With 1,285 MW, Xayaburi is the largest hydropower plant in the country and one of the largest on the Mekong River.

Xayaburi, Mekong River, 1,285 MW; The world's largest and most powerful oil-free Kaplan runners built to date.



Xayaburi, Mekong River, 1,285 MW

Nam Theun 1 (670 MW): Nam Theun 1 and 2 Power Co., Ltd. (NT1 PC) awarded ANDRITZ the 2016 contract to design, manufacture, supply, and commission the complete electro-mechanical equipment, including turbines, generators, governors, automation system, as well the electrical power systems, 500 kV GIS, and main inlet valves. Commercial operation is scheduled to start at the end of 2021.

Houay Kapheu (5 MW): Vientiane Automation and Solution Engineering (VASE) contracted ANDRITZ for supply, installation and commissioning of electro-mechanical equipment including two Pelton units in 2017. Operation is scheduled to start in 2020.

Nam Kong 3 (54 MW): Chaleun Sekong Energy Co., Ltd. (CSE) rewarded ANDRITZ with the 2018 contract for the supply, installation and commissioning of the electro-mechanical equipment including 3 × 18 MW vertical Francis turbines. Project completion is expected by 2020.

AUTHORS

Vithagna Kedsadasak
Albin Königshofer

GENERAL FACTS

Population: **7.061 million**
Access to electricity: **93.6%**
Installed hydro capacity: **7,213 MW**
Hydropower under construction: **7,598 MW**
Share of generation from hydropower: **85%**
Hydro generation per year: **24.204 GWh**
Technically feasible hydro generation potential per year: **18,000 MW**

ANDRITZ Hydro:
Total installed / rehabilitated units: **50**
Total installed / rehabilitated capacity: **4,238 MW**
Location: **Vientiane**
E-Mail: **contact-hydro.la@andritz.com**

GROWING POWER DEMAND

Vietnam is ranked as one of the fastest developing economies in the world, maintaining annual GDP growth rates of 6.5-7% throughout the last decade. With a total operational capacity of about 20,000 MW, Vietnam has successfully tapped more than 75% of its technically feasible hydropower potential of 123 TWh/year.

GENERAL FACTS

Population: **95.5 million**
Access to electricity: **99%**
Installed hydro capacity: **18,548 MW**
Hydropower under construction: **2,200 MW**
Share of generation from hydropower: **37.7%**
Hydro generation per year: **83,000 GWh**
Technically feasible hydro generation potential per year: **123,000 GWh**

ANDRITZ Hydro:
Total installed / rehabilitated units: **95**
Total installed / rehabilitated capacity: **1,950 MW**
Location: **Hanoi**
E-Mail: **contact-hydro.vn@andritz.com**

Nhan Hac, Nghe An Province, 55 MW

Vietnam is now focusing on renewables, chiefly solar, wind and biomass, with hydropower as an efficient tool for grid balancing.

According to Vietnam Power Development Plan No. 8 (PDP-8), which is due to be promulgated by the end of 2020, to help meet the 10% average annual increase in power demand, total hydropower capacity will increase to 30 GW by 2030.

PDP-8 also indicates that 20% of Vietnam's electricity is to be supplied by renewables by 2030. An additional 16,000 MW of renewable capacity is anticipated under this plan. However, with rapid growth of variable renewable resources causing grid fluctuations, high grid loads and bottlenecks, this is posing a major challenge for Vietnam's power system. Expansion and strengthening of the transmission grid are required, alongside the development of more responsive reserve power capacity. About 2,200 MW of medium, large, and pumped storage hydropower capacity is currently under construction and development. This includes the expansion of Hoa Binh (480 MW), Ialy (360 MW) and the country's first pumped storage capacity, 1,200 MW in Bac Ai District in Ninh Thuan Province.

To meet the 10% average annual increase in power demand, the total hydropower capacity will increase to 30 GW by 2030.

ANDRITZ HYDRO IN VIETNAM

For more than 15 years, ANDRITZ has been serving the Vietnamese market through a representative office in the capital Hanoi. In 2016, a full legal entity – ANDRITZ Vietnam Co., Ltd. – was established. Our competence is demonstrated by the high-quality equipment and services delivered, with about 95 units and total installed capacity of almost

Hoa Binh, Da River, 1,920 MW

2,000 MW supplied to the country by ANDRITZ over the years.

Pac Ma, Lai Chau Province: A contract for the supply of four Bulb turbines of 40 MW each, including turbine governors, generators, excitation and control system, was won by ANDRITZ. Commissioning is scheduled for the first half of 2021. Pac Ma will be the largest Bulb-type hydropower plant in South East Asia.

Thuong Kontum, Kontum and Binh Dinh Provinces: A contract was awarded to ANDRITZ for the supply of the complete electro-mechanical equipment, including two 110 MW high-head Pelton turbines with speed governors, generators with digital excitation, and auxiliary systems. This hydropower plant is due to be commissioned in the first half of 2020 and will generate about 1,000 GWh per year.

