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World Small Hydropower Development Report 2019

Global Overview

Disclaimer

The *World Small Hydropower Development Report 2019* is jointly produced by the United Nations Industrial Development Organization (UNIDO) and the International Center on Small Hydro Power (ICSHP) to provide development information about small hydropower.

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Global Overview

Foreword

LI Yong, Director General, UNIDO

On 24 and 25 September 2019 the world leaders, policy-makers, civil society and the private sector gathered in New York to comprehensively review the progress in implementing the 2030 Agenda, a blueprint for shared prosperity in a sustainable world, adopted five years ago. The review highlighted encouraging advancements on many fronts, with concerted action being taken to alleviate poverty and hunger, protect our seas and forests, and make our cities greener and healthier. It also showed that the progress on many crucial goals is too slow: millions of people world-wide still live without reliable access to sustainable energy and clean water, the industrialization rate in sub-Saharan Africa remains below the target and global climate action lacks required ambition. To accelerate the implementation of Sustainable Development Goals and create the future we want by the year 2030, the global community must delineate the best strategies for affordable and concrete solutions.

Small hydropower presents one of such simple, affordable, practical and low-cost solutions. When implemented with environmental and socio-economic aspects in mind, it can simultaneously improve access to energy from renewable sources for remote and vulnerable rural communities, offer employment opportunities for youth, expand possibilities for growth for small-scale businesses, and contribute to combatting of climate change. Small hydropower technologies are easily adaptable for local conditions as well as various geographical and infrastructural circumstances. Moreover, small hydropower installations come with the lowest electricity generation prices in comparison to other off-grid technologies.

However, the potential of small hydropower in developing countries remains largely untapped with only 34 per cent of global potential being utilized. To provide policy-makers with a solid basis for informed decisions and attract prospective financiers to invest in sustainable energy solutions, the United Nations Industrial Development Organization partnered with the International Center on Small Hydro Power to launch this third edition of the *World Small Hydropower Development Report* and the accompanying knowledge platform (www.smallhydroworld.org). The rich content of the report is an outcome of a collective effort of more than 200 authors and contributing organizations from all over the world. The production of this comprehensive report would not be possible without generous support and intellectual leadership from the Ministry of Water Resources of the People's Republic of China.

I am confident that this report will be beneficial not only for sustainable energy stakeholders, but also for the global development community while we are embarking on our ambitious journey to 2030, leaving no one behind.

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The Report was headed by LIU Heng, Senior Technical Expert at UNIDO and consulted by HU Xiaobo, Chief of the Division of Multilateral Development at ICSHP. This lengthy, and at times, arduous endeavour was coordinated by Eva Krēmere at UNIDO and WANG Xianlai at ICSHP. The Report is the result of three years of intense research efforts and was backed by a talented and indispensable team of researchers at ICSHP and a vast number of experts in the field of small hydropower.

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Prologue

World today

It is estimated that 1.06 billion people (13 per cent) worldwide, a predominantly rural population, still do not have access to electricity. Half of those people live in sub-Saharan Africa.

Access to reliable and affordable electricity has an immediate and transformative impact on quality of life, access to basic services (e.g., health, education) and livelihoods. Renewable energy is a key building block towards the broader development goals associated with environmental sustainability, delivery of public services and poverty eradication.

The number of people gaining access to power every year has been increasing since 2010 and is now around 118 million, but progress has been uneven and needs to be even faster if SDG 7 of universal access to electricity is to be met by 2030.

Based on current policies, the share of renewable energy is expected to reach just 21 per cent by 2030 (from 16.7 per cent in 2010 and 17.5 per cent in 2015), falling short of the significant increase required. As many as 674 million people (8 per cent of the world's population) will be still in the dark in 2030 if current electrification trends continue. And as many as an estimated 2.3 billion people will continue to use wood and coal for cooking in 2030 (3 billion in 2016), which poses major health risks worldwide.[1]

China's growth in renewable energy alone accounted for nearly 30 per cent from 2010 till 2015 of absolute renewable energy consumption worldwide. Brazil is the only country among the top 20 largest energy consumers to substantially exceed the global average renewable energy share in all end uses: electricity, transport and heating. In Africa: Ethiopia, Kenya and Tanzania and in Asia: Indonesia and Vietnam increased their electricity access rate by 3 per cent or more annually between 2010 and 2016. In Latin America: Guyana, Peru, El Salvador and Paraguay made the fastest progress. Meanwhile, India provided electricity to 30 million people annually, more than any other country.[2]

Hydropower and SDGs

Hydropower can provide multiple services – including freshwater management, climate mitigation, and climate adaptation secondary services. Therefore, it can contribute to the affordable services, firm energy, and energy storage and the clean energy goal (SDG 7) as well as to other SDGs, including those for water (SDG 6), resilient infrastructure (SDG 9) and climate change (SDG 13).

In both developing and developed countries the need for clean and sustainable sources of energy is growing more acute in the face of climate change. As the lowest cost renewable energy technology, hydropower remains at the centre of international efforts to fight climate change and transition to a clean energy future. Small hydropower (SHP) is an integral part of a broader strategy to promote development whilst at the same time reducing greenhouse gas emissions and promoting greater energy independence.

Based on current policies, the share of renewable energy is expected to reach just 21 % by 2030.

Project financing

A lack of modern energy access is one of the key hindrances to economic development, and it slows down poverty alleviation and the growth of the rural economy. Smaller-scale hydropower can be a solution for rural populations with public finance catalyzing private investments, as well as providing alternative sources of funding, such as social financing.

It is estimated that investments of US$ 48 billion to US$ 1 trillion per year will be required between 2010 and 2030 if the goal of universal access to modern energy services is to be met by 2030 and the majority of these investments are required in Africa. Several mechanisms and strategies do exist to promote the financing of SHP, but much more still needs to be done to allow the available potential to be fully exploited.

It is estimated that investments of US$ 48 billion to US$ 1 trillion per year between 2010 and 2030 are required if the goal of universal access to modern energy services is to be met by 2030.

Small-scale energy projects could be financed through public and/or private funds, and there are possible international financing sources for the small-scale clean energy environment, such as grants, co-financing, loans, equity, official development assistance (ODA) and technology assistance through various international bodies such as the GEF, World Bank and AfDB to name just a few.

But many problems remain. There remains a major financing gap, and particularly a lack of private sector funding. For example, in Africa, there is little or no private funding presence in domestic energy sectors, due to low rates of return caused by low consumption and high costs. In Nepal too, there is a huge financial gap between the cost of electrification and its affordability, and a commercial sector that is reluctant to engage in rural off-grid investments.

Proactive public policies for the application of public-private partnerships have the potential to bolster the flow of financing into the SHP sector. Private sector involvement can also be encouraged by introducing better institutional frameworks for investment, such as for banking procedures, doing business, stronger laws governing contracts and transparent policy environments for mergers and acquisitions.

Innovative mechanisms can be used to attract capital for SHP, such as fee for service schemes, the leasing of energy-generating products, credit from local cooperatives, revolving funds and credit from commercial banks against some sort of collateral. Some of these mechanisms have already had much success, such as with Zambia's fee-for-service scheme. The role of micro-finance institutions (MFIs) in financing SHP should also be investigated.

Ultimately, greater innovation in financing mechanisms and better governance and policy-making is needed to catalyze private sector investment in SHP.

Mini-grid solutions

The electricity demands of rural areas urgently need to be met, so that key development needs, such as reliable lighting, better information and communication, improved security, and higher productivity and more advanced product processing can be realized. In remote rural areas with a low density of energy demand, SHP is especially suitable because it can be deployed in various sizes of schemes that are adapted and suitable to the particular community's needs and local conditions.

Off-grid SHP solutions have emerged as a mainstream option to expand access to renewable energy in a timely and environmentally-sustainable manner. The population served by mini-grids based on SHP has more than doubled since 2007, reaching 6.4 million in 2016, mainly due to growth in Asia.[3]

Off-grid SHP solutions have emerged as a mainstream option to expand access to renewable energy in a timely and environmentally sustainable manner.

Mini-grids can contribute to gender equality. They reduce women's and girls' drudgery and save them time on labour-intensive tasks and chores. Electrification means that women can gain opportunities to work outside their homes, and that healthcare and education facilities for women and girls, as well as men and boys, can be improved.

Gender equality in the hydropower sector

The gender imbalance in the sector needs to be redressed, such as through partnerships between hydropower companies and universities, mentoring schemes.

SHP projects, if effectively and sensitively formulated, provide a rich opportunity for the empowerment of women and girls and progress towards gender equality. UNIDO's mandate to promote inclusive and sustainable industrial development (ISID) relies on the advancement of gender equality and the empowerment of women as economic agents of change and leaders, thereby transforming economies and generating inclusive growth. SHP has a great potential to reduce women's labour, increase their productivity and empower them economically.

There is a great need to promote women's participation in rural environmental governance. Despite the fact that women play a key role in rural environmental protection, they often have low involvement in public affairs. Women also often lack decision-making power in hydropower.

Men, particularly in less developed countries, occupy most of the high management positions in the hydropower industry. A large pay gap also exists in the engineering sector. The gender imbalance in the sector needs to be redressed, such as through partnerships between hydropower companies and universities, mentoring schemes with other women in the sector and promoting gender-sensitive working practices, such as parenting leave.

Furthermore, women should be trained and educated in the use and maintenance of electricity services, since they are the ones who most frequently use electricity in the household.

Youth and the Fourth Industrial Revolution (4IR)

The 1.8 billion global youth who today are between the ages of 15 and 29 (approximately 25 per cent from total population) are challenged by the Fourth Industrial Revolution (4IR).

Millions of young people around the world are unemployed or underemployed. If left unaddressed, this issue might slow down economic growth and promote social unrest, especially in developing countries where the ratio of youth is much higher.

The 1.8 billion global youth who today are between the ages of 15 and 29 (approximately 25 per cent of the total population) are challenged by the Fourth Industrial Revolution (4IR). About 87 per cent of these young people live in countries with developing economies.[4] The 4IR significantly influences their roles as the future workers, consumers and competitors.

Due to unparalleled global connectivity and demographic change, existing gaps are likely to worsen between those who are prepared for the 4IR and those who are not. There is a growing mismatch between youths' skills and employers' needs. If unaddressed, the problem will likely intensify as the 4IR transforms society, economies, jobs and people's personal lives. Providing education and training, for the youth in particular, is a win-win.

In order for growth in the SHP sector to be sustainable, the focus must be placed on building local capacities to plan, implement and manage SHP projects. For youth to excel in the changing world would require that the business community be actively involved in a setting aligned across education, workforce development programmes, young people and public policy. It must be a joint effort aimed at improving the potential employment opportunities for global youth.

Innovation and digitalization

Technological innovations in recent years have vastly broadened the scope of SHP applications. New low and zero head turbines promise to significantly increase the number of locations where the technology can be applied. New in-conduit turbines in waste and drinking water pipelines are now a proven reality.

Hydropower plants worldwide could potentially benefit from digitalization through preventive monitoring and increased operational efficiencies. Digitalized hydropower is an end-to-end solution that employs data, analytics and hydropower plant software applications in partnership with hardware solutions. It can enhance efficiency, cybersecurity, reliability, as well as the profitability of a hydropower plant over its lifetime.

Unfortunately, hydropower somewhat lags behind other generating sectors in the field of digitalization, due to many projects that were constructed decades ago and have equipment aged to match.

A fully digitalized plant could contain self-learning systems that intelligently support plant owners in strategic decisions and enable them to maximize the profit.

Way forward for hydropower

The rehabilitation of historical sites, existing dams and waterways is viewed as a key area of development. In developed countries, advancements in SHP technology have opened up new potential applications through the utilization of existing waterways and pipelines helping to support renewable energy targets and reduce greenhouse gas emissions.

The first step to remedying the situation is through the dissemination of reliable data that can inform policy development and energy planning, as well as guide investors entering renewable energy markets, which is what the *World Small Hydropower Development Report* aims to do.

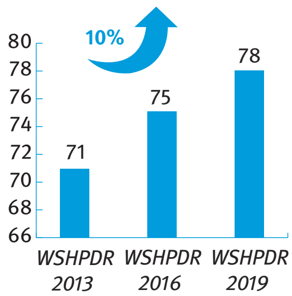
World Small Hydropower Development Report

So far, the *World Small Hydropower Development Report* is the only report and knowledge platform dedicated to the dissemination of in-depth SHP development information. The United Nations Industrial Development Organization (UNIDO) together with the International Center on Small Hydro Power (ICSHP) have been leading this effort since the first publication of the report in 2013. While a lot of research results and data on SHP are available, most are scattered and presented in varying formats and languages.

In order to more effectively promote SHP as a renewable and rural energy source and overcome existing barriers, it is essential to identify the development status of the technology in different regions and engage stakeholders to share existing information and experiences. UNIDO and ICSHP, as the SHP knowledge leaders, are continuing their partnership for the third edition: the *World Small Hydropower Development Report 2019 (WSHPDR 2019).*

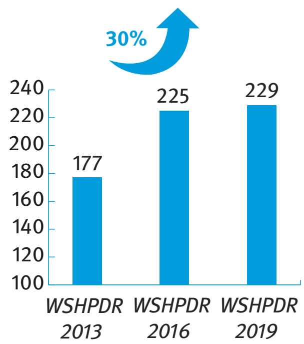
The *WSHPDR 2019* contains 20 regional and 166 country chapters. The country-level chapters cover: electricity sector; SHP capacity and potential; renewable energy policy and barriers to SHP development. Since the first edition of the *WSHPDR* in 2013, global SHP installed capacity has increased by an impressive 10 per cent and keeps growing (Figure 1)

Figure 1.
World SHP installed capacity (GW)



Note: SHP up to 10 MW.

Figure 2.
World SHP potential (GW)



Note: SHP up to 10 MW.

the same as discovered potential since the *WSHPDR 2013* has increased by a notable 30 per cent (Figure 2).

Case studies

SHP revolutionizes the daily life of communities worldwide, particularly in rural areas.

The case study section is a new addition to the *WSHPDR*. It is comprised of 18 case studies of successful SHP implementation in a range of communities. The case studies add a more detailed, practical perspective on the transformative potential of SHP and the best practices. Case studies give specific examples of communities that are using SHP for productive purposes to meet their needs and improve quality of life. The purpose of this new section is to provide easy access to the learnings drawn from such experience, thus forming a knowledge base that can benefit communities, decision-makers and developers elsewhere.

The cases demonstrate how reliable access to electricity provided by SHP revolutionizes daily life in communities worldwide, particularly in rural areas, creating employment opportunities, stimulating economic development, strengthening the capacity of existing infrastructure and local institutions, while minimizing negative environmental impacts. The following five aspects of SHP development are covered in the case studies.

SHP for productive use. While lack of access to electricity holds back economic development, SHP can create new opportunities for local businesses by providing power infrastructure, as demonstrated by the examples of 165 SHP projects developed under the Sarhad Rural Support Programme in Pakistan and the Gura SHP developed by the Kenya Tea Development Agency in Kenya. In these cases, reliable access to electricity through SHP allowed local enterprises to expand and create new business opportunities through greater efficiency and productivity, and reduced costs.

SHP for social and community development. Lack of electricity also constitutes a significant barrier to human, social and community development, specifically impacting vulnerable groups, including women and young people. The examples of SHP projects in the Dominican Republic, Nicaragua, Zambia, Tajikistan, Japan, the Democratic Republic of the Congo and China demonstrate that SHP can create conditions for communities to improve their quality of life, create employment, increase the standard of public service provision, improve overall health and education and achieve greater autonomy, even in areas affected by armed conflicts.

Case studies demonstrate, a range of technical solutions exist that can help adapt the technology to local regulations and bring it to more communities.

SHP financing. Access to financial resources is one of the most common barriers to SHP development across countries due to the high upfront investment required to launch a project. It is often the case that local banks' ability to support SHP projects is constrained by single- borrower exposure limits imposed by central banks, with their own internal guidelines being predominantly based on collateral borrowing. However, innovative mechanisms have been developed by some international and local banks to support projects such as SHPs. The Risk Sharing Framework of the European Bank for Reconstruction and Development offers local partner banks funded or unfunded risk-participation schemes, which, for example, supported the development of the Akmeta SHP in Georgia. Ping An Bank, a commercial Chinese bank, offers customized financial assistance for SHP construction and operation in poverty-stricken areas of the country.

Technology, innovation and smart SHP. SHP development can also be restricted due to a lack of suitable sites, in particular when the most attractive potential has already been harnessed or when strict environmental or other regulations limit further development in areas with available potential. However, as the case studies demonstrate, a range of technical solutions exist that can help adapt the technology to local regulations and bring it to more communities. These include using existing hydro-technological infrastructure for the installation of an SHP, as in the case of the Zagrody SHP in Poland; the innovative fish lift sluice system developed by Der Wasserwirt; the Turbulent turbines which allow harnessing the potential of low head streams; and hydrokinetic turbines developed by Smart Hydro

Power that can be installed in rivers, but also in existing infrastructure such as canals or water regulation dams.

Incentive policies for SHP development. Another common barrier to SHP development is the lack of a regulatory framework that would encourage the use of SHP and make the sector more attractive for investment. The example of Panama demonstrates how SHP development can accelerate with the support of appropriate incentive policies.

Green SHP. Unregulated SHP development can result in significant ecological impacts, including river loss of water, changed river ecology, reduced river connectivity and affected migratory fish and other aquatic species. To maintain the ecological safety of the sector, the future of SHP development should be in the form of green SHP, supported by regulations, guidelines, incentive policies and practices. Two case studies outline the measures taken in China and Austria to promote SHP construction and rehabilitation in line with the principles of ecological sustainability.

The future of SHP development should be in the form of green SHP, supported by regulations, guidelines, incentive policies and practices.

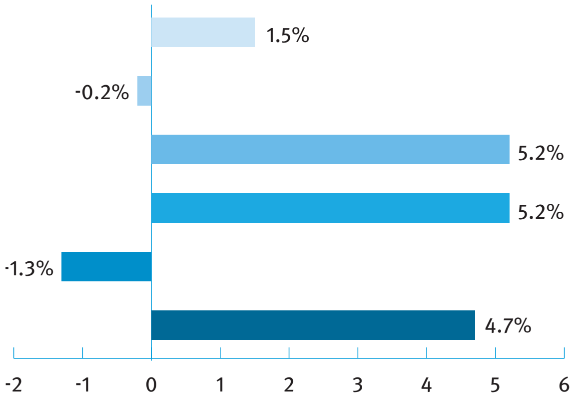
The children in the Kalaash community, Pakistan benefit from Internet access thanks to locally generated electricity from SHP.

Introduction

Despite the appeal and benefits of small hydropower (SHP) solutions, much of the world's SHP potential remains untapped (66 per cent). The global installed SHP capacity for plants up to 10 MW is estimated at 78 GW according to the *World Small Hydropower Development Report (WSHPDR) 2019*, an increase of approximately 10 per cent compared to data from the *WSHPDR 2013* and 4.7 per cent since the *WSHPDR 2016*. The greatest increase in SHP installed capacity has been in Asia and Europe with 5.2 per cent each. The Americas have experienced a slight decrease due to updated information for SHP up to 10 MW, while in Oceania the decrease is due to updates and natural catastrophes. Africa experienced only a 1.5 per cent increase (Figure 3).

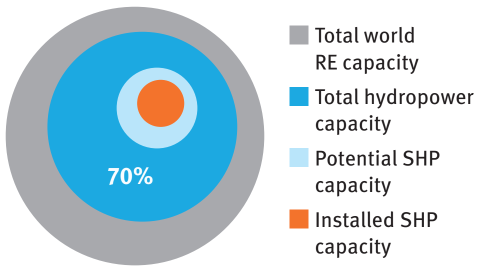
SHP represents only approximately 1.5 per cent of the world's total electricity installed capacity, 4.5 per cent of the total renewable energy capacity and 7.5 per cent (< 10 MW) of the total hydropower capacity. Nonetheless, it plays a major role in improving many lives (Figure 4). This impact is shown in the *WSHPDR 2019* case studies.

Figure 3.
Installed SHP capacity change for *WSHPDR 2016 - 2019*



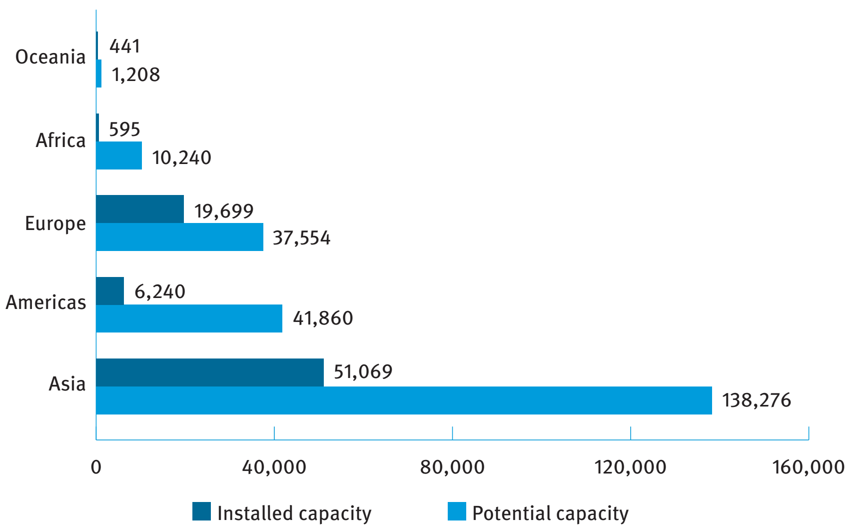
Source: *WSHPDR 2019*

Figure 4.
Share of SHP in the global electricity sector



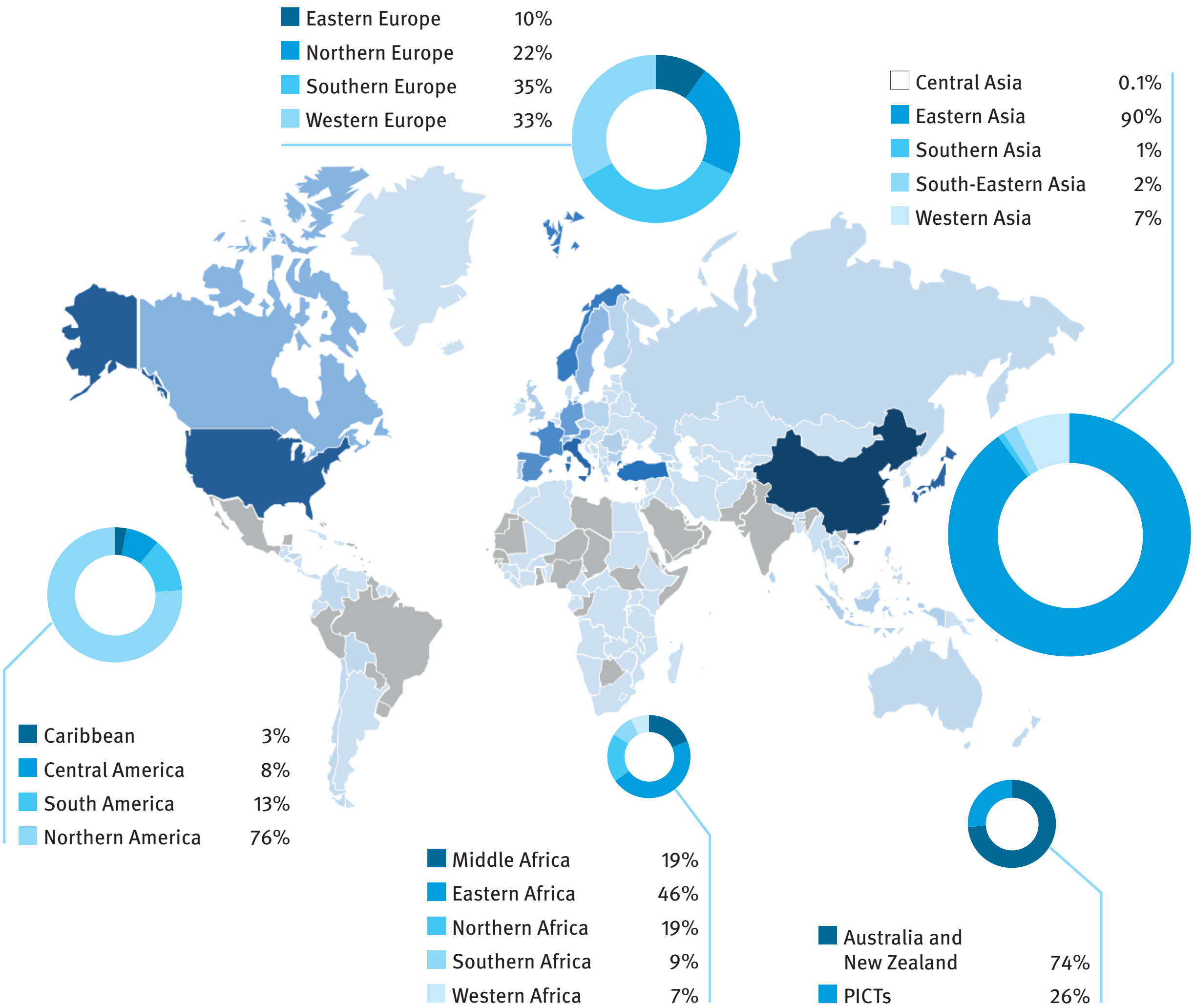
Asia continues to have the largest installed capacity and potential for SHP up to 10 MW. Europe has the highest percentage of SHP development, with Western Europe having 85 per cent of its potential already developed (followed by Eastern Asia with 61 per cent developed). In the Americas, most of the SHP is concentrated in the Northern America and South America regions. In 2019, the Americas reached an SHP development rate of 15 per cent (Figure 5).

Figure 5.
Regional installed SHP capacities up to 10 MW in *WSHPDR 2019*



Source: *WSHPDR 2019*

Figure 6.
Installed SHP up to 10 MW capacities worldwide



Source: *WSHPDR 2019*

Note: SHP up to 10 MW. Countries without available data on SHP up to 10 MW are not included and highlighted in grey.

China continues to dominate the global SHP landscape. With 54 per cent of the world's total installed capacity (definition of up to 10 MW) and approximately 28 per cent of the world's total SHP potential located in China, it has more than four times the SHP installed capacity of Italy, Japan, Norway and the United States of America (USA) combined. Together, the top five countries – China, the USA, Japan, Italy, Norway and Turkey account for 67 per cent of the world's total installed capacity of SHP (Figures 7, 8 and 9).

Figure 7.
Share of total installed SHP capacity by region (%)

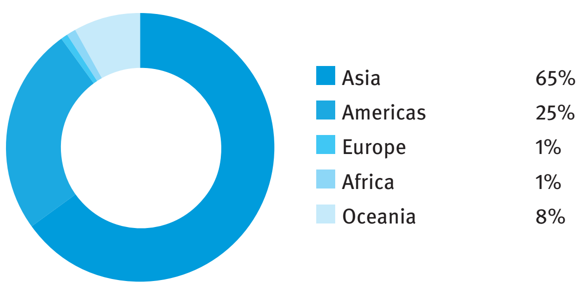


Figure 8.
Share of total installed SHP capacity of top 5 countries compared to the world (%)

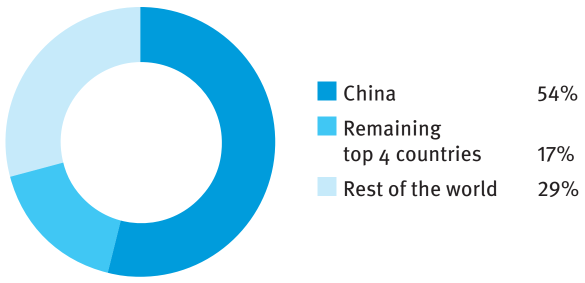


Figure 9.
Share of total remaining SHP potential by region (%)

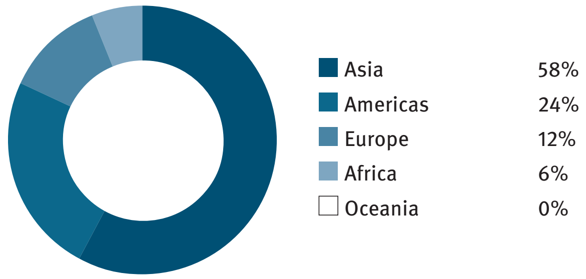
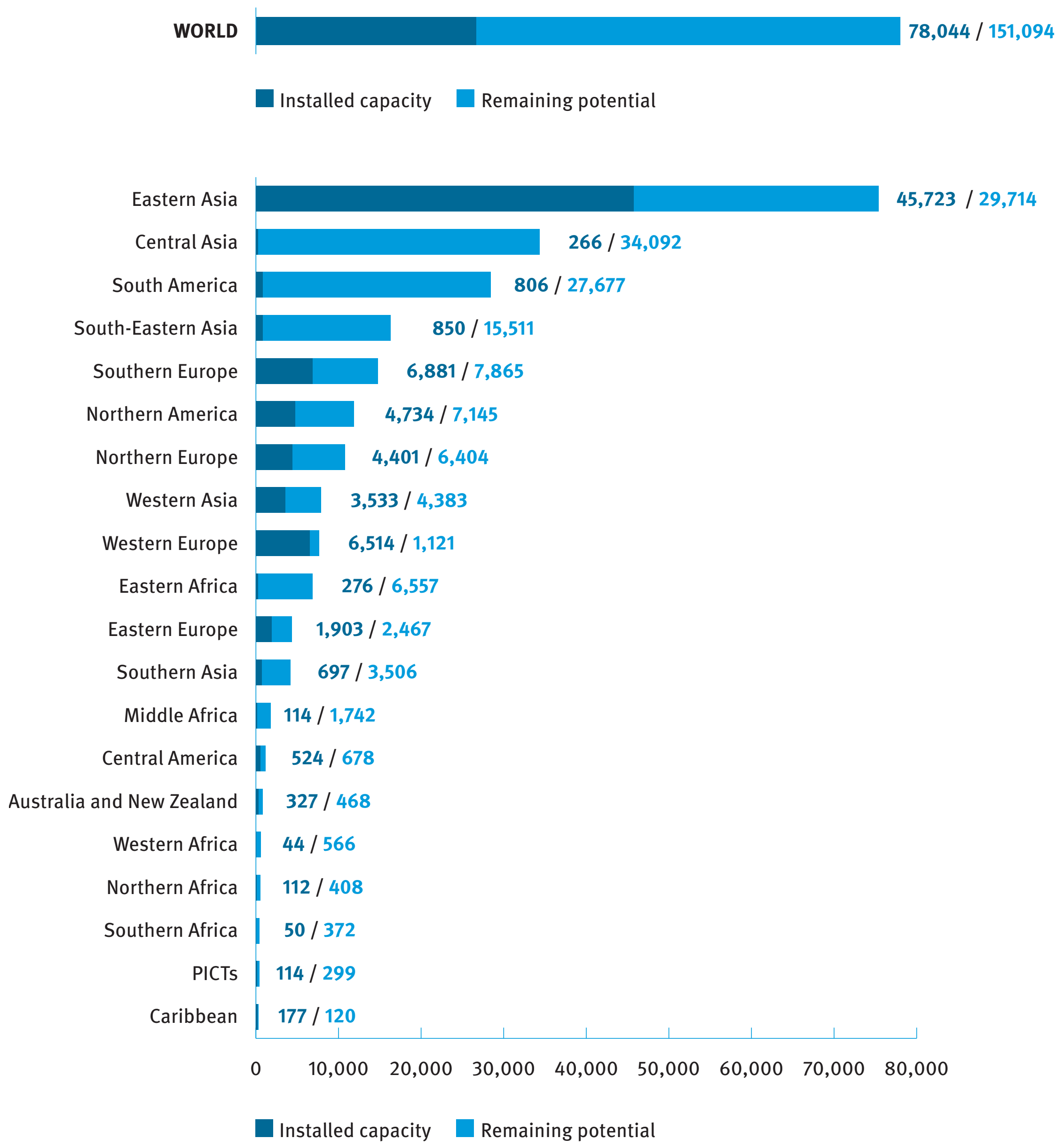


Figure 10.
Remaining SHP potential by region (MW)



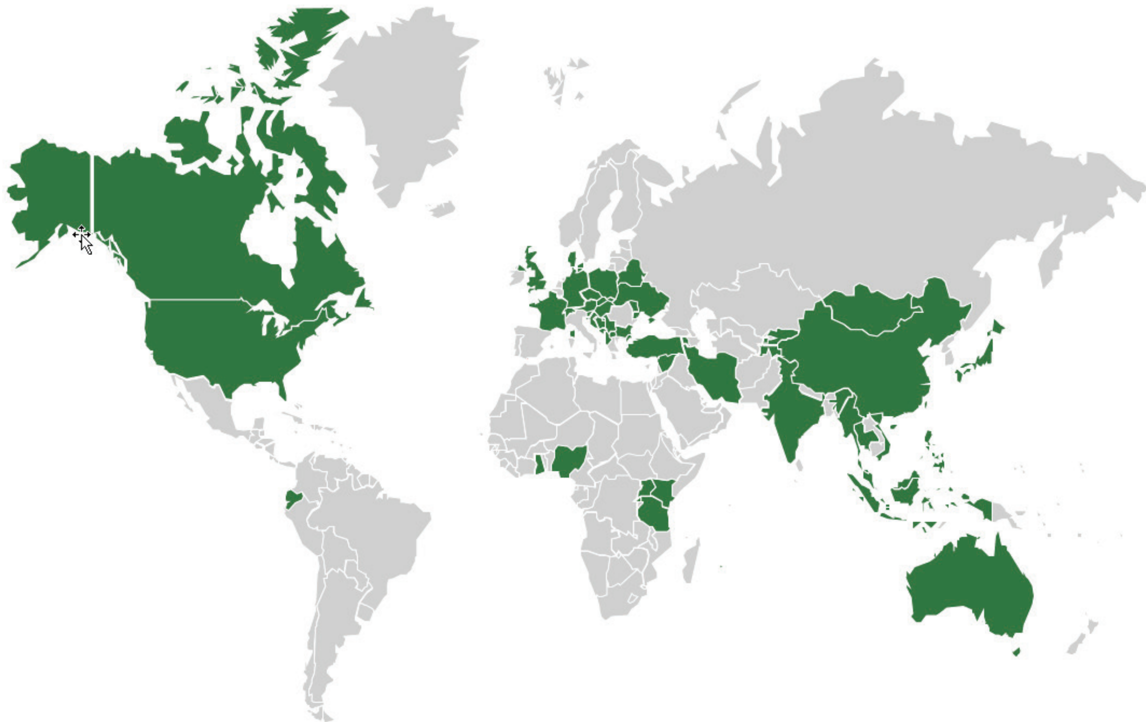
Source: *WSHPDR 2019*

Feed-in Tariff

In total there are 50 countries with existing feed-in tariffs (FITs) for SHP (Figure 11). The number has decreased in comparison with the *WSHPDR 2016.* One of the biggest decreases in the number of countries with FITs happened in Europe – from 28 reported in the *WSHPDR 2016* to only 22 in the *WSHPDR 2019*. In the Americas, the number of countries with FITs decreased from eight to three between the reports. These decreases are mainly due to many countries shifting to other forms of support for renewable energy technologies, such as green certificates, premiums and tenders.

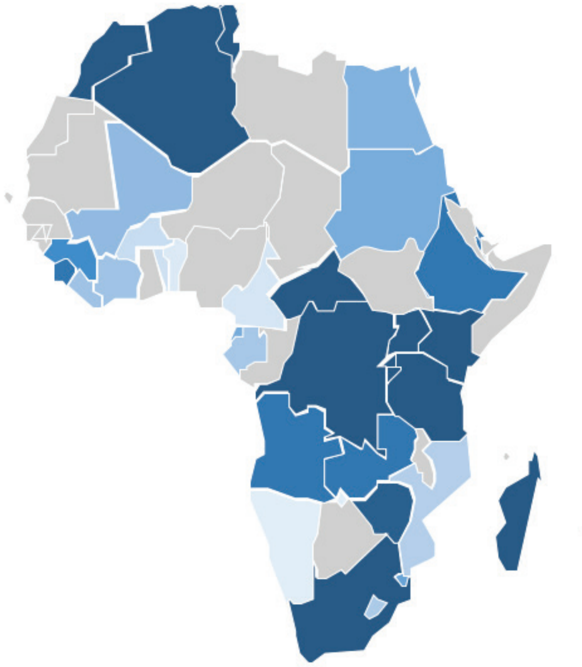
At the same time, Asia has seen an increase in the spread of FIT schemes covering SHP reaching 16 countries. In Africa, there is particularly great interest in developing FITs, with many counties planning to introduce this support system: Angola, Ethiopia, Gambia, Malawi, Mozambique, Lesotho, Sudan, Senegal, Sierra Leone, Zambia and Zimbabwe. Some countries have put in place other support mechanisms, for example, in the Russian Federation, SHP projects selected on a competitive basis can receive certain compensation for investment costs.

Figure 11.
Countries with existing feed-in tariffs for SHP (marked in green)



Source: *WSHPDR 2019*

Africa



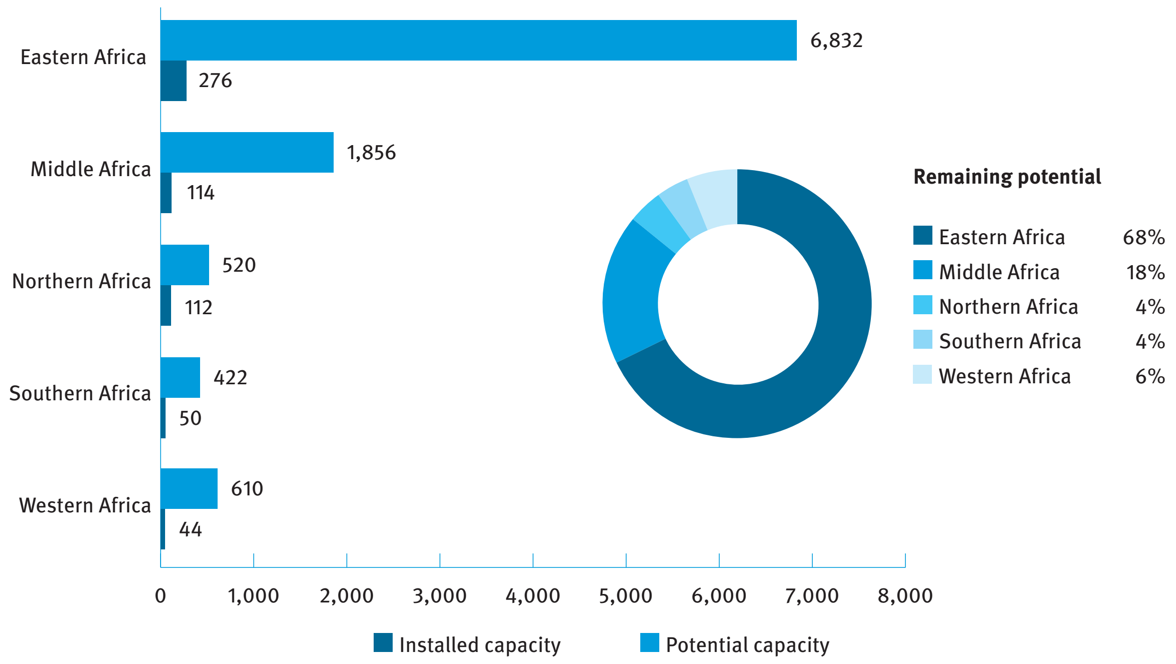
SHP in Africa can be characterized as having a relatively low level of installed capacity but with considerable potential for development. Climatic and topographic characteristics vary tremendously, resulting in a large variance in SHP potential in the north and south as compared to the east and west of the continent. The total installed capacity of SHP up to 10 MW in Africa is 595 MW and the total estimated potential is 10,240 MW. This indicates that only approximately 6 per cent has so far been developed.