Nhan Hac, Nghe An Province: In 2016, ANDRITZ won a contract for the supply of two Francis units (each 27.5 MW) for Nhan Hac A and one Kaplan unit with 4 MW for Nhan Hac B, including all auxiliary equipment and accessories, as well as design, manufacturing, and commissioning. Commissioning of all three units successfully took place in mid-2018. The Nhan Hac A units are the largest small hydro units in the country, providing peak power to improve grid stability of the regional network.

Da Cho Mo, Lam Dong Province: In 2018, ANDRITZ was contracted to supply and install two horizontal Francis turbines, generators, and electrical and mechanical auxiliary systems for this mini hydro plant. Successful commercial operation of both units started in October 2019. The plant is strategically important. It connects to the local national power grid and will also increase the head, helping to regulate and improve irrigated fields for local cash-crop farmers.

Hoa Binh, Hoa Binh Province: In 2015, ANDRITZ won a contract for the design and supply of equipment and technical services for a major upgrade of automation, control and instrumentation systems in this plant. The last two paired units were completed in December 2018, 30 days ahead of the contractual schedule. The 8 × 240 MW Hoa Binh hydropower plant achieved its highest ever annual power production of 12,290 GWh in 2018.

AUTHORS

Nguyen Thanh Tan
Albin Königshofer

Hoa Binh, Da River, 1,920 MW, Inauguration ceremony August 2019

Thuong Kontum, Dak Snghe River, 220 MW

Pac Ma, Da River, 160 MW

WATER SCARCITY OR EXCESS ENGINEERED PUMPS SOLVE IT

SPECIAL TOPIC

The earth's small supply of freshwater – only 3% of the total – is very unevenly distributed across the planet. By causing either more frequent and severe flooding in one area or long draughts in another, climate change is further intensifying this regional inequality. Asia is a prime example in this repsect, as it is facing serious water issues. Thanks to its wide range of engineered pump solutions, ANDRITZ has been continuously supporting numerous countries around the world in sustainably handling any given water resources issues.

AUTHOR
Vera Muellner

TO GET MORE INFORMATION ABOUT OUR ENGINEERED PUMPS PLEASE VISIT THE FOLLOWING LINKS:

ANDRITZ vertical volute and concrete volute pumps
andritz.com/products-en/group/pumps/vertical-volute

ANDRITZ vertical line shaft pumps
andritz.com/products-en/group/pumps/vertical-line-shaft

Kaleshwaram project, 27 vertical volute pumps

CASE 1: INDIA

WATER SCARCITY

Bheema pumping station, three vertical volume pumps

In recent years, India has been hit by extremely high temperatures, causing droughts and creating problems for agriculture, economic development, and human lives. With a series of irrigation projects within the overarching Jala Yagnam project, local government has undertaken measures to provide sustainable irrigation for about 3.3 million ha of agricultural land.

ANDRITZ supports this mega infrastructure project across numerous sub-projects with its customized vertical volute pumps. For the **Bheema** sub-project, ANDRITZ supplied three of these pumps for two pumping stations between 2008 and 2009. The first of these, with three units, conveys 63 m³/s of water to a level 38 m higher. From there, the water flows through canals to a second pumping station, which conveys approximately 32.3 m³/s into a further canal system that is 22 m higher.

ANDRITZ manufactured even larger pumps for the **Kalwakurthy** station. Dimensioned for a total flow rate of 115 m³/s, the five vertical volute pumps, each with an output of 30 MW, reliably pump this enormous volume of water to a head of 86 m. Large vertical volute pumps are ideal when very large volumes of water need to be conveyed over long distances. A special aspect of these pumps is that they are very similar to turbines due to their size and integrated guide vane mechanism. The guide vane mechanism is adjusted by means of a hydraulic servomotor to suit the changing tailwater level to achieve better efficiencies.

Currently, ANDRITZ is manufacturing some of the 27 vertical volute pumps destined for three pumping stations at the **Kaleshwaram** project. This is one of the largest sub-projects, designed to store about 4.7 trillion liters of water to irrigate 740,000 ha. Comprising a dam and several pumping stations with reservoirs, the solution requires water transport over a height of 500 m and a distance of 200 km. It is the first multi-stage lift irrigation project of this magnitude worldwide. Each pump has an efficiency of up to 90% and achieves heads between 25-107 m and flow rates of 31.1-83 m³/s. The first of the three pumping stations was completed in December 2019, while the remaining will follow in Q2 2020 and Q1 2021.

CASE 2: VIETNAM

WATER EXCESS

Yen Nghia flood control station, 10 vertical line shaft pumps

Doan Ha pumping station, two concrete volute pumps

VIETNAM

In contrast to India, Vietnam is one of the rainiest countries in the world. The incoming annual monsoon causes flooding as rivers and streams burst their banks. According to forecasts by the International Panel on Climate Change, the future scenario for Vietnam becomes worse as even higher rainfall is predicted in those months that already experience the most precipitation.

To contain these severe effects, the Vietnamese Ministry of Agriculture and Rural Development has launched numerous flood control projects. The **Yen Nghia** project marks the beginning of this initiative. ANDRITZ supplied 10 vertical line shaft pumps from April to August 2018 for the biggest flood discharge pumping station in the country. Located near Hanoi and specially designed for flood control applications, the pumps are only activated in case of need, but then have to work 100% reliably. Therefore, each pump has an axial hydraulic and extremely robust design to successfully defy diverse materials washed away by floods. Each pump conveys up to 15 m^3/s of water.