Eastern Africa has the highest installed capacity and potential for SHP on the continent, followed by the Western and Middle Africa regions. Northern Africa has the highest electrification rate, but, due to climatic conditions, it has low potential for hydropower. Southern Africa has the lowest installed capacity, the vast majority of which is located in South Africa. Of the 48 countries in the region, many have some form of renewable energy policy, while eight countries have established FITs relating to SHP.

Country	*Local SHP definition*	*Installed capacity (local def.)*	*Potential capacity (local def.)*	*Installed (<10 MW)*	*Potential (<10 MW)*
Algeria	up to 10	42.1	-	42.1	-
Angola	up to 10	13.1	600.0	13.1	600.0
Benin	up to 30	0.6	304.9	0.6	69.9
Botswana	-	-	-	0	1.0
Burkina Faso	-	-	-	2.3	17.0
Burundi	up to 1	3.1	30.5	15.8	61.0
Cameroon	up to 10	1.0	970.0	1.0	970.0
Central African Republic	up to 10	28.8	41.0	28.8	41.0
Congo	-	-	-	0	65.0
Côte d'Ivoire	up to 10	5.0	45.7	5.0	45.7
Democratic Republic of the Congo	up to 10	56.0	101.0	56.0	101.0
Egypt	-	-	-	6.8	51.7
Equatorial Guinea	-	-	-	7.5	-
Eswatini	-	-	-	8.2	16.2
Ethiopia	up to 10	12.9	1,500	12.9	1,500
Gabon	-	-	-	4.6	7.8
Gambia	up to 30	0	-	0	12.0
Ghana	up to 1	0	12.1	0	17.4
Guinea	-	-	-	10.8	198.0
Kenya	up to 10	39.4	3,000	39.4	3,000
Lesotho	up to 10	3.8	38.2	3.8	38.2
Liberia	up to 30	4.9	85.9	4.9	56.4
Madagascar	-	-	-	33.0	82.0
Malawi	up to 5	5.6	150.0	-	-
Mali	up to 30	5.7	61.7	5.7	28.4
Mauritania	-	-	-	0	-
Mauritius	-	-	-	19.3	19.7

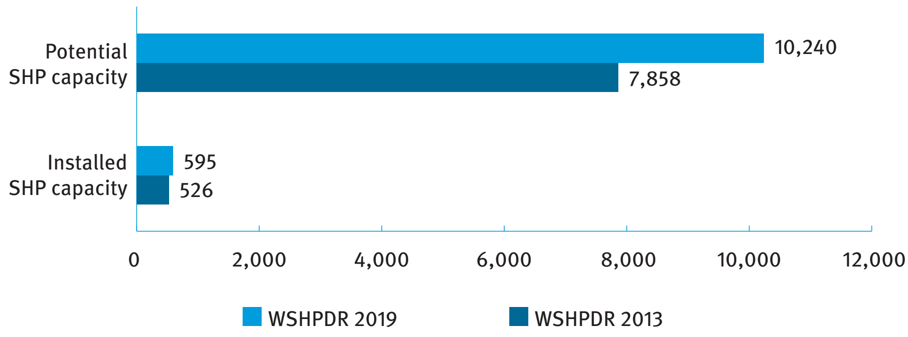
Morocco	up to 10	38.4	306.6	38.4	306.6
Mozambique	up to 25	19.4	N/A	3.4	1,000
Namibia	-	-	-	0.05	120.0
Niger	-	-	-	0	8.0
Nigeria	up to 30	64.2	735.0	-	-
Réunion	up to 10	11.0	17.0	11.0	17.0
Rwanda	up to 5	24.8	111.1	-	-
Sao Tome and Principe	up to 10	2.7	63.8	2.7	63.8
Senegal	up to 10	0	-	0	-
Sierra Leone	up to 30	12.9	639.0	12.9	-
Somalia	-	-	-	0	4.6
South Africa	up to 40	-	-	38.0	247.0
South Sudan	-	-	-	0	24.7
Sudan	up to 5	7.2	63.2	7.2	-
Tanzania	up to 10	30.4	480.0	30.4	480.0
Togo	-	-	-	1.6	144.0
Tunisia	-	-	-	17.0	56.0
Uganda	up to 20	82.8	258.0	51.8	200.0
Zambia	up to 20	39.7	138.7	12.9	62.0
Zimbabwe	up to 30	30.2	-	15.2	120.0

Figure 12.
Installed and potential capacity in Africa's regions for SHP up to 10 MW (MW)



Source: *WSHPDR 2019*

Figure 13.
Comparison of installed and potential capacity in Africa's regions for SHP up to 10 MW (MW)

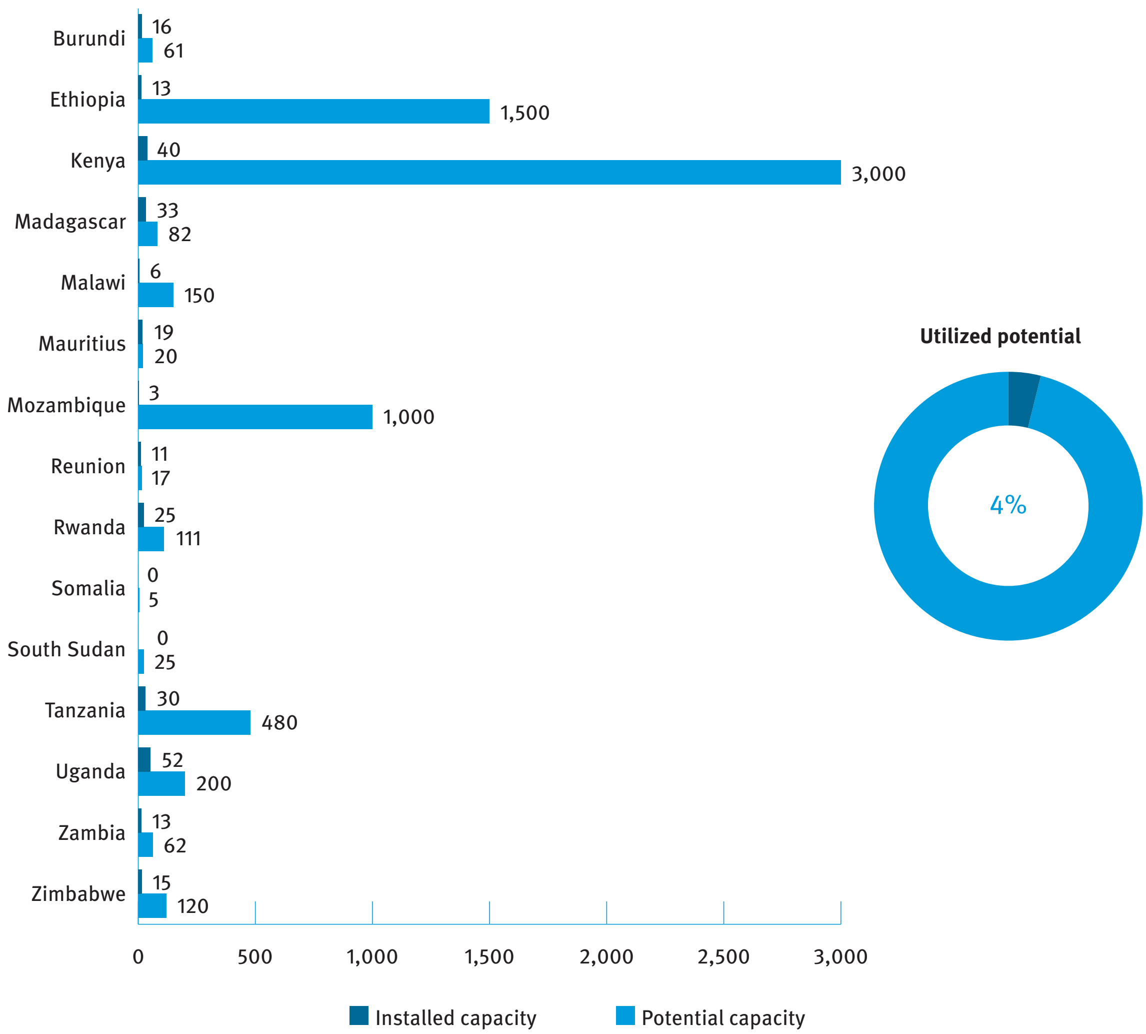


Source: *WSHPDR 2019*

Eastern Africa SHP overview

Burundi, Ethiopia, Kenya, Madagascar, Malawi, Mauritius, Mozambique, Réunion, Rwanda, South Sudan, Tanzania, Uganda, Zambia and Zimbabwe

Figure 14.
Installed and potential capacity in Eastern Africa for SHP up to 10 MW (MW)



Source: *WSHPDR 2019*

An overview of SHP for selected countries in Eastern Africa is outlined below. The information used in this section is extracted from the country profiles, which provide detailed information on SHP capacity and potential, among other energy-related information.

Following the local definition of 1 MW, **Burundi** has SHP potential of approximately 30.5 MW and an installed capacity of 3.1 MW. However, with regards to the standard classification of SHP as plants up to 10 MW, the installed capacity is 15.8 MW, whereas the potential of SHP up to 10 MW, as determined based on planned SHP projects, is 61.0 MW. Compared to the *WSHPDR 2016*, both the installed and potential capacities have remained unchanged.

The installed capacity of SHP up to 10 MW in **Ethiopia** is 12.9 MW. However, the potential is estimated to be 1,500 MW, indicating that less than 1 per cent has been developed. Since the publication of the *WSHPDR 2016*, the installed capacity has more than doubled, while the estimated potential has not changed.

It is argued that **Kenya** has one of the best energy mixes in the region, in the sense that the country's total installed capacity includes hydropower (both small and large), geothermal power, fossil fuels and bagasse, among others. Although the potential for SHP development (up to 10 MW) in Kenya is estimated at 3,000 MW, the installed capacity stands at only 39.4 MW. Compared to the *WSHPDR 2016*, potential capacity has remained the same, while the installed capacity has increased by 22 per cent. The latest addition was the Gura hydropower station in 2017, a SHP plant with an installed capacity of 5.8 MW.

Madagascar is endowed with significant potential for SHP. As such, the Government of Madagascar is seeking contributions from national and international private sector technical and financial partners to finance a significant portion of the investments planned for the development of the identified SHP projects. In 2017, the combined installed capacity of SHP plants up to 10 MW was approximately 33 MW. In comparison to the *WSHPDR 2016*, the installed capacity has increased by 6.5 per cent.

The total installed capacity of SHP plants under 5 MW in **Malawi** is approximately 5.6 MW, with an additional proven potential of at least 7.7 MW and a theoretical estimated potential of 150 MW. This indicates that approximately 5 per cent of the country's known potential has been developed. Compared to data from the *WSHPDR 2016*, the installed capacity has remained unchanged.

The installed capacity of SHP up to 10 MW in **Mauritius**, which has 10 existing plants, was 19.34 MW in 2018. This indicates an increase of 10 MW compared to the *WSHPDR 2016*, which can be attributed to the availability of updated data. There are no existing studies that give an accurate estimate of the SHP potential in the country. A new SHP station at the Bagatelle Dam, with a capacity of 350 kW, has been commissioned, which, once it is fully operational, will bring the country's total installed capacity up to at least 19.69 MW.

The total installed capacity of SHP plants up to 10 MW in **Mozambique** in 2016 was 3.37 MW, while available capacity stood at only 2.77 MW. Compared to the *WSHPDR 2016*, the installed capacity up to 10 MW has increased by 1.1 MW, while the potential capacity has remained unchanged. It should be noted that under the Mozambican definition of SHP as plants with an installed capacity up to 25 MW, the 16 MW Corumana hydropower plant would be included, bringing the installed capacity of SHP to 19.37 MW.

The total installed capacity of SHP up to 10 MW in **Réunion** is approximately 11 MW. The country has only 6 MW of untapped potential, making its SHP total potential 17 MW, of which 65 per cent has been developed. Compared to the *WSHPDR 2016*, the installed capacity remained unchanged, as no new projects were developed, while potential capacity decreased due to the availability of updated data.

Rwanda defines SHP as plants with an installed capacity up to 5 MW. In this regard, the current installed capacity of SHP in Rwanda is 24.8 MW, with an additional potential of at least 86.4 MW (based on the projects under development and identified sites). This indicates that only 22 per cent of the country's total potential has been developed. In comparison to the data from the *WSHPDR 2016*, the installed and potential capacities have increased by 7 and 131 per cent, respectively.

Currently, there are no operational hydropower plants in **Somalia**, however, there is a potential to rehabilitate the Fanoole hydropower plant that was operational prior to the civil war. The rehabilitation of the plant would bring the country's SHP capacity up to 4.6 MW

South Sudan is rich in hydropower resources, both large- and small-scale, which remain untapped. South Sudan has identified several SHP sites with a combined capacity of 24.7 MW and has finalized feasibility studies. These sites are pending available financing.

The current SHP installed capacity up to 10 MW in the **United Republic of Tanzania** is estimated at 30.4 MW, which includes isolated and unconnected plants. The country's total estimated potential is 480 MW, indicating that approximately 6 per cent of the potential has been developed. Compared to the data from the *WSHPDR 2016*, both the installed and potential capacities have increased by 20 per cent. Potential capacity has been increasing due to new studies identifying new sites suitable for SHP development.

The total installed capacity of SHP plants up to 20 MW in operation in **Uganda** is 82.8 MW, while the potential is estimated at approximately 258 MW, indicating that approximately 32 per cent of this potential capacity up to 20 MW has been developed. The installed capacity of SHP plants up to 10 MW is 51.8 MW and potential capacity is approximately 200 MW, indicating that 26 per cent of the potential capacity up to 10 MW has been developed. Compared to the *WSHPDR 2016*, the potential of SHP plants up to 10 MW has remained unchanged, while the installed capacity has increased by 51 per cent as a result of the commissioning of four new plants (Ishasha, Rwimi, Siti 1 and Kisilzi hydropower plants).

As of 2016, the total installed capacity for micro- and SHP plants in **Zambia** stood at 39.7 MW, based on the country's definition of SHP up to 20 MW. Zambia is currently rehabilitating and upgrading three SHP plants: the Chishimba hydropower plant is being rehabilitated and upgraded from 6 MW to 10 MW; the Lusiwasi hydropower plant is being replaced by new plants upstream and downstream with capacities of 12 MW and 86 MW; and the Musonda hydropower plant is being rehabilitated and upgraded from 5 MW to 10 MW.

In **Zimbabwe**, the installed capacity of SHP up to 10 MW reached 15.2 MW by 2017, mainly from run-of-river schemes in the Eastern Highlands. The total capacity under development is 27.3 MW. Most of the micro-scale schemes were installed by Practical Action and Oxfam as donations, while the SHP schemes which are connected to the grid were completed by IPPs such as Nyangani Renewable Energy (NRE) and Kupinga Hydro. Many more IPPs were licensed by the Zimbabwe Energy Regulatory Authority for different sites and are at different stages of development.

FITs have been introduced in Kenya, Mauritius, Réunion, Rwanda, the United Republic of Tanzania and Uganda. The Zimbabwe Energy Regulatory Authority developed some FITs that have not yet been approved by the Government of Zimbabwe. The Ethiopian Energy Authority is currently developing a FIT scheme, while the Government of Zambia initiated the introduction of a FIT programme and the Government of Malawi has set the objective to introduce such tariffs.

Middle Africa SHP overview

Angola, Cameroon, Central African Republic (CAR), Democratic Republic of the Congo (DRC), Congo, Equatorial Guinea, Gabon and Sao Tome and Principe

An overview of SHP in the countries of Middle Africa is outlined below. The information used in this section is extracted from the country profiles, which provide detailed information on SHP capacity and potential, among other energy-related information.

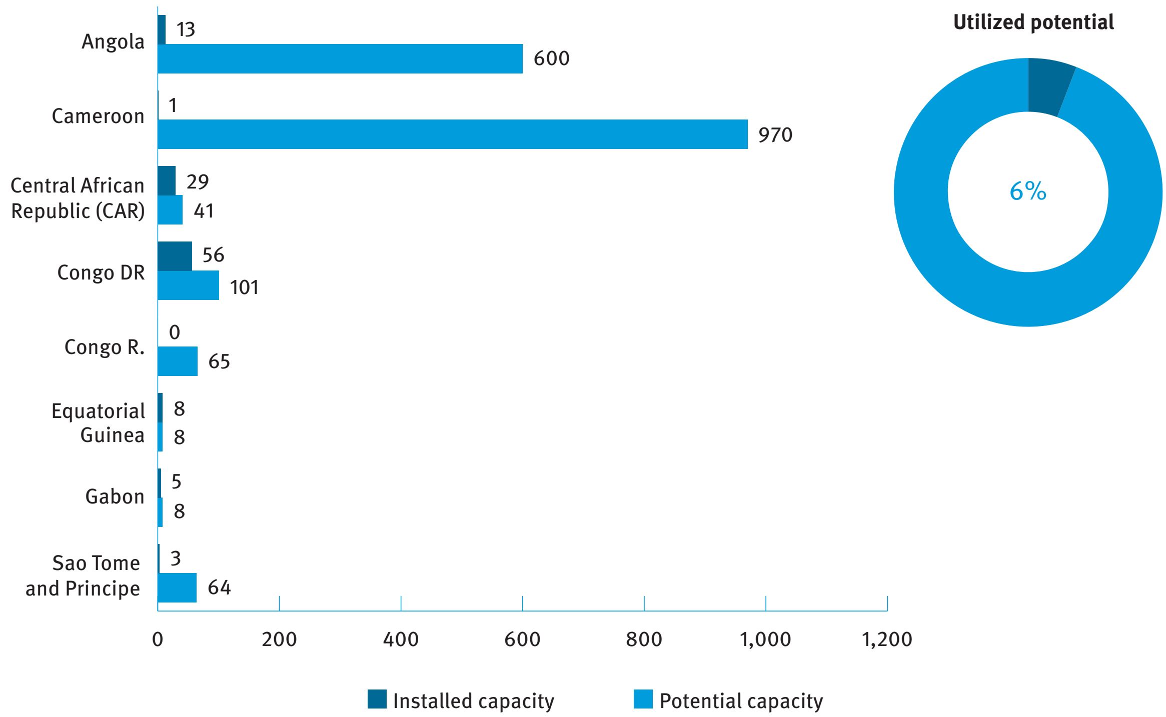
The installed capacity of SHP in **Angola** is 13.12 MW coming from four plants. Since the *WSHPDR 2016*, installed capacity has slightly increased. As part of the 2025 Angola Energy Strategy, the Ministry of Energy and Water identified 100 locations suitable for the construction of 600 MW of SHP. Of this potential, roughly 2.2 per cent has been developed to date. The Government of Angola is planning further refurbishment procedures on the existing plants. In addition to a large hydropower potential, Angola also has a significant potential for the use of other renewable energy sources, including solar, wind and biomass.

No comprehensive and accurate data on the installed SHP capacity of **Cameroon** is currently available. However, it is estimated to be at least 1 MW. Thus, compared to the results of the *WSHPDR 2016*, the installed capacity has doubled. The total potential is estimated to exceed 970 MW. Five potential sites with a combined capacity of 16.1 MW are targeted for development through private initiatives by 2021.

The Central African Republic has 28.8 MW of SHP installed capacity. The increase since the *WSHPDR 2016* is due to the construction of the Boali III hydropower plant with an installed capacity of 10 MW. In addition to the new plant, there are two other SHP plants with installed capacities of 8.75 MW and 10 MW. Moreover, it is believed that off-grid plants as well as multiple micro- and pico-hydropower units also exist. However, there is no data available with regards to their installed capacity or generation potential at the moment. The country's SHP potential is estimated at 41 MW, of which 70 per cent has been developed.

Since the WSHPDR 2016, **Congo** has not developed any SHP plants, and still has only large-scale hydropower plants in its energy mix. Based on two studies carried out in the country, the potential of SHP in Congo should be at least 65 MW. However, no exact and comprehensive estimate of the total potential is available, and it is expected that SHP potential in the country is more significant.