Doan Ha is another pumping station designed for flood protection and irrigation. Located in the Thanh Thuy district of PhuTho Province, it will have the capacity to reliably irrigate up to 672,000 m^2 of paddy land and drain up to 2,122,000 m^2 of agricultural land if necessary. ANDRITZ received the order to equip the station with two concrete volute pumps. ANDRITZ has been successfully installing these pumps – based on the Kaplan turbine design principle – around the world since 1926. They are the best technological and economic solution when it comes to transporting large volumes of water. The concrete casing has a long life cycle, is resistant to erosion as well as brackish and salt water and requires no maintenance whatsoever. Each pump achieves a flow rate of 12.5 m^3/s at a maximum head of 8.15 m with an efficiency of up to 88%. Both the 1,000 kW motors and pumps are monitored fully automatically by a monitoring and control system. The completion of the pumping station is scheduled for mid-2020.

Shanxi Xiaolangdi Yellow River Diversion Project, four two-stage vertical volute pumps

CASE 3: CHINA

WATER TRANSFER

CHINA

China is facing the difficult situation of having 80% of its water resources in the southern part of the country, but 64% of the agricultural land and more than 50% of the population is in the north. In order to solve this problem, China started the South-North Water Transfer Project in 2002. Primarily based on three main routes – eastern, central, and western – it will transport 44.8 billion m³ of water from the wet south to the dry north every year from 2050 onwards.

ANDRITZ has been supporting China in this mega endeavor and other water projects for years. In November 2010, for example, 12 double-suction pumps went into operation at the **Xijiang Intake Pumping Station.** They are designed for a flow rate of approximately 4 to 5 m³/s, operating at heads of 35 to 42 m and with an efficiency of up to 91%. The station itself supplies around 45 m³ of water per second over a distance of 40 km to guarantee the needs of the growing metropolis Guangzhou.

Moreover, the **Hui Nan Zhuang** pumping station is equipped with eight ANDRITZ horizontally split double-suction pumps, among the world's largest double-suction split case pumps. It is the only pumping station on the central water supply channel for the South-North Water Transfer Project. The pumps convey a total of 60 m³ of water per second over a distance of some 60 km to provide a safe drinking water supply to Beijing.

In 2019, ANDRITZ also received the order to supply four two-stage vertical volute pumps for the **Shanxi Xiaolangdi Yellow River Diversion Project.** This sub-project of the central route is designed to divert 247 million m³ of water annually. For this, water from the Yellow River will be transported to a subsurface pumping station through a 6 km-long tunnel. The pumping station is equipped with four pumps conveying the water to an artificial lake roughly 60 km away. These customized pumps achieve a flow rate of 5 m³/s over a head of 236 m at more than 91% efficiency. Optimum flow in the volute is achieved due to its individual shaping, which also guarantees a high level of efficiency. As the Yellow River conveys large quantities of sand, the pumps will be provided with a special abrasion-resistant coating. Delivery, installation, and start-up of the ANDRITZ pumps are scheduled to take place in about two years.

Hui Nan Zhuang, 8 horizontally split double-suction pumps

Xijiang Intake Pumping Station, 12 double-suction pumps

IN NEED OF RENEWABLE POWER

Guthega, New South Wales, 45 MVA

GENERAL FACTS

Population: **24,992 million**
Access to electricity: **100%**
Installed hydro capacity: **8,044 MW** incl. PSPP
Share of generation from hydropower: **6.7%**
Hydro generation per year: **17,452 GWh**
Technically feasible hydro generation potential per year: **60,000 GWh**

ANDRITZ Hydro:
Total installed / rehabilitated units: **98**
Total installed / rehabilitated capacity: **1,502 MW**
Location: **Sydney**
E-Mail: **contact-hydro.au@andritz.com**

Australia

One of the largest countries in the world, Australia has a strong economy and a GDP growth that is stable at around 2.9%. Well-known for its numerous wonderful beaches, beautiful landscapes and diverse wildlife, Australia forms its own continent.

One of the longest transmission lines in the world is found in Australia, covering the east coast from the far north of Queensland to South Australia, the network stretches about 6,500 km. Most of Australia's installed generation capacity comes from ageing coal- and gas-fired power stations distributed strategically within the National Electricity Market. Australia is going through an energy transition though, continuously building large new wind and solar farms. A clear trend towards a zero-carbon emission is underway by pursuing the decommissioning of fossil-fuelled power stations by 2050. Total electricity generation in Australia was estimated to be 261,405 GWh in 2018; renewable sources contributed 49,339 GWh (19%) and the largest source of renewable generation was hydropower with 36% of the total. At the end of 2018, Australia had 14.5 GW of ongoing renewable energy projects under construction or financially committed.

A clear trend towards a zero-carbon emission is underway by pursuing the decommissioning of fossil-fuelled power stations by 2050.

Pumped storage hydro technology is not only a sustainable approach to bulk energy storage, it also provides important ancillary services, such as voltage and frequency control and black start capability. These services are needed for a stable grid and help to avoid major blackouts caused by intermittent renewable energy generation. In July 2019, the Australian Energy Market Operator (AEMO) published a forecast showing that the country

will need to exceed 15 GW of storage capacity by the early 2040s. Currently installed capacity of pumped storage is 1.49 GW.

ANDRITZ HYDRO IN AUSTRALIA

ANDRITZ is closely engaged with Australia's energy transition and is ready to supply suitable products for even the most sophisticated pumped storage hydro plant. This includes synchronous condensers for grid stability purposes, for example.

ANDRITZ is also deeply involved in the servicing and rehabilitation of existing hydropower plants. Australia has a total installed and/or rehabilitated capacity of about 8.04 GW.

Taking over GE Hydro in 2009 provided an opportunity to build on a basic structure. Strategically positioned in Sydney, the local organization is more than prepared to monitor and respond to changing business activities and the electricity market.

Paloona (31.5 MW), **Meadowbank** (31.5 MW): Hydro Tasmania awarded ANDRITZ a contract for the rehabilitation and upgrade of two oil-free Kaplan units in 2011. Both units have been already successfully commissioned.

Repulse (34 MW) and **Cluny** (22.9 MW): Hydro Tasmania awarded ANDRITZ in 2014 with a contract for design, manufacture and supply of turbine and governor equipment for a Kaplan upgrade. The last unit was commissioned end of 2019.

Control and governor frame contract: Hydro Tasmania signed a frame contract with ANDRITZ to jointly develop a control standard model to be installed first on Tungatinah and subsequently on all of Hydro Tasmania's 26 hydropower stations totaling 56 units.

Cethana (113 MVA), **Fisher** (48 MVA): In 2013, ANDRITZ received a contract from Hydro Tasmania for the supply of new generator stators and auxiliary equipment.

Generator rehabilitation program (12 × 11–66 MVA): Hydro Tasmania and ANDRITZ signed in 2015 a frame agreement for a generator rehabilitation program, which forms part of Hydro Tasmania's overall upgrade program – a contract lasting until 2028. ANDRITZ agreed to supply seven stators, five stator windings and four pole sets for 12 generators in eight different hydropower plants.

A Repulse, Tasmania, 34 MW
B Fisher, Tasmania, 48 MVA
C Cluny, Tasmania, 22.9 MW

Guthega (45 MVA): Snowy Hydro awarded ANDRITZ in 2017 a contract for design, delivery and installation of a completely new generator, which was successful commissioned end of 2019.

Shoalhaven Scheme: In 2019, Origin Energy contracted ANDRITZ with design, delivery and installation of four new digital and hydraulic governor systems. The installation of the first two sets is scheduled for 2020, for the second two sets installation is planned in 2021.

AUTHOR

Stefan Cambridge
Michael Stepan

Installation works, Guthega, New South Wales, 45 MVA

ON A CHALLENGING PATH TO 100% RENEWABLE ENERGY

Aratiatia, Waikato River, 92 MW

New Zealand is fortunate to have a wide range of natural resources available to power its industry and homes. Hydropower is the main renewable resource, supplying 62% of the total.

New Zealand has committed to 100% renewables by 2035 and this trend is expected to lead to a doubling of electricity demand by 2050. This poses a significant challenge. New Zealand's 5,381 MW of installed hydro is entirely conventional, with no pumped storage. Most of the hydropower plants in New Zealand were installed between the 1940s and 1980s. As a result, the bulk of recent capacity growth has been the refurbishment of existing plants, along with the installation of smaller run-of-river schemes. With lower environmental impact, run-of-river schemes and small storage schemes continue to be the favored option for new hydro. Consequently, uprating and refurbishment of existing hydro plants will also likely continue in the medium term.

In order to reach the ambitious renewables goals, much of the new capacity development will be focused on geothermal and wind. Nonetheless, to perform vital grid control functions, such developments will require the higher performance, flexibility and reliability available from traditional sources of generation like hydropower.

ANDRITZ HYDRO IN NEW ZEALAND

ANDRITZ has contributed to the development of hydropower in New Zealand since its early beginnings. Subsequently, through the mid-20th century, ANDRITZ supplied 50% of the installed capacity in the country.

The ANDRITZ team in New Zealand is passionate about delivering fit-for-purpose engineering solutions to customers. The supply and installation of new equipment on a "from water-to-wire" basis is the team's core expertise. The ANDRITZ portfolio in New Zealand

Piripaua, Lake Waikaremoana, 42 MW

Whakamaru, Waikato River, 128 MW

Upper Fraser, Fraser River, 8.1 MW

includes major refurbishments of electro-mechanical equipment and valves, turbine governing and excitation control, as well as services. Systems condition assessment, spare parts supply and installation, detailed engineering calculation and advice on technical issues, as well as troubleshooting are all part of this strong portfolio.

NEW OFFICE

ANDRITZ has recently relocated to a larger office and warehouse facility. Located in Christchurch on the South Island, the new office allows for business expansion, more storage on site, and room for a small workshop area for the growing service team.

Karapiro (90 MW): In 2019, ANDRITZ was awarded a contract for the major refurbishment of three Kaplan units to improve reliability, efficiency and output. It is the first water-lubricated Kaplan hub to be supplied in New Zealand. Installation is scheduled to be completed and commissioned by April 2024.