Figure 15.
Installed and potential capacity in Middle Africa for SHP up to 10 MW (MW)



Source: *WSHPDR 2019*

The Democratic Republic of the Congo has approximately 56 MW of SHP installed capacity, of which roughly 6 MW is from plants of up to 1 MW. However, the available data on SHP varies by source, and the number of privately-owned and operated SHP plants has not been fully identified. The potential capacity in the Democratic Republic of the Congo is approximately 101 MW. Approximately 100 potential SHP sites have been identified, but more thorough research could double this amount due to the large number of rivers yet to be surveyed. Compared to the *WSHPDR 2016*, both installed and potential capacity remained unchanged. The promotion of SHP is included in the national electrification plan.

Equatorial Guinea has three SHP plants with a combined capacity of 7.5 MW: the 0.5 MW Musola plant, the 3.8 MW Riaba plant and the 3.2 MW Bikomo plant. The increase of 5 MW installed capacity observed between the *WSHPDR 2016* and *2019* may be due to the previous lack of data on the Musola hydropower plant. The potential for SHP development in the country remains unknown. There are no known plans for future SHP development. Conversely, solar power and large-scale hydropower have seen some development.

Gabon also has three SHP plants. Their combined installed capacity is 4.58 MW. The total potential of SHP is unknown. However, based on planned projects, it is possible to conclude that there is at least 7.84 MW of available potential. Compared to the *WSHPDR 2016*, installed capacity decreased by 1.4 MW due to a decrease in the installed capacity of the Bongolo plant as a result of renovation work. The total hydropower potential in Gabon is estimated to be up to 8,000 MW, and hydropower is seen as an integral part of the Government's vision for the development of Gabon.

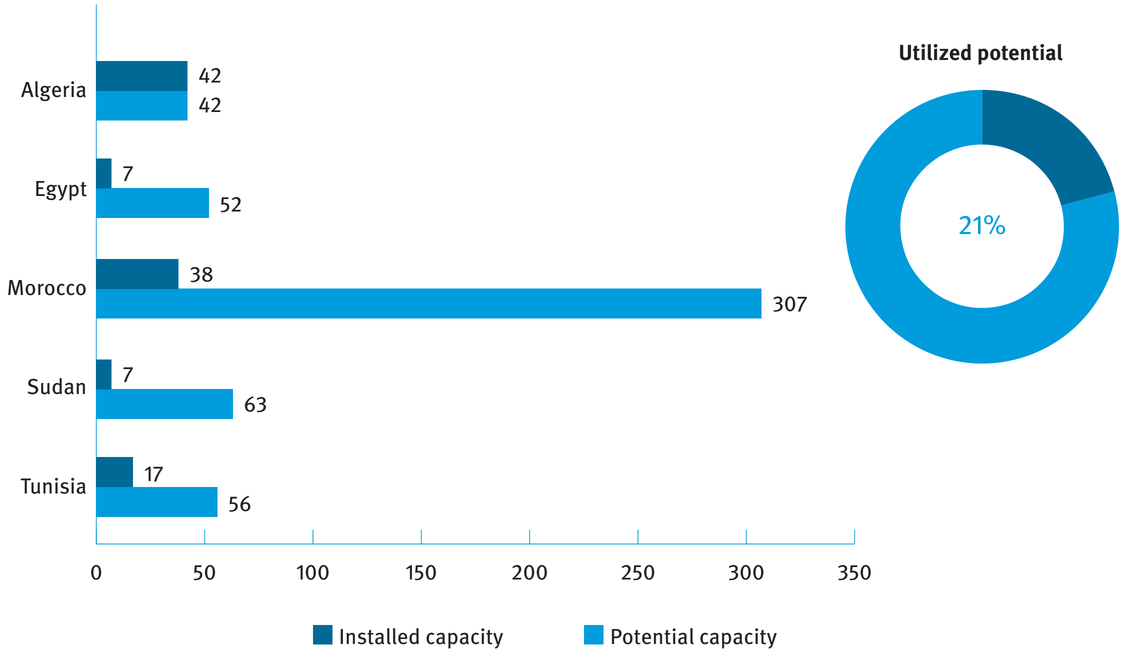
All four hydropower plants operating in **Sao Tome and Principe** are small-scale. Their combined capacity is 2.7 MW. There is considerable potential for further development of hydropower resources in the country. This includes 34 exploitable SHP sites across the two islands with an estimated capacity of 61.1 MW. With the support of the World Bank and the European Development Bank, the Rio Contador hydropower plant is undergoing modernization work that will increase the plant's capacity from the current 2 MW to approximately 4 MW.

Although there is significant political support for renewable energy sources across the region, none of the countries in the region have yet introduced **FITs.** However, the 2025 Energy Strategy of Angola foresees the introduction of FITs.

Northern Africa SHP overview

Algeria, Egypt, Morocco, Sudan and Tunisia

Figure 16.
Installed and potential capacity in Northern Africa for SHP up to 10 MW (MW)



Source: *WSHPDR 2019*

An overview of SHP in the countries of Northern Africa is outlined below. The information used in this section is extracted from the country profiles, which provide detailed information on SHP capacity and potential, along with other energy-related information.

In 2014, **Algeria** formally renounced any future hydropower development. The country plans to convert the usage of existing hydropower plants away from power generation and towards water supply. Currently, the installed capacity of SHP plants in Algeria remains at 42.1 MW.

The installed capacity of SHP in **Egypt** has remained unchanged as well, with four plants with a combined capacity of 6.8 MW currently in operation. Only approximately 13 per cent of the country's known potential has been developed. A further three plants are planned for development and 26 potential sites have been identified.

Morocco, the sole country in the region without substantial oil reserves, is also the sole country in the region with any meaningful policy for the development of SHP. Since 2010, it has been embarking on a programme for the identification and development of micro-hydropower. Morocco has recently identified 125 new sites suitable for small or micro-hydropower plants, with a total potential capacity estimated at 306.6 MW. The country's current SHP installed capacity remains at 38.4 MW. **Sudan** is the principal country in the region that is currently engaged in significant hydropower development, but it continues to focus on larger schemes. Currently, Sudan has a single hydropower plant with a capacity of 7.2 MW, while the total potential is estimated to be at least 63.2 MW.

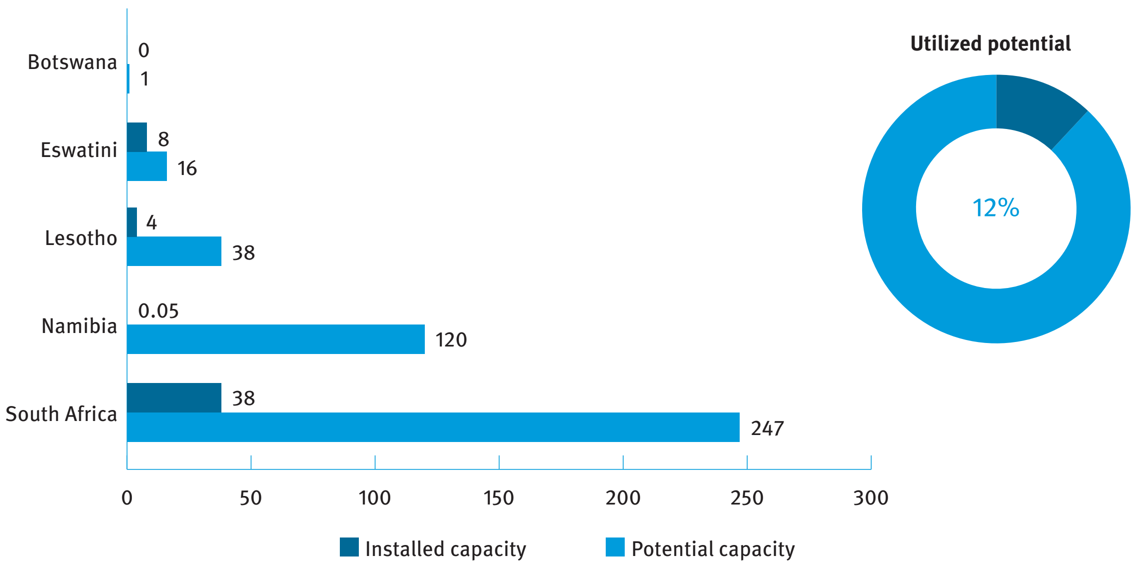
The total installed capacity of SHP in **Tunisia** is 17 MW. It comes from five plants and has remained unchanged since the *WSHPDR 2016*. Potential capacity is estimated to be 56 MW. However, there is little interest in hydropower from either the Government or private investors. Therefore, no significant development in the sector can currently be expected.

Currently, no country in the region has a **FIT** scheme covering SHP. In 2014, Algeria and Egypt introduced FITs, but neither include hydropower. The Government of Sudan, with the support of the United Nations Development Programme (UNDP), is developing a FIT programme to encourage renewable energy projects, both grid-connected and off-grid, which might also include SHP.

Southern Africa SHP overview

Botswana, Eswatini, Lesotho, Namibia, and South Africa

Figure 17.
Installed and potential capacity in Southern Africa for SHP up to 10 MW (MW)



Source: *WSHPDR 2019*

An overview of SHP in the countries of Southern Africa is outlined below. The information used in this section is extracted from the country profiles, which provide detailed information on SHP capacity and potential, along with other energy-related information.

Botswana has very limited SHP potential estimated at 1 MW, and is not currently using SHP at all. Solar power is the most important source of RE in the country with an average daily solar radiation of 6.1 kWh/m2. Nonetheless, the photovoltaic systems installed in the country have a capacity of 1 MW, accounting for only 0.8 per cent of the country's total capacity.

The first electric lighting system in **Eswatini** was installed with a 42 kW SHP turbine. Since then, the country has had several public and private hydropower plants installed, as well as some industrial installations. The total installed SHP capacity of Eswatini is at 8.21 MW, including one decommissioned plant of 0.5 MW. At the national level, a comprehensive resource assessment has been carried out showing that there is at least another 8 MW available for further SHP development, with some sites currently under consideration. Since 2007, Eswatini has had a strategic framework and an action plan for the development of renewable energy in the country. The Government seeks to maximize the use of RE, encourage education and training on RE, promote greater awareness of RE and develop accurate data on available RE resources. However, the development in this area still remains relatively slow.

Lesotho has two operational SHP plants of 0.57 MW and 0.18 MW, both owned and operated by the national utility company, the Lesotho Electricity Company. Although there is an untapped potential of approximately 34 MW and some plans exist for the construction of additional SHP capacity, circumstances do not seem to be facilitating the swift development of these projects. Nonetheless, the Lesotho Highlands water project does offer opportunities for more hydropower development. Several studies have also been conducted on possible pumped-storage plants. Besides hydropower, Lesotho has identified wind and solar power as potential RE sources. Solar power has been implemented in several schemes with the support of the World Bank, the UNDP and the Global Environment Faculty.

The current installed SHP capacity in **Namibia** is 0.05 MW and the potential is estimated at 120 MW, which includes hundreds of small farm dams around the country where SHP could be developed. The Namibia Power Corporation, the leading national energy company, has set the target of sourcing at least 10 per cent of national energy from renewable sources other than hydropower. It has also launched tenders for independent power producers (IPPs) to develop 30 MW of solar power as part of a national programme to commission a total of 94 MW through solar and wind technologies.

South Africa has 38 MW of installed SHP capacity and a proven potential of 247 MW (up to 10 MW). SHP played an important role in the historic electrification of the country, but was not developed for decades up until recently. The Integrated Resource Plan of South Africa outlines the expected electricity mix in the country until 2030, including the projected role of hydropower. The Government has implemented this plan through the Renewable Energy Independent Power Producers Procurement Programme (REIPPPP), which aims to add 17,800 MW of RE (solar and wind) to the country's installed capacity, as well as 75 MW from SHP. This programme has already resulted in the installation of three SHP systems (19.1 MW) contracted by the Government to feed into the national grid. In parallel to this, a number of privately-owned systems have been developed purely for private consumption. Traditionally, the country's energy policy has focused on large-scale, grid-connected RE projects. However, with the national energy regulator, NERSA, preparing guidelines and policies targeting small-scale plants, future activities in the area of small power plant development, including SHP, will be facilitated. The future development of SHP in South Africa will be based both on IPP-developed plants feeding into the national electricity system and small-scale plants for private use that do not feed into the grid. Currently, no support is available for stand-alone systems for rural electrification purposes, although the Government is currently reviewing its rural electrification strategy.

There was a **FIT** scheme in place in South Africa up until 2011, but it was replaced by the Renewable Energy Independent Power Producers Procurement Programme (REIPPPP). Namibia has a functioning FIT programme. However, it focuses mainly on solar and wind power. The Government of Lesotho has been considering the introduction of FITs.

Western Africa SHP overview

Benin, Burkina Faso, Côte d'Ivoire, Gambia, Ghana, Guinea, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone and Togo

An overview of SHP in the countries of Western Africa is outlined below. The information used in this section is extracted from the country profiles, which provide detailed information on SHP capacity and potential, along with other energy-related information.

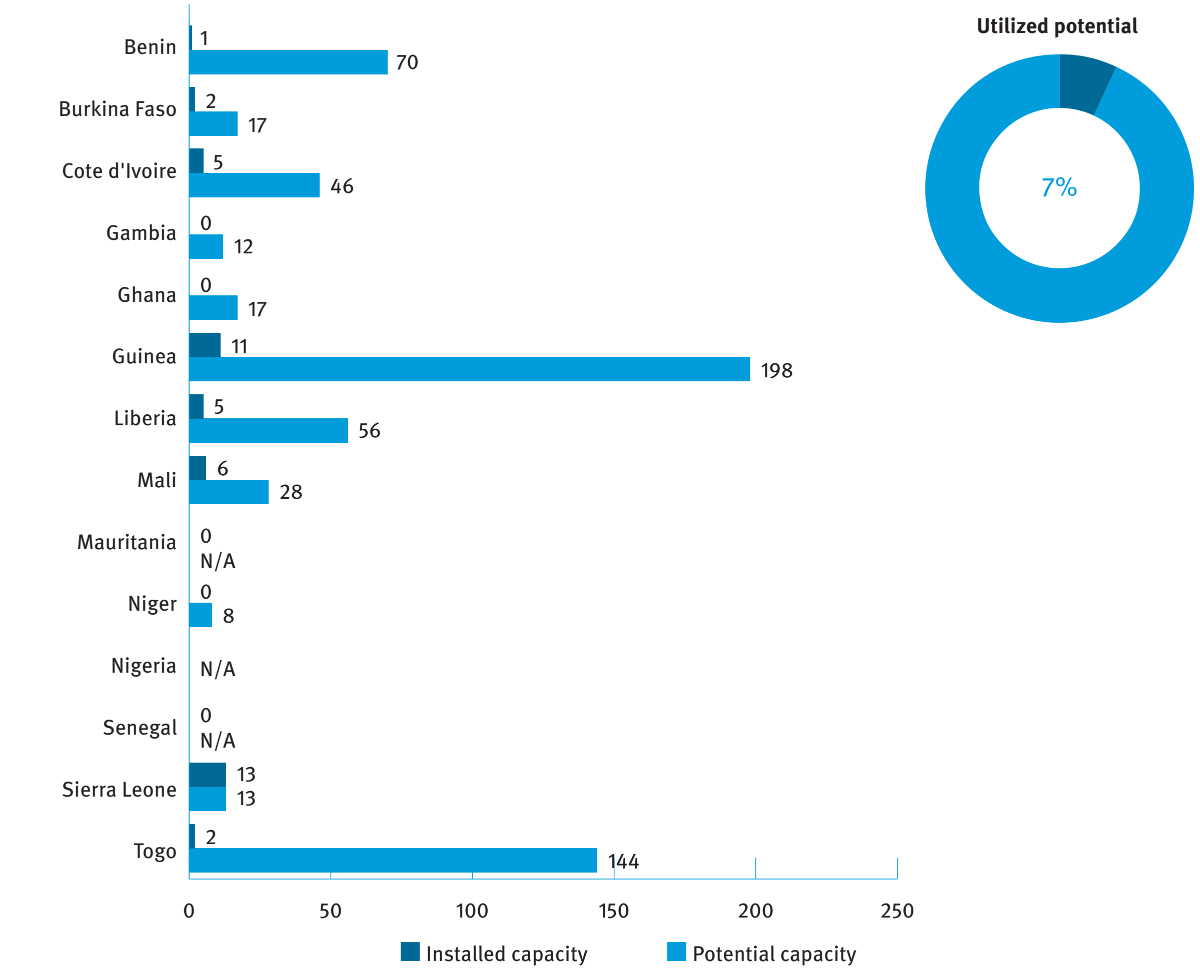
With regards to hydropower, **Benin** has great potential, particularly for SHP up to 30 MW and large-scale hydropower, but also mini- and micro-units. While the country's current SHP installed capacity (for SHP up to 30 MW) is 0.6 MW, three other sites up to 30 MW are in the planning stages and another 96 sites have been identified as potential sites for SHP development. Compared to the *WSHPDR 2016*, the installed SHP capacity increased by 100 kW, which is due to access to more accurate data.

In **Burkina Faso**, although SHP installed capacity has remained unchanged since the *WSHPDR 2013*, SHP is slated for an increase in installed capacity. The Samandeni dam has already been built, and the construction of a 2.5 MW plant is reported to be underway on it. The currently available SHP plants (up to 10 MW) – the Tourni (0.6 MW) and the Niofila (1.68 MW) – provide 2.3 MW of capacity. The country also plans an extension of the Bagré dam and the improvement of its economic profitability. A number of other projects have been considered for development, but no progress has been made in this regard as of yet.

In **Côte d'Ivoire,** there is a single operational SHP plant of 5 MW, which was constructed in 1983. However, the plant is currently in need of refurbishment. When drawing upon the ECOWAS definition of up to 30 MW, the country's SHP capacity increases to 55 MW due to the Ayame 1 and Ayame 2 plants. Studies conducted in previous years have identified promising hydropower development projects, with a total potential of 40.7 MW (for SHP up to 10 MW).

Gambia has no installed hydropower capacity. However, within the framework of the OMVG (Gambia River Basin Development Organization), hydropower projects are planned in neighbouring countries that will also benefit Gambia. Cross-border trade will be important for the country to emerge from its current situation of isolation in regards to the energy supply. There are five hydropower projects that are being planned or considered in conjunction with the OMVG that will affect Gambia, and they are forecast to have a combined capacity of 68 MW.

Figure 18.
Installed and potential capacity in Western Africa for SHP up to 10 MW (MW)



Source: *WSHPDR 2019*

In **Ghana**, the Sustainable Energy for All Action Plan 2012 sets targets of reaching 10 per cent of the energy mix from RE and of reducing the share of combustible RE sources to below 50 per cent by 2020. Currently, there are no SHP plants and no financial mechanisms specifically for SHP. However, there are a number of incentives for rural electrification that exist as part of the National Electrification Scheme.

The Government of **Guinea** has several plans for the development of SHP plants in its pursuit of increasing the efficiency of, and access to the grid. Four projects with a combined capacity of 13.7 MW have been prioritized. The Government has already developed hydropower plants in Tinkisso (1.65 MW) in order to generate electricity for the cities of Dabola, Faranah and Dinguiraye, and at Kinkon (3.5 MW) in order to generate electricity for the cities of Pita, Labe and Dalaba. The total installed capacity of SHP up to 10 MW in Guinea is 10.8 MW, while the potential is estimated at 198 MW. Compared to the *WSHPDR 2016*, the SHP installed capacity has slightly decreased due to the Seredou plant no longer being in operation.

The current installed SHP capacity (up to 30 MW) in **Liberia** comes from two plants: a community-owned 60 kW plant and a concession-owned 4.8 MW plant belonging to the Firestone Company. The increase of 0.8 MW compared to the *WSHPDR 2016* is due to access to more accurate data. A number of SHP projects are currently being implemented and/or have been earmarked. The construction of a 1 MW Mein River plant was expected to be completed in 2015, but has presently stalled. Additionally, a feasibility study has been completed for a 15 kW project along the Wayavah Falls and a number of hybrid renewable energy systems have been developed under the Scaling Up Renewable Energy Programme (SREP).
The installed capacity of SHP in **Mali** has remained unchanged since the *WSHPDR 2016*, at 5.7 MW (for SHP up to 30 MW). However, a number of micro- and mini-hydropower plants are under development with the support of SREP and the African Development Bank. These projects combined are projected to bring an additional capacity of 30.5 MW. It is estimated that there is at least 56 MW of SHP potential up to 30 MW that could be developed in the country.

Mauritania has some hydropower capacity, however, it all originates from large-scale plants developed through the Senegal River Basin Development Organization (OMVS) and, hence, it is shared among the participating countries. The country has no SHP plants and the SHP potential remains unknown.

Similarly, **Niger** has no installed SHP capacity. However, four rivers on its territory have been identified as having a combined potential for SHP development of 8 MW (for SHP up to 10 MW).

Conversely, **Nigeria** has the highest SHP installed capacity in the region at 64.2 MW and an economic potential of at least 735 MW (both for SHP up to 30 MW). A number of projects in the country were developed with the support of the UNIDO and a significant number of potential sites have been identified. Compared to the *WSHPDR 2016*, the installed capacity increased by 9.2 MW. However, the progress in SHP development has been slower than expected. There are plans to encourage investment from the private sector in small, mini- and micro-hydropower projects, particularly in rural and off-grid areas.

While **Senegal** does not currently have any installed hydropower plants on its territory, hydropower in general plays an important role in electricity generation for the country. Under the OMVS framework, the Manantali plant in Mali provides Senegal, Mali and Mauritania with 200 MW of electricity. Senegal also receives electricity from the 60 MW Felou plant shared with Mali and Mauritania.

In **Sierra Leone**, the total SHP installed capacity is 12.9 MW (according to the 30 MW definition). Between 2015 and 2017, three new SHP plants were commissioned – the 2.2 MW project in Charlotte, the 2 MW project in Port Loko and the 3 kW Makali project. Compared to the *WSHPDR 2016*, installed capacity has increased by approximately 0.7 MW, which is due both to new developments and to access to more accurate data. A Small Hydropower Technology Centre was also opened at Fourah Bay College in 2016.

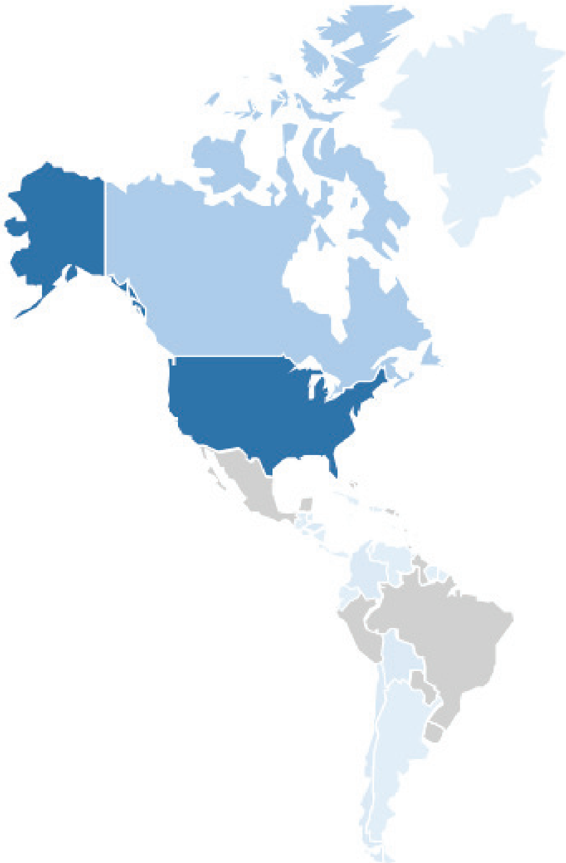
Even though **Togo** has only one SHP (up to 10 MW) plant of 1.6 MW currently in operation, the Government is making investments to change this in the foreseeable future. Seven economically-feasible sites with a combined capacity of 40 MW have been identified. Since the *WSHPDR 2016*, installed SHP capacity has remained unchanged.

FITs are in place in Ghana and Nigeria, while legislation in Gambia and Senegal has laid the foundation for the introduction of a FIT scheme. In Sierra Leone, the Government has plans to introduce policies for FITs.

Mutwanga SHP supplying reliable and affordable electricity to the people of North Kivu, the Democratic Republic of the Congo.

Americas

The Americas consist of four regions: the Caribbean, Central America, Northern America and South America. Northern America and South America dominate the SHP landscape in all of the Americas through Brazil, Canada and the United States of America, with these three countries having an extensive amount of installed and potential SHP capacities. Countries in the Caribbean and Central America regions, with the exception of Mexico, have significantly less estimated potential. However, it is likely that further studies in the future could reveal greater potential in the Caribbean and Central America.



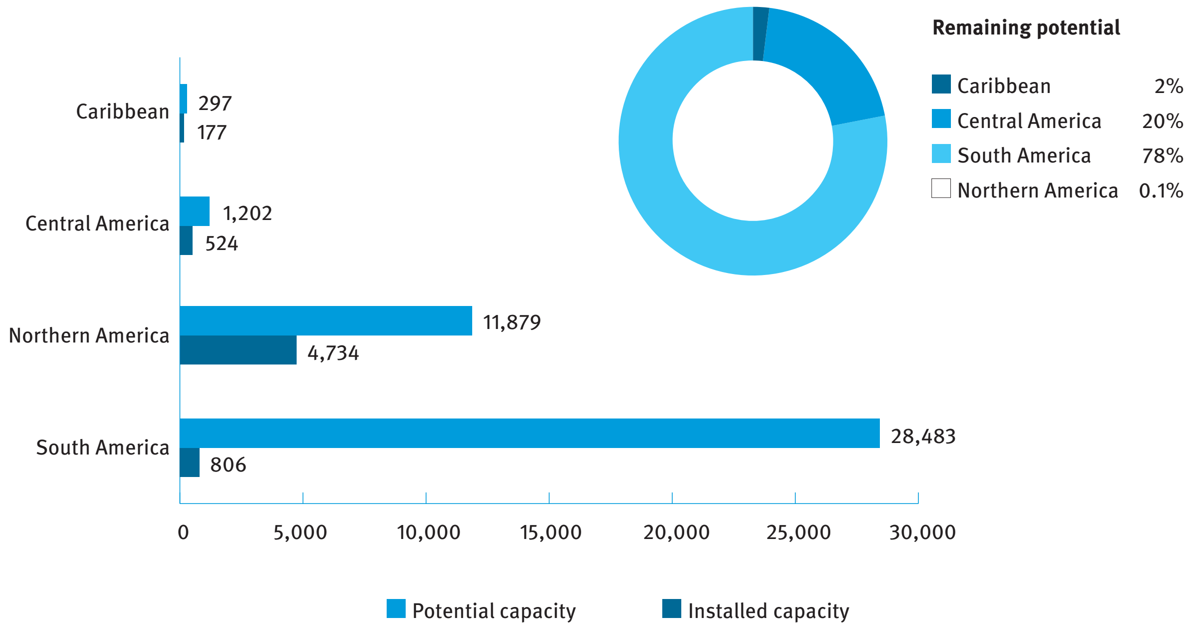
The total SHP capacity in the Americas is 6,240 MW, while the total estimated potential is at 41,860 MW for up to 10 MW. Some countries with enormous expected SHP potential have not performed feasibility studies to determine their exact potential capacity. Mexico, for example, is a country that is suspected to have significant SHP potential but no studies have been conducted to determine the country's true SHP potential. According to the available data, at least 15 per cent of the SHP potential capacity has been developed in the Americas. Of the 30 countries in the region, three have established FITs relating to SHP. These three countries are Canada, the United States of America (though in the USA FITs are only implemented by certain states) and Ecuador.

Many of the countries in these four regions have also established policies that incentivize the SHP sector. The Americas as a whole, however, still face barriers to SHP development. This is mainly due to the high upfront costs of SHP plants, the lack of regulatory policies in many of its 30 countries and social resistance to hydropower as it is perceived by many local populations as a technology that degrades the environment and destroys ecosystems.

Country	*Local SHP definition*	*Installed capacity (local def.)*	*Potential capacity (local def.)*	*Installed (<10 MW)*	*Potential (<10 MW)*
Argentina	up to 50	410.2	-	97.0	430.0
Belize	-	-	-	10.3	21.7
Bolivia	up to 5	-	-	152.8	200.0
Brazil	up to 30	5,670	20,506	-	-
Canada	up to 50	3,400	15,000	1,113	-
Chile	up to 20	488.0	10,825	236.0	2,113
Colombia	up to 10	214.0	25,000	214.0	25,000
Costa Rica	-	-	-	125.5	-
Cuba	-	28.9	84.9	28.9	84.9
Dominica	up to 10	4.8	4.8	4.8	4.8
Dominican Republic	up to 10	59.3	59.3	59.3	59.3
Ecuador	up to 10	98.2	296.6	98.2	296.6
El Salvador	up to 20	42.0	158.0	22.6	119.8
French Guiana	up to 10	6.3	-	6.3	-
Greenland	up to 10	8.8	183.1	8.8	183.1
Grenada	-	0	7.0	0	7.0
Guadeloupe	up to 10	11.1	16.1	11.1	16.1
Guatemala	up to 5	114.3	201.0	-	-
Guyana	up to 5	0	24.2	0	92.1

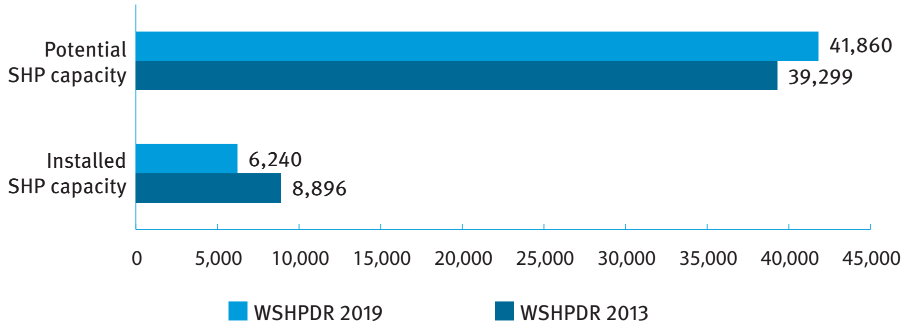
Haiti	up to 10	7.0	20.9	7.0	20.9
Honduras	up to 30	301.8	-	128.0	385.0
Jamaica	up to 10	16.6	45.5	16.6	45.5
Mexico	up to 30	699.3	-	-	-
Nicaragua	up to 10	18.6	85.7	18.6	85.7
Panama	up to 20	213.5	417	104.8	263.3
Paraguay	up to 50	0	116.3	0	86.3
Peru	up to 20	363	1,600	-	-
Puerto Rico	up to 10	41.8	47.9	41.8	47.9
Saint Lucia	-	0	2.7	0	2.7
Saint Vincent and the Grenadines	up to 10	7.0	7.4	7.0	7.4
Suriname	-	-	-	1.0	2.7
Uruguay	up to 50	0	232.0	0	207.8
USA	-	-	-	3,612.0	10,583.0
Venezuela	-	-	-	0.3	48.0

Figure 19.
Installed and potential capacity in the Americas regions for SHP up to 10 MW (MW)



Source: *WSHPDR 2019*

Figure 20.
Comparison of installed and potential capacity in the Americas regions for SHP up to 10 MW (MW)

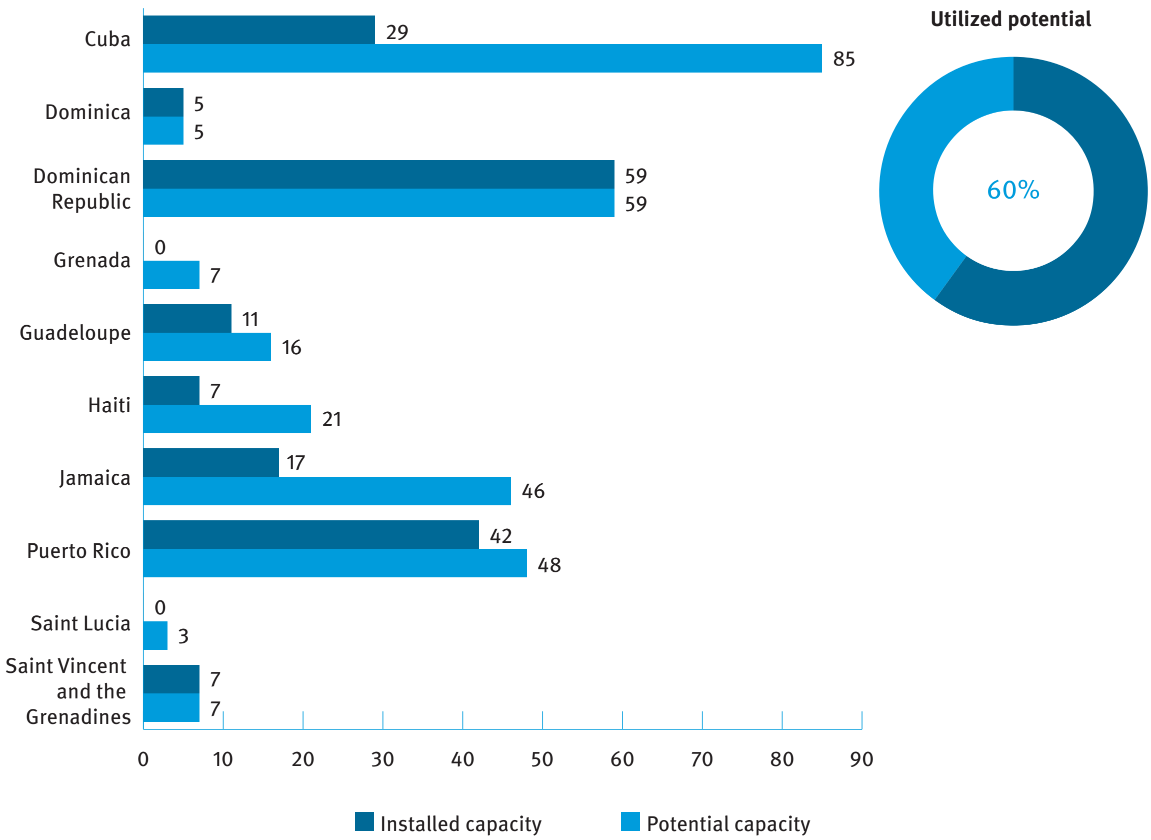


Source: *WSHPDR 2019*

Caribbean SHP overview

Cuba, Dominica, the Dominican Republic, Grenada, Guadeloupe, Haiti, Jamaica, Puerto Rico, Saint Lucia and Saint Vincent and the Grenadines

Figure 21.
Installed and potential capacity in the Caribbean for SHP up to 10 MW (MW)



Source: *WSHPDR 2019*

An overview of SHP in the countries of the Caribbean is outlined below. The information used in this section is extracted from the country profiles, which provide detailed information on SHP capacity and potential, along with other energy-related information.

With 161 SHP plants with a combined capacity of 28.9 MW, **Cuba** accounts for 15 per cent of the region's installed SHP capacity. Its total potential remains unknown. However, based on the planned projects, it is possible to conclude that there is at least 56 MW of undeveloped potential, indicating that approximately 34 per cent of the known SHP potential has been developed. The Government has initiated construction of these plants and will include the conversion of existing dams and water channels for hydropower generation.

The installed capacity of SHP in **Dominica** is estimated at 4.8 MW. Previously, the country had three SHP plants – Laudat, Trafalgar and Padu. However, Hurricane Maria severely affected the entire country, including the existing hydropower facilities. The Padu hydropower plant was destroyed and as of the end of 2018 it remains non-operational. The Trafalgar plant experienced minor damage to the building structure, while the Laudat plant remained intact. The country's SHP potential remains unknown.

The **Dominican Republic** has 16 state-owned operational SHP plants with a combined installed capacity of 57.8 MW. More than 60 per cent of these plants have a capacity of less than 2.5 MW. There are also 52 operational micro-hydropower systems, ranging from 10 kW to 150 kW, with a combined installed capacity of 1.5 MW. There has been no comprehensive study of the country's hydropower potential. Therefore, the country's SHP potential remains unknown.

In **Grenada**, there are no operational SHP plants. In the past, sugar cane estates used hydro wheels to operate mills, but none of these early hydropower stations are still in operation today. Several studies have been undertaken to assess hydropower potential, which is estimated to be at least 7 MW. However, none of the identified sites have been developed as yet.

The installed capacity of SHP in **Guadeloupe** is 11.1 MW, while the total potential remains unknown. However, two feasibility studies have identified an additional potential of 5 MW. Therefore, the SHP potential can be estimated to be at least 16.1 MW. Although the Government has expressed the intention of increasing hydropower's share of the country's energy mix, the development of these sites still remains in the planning phase.

The installed SHP capacity of **Haiti** is 6.96 MW, which comes from seven plants. Over the years, the available capacity of the plants has decreased by almost half due to ageing equipment and a lack of maintenance, and currently stands at 3.7 MW. The most recently commissioned plant is an 11 kW micro-hydropower plant installed in the small community of Magazen in the Nord-Est province in 2016. The country's untapped SHP potential is estimated at 13.95 MW.

Jamaica has eight SHP hydropower plants, which contribute approximately 30 MW to the grid. It should be noted that the Maggoty plant recently had an extension, which brought its total capacity above the 10 MW upper limit. Therefore, the plant is no longer included in the country's SHP total capacity, which now stands at 16.6 MW. In addition, 11 sites with approximately 29 MW of potential capacity have been identified as having potential for hydropower development, indicating that 36 per cent of the known potential has been developed.

There are eight SHP plants in **Puerto Rico**, with an aggregate capacity of 41.8 MW distributed among 15 units. Before Hurricane Maria, there were plans to redevelop a 3 MW plant at the Carraizo Dam, which had been destroyed in 1989 by Hurricane Hugo. SHP potential is estimated at 47.9 MW, indicating that almost 88 per cent of the known potential has been developed.

There are no hydropower plants operating in **Saint Lucia**. A small plant of 240 kW, which was installed several years ago at a small eco-tourist attraction at Latille Falls, is no longer operational due to the damage incurred during a storm. The country's SHP potential is estimated at 2.7 MW.

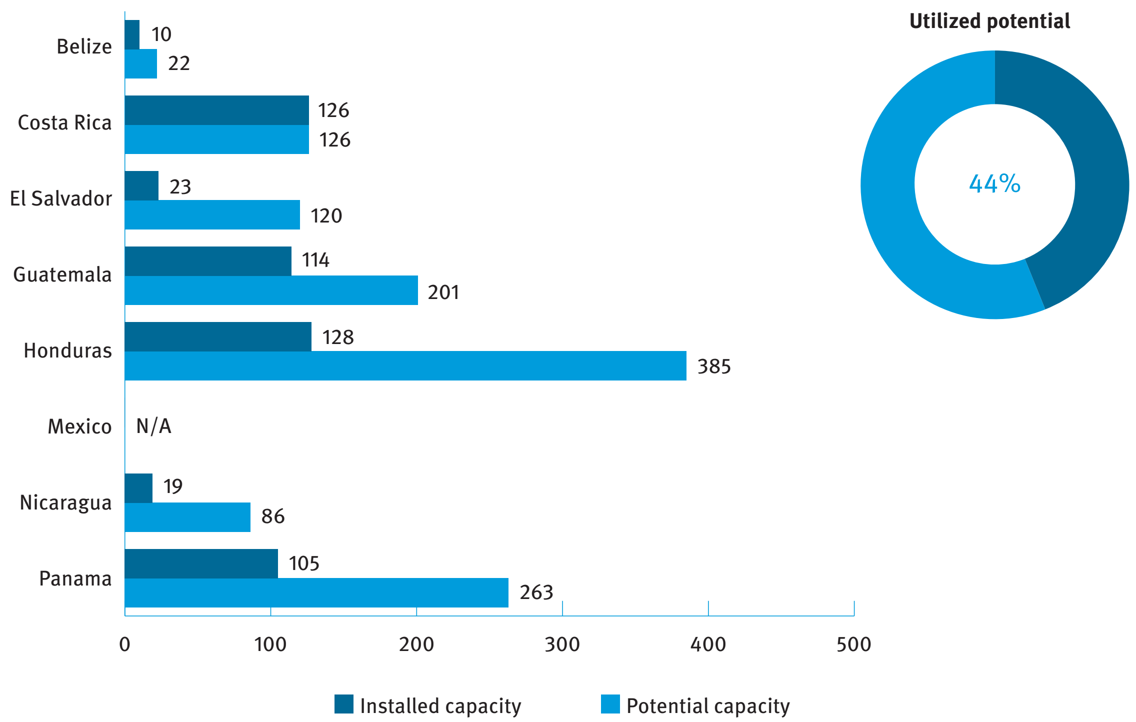
The installed capacity of SHP in **Saint Vincent and the Grenadines** is 7 MW. The potential capacity is estimated at 7.4 MW, which is based on the planned projects. However, considering the Government's ambitious renewable energy programmes, it may be assumed that the actual potential is much greater. A programme also exists that aims to modernize the existing plants in order to enhance their efficiency.