Piripaua (42 MW): In 2019, a contract for the supply of two replacement butterfly main inlet valves was awarded to ANDRITZ. and completed in the same year.

Aratiatia (92 MW): In 2015, ANDRITZ won a contract for three generators, one Francis runner including model test, and three turbine governors with a significant increase in efficiency and reliability. Project completion is expected by mid-2020.

Whakamaru (128 MW): In 2013, a contract for the supply of four Francis turbine runners, head covers, bottom rings, guide vanes, and the complete replacement of the governing equipment was awarded to ANDRITZ. With a new turbine design system, the turbine rating rose to just under 32 MW – an increase of 22%. Completion of the project is scheduled for mid-2020.

Upper Fraser (8.1 MW): In 2019, ANDRITZ was awarded a contract for one vertical, five-jet 8.1 MW Pelton compact turbine, main inlet valve, generator, excitation system and ancillary plant. Commissioned in July 2019 and with a gross head of 475 m, it is a power station with one of the highest heads in New Zealand.

Tekapo B (160 MW): In 2016, a contract for new Francis turbine runners, guide vanes and associated parts, along with refurbishment and installation of all equipment at site was awarded to ANDRITZ. The project objective is to improve reliability, hydraulic stability and efficiency. Completion is expected in 2020.

AUTHOR

Tony Mulholland

A Karapiro, Waikato River, 90 MW
B Tekapo B, Lake Pukaki, South Island, 160 MW

GENERAL FACTS

Population: **4.794 million**
Access to electricity: **100%**
Installed hydro capacity: **5,381 MW**
Share of generation from hydropower: **58%**
Hydro generation per year: **24,928 GWh**
Technically feasible annual hydropower potential: **77,000 GWh**

ANDRITZ Hydro:
Total installed / rehabilitated capacity: **3,131 MW**
Total installed / rehabilitated units: **134**
Location: **Christchurch**
E-Mail: **contact-hydro.nz@andritz.com**

New drivers shaping the future

A NEW LIFE FOR HYDRO ASSETS

The demand for rehabilitation, modernization, and upgrading of installed hydropower equipment has seen dramatic growth in recent years. About 40% of all hydropower plants worldwide were originally commissioned more than 40 years ago and have been in operation ever since. Europe and North America are particularly exposed in this respect, but Asia is also facing an increasing demand for rehabilitation of much of its aging hydropower capacity.

Existing hydropower plants also need to adapt to new grid requirements in response to growing renewable energy penetration. Increasing environmental constraints for both new and existing hydropower plants call for new solutions such as fish-friendly turbine technology and oil-free turbine runner hubs.

Today, many hydropower plants are facing extraordinary challenges due to more frequent start-stop cycles, operating at very low part-loads and as spinning reserve or as fast response capacity to stabilize the transmission grid. In parallel, the efficiency of turbines and generators has been significantly increased over the last few decades.

Each of the various elements and components within a hydropower plant have a different and specific lifetime. However, aging is accelerated by certain plant operational regimes. This can include frequent start-stop cycles, abrasion due to large volumes of suspended solids like silt, and corrosion. All can have a significant impact on service life. As a

result, refurbishments to modernize and upgrade a plant's performance are necessary and highly cost-effective.

ANDRITZ SYSTEMATIC APPROACH

The modernization of a hydropower plant is an extremely complex issue. As noted, aging of the various plant components and systems depends on operational, environmental, and ambient conditions.

Innovative modernization measures and top-notch technologies increase profitability and extend the lifespan of hydro assets.

Based on well over a century of hydropower experience, ANDRITZ has developed a structured process for assessing and modernizing hydropower plants in the most economical way. This systematic approach ensures tailor-made solutions that guarantee the maximum benefit for asset owners and operators.

Our Three-Phase Approach includes diagnosis, analysis, and therapy for all involved systems. In addition to standard solutions, our scope includes lifetime services, 24/7 customer support, life cycle and risk analysis, operation and maintenance services, as well as the long-term operation of assets.

Changing social, political and economic trends across the globe demand different perspectives. Hydropower technology and operation of the assets have to adapt to support new ideas and to meet all new upcoming requirements as they emerge. Examples for these global megatrends are new small-scale hybrid solutions (combining batteries with hydropower units), digitalization of all parts of a hydropower asset, and new long-term concepts for operation and maintenance.

ANDRITZ specializes in the rehabilitation, upgrading, and uprating of existing hydropower equipment. In addition, we offer solutions and services to optimize operation and maintenance of hydropower plants. Innovative modernization measures and state-of-the-art technologies increase profitability and extend plant lifetimes – all while taking into account basic economic, ecological, and legal conditions.

AUTHOR

Jens Paeutz

MODERNIZATION AND ECONOMIC GROWTH

Central Asia is a region that stretches from the Caspian Sea in the west to China in the east, and from Afghanistan and Iran in the south to Russia in the north. The region consists of the republics of Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan and counts a population of about 72 million people.

Since gaining independence from the Soviet Union in the early 1990s, the Central Asian republics have gradually been moving from a state-controlled economy to a market economy. All five countries are implementing structural reforms to improve competitiveness, modernizing the industrial sector and fostering the development of service industries through business-friendly fiscal policies and other measures.