Most countries in the region have not introduced **FITs**. The Dominican Republic has established incentives and FITs for renewable energy sources, but these do not apply to hydropower. In Puerto Rico, companies producing energy for domestic consumption can benefit from the Green Energy Fund programme. The Government of Puerto Rico also introduced tradable Renewable Energy Certificates (RECs), which support the development of the renewable energy sector.

Central America SHP overview

Belize, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua and Panama

Figure 22.
Installed and potential capacity in Central America for SHP up to 10 MW (MW)



Source: *WSHPDR 2019*

An overview of SHP in the countries of Central America is outlined below. The information used in this section is extracted from the country profiles, which provide detailed information on SHP capacity and potential, along with other energy-related information.

In **Belize**, the installed capacity of SHP plants below 10 MW has not changed since the *WSHPDR 2016* and remains at 10.3 MW. The additional potential is estimated to be at least 11.4 MW, indicating that 48 out of nearly 50 per cent of the country's potential has been developed. The national development plan for Belize, called Horizon 2030, includes the promotion of green energy and energy efficiency as one of its strategic priorities. This includes the creation of an institutional framework for producing a viable energy policy. The country's National Sustainable Energy Strategy 2012-2033 aims to institutionalize a countrywide infrastructure to collect data in order to identify feasible sites for the development of solar, wind and hydropower energy.

In terms of RE development, **Costa Rica** has invested heavily in the sector and has become a world leader in generating electricity through RE sources. The installed capacity of SHP up to 10 MW in Costa Rica is reported to be 125.5 MW, while the available potential remains unknown. However, SHP does not seem to be a priority among RE sources. In the 2016-2035 Generation Expansion Plan, there are no planned SHP projects from the public services distribution companies. In addition, over the last years, moratoriums on hydropower development (including SHP) have been signed by some municipal councils concerned about the environmental impacts. Finally, the central Government has also established a moratorium on watersheds with a high potential for hydropower development. In general, the energy plans in Costa Rica seek to diversify RE sources, especially with respect to non-conventional sources (wind, solar and biomass), however, there are no specific plans for hydropower or SHP development.

In **El Salvador**, the installed capacity of SHP up to 10 MW is 22.6 MW. This slight increase, compared to the *WSHPDR 2016*, is due to the modernization and refurbishment of certain plants. The potential capacity is at least 119.8 MW and could be developed by the year 2026. In terms of RE policies, one of the strategic guidelines of the National Energy Policy 2010-2024 (NEP) is the diversification of the energy mix and the promotion of RE sources. Therefore, in order to ease the implementation of RE generation projects, several adjustments were made to the legal and regulatory frameworks of the electricity and environmental sectors, and to taxation regulations.

In **Guatemala**, the installed capacity for SHP plants up to 5 MW was 114.3 MW, while the potential is estimated to be at least 201.0 MW, indicating that approximately 57 per cent of the known potential has already been developed. The 2013-2027 Energy Policy includes plans for the promotion of RE sources in electricity generation, with a long-term goal of generating 80 per cent of electricity from RE. There is also the National Energy Plan 2017-2032, which establishes an additional installed capacity target of 6,102 MW by 2032, with 58 per cent coming from hydropower. This Plan also promotes the "Law of Incentives for Renewable Energy Development", energy efficiency and the reduction of greenhouse gas emissions by 29.2 per cent by 2032.

The installed SHP capacity of **Honduras** (up to 10 MW) increased to 128 MW, with the potential being estimated at 385 MW. The Government of Honduras intended to reverse the structure of the country's electricity sector to a ratio of 60 per cent RE and 40 per cent fossil fuel by 2022, but that target has already been achieved. Also, the Honduras Scaling-Up Renewable Energy Programme in Low-Income Countries (SREP) is financing a series of activities aimed mainly at improving rural electrification and developing the country's RE sector.

In the case of **Mexico**, the installed SHP capacity (up to 30 MW) has reached 699.3 MW. This increase is due to a significant number of generation permits being issued before the 2013 Energy Reform, and to developers willing to benefit from the previous regulatory framework. The new Government plan from the 2018 Presidential election focuses on reducing the use of natural gas by increasing the generation from existing hydropower plans and building new ones. Also, this plan aims to reduce domestic electricity tariffs. The potential of SHP in Mexico remains unknown.

In **Nicaragua**, there are 14 operational SHP plants up to 10 MW with a combined capacity of 18.61 MW, and an additional 20 potential sites with a combined capacity of 67.06 MW have been identified. Even though there is no RE policy in place in Nicaragua, the National Energy Policy (2004) established a framework for the promotion of RE energy. Also, the Plan for Electricity Generation Expansion for the 2016-2030 period includes the addition of 1,223 MW of new capacity, of which 783 MW will come from RE sources. Among these RE sources, hydropower will see the greatest capacity addition in the coming decade. There is also a favourable legal and attractive incentive structure for SHP projects up to 5 MW.

It is reported that for SHP up to 10 MW in **Panama**, there are 20 plants with a combined installed capacity of 104.8 MW and 33 plants with concessions granted or pending with a combined capacity of 158.45 MW. High prices and energy consumption levels led to the promulgation of Law 44 of April 2011, which aims to promote wind power and diversity in RE sources. Also, the Paris Climate Change Agreement has become a driver in promoting the use of RE sources. Panama has pledged to increase the RE share in its electricity generation mix by 30 per cent by the end of 2050, using the year 2014 as a baseline.

No **FITs** have been introduced in the region. However, the Governments in the region grant a range of other incentives for the development of RE technologies.

Northern America SHP overview

Canada, Greenland and the United States of America (USA)

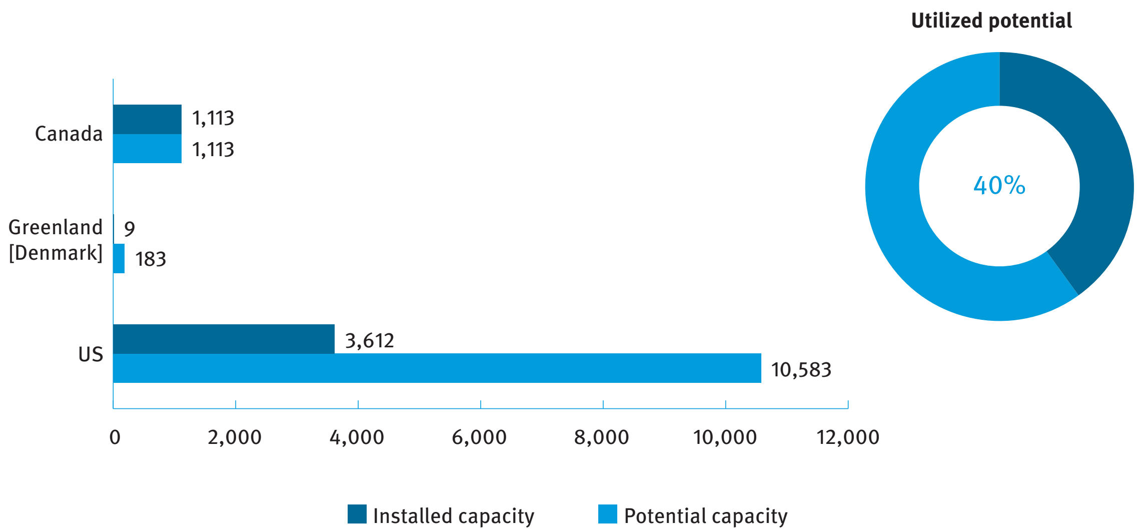
An overview of SHP in the countries of Northern America is outlined below. The information used in this section is extracted from the country profiles, which provide detailed information on SHP capacity and potential, along with other energy-related information.

The installed capacity of SHP up to 50 MW in **Canada** is 3,400 MW, while the technical potential is estimated to be 15,000 MW, indicating that 23 per cent has been developed to date. Since the *WSHPDR 2016*, the installed and potential capacities for SHP up to 50 MW have remained unchanged. No new data has been made available for SHP up to 10 MW either. Therefore, it is assumed to have remained at the same level (1,113 MW). SHP accounts for approximately 4 per cent of total hydropower installed capacity in Canada. In general, hydropower plays an important role in the country's energy mix, accounting for approximately 60 per cent of its electrical energy. Some Canadian provinces, such as British Columbia, Manitoba and Quebec, are nearly exclusively hydroelectric, while other regions contain virtually no small or large hydropower.

Greenland has two SHP plants with a combined capacity of 8.8 MW, while the potential is estimated to be over 180 MW. Thus, only 4.8 per cent of the known potential has been developed. The small degree of utilization might to some extent be explained by low levels of electricity consumption. Since the *WSHPDR 2016*, no updates have been made available with regards to the country's SHP capacities, and no further plans to develop SHP have been announced. While hydropower remains by far the most important renewable energy source in Greenland, there have been several small-scale initiatives to examine the potential of other renewable energy technologies, including solar and wind.

The **USA** has the greatest capacity of SHP up to 10 MW in the region at 3,612 MW, which accounts for 34 per cent of the country's known technical SHP potential. This cumulative installed capacity comes from 1,646 SHP plants. Even though hydropower accounts for only 7 per cent of the country's electricity generation, similar to Canada there are regions in the USA that are dominated by hydroelectric generation (e.g. the north-west and Appalachia). As of the end of 2017, the "pipeline" of planned SHP projects contained 165 projects with a total combined capacity of 420 MW, the majority of which (159 projects) involve adding hydropower generation to existing dams or conduits

Figure 24.
Installed and potential capacity in Northern America for SHP up to 10 MW (MW)



Source: *WSHPDR 2019*

Among the countries of the region, **FITs** have been introduced in Canada and the USA. In Canada, incentives for renewable energy sources are provided at the provincial level, leading to a significant variation in such incentives across the country. Ontario recently suspended its FIT programme in 2016 and the Nova Scotia Community FIT Programme is no longer accepting applications. In the USA, individual states have adopted policies to encourage renewable energy development, including renewable portfolio standards and FITs. Some states have created programmes and policies specifically to provide financial support for the development of SHP. Certain incentives are also provided at the federal level.

South America SHP overview

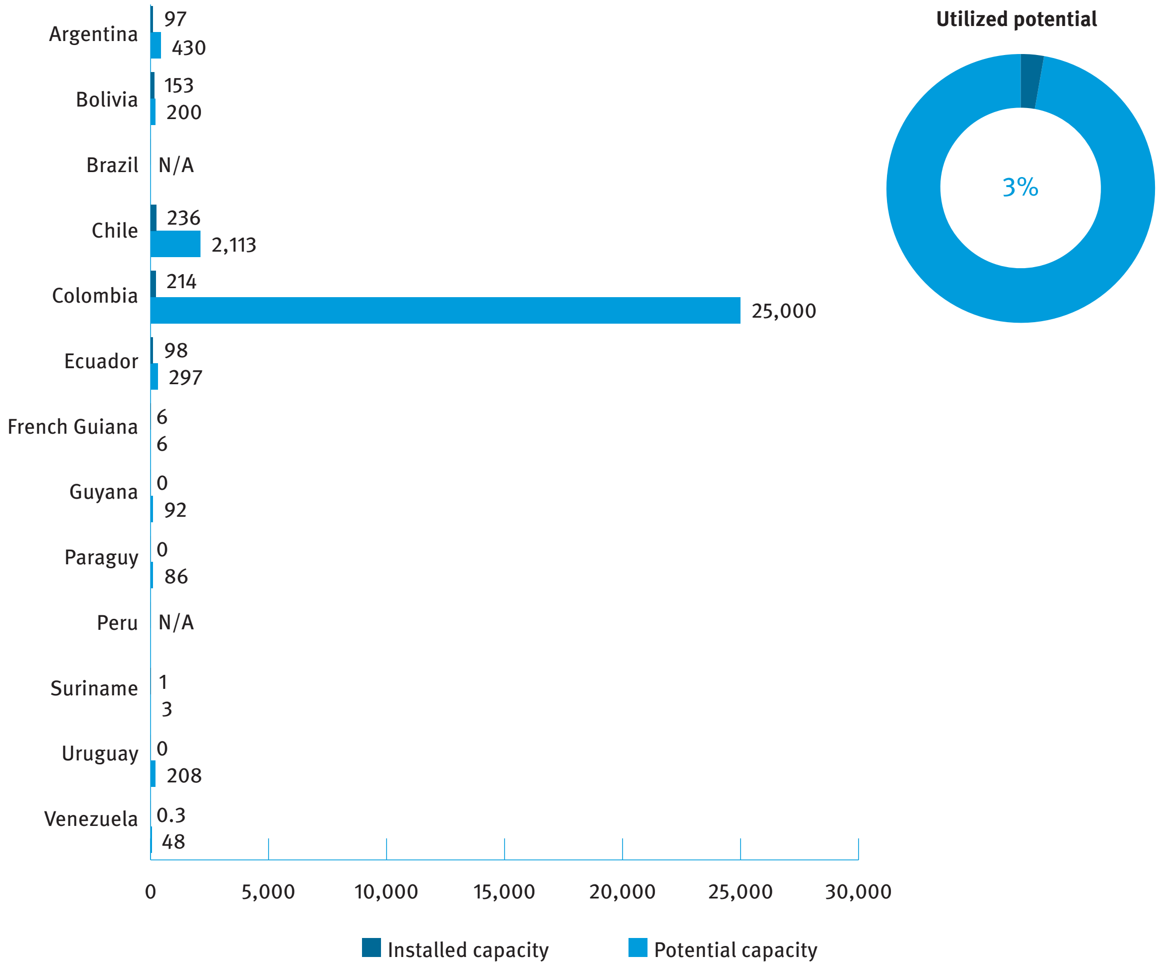
Argentina, the Plurinational State of Bolivia, Brazil, Chile, Colombia, Ecuador, French Guiana, Guyana, Paraguay, Peru, Suriname, Uruguay and the Bolivarian Republic of Venezuela

An overview of SHP in the countries of South America is outlined below. The information used in this section is extracted from the country profiles, which provide detailed information on SHP capacity and potential, along with other energy-related information.

In **Argentina**, the installed capacity of SHP following the local definition of up to 50 MW is 410 MW. For SHP up to 10 MW, the installed capacity is 97 MW. Multiple renovation projects for SHP plants are planned for the period between 2019 and 2023. It is thus expected that the installed capacity will increase considerably in the coming years. There is great potential for SHP in Argentina, which is estimated at 430 MW.

Bolivia has 33 SHP plants (up to 10 MW). Their total installed capacity is 152.8 MW, while the available capacity is 124.8 MW. In rural areas, there are many SHP plants supplying small villages or industry, most of which are out of service or in a poor condition and could be eligible for refurbishment. The Government's strategic plan foresees the development of hydropower below 30 MW and includes SHP projects of approximately 30 MW for grid connection and another 20 MW for isolated networks. This brings the total known potential of SHP in Bolivia up to approximately 200 MW.

Figure 23.
Installed and potential capacity in South America for SHP up to 10 MW (MW)



Source: *WSHPDR 2019*

According to the latest data, there are 1,098 SHP plants up to 30 MW in operation in **Brazil** with a combined installed capacity of 5,670 MW. The potential is estimated at 20,506 MW, including 7,021 MW of the potential available in the short term and 1,856 MW already suitable for auctions. However according to the Brazilian Decennial Plan for Energy Expansion 2026, the installed capacity of SHP is predicted to reach 6,658 MW in 2020 and 7,858 MW in 2025, thus indicating that the relative share of SHP in the country's energy mix is not expected to grow substantially.

In **Chile**, the available installed capacity of SHP up to 20 MW is 488 MW. Additionally, in 2018 there were 46 MW of SHP under construction and 824 MW was approved for development. For SHP up to 10 MW, the total installed capacity was estimated to be 236 MW out of a potential 2,113 MW. The increase in the installed capacity compared to the WSHPDR 2016 was mainly due to regulatory changes that simplified the processing of projects under 9 MW and particularly those under 1.5 MW.

The SHP installed capacity of **Colombia** is 214 MW. A decrease of 14 per cent compared to the *WSHPDR 2016* is based on more accurate data. The SHP potential is estimated at 25,000 MW, of which less than 0.9 per cent has been developed. From the beginning of 2016 until the end of May 2019, 23 applications for SHP certification were received, of which 17 projects with a combined capacity of 54.2 MW were approved.

The total installed capacity of SHP plants of up to 10 MW in **Ecuador** stands at 98.2 MW, from 37 plants. Some of the most recently commissioned plants include the Victoria SHP plant of 10 MW, the Hydrotambo plant of 8 MW and the Central Alazan plant of 6.23 MW and the Government has approved the construction of a number of new projects. Based on the conducted feasibility studies, the potential capacity is estimated at 296.6 MW.

In **French Guiana**, the installed capacity of SHP remains at 6.3 MW, similar to figures from the *WSHPDR 2016*. The two SHP plants in operation are: La Mana, with an installed capacity of 4.5 MW and Saut-Maripa, with a capacity of 0.88 MW. The potential SHP capacity figures for French Guiana are unavailable, but several sites were identified on the Mana, Compté and

Approuague rivers. These sites may produce 7 MW to 15 MW in the near future. However, the lack of funding in the field of SHP as well as the growing popularity of electricity generated through solar power, makes investment in this sector less probable.

Although **Guyana** has a track record of hydropower use, not one single hydropower plant is currently operational. Nevertheless, hydropower initiatives are currently being considered and supported by the Government of Guyana. The potential capacity is estimated to be 24.2 MW for the 5 MW threshold and 92.1 MW for the 10 MW threshold.

There are no SHP plants (up to 50 MW) in operation in **Paraguay**. The country has enormous hydropower potential, but total SHP potential remains unknown. Based on the projects planned for completion by 2025, it is possible to conclude that there is at least 116.3 MW of undeveloped potential. This capacity comes from 18 SHP projects (up to 50 MW) planned to be developed across the country for decentralized electricity generation.

Peru has significant SHP potential (up to 20 MW), which is estimated to be at least 3,500 MW based on a portfolio of potential hydropower projects compiled by the Ministry of Energy and Mines in 2016. The total installed capacity for all SHP plants up to 20 MW is 362.9 MW. Compared to the *WSHPDR 2016*, the reported installed capacity decreased by 7 per cent since the new reported values were obtained from more accurate data.

The installed SHP capacity of **Suriname** (up to 10 MW) is 1 MW. Based on the planned plants, the potential is estimated to be at least 2.7 MW, but is expected to be higher. But the Rural Small Hydro Project was cancelled nonetheless due to budget limitations.

Uruguay has only large-scale hydropower plants with capacity above 50 MW. The potential of SHP up to 50 MW is estimated at 232 MW, which comes from 70 potential sites, including existing irrigation dams. Out of these sites, 68 have a capacity of less than 10 MW, with their combined capacity being 207.8 MW.

There are several SHP plants in **Venezuela**, all of them below 1 MW. The total installed capacity is at least 295 kW. The potential is estimated at 48 MW, and thus less than 1 per cent of the potential has been developed so far.