In Tajikistan and Kyrgyzstan and, to a less extent, Uzbekistan, there are vast water resources that have been used for hydropower production since the early 20th century. Most of these power stations were constructed during the 1950s and 1960s and in recent years, modernization programs for large power stations were launched by the governments of these countries with the help of international development banks.

The countries of Tajikistan and Kyrgyzstan are participating in the "Central Asia-South Asia" power project (CASA-1000), a multibillion project that will allow for the

GENERAL FACTS

Population: **72 million**
Installed hydro capacity: **12,485 MW**
Hydropower under construction: **4,175 MW**
Technically feasible hydro generation potential per year: **632,567 GWh**

ANDRITZ Hydro:
Total installed / rehabilitated capacity: **3,710 MW**
Total installed / rehabilitated units: **25**
Location: **Almaty, Kazakhstan**
E-Mail: **contact-hydro.kz@andritz.com**
Location: **Dushanbe, Tajikistan**
E-Mail: **contact-hydro.tj@andritz.com**

Shardarinskaya, Syr-Darya River, Kazakhstan, 126 MW

intermittent export of 1,300 MW of surplus hydroelectricity from Kyrgyzstan and Tajikistan to Afghanistan (300 MW) and Pakistan (1,000 MW).

The "One Belt One Road" Initiative will further boost the economy of the Central Asian countries situated along the original Silk Road from China to East Europe. The initiative would create a cohesive economic area, increasing cultural exchanges and broadening trade by building both hard infrastructure, such as rail and road links, and soft infrastructure, such as trade agreements, as well as a common commercial legal structure with a court system to police the agreements.

KAZAKHSTAN

The economically dominant nation in Central Asia generates more than half of the region's GDP through its enormous oil and gas industry and vast mineral resources. Of its total installed generation capacity of 21,673 MW, only 10% is generated by hydropower (2,456 MW). Supply and distribution of electricity through Kazakhstan is problematic because most of the energy is produced far from demand centers and the bulk power grid is in significant need of modernization.

Although Kazakhstan has an estimated technically feasible annual hydropower potential of about 62,000 GWh, only 13% of this potential has been developed so far. To meet future demand and address ambitious targets to increase the share of renewables to about 50% by 2050, the country needs to increase investment in the sector. Measures regarding decentralized electricity, trading markets, and new

KAZAKHSTAN

Issyk 2, Issyk River, Kazakhstan, 5.26 MW

Issyk 1, Issyk River, Kazakhstan, 5.26 MW

tariffs are beginning to show results, but more energy market reforms are required.

TAJIKISTAN

Total installed capacity stands at some 6,000 MW of which hydropower is about 95%. From the impressive technical potential of more than 400 TWh, only 5% has been developed so far.

Tajikistan is pursuing efforts to harness its vast hydro resources to address electricity shortages in winter and ensure security of power supply in the long term. The government has now prioritized eight projects with a combined capacity of 6,045 MW, including the 3,600 MW Rogun hydro project, project, which is currently under construction.

The largest hydropower stations in operation are Nurek (3,000 MW), Baipaza (600 MW), Golovnaya (250 MW) and Qairokkum (126 MW), which are all part of big modernization programs financed by international financial institutions.

KYRGYZSTAN

As of the end of 2019, total installed capacity stands at 3,800 MW, of which hydropower is about 80% (11.5 TWh p.a., 10% of gross hydro potential). The government also launched a privatization program to develop the small and mini hydro sector projects up to 30 MW output.

The largest hydropower stations in the country are Toktogul (1,440 MW), currently under modernization, and Kurpskaya (800 MW). In addition, the government plans several new hydropower stations, i.e. Upper Naryn Cascade (237 MW), Kambarata 1 (1,860 MW) and the Kazarman Cascade (1,160 MW). For all these new facilities, international investors are presently being sought.

UZBEKISTAN

Total installed capacity stands at around 12,500 MW, of which hydropower contributes about 1,900 MW. Currently, there are 21 plants with a capacity of 10 MW or larger in operation, and 75% of the capacity is more than 40 years old. In May 2017, a new state-owned hydropower producer and developer, UzbekHydroEnergo, was formed and entrusted with implementing a five-year program for the development of the hydropower sector. The program envisages the construction of 42 new plants and the modernization of 32 operating plants. In addition, the importance of pump storage power plants is growing.

TURKMENISTAN

There are only three small hydro plants in operation, totaling 5 MW of capacity. It is estimated that about 57 MW of hydropower could be developed, mainly by retrofitting existing water infrastructure.

ANDRITZ HYDRO IN CENTRAL ASIA

ANDRITZ has been active in this region for more than a decade and has so far booked a number of contracts for large rehabilitation and service projects, as well for small hydro projects.

A representative office was established in 2017 in Almaty, Kazakhstan, as a regional hub to support better access to local markets and to explore the excellent business opportunities across the entire region.

To date, ANDRITZ has contracts completed or under execution for 10 hydropower stations with 25 units totalling 3,710 MW across the region. Besides projects such as Nurek in Tajikistan, Shardarinskaya, Moinak, Issyk 1 and 2 in Kazakhstan, orders for turbine governors for Rogun in Tajikistan and Gissarak in Uzbekistan, as well as the small hydro projects Kok Say and Konur Olon in Kyrgyzstan, highlight the competences of ANDRITZ in the region.

KYRGYSTAN

Surrounding area Kok Say 3.3 MW and Konur Olon 3.3. MW, Yssykköl, Kyrgystan

UZBEKISTAN

Kamolot, Chirchik Bozsu Canal, Uzbekistan, 8.8 MW

Additionally, 23 turbo generator units with a total capacity of 3,270 MVA have been supplied for gas-fired power plants in Kazakhstan, Uzbekistan and Turkmenistan.

Nurek, Tajikistan: In 2018, ANDRITZ received a contract for the rehabilitation and modernization of the entire electro-mechanical equipment for the largest hydropower plant in Central Asia, including inspection and repair of the penstocks. The scope of supply comprises comprehensive modernization of the existing nine generating units by supplying and installing new 380 MW Francis turbines and generators, new transformers, and electrical and mechanical auxiliary equipment. The capacity of the power generation station will be boosted by about 700 MW. The completion of the project is scheduled for 2028.

Shardarinskaya, Kazakhstan: In 2013, ANDRITZ replaced four Kaplan turbines with new runners, new generators, automation, and auxiliary systems. The power output was increased by about 20% – from 26 MW to 31.5 MW per unit. All units are in commercial operation.

Kamolot, Uzbekistan: In 2018, ANDRITZ received a contract for the complete electro-mechanical equipment for the Kamolot hydropower plant, using the significant hydropower potential of a wide network of irrigation canals. The scope of supply for ANDRITZ comprises four identical Bevel Gear Bulb turbines with a power output of 2.13 MW each, including auxiliary equipment and a package of controls, automation, and supervision works.

AUTHOR
Norbert Schwarz

With 3,420 MW, Nurek is the largest hydropower plant in Central Asia and has the second highest earth-filled dam in the world. It covers 70% of the national electricity demand.

TAJIKISTAN

Nurek, Vakhsh River, Tajikistan, 3,420 MW

Nurek, Vakhsh River, Tajikistan, 3,420 MW
Grand official ceremony for the start of the rehabilitation program

HEART OF THE CORAL TRIANGLE

The Southeastern Pacific (known as Melanesia) is a subregion of Oceania extending from New Guinea in the western side of the eastern Pacific to the Arafura Sea. Melanesia includes the four independent countries of Vanuatu, Solomon Islands, Fiji, and Papua New Guinea, as well as French New Caledonia and others. The more than 2,000 Melanesian islands have rich natural resources and live mostly off subsistence farming and fishing, tourism, and exports of palm oil, coffee, and sugar.

HYDROPOWER

Most of the islands depend on fossil fuels for electricity. While countries like New Caledonia or Fiji have an almost 100% electrification rate, Papua New Guinea and the Solomon Islands are striving to improve electricity access, with only about 54% and 62%, respectively.

Papua New Guinea formed the Papua New Guinea Electrification Partnership to increase electricity access up to 70% by 2030. The initiative will support hydropower investments to tap a potential of about 45,000 MW.

Fiji has an installed capacity of 187 MW from three hydropower plants. The vast rivers of the mountainous country are ideal for development of small hydropower.

ANDRITZ HYDRO IN SOUTHEASTERN PACIFIC

ANDRITZ has been active in the region for many years and has installed and/or rehabilitated numerous units in Papua New Guinea. It is also the OEM supplier for Waiola, the largest hydropower complex in Fiji.

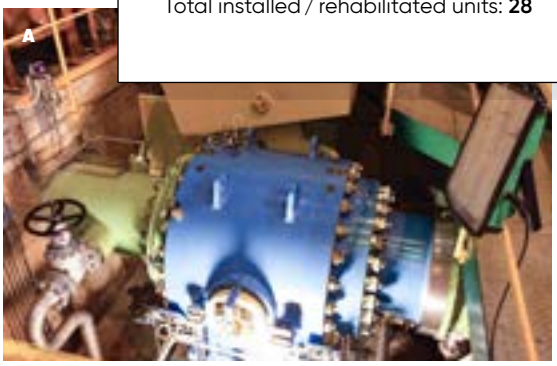
Waiola, Fiji: The Monasavu-Waiola hydroelectric scheme is Fiji's largest storage reservoir, impounding 133 million m³ of water on the Nanuka River. The turbines at the Waiola plant produce about 80 MW of energy, half of the island's needs.

After almost 40 years of continuous operation, Energy Fiji Limited (EFL) decided to carry out the 'Waiola Mid-Life Refurbishment Project'. In 2016 and 2017, ANDRITZ received two contracts for refurbishment of the electro-mechanical equipment. The scope of supply of both contracts comprised design, manufacturing, installation and commissioning of four new spherical valves and four new turbines and governors. Both contracts include hydraulic systems and accessories. Commissioning of the first unit was successfully completed in December 2019, installation and commissioning work for the remaining three units will be completed in 2020.