Ecuador is one of the very few Latin American countries that implemented a **FIT** scheme for renewable energy, which applies to SHP up to 10 MW

People from Magazen community, Haiti transporting a community SHP generation system, which was inspired by community SHP projects in the Dominican Republic.

Asia

Asia has vast SHP resources that are, however, unevenly distributed across the continent. The total installed SHP capacity for Asia is 51,069 MW and the total estimated potential is 138,276 MW (for SHP up to 10 MW). This indicates that approximately 37 per cent has so far been developed.

The continent's installed SHP capacity has been increasing over the past few years. China dominates not only the Asian SHP landscape but also the whole world's. Globally, China accounts for approximately 54 per cent of the installed capacity and 28 per cent of the total potential capacity.

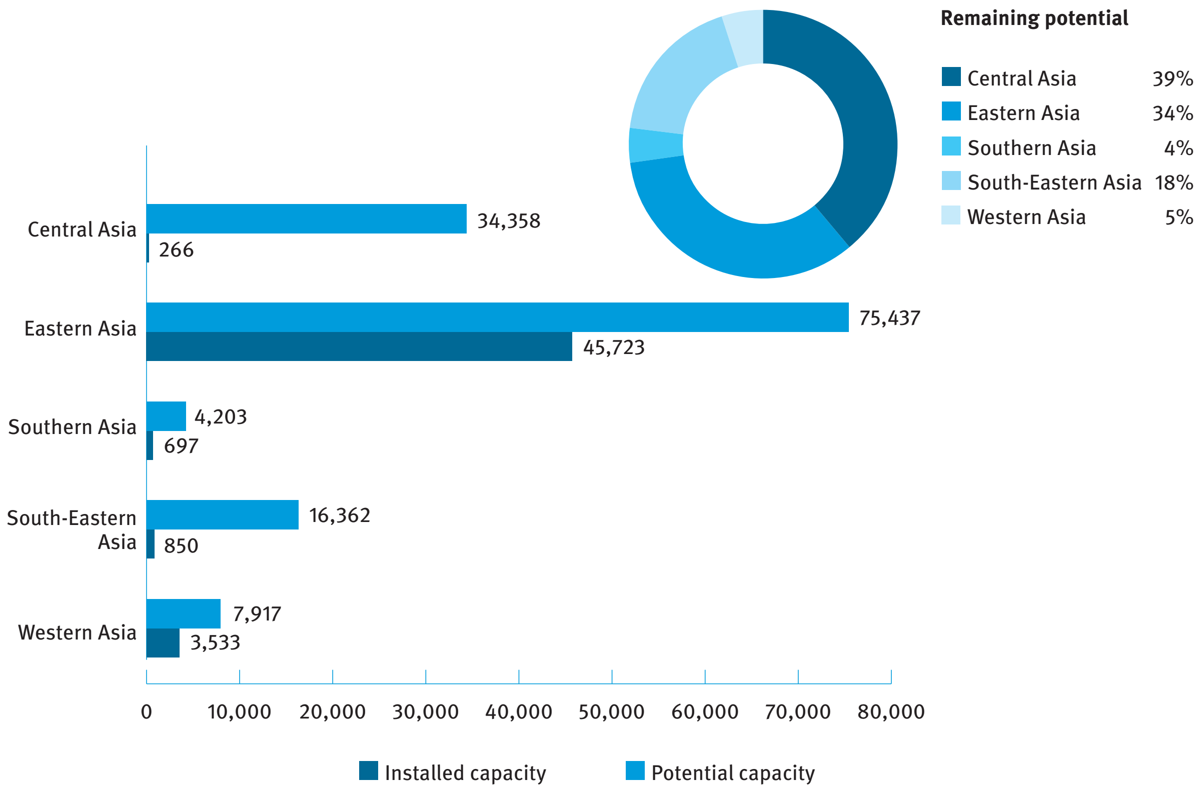
SHP development is one of the major priorities for countries in Asia. The key motives for SHP development in the content are to decrease dependence on fossil fuels, thus mitigating environmental problems; decrease dependence on energy imports; and improve access to electricity, especially in rural areas. Of the 37 countries on the continent covered in this Report, many have some form of renewable energy policy while 16 have established FITs related to SHP.

The barriers to SHP development vary across the continent. The major issues that complicate SHP development include the lack of skilled personnel and local technologies, limited financial resources, low electrify tariffs, water scarcity and limited data.

Country	*Local SHP definition*	*Installed capacity (local def.)*	*Potential capacity (local def.)*	*Installed (<10 MW)*	*Potential (<10 MW)*
Afghanistan	up to 10	75.7	1,200.0	75.7	1,200.0
Armenia	up to 30	353.0	422.0	327.8	-
Azerbaijan	up to 10	26.0	520.0	26.0	520.0
Bangladesh	-	-	-	0.06	59.5
Bhutan	up to 25	32.1	17,792.0	8.1	8.1
Cambodia	up to 10	1.7	300.0	1.7	300.0
China	up to 50	79,300	128,000	41,900	63,500
DPRK	-	-	-	83.2	-
Georgia	up to 13	178.0	335.5	142.3	187.4
India	up to 25	4,485	21,134.0	-	-
Indonesia	up to 10	403.0	12,800.0	403.0	12,800.0
Iran	up to 10	19.5	102.5	19.5	102.5

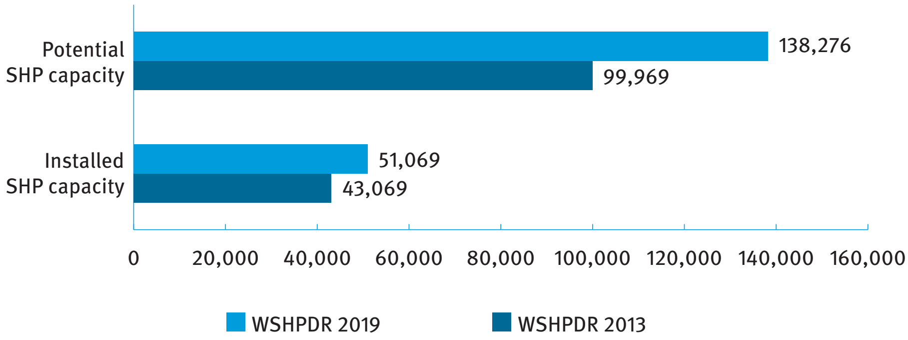
Iraq	-	-	-	6.0	26.4
Israel	-	-	-	6.0	-
Japan	up to 10	3,545	10,327	3,545	10,327
Jordan	up to 10	12.0	58.2	12.0	58.2
Kazakhstan	up to 35	200.3	4,800.0	116.0	2,707.0
Kyrgyzstan	up to 30	46.6	409.0	46.6	275.0
Laos	up to 15	148.1	2,287.0	50.4	-
Lebanon	up to 10	31.0	140.0	31.0	140.0
Malaysia	-	-	-	39.5	-
Mongolia	up to 10	5.22	27.0	5.22	27.0
Myanmar	-	-	-	36.4	231.0
Nepal	up to 25	446.8	4,196.2	236.2	1,959.5
Pakistan	up to 50	410.0	3,100.0	-	-
Philippines	up to 10	147.0	2,021.0	147.0	2,021.0
ROK	up to 10	189.7	1,500	189.7	1,500
Saudi Arabia	-	-	-	0	130.0
Sri Lanka	up to 10	357.0	873.0	357.0	873.0
Syria	up to 10	20.8	-	20.8	-
Tajikistan	up to 30	-	-	26.6	30,000.0
Thailand	up to 6	172.0	700.0	-	-
Timor-Leste	up to 50	0.35	-	0.35	219.8
Turkey	up to 10	2,961.3	6,500.0	2,961.3	6,500.0
Turkmenistan	-	-	-	1.2	1,300.0
Uzbekistan	up to 30	262.0	1,391.8	75.8	-
Viet Nam	up to 30	1,665.8	7,200.0	-	-

Figure 25.
Installed and potential capacity in Asia regions for SHP up to 10 MW (MW)



Source: *WSHPDR 2019*

Figure 26.
Comparison of installed and potential capacity in Asia regions for SHP up to 10 MW (MW)

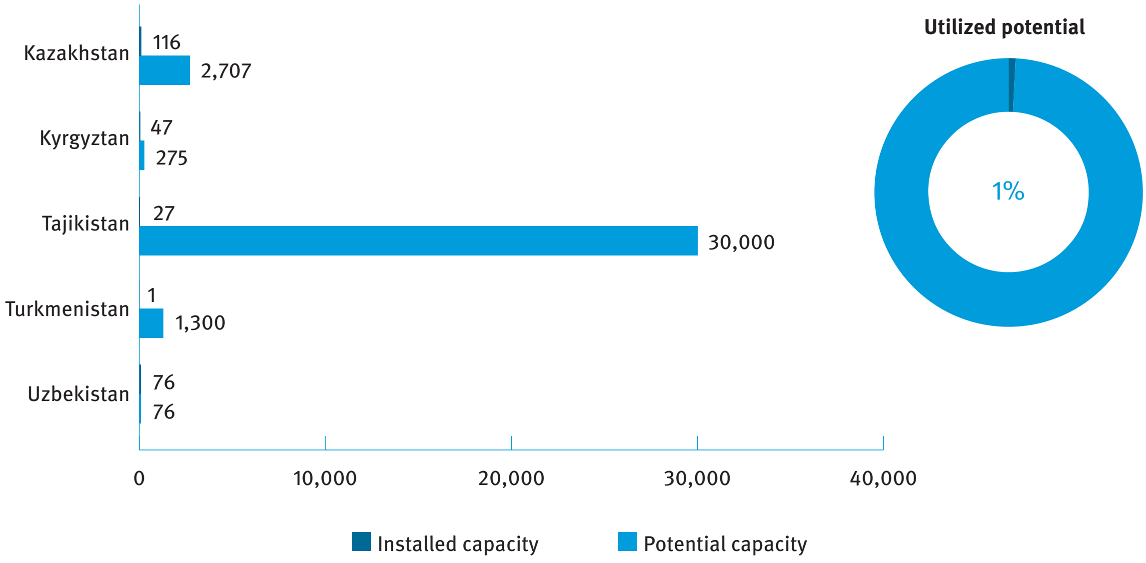


Source: *WSHPDR 2019*

Central Asia SHP overview

Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan

Figure 27.
Installed and potential capacity in Central Asia for SHP up to 10 MW (MW)



Source: *WSHPDR 2019*

An overview of SHP in the countries of Central Asia is outlined below. The information used in this section is extracted from the country profiles, which provide detailed information on SHP capacity and potential, along with other energy-related information.

The installed capacity of SHP up to 35 MW in **Kazakhstan** in 2018 was about 200 MW, while the technical potential was estimated to be at least 4,800 MW, indicating that 4 per cent has been developed. According to the most recent data available (2017), the installed capacity of SHP up to 10 MW is 78 MW, while the potential is estimated at 2,707 MW. Compared to the *WSHPDR 2016*, the installed capacity up to 35 MW increased by 68 per cent. According to the national plan concerning transitioning to a green economy, the share of alternative and renewable energy sources should make up 3 per cent by 2020, 30 per cent by 2030 and 50 per cent by 2050. The plan pledges to reduce the country's greenhouse gas emissions as well as introduce a pilot emissions trading system. There is considerable interest from investors in developing SHP in Kazakhstan, with many new prospective projects. In 2018, through tenders for renewable energy projects, a further 82 MW of SHP capacity was approved for development.

During the 1960s, **Kyrgyzstan** had 66 MW from some 200 SHP plants, which were all later decommissioned. The installed capacity of SHP (up to 30 MW) in 2017 was 46.6 MW coming from a total of 16 plants. There are also some micro-hydropower plants that are not registered however, and their total capacity is unknown. The SHP potential in the country is estimated at 409 MW, indicating that approximately 11 per cent has been developed. Since the *WSHPDR 2016*, the installed capacity has increased by almost 10 per cent. With the revival of SHP in the country, the State Committee for Industry, Energy and Subsoil Use plans to build and rehabilitate 132 SHP plants with a total capacity of 275 MW (less than 30 MW) by 2025.

A big part of the water resources in Central Asia originate from **Tajikistan**, and as such the country has among the highest hydropower potential in the region and in the world. As a result, the majority of the country's electricity generation comes from large-scale hydropower plants. However, SHP plays a vital role in providing electricity access to remote rural areas due to the sparse distribution of the population. The SHP potential up to 10 MW is estimated at 30 GW and the installed capacity is reported to stand at 26.6 MW, i.e. an increase of 2 MW in comparison with the *WSHPDR 2016.* More recent restoration initiatives for certain SHP plants, such as the Rudaki substation in the Sughd region, also contributed to this increase. A number of other reconstruction and rehabilitation projects in the SHP sector are underway. Furthermore, an action plan for investment in SHP was developed, which focuses on the commercialization of SHP, FITs and grid access systems, the SHP tax regime and accessible investment procedures.

Turkmenistan is located on the world's fourth largest natural gas reserve and has vast quantities of oil resources. Its abundance of fossil fuels has resulted in an energy sector dominated by thermal generation. Although hydropower potential, including SHP, is high (1,300 MW for SHP up to 10 MW), there are few incentives at the moment for the development of hydropower projects. There is only one hydropower plant in operation in Turkmenistan, which has a capacity of 1.2 MW and was commissioned in 1913. No other SHP plants have been constructed. However, a potential for the development of SHP on existing irrigation dams has been studied, particularly with the support of the European Bank for Reconstruction and Development (EBRD).

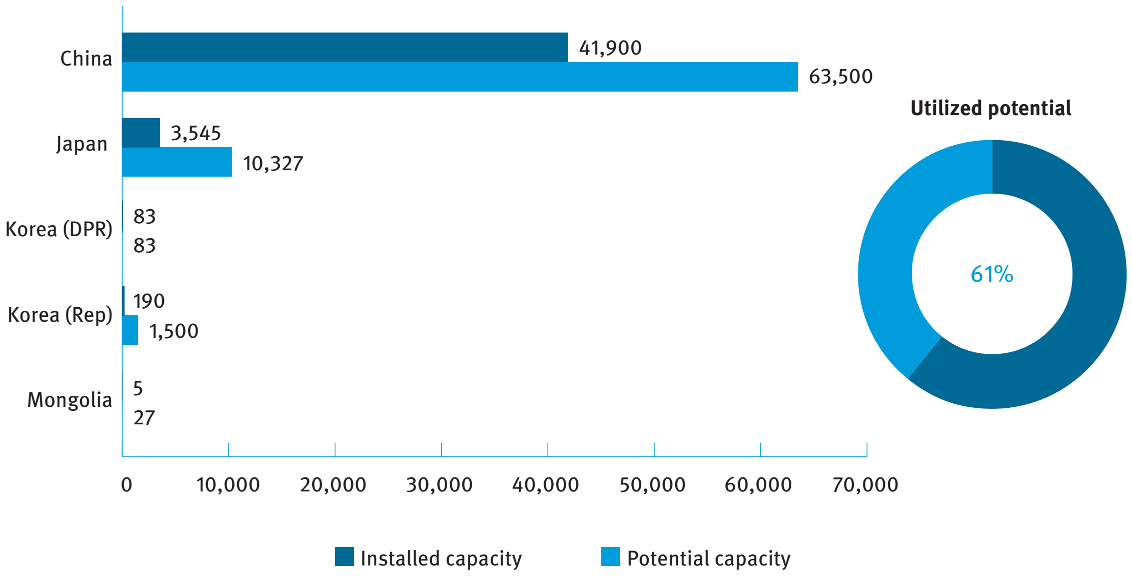
Both the Amu Darya and Syr Darya rivers flow through **Uzbekistan**, providing ample hydropower potential. However, due to previously built canals that have altered river flows and affected the Aral Sea, hydropower in general has not been widely pursued. In 2017, there were 15 SHP plants with capacities up to 10 MW and a combined installed capacity of 75.8 MW. The total installed capacity of SHP plants up to 30 MW was about 262 MW. The technical SHP potential of all water resources in the country including the small rivers, canals and reservoirs (up to 30 MW) was estimated to be about 1,392 MW. Thus, about 19 per cent of the potential has been developed. Since the *WSHPDR 2016*, the installed capacity up to 10 MW increased by 8 per cent. Construction of several new SHP plants with a combined capacity of 23.5 MW as well as refurbishment of the existing ones is planned by 2020.

All the countries in the region, except Turkmenistan, have adopted primary legislation on renewable energy and energy efficiency. The legislative framework includes introducing incentives such as grid-access, tax exemptions and **FITs**. FITs have been introduced in Kazakhstan, Kyrgyzstan and Tajikistan. However, starting from 2018, Kazakhstan switched from the FIT system to an auction system.

Eastern Asia SHP overview

China, the Democratic People's Republic of Korea (DPRK), Japan, Mongolia and the Republic of Korea (ROK)

Figure 28.
Installed and potential capacity in Eastern Asia for SHP up to 10 MW (MW)



Source: *WSHPDR 2019*

An overview of SHP in the countries of Eastern Asia is outlined below. The information used in this section is extracted from the country profiles, which provide detailed information on SHP capacity and potential, along with other energy-related information.

China is the regional leader in terms of both installed and potential SHP capacity (for both: up to 10 MW and 50 MW). Due to the support from the Government and the technological maturity of the domestic hydropower sector, SHP has developed rapidly in the country, with 47,498 SHP plants (up to 50 MW) widely distributed across the country as of 2017 (425 SHP plants more than in 2014). The total installed capacity of SHP up to 10 MW is 42 GW and of SHP up to 50 MW is 79.3 GW, of which approximately 60 per cent has been developed. According to the national programme of SHP development, by 2030 it is expected to exceed 93 GW of total installed SHP capacity or 77.5 per cent of the potential; and by 2050, it is expected to reach 100 GW or 83 per cent of the potential. According to the Ministry of Water Resources, during the Thirteenth Five- Year Plan (2016-2020), the national plan for refurbishing China's rural SHP projects will aim to refurbish 2,333 old SHPs and complete an ecological mitigation plan for 2,110 SHPs.

The Democratic People's Republic of Korea has an installed capacity of 83 MW for SHP up to 10 MW. The country's potential for SHP development is speculated to be significant due to its numerous rivers. However, no comprehensive data is available. The Government has encouraged the development of micro-hydropower as part of the national programme for rural energy development. In general, the Government's energy policy focuses on the development of non-fossil fuel energy sources and seeks to solve the issue of the ageing infrastructure and transmission and distribution networks, as well as to improve the rural energy supply.

Japan has a total SHP installed capacity of 3,545 MW, which is about 34 per cent of its potential. The country has a long history of hydropower development. For a while, SHP was considered to be inefficient, and thus was not developed. In the 2000s, SHP again attracted attention as a solution to climate change and to reduce greenhouse gas emissions, and is now gaining new status as a natural energy resource to be developed.

Mongolia has eleven SHP plants with capacities of up to 2 MW. Their combined installed capacity is 5 MW (19 per cent of its potential). As opposed to the two large existing hydropower plants in the country, SHP plants only serve isolated areas of the country and operate during the summer. Hydropower development in the country is mainly focused on large hydropower, which is seen as a solution to better national energy security and energy independence. The Government aims to increase the use of renewable energy sources, particularly in remote areas, as well as to perform research and development in the field of renewable energy. However, there are no known plans for the further development of SHP.