GENERAL FACTS

Population: **10,719 million**
Installed hydro capacity: **425 MW**
Hydropower under construction: **67 MW**
Technically feasible annual hydropower potential per year: **47,712 GWh**

ANDRITZ Hydro:
Total installed / rehabilitated capacity: **215 MW**
Total installed / rehabilitated units: **28**



A Monasavu-Waiola complex, Nanuka River, Fiji, 80 MW
B Rouna II, Rouna hydro cascade, Laloki River, Papua New Guinea, 39.5 MW

AUTHOR

Marie-Antoinette Sailer
Anton Prammer

JAPAN

LAND OF THE RISING SUN

Japan is the fourth largest economy in the world by Purchasing Power Parity (PPP) and world-leading in the automotive and electronics industry. However, with no significant natural resources, Japan is strongly dependent on imported energy and raw materials. This is even more of an issue since the tsunami disaster of 2011, which impacted the nation's nuclear generation fleet. In order to strengthen the economy, the government has now implemented an economic program including liberalization of the electricity and gas sectors.

Total installed hydro capacity in Japan is about 49,050 MW. Of this total, 27,470 MW is pumped storage, which puts Japan second in Asia after China. Three major pumped storage plants are also under construction and are soon to be commissioned. Japan is aiming to double generation from renewables to become more self-sufficient. Generation from solar PV has grown by a factor beyond 25 since 2011. This increases demand for energy storage requirements. Although the sites for large-scale hydropower are already utilized, some interesting opportunities for small hydropower do exist.

ANDRITZ HYDRO IN JAPAN

The activities of ANDRITZ in Japan reach back to the beginning of the 20th century with first deliveries taking place in 1907. Since then more than 500 units with a total output of about 1,060 MW have been delivered, installed and/or rehabilitated in the country. ANDRITZ also has major activities underway with Japanese investors in markets outside of Japan.

AUTHOR

Marie-Antoinette Sailer

GENERAL FACTS

Population: **126.53 million**
Access to electricity: **100%**
Installed hydro capacity: **21,580 MW**
Share of generation from hydropower: **8.4%**
Hydro generation per year: **79,100 GWh**
Technically feasible annual hydropower potential per year: **284,600 GWh**

ANDRITZ Hydro:
Total installed / rehabilitated capacity: **1,060 MW**
Total installed / rehabilitated units: **503**
Location: **Tokyo**
E-Mail: **contact-hydro.jp@andritz.com**

FACTS AND FIGURES

Country	Capacity in MW	
Afghanistan	330.00	
Bangladesh	230.00	
Bhutan	1,615.00	
Cambodia	1,330.00	
China PDR	352,260.00	excl. PSPP
Taiwan	2,092.00	
India	45,217.00	
Indonesia	5,742.00	
Japan	21,580.00	excl. PSPP
Kazakhstan	2,456.00	
Korea North	5,474.00	
Korea South	1,789.00	excl. PSPP
Kyrgyzstan	3,065.00	
Lao PDR	7,213.00	
Malaysia	6,095.00	
Mongolia	28.00	
Myanmar	3,477.00	
Nepal	1,074.00	
Pakistan	9,500.00	
Philippines	3,701.00	excl. PSPP
Sri Lanka	1,768.00	
Tajikistan	6,000.00	
Thailand	3,561.00	incl. PSPP
Timor Leste	0.40	
Turkmenistan	5.00	
Uzbekistan	1,889.00	
Vietnam	18,548.00	
Australia	8,044.00	incl. PSPP
Fiji	148.00	
French Polynesia	47.00	
New Caledonia	78.00	
New Zealand	5,381.00	
Papua New Guinea	198.00	
Samoa	13.20	
Solomon Islands	0.15	
Vanuatu	0.60	

Source: Hydropower & Dams Worldatlas 2019

Top 5 Countries

China
India
Japan
Vietnam
Pakistan

Population in Asia
4.138 billion

Total installed capacity in Asia
519 GW

GW installed excl. PSPP

352.3
45.2
21.5
18.5
9.5

ANDRITZ
installed and/or rehabilitated
3,000 units
100 GW total capacity (100,000 MW)

Hydropower in Asia

With a total installed capacity of about 519 GW, of which some 74 GW is pumped storage, Asia is home to over a third of the world's total hydropower generation. More than 12 GW of additional hydropower capacity was commissioned across the region in 2018, with 8.5 GW in China alone – more than in any other part of the world.

Hydropower is playing an important role in many countries across Asia. Growing demand prompted by demographic changes and economic growth is being increasingly met with renewable energy sources, including hydro.

Ambitious goals to raise the share of renewables is also boosting demand for pumped storage in particular. Able to balance other more variable sources of renewable power generation, pumped storage capacity provides grid stability, helping to achieve independence from fossil fuels.

With its long history of hydropower development, Asia continues to offer interesting business opportunities in the modernization and rehabilitation of the hydropower fleet. Many installations are more than 40 years old, especially in the former GUS member states.

Many Asian countries are developing the necessary market liberalization measures and adopting appropriate legal frameworks to encourage infrastructure investment. In combination with environmentally-friendly, flexible, cost-effective and constantly evolving sustainable technology, this creates many attractive prospects for hydropower in this dynamic and diverse region.

Source: (HP&D World Atlas 2019, IHA Status Report 2019)

Thereof pumped storage
74 GW

Additional capacity in 2018
12.1 GW
incl. pumped storage

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ANDRITZ

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