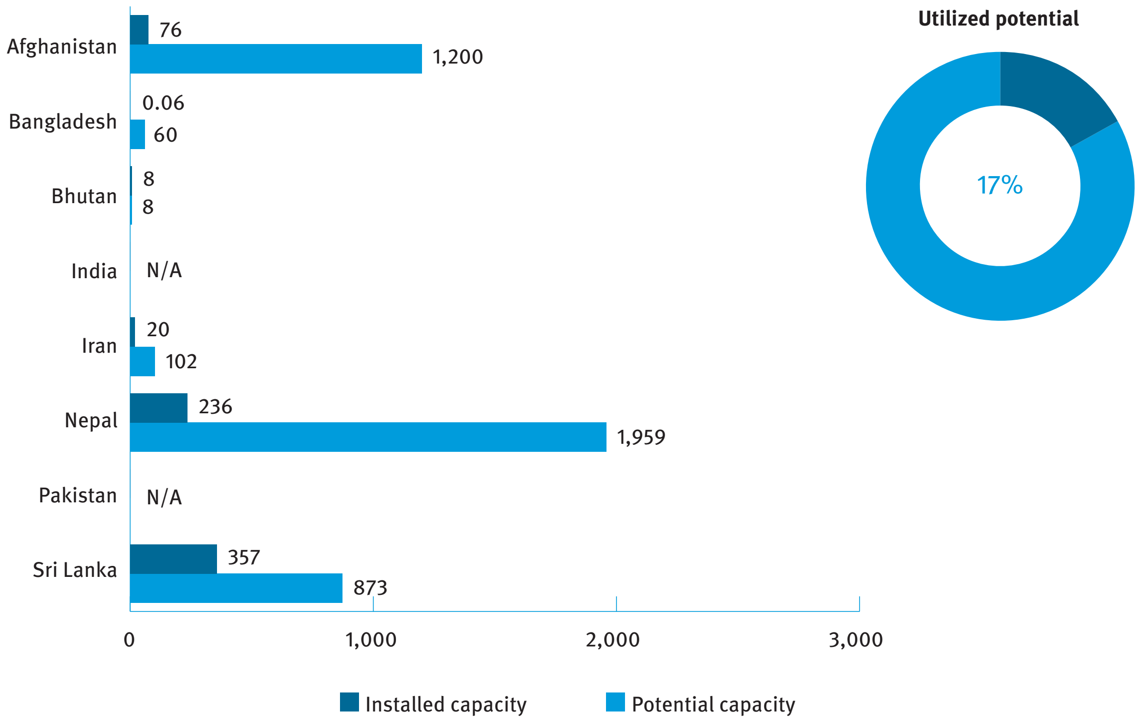
The Republic of Korea has 190 MW of installed SHP capacity with 240 plants nationwide. The technical potential of SHP from rivers and other water-related facilities (such as sewage treatment plants, water treatment systems, irrigation reservoirs, multi-purpose dams and irrigation dams) is estimated to be 1,500 MW, of which 660 MW is economically feasible. Since the two oil crises in the 1970s, the Government has actively encouraged the development of renewable energy sources, including SHP. The goal is to replace 11 per cent of the primary energy supply with a new and renewable energy supply by 2035. There is a range of financial support mechanisms for the renewable energy industry. The Government provided KRW 35 billion (US$ 0.030 billion) in financial support between 2008 and 2015. The Government is mainly focused on automation and unmanned technology, small-scale turbine development and electricity technology.

Three countries in the region have introduced **FITs**. In Japan, FITs were introduced in 2012. These have been set up for each renewable energy category, and are revised each year based on the degree of circulation and market conditions. Mongolia created a FIT system applicable to renewable energy generators in 2007. The tariffs are set by the Energy Regulatory Authority (ERA) within set limits for grid-connected and off-grid generators, according to energy type. China has FITs for solar, hydropower, wind and biomass. However, there is no unified FIT for SHP – each province establishes the benchmark price for SHP projects based on the average purchasing price for the provincial grid company.

Southern Asia SHP overview

Afghanistan, Bangladesh, Bhutan, India, Iran, Nepal, Pakistan and Sri Lanka

Figure 29.
Installed and potential capacity in Southern Asia for SHP up to 10 MW (MW)



Source: *WSHPDR 2019*

An overview of SHP in the countries of Southern Asia is outlined below. The information used in this section is extracted from the country profiles, which provide detailed information on SHP capacity and potential, along with other energy-related information.

In **Afghanistan**, with the support of international institutions, the Government has developed 75.7 MW of SHP (up to 10 MW), which is approximately 6 per cent of the country's total SHP potential. Several more SHP projects are underway. Increasing access to electricity remains an important task for the Government. With the limited reach of the regional grids, smaller scale off-grid units, including SHP plants, can play a significant role in providing electricity.

Bangladesh has an SHP potential estimated to be at least 59.5 MW (for SHP up to 10 MW). The current installed capacity is 0.06 MW with two operating SHP plants.

Bhutan has four small and 20 mini/micro-hydropower plants (up to 25 MW) with a total installed capacity of 32.11 MW. The theoretical potential for SHP less than 25 MW, as was announced in 2016 as a part of the Renewable Energy Master Plan formulation, reaches 17,792 MW, indicating that SHP potential is largely untapped.

The regional leader in terms of SHP is **India** with an estimated SHP potential (up to 25 MW) of 21,134 MW, of which 21 per cent (4,485 MW) has been developed. The country's SHP programme, administered by the Ministry of New and Renewable Energy at the national level and the state electricity departments at the state level, receives major contributions from private investment. As a result, the major focus of the programme is to make SHP projects cost-effective and reliable. For this purpose, a range of documents have been issued covering various aspects of SHP activities for use by developers, manufacturers, consultants and regulators. India has a strong equipment manufacturing base for development, including for export to other regions and especially to Southern and Eastern Asia.

For **Iran**, the main source of electricity generation is fossil fuels, and hydropower accounts for only 5 per cent of the generated electricity. However, the Government aims to increase the share of renewable energy sources. The total installed capacity of SHP plants (up to 10 MW) has increased by 19 per cent compared with the *WSHPDR 2016*, having now reached 19.5 MW. There is no clear information on the country's potential SHP capacity, however, based on the planned and ongoing projects, it can be estimated to be at least 102.48 MW, with 82.98 MW of still undeveloped potential.

Nepal has considerable SHP potential (1,960 MW for SHP up to 10 MW and 4,196 MW for SHP up to 25 MW) and has had extremely successful instances of implementing SHP programmes, especially micro-hydropower plants in isolated rural areas. This has made SHP crucial for the country's rural development. The total installed capacity of SHP plants up to 10 MW in Nepal is 236 MW. Almost all the hydropower projects damaged in the earthquake in April 2015 have been restored. Nepal has well-structured institutions to facilitate micro-hydropower development, including local manufacturing and the skills for implementation.

Pakistan has low hydropower potential (up to 50 MW) of 3,100 MW. So far, 13 per cent of this potential has been developed with 410 MW of installed capacity. The Government aims to boost the renewable energy sector through incentives, such as partial risk coverage, premium tariffs and guaranteed purchase. SHP projects in Pakistan are developed by provincial governments, in cooperation with the public sector, individuals and communities, as well as other organizations.

Sri Lanka has 183 SHP plants (up to 10 MW) with a total installed capacity of 357 MW, which accounts for less than 41 per cent of the country's total SHP potential. The development of SHP in the country is supported by the Sustainable Energy Authority (SEA), which aims to increase the share of renewable energy sources in electricity generation and promotes the participation of the private sector in renewable energy projects, including SHP. Sri Lanka has well-defined institutions to regulate and support SHP development.

Most countries in the region do not offer **FITs** for renewable energy, with India and Iran being the exceptions. However, in India there are no national FITs, but these can be introduced by the governments of the states. In order to boost confidence among investors, the Bangladesh Electricity Regulatory Commission has prepared draft regulations for the implementation of FITs.

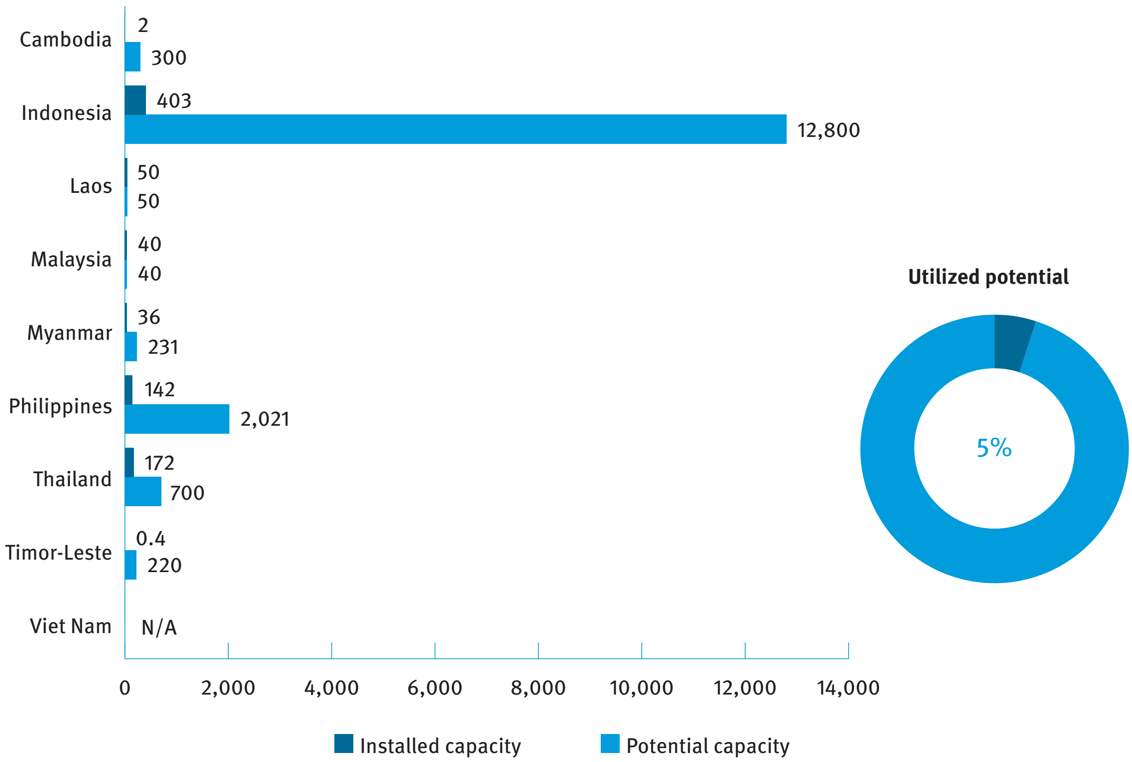
South-Eastern Asia SHP overview

Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Thailand, Timor-Leste and Viet Nam

An overview of SHP in the countries of South-Eastern Asia is outlined below. The information used in this section is extracted from the country profiles, which provide detailed information on SHP capacity and potential, along with other energy-related information.

Viet Nam is the regional leader in terms of installed and potential SHP capacity. It has 1,666 MW of installed SHP capacity (according to the national definition of SHP up to 30 MW), whereas the total potential is estimated to be 7,200 MW. Hydropower accounts for about 37 per cent of the country's electricity generation, and there are plans for the further development of hydropower. However, in 2013, the Government began to cancel hydropower projects (planned and under construction) due to high social and environmental risks caused by poor planning and construction. In 2016, after a three-year review, the Ministry of Industry and Trade (MOIT) decided to remove 471 small and cascade hydropower plants with a combined installed capacity of 2,059 MW from the Power Development Plan. Another 213 potential projects were rejected because of environmental and efficiency concerns.

Figure 30.
Installed and potential capacity in South-Eastern Asia for SHP up to 10 MW (MW)



Source: *WSHPDR 2019*

Cambodia has a total installed SHP capacity (up to 10 MW) of 1.66 MW, which consists of four plants constructed with grant aid. There are also several privately-owned micro- and pico-hydropower plants. An additional 48 sites with a combined capacity of 50 MW have been identified as having potential for development or are under development. Cambodia has a total hydropower potential of approximately 10,000 MW. However, many of the large hydropower sites identified are highly controversial and unlikely to be developed due to factors such as resettlements, land issues, negative impacts on fisheries, community consultations and limited environmental and social impact assessments. The potential of SHP up to 10 MW is estimated at approximately 300 MW, indicating that a mere 0.55 per cent of the country's potential has been harnessed.

Indonesia has an installed SHP capacity of 403 MW and substantial potential of at least 12.8 GW (for SHP up to 10 MW). SHP development is perceived as a key means of achieving increased electrification, particularly in rural areas. New SHP plants were installed in Bengkulu, Semendo and Sumatera, with a combined capacity of approximately 162.2 MW. Due to the promising progress that SHP has made in Indonesia, multiple feasibility studies have been conducted in recent years, resulting in the discovery of new SHP sites.

Hydropower is the most important source of electricity for **Lao PDR**. The country's total technical hydropower potential is estimated at 26,000 MW, of which SHP up to 15 MW accounts for 2,287 MW. In 2017, there were 30 SHP plants in operation in Lao PDR, with capacities ranging from 0.06 MW to 15 MW and a combined capacity of 148.14 MW. In addition, there were 273 projects in various stages of development, with a combined capacity of 2,139 MW. Most of the existing and planned SHP plants are operated or planned by independent power producers (IPPs). The development of SHP could play an important role in rural electrification and provide a solution, with minimum production costs, for remote areas that currently rely on imported electricity.

As of 2018, the installed capacity of SHP plants up to 10 MW in **Malaysia** was 39.5 MW, indicating a more than two-fold increase since the *WSHPDR 2016*. The installed capacity of SHP up to 20 MW was 71 MW, and installed capacity of SHP up to 30 MW was 113 MW. The potential capacity for SHP up to 30 MW was 490 MW, whereas the potential for the 10 MW threshold is unknown. The development of SHP in the country has been stimulated by both the Renewable Energy Act 2011 and the introduction of a FIT scheme in 2011.

The current installed SHP capacity in **Myanmar** is 36.4 MW. The total potential is 231 MW for SHP plants up to 10 MW with more than 300 potential sites identified. Myanmar has abundant hydropower resources that account for about 60 per cent of total installed electricity capacity in the country. Nevertheless, policies and legislation for the hydropower sector, including SHP, are limited. Although Myanmar adopted a new Electricity Law in 2014 to replace the previous Electricity Law (1984), there are no specific bylaws or regulations for hydropower.

The SHP potential (up to 10 MW) of the **Philippines** is estimated to be 2,021 MW, and its current installed capacity of 147 MW accounts for only 7 per cent of this potential. Compared to the results of the *WSHPDR 2016*, the installed capacity has increased by more than 45 per cent. As of the end of 2017, 89 SHP projects with a combined capacity of approximately 400 MW had been confirmed for development. These projects are to be completed between 2018 and 2025 and vary in size from 0.5 MW to 10 MW.

The installed capacity of SHP up to 20 MW in **Thailand** as of September 2015 was 172 MW, indicating a 59 per cent increase compared with the *WSHPDR 2016*. Potential capacity is estimated to be 700 MW. The development of SHP in the country has been fostered through the national Alternative Energy Development Plan (AEDP2015), which set the goal of increasing the installed capacity of SHP to 376 MW by 2036.

The hydropower potential of **Timor-Leste** is estimated to be 220 MW for SHP plants up to 10 MW, with a potential annual production of 812.8 GWh. The total installed capacity of SHP is 0.353 MW, which comes from one mini- and two micro-hydropower plants. However, these three plants are not in operation due to technical issues. In 2016, public consultations on the basic law on renewable energy were held throughout the country and, as of 2018, they were still awaiting promulgation in the Parliament. The Government plans to provide half of the country's energy needs from renewable energy sources by 2025.

FITs for SHP are covered in the regulatory framework in Indonesia, Malaysia, Myanmar, the Philippines, Thailand and Viet Nam.

Western Asia SHP overview

Armenia, Azerbaijan, Georgia, Iraq, Israel, Jordan, Lebanon, Saudi Arabia, the Syrian Arab Republic and Turkey

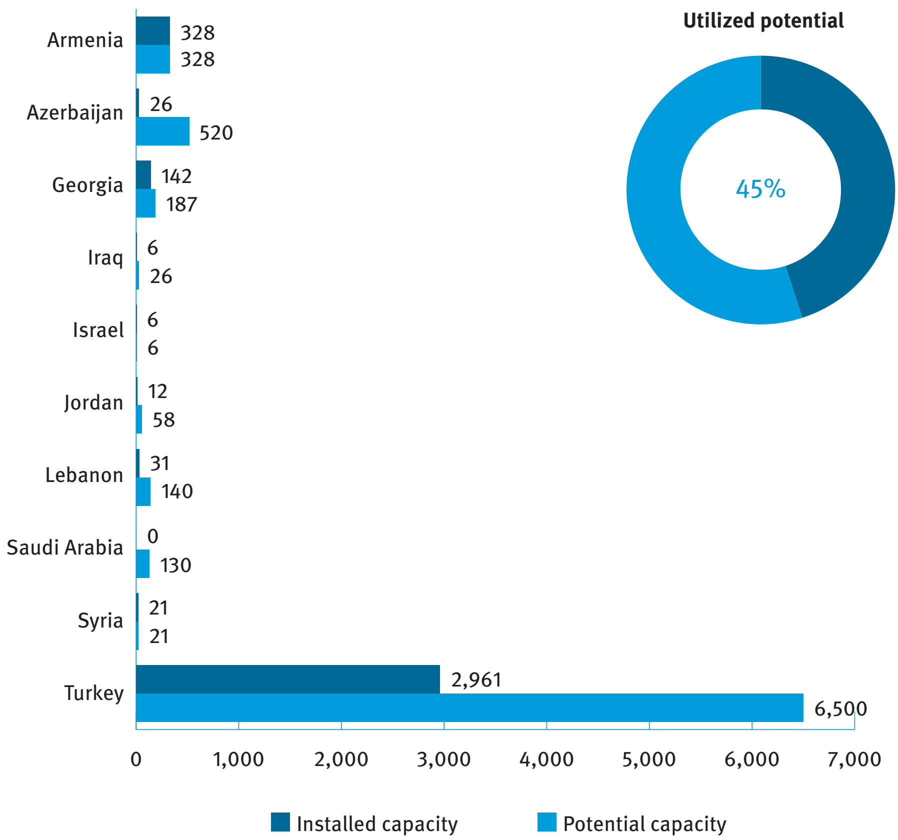
An overview of SHP in the countries of Western Asia is outlined below. The information used in this section is extracted from the country profiles, which provide detailed information on SHP capacity and potential, along with other energy-related information.

As of early 2018, there was a total of 183 SHP plants in **Armenia** with a combined installed capacity of 353 MW, which generated approximately 964 GWh in 2017. A further 36 SHP plants with an additional estimated potential capacity of 69 MW had received licences for construction, thus indicating that approximately 84 per cent of the country's known SHP potential has been developed. Between the *WSHPDR 2016* and *WSHPDR 2019*, Armenia deployed 71 MW of SHP capacity. In general, the country's energy strategy prioritizes the use of renewable energy sources, including geothermal and solar power.

In **Azerbaijan**, as of the end of 2017, there were 11 SHP plants with a combined capacity of approximately 26 MW. The economic potential of SHP is estimated to be at least 520 MW, indicating that approximately 5 per cent has been developed. Compared to the results of the *WSHPDR 2016*, installed capacity has doubled. In 2016 and 2017, three new SHP plants were commissioned, another plant was commissioned in 2018 and three other plants had been put into operation by the end of 2018. Azerbaijan possesses substantial renewable energy resources, and between 2016 and 2020 it plans to introduce 420 MW of new renewable energy capacity (including wind power, solar power and biomass).

The total installed capacity of SHP plants in **Georgia** less than 13 MW is 177.98 MW, 142.34 MW of which comes from plants of up to 10 MW. Currently there are 51 SHP plants (less than 10 MW) in operation, all of which are privately owned and most of them in need of refurbishment. Since the *WSHPDR 2016*, Georgia has reported an additional 10 MW of SHP deployment. The SHP potential for plants below 13 MW is estimated at 335.5 MW, of which 187.4 MW is for plants up to 10 MW. Thus, approximately 53 per cent of SHP potential for plants up to 13 MW and approximately 76 per cent of plants up to 10 MW has been developed. Optimal utilization of water resources is one of the priorities of the Government of Georgia for realizing the country's national energy strategy and energy security.

Figure 31.
Installed and potential capacity in Western Asia for SHP up to 10 MW (MW)



Source: *WSHPDR 2019*

The installed and potential capacity of SHP up to 10 MW in **Iraq** has shown no change since the *WSHPDR 2016*, standing at 6 MW and 26 MW respectively. Thus, 23 per cent of the known potential for SHP up to 10 MW has been developed. Although there is no official definition, a capacity of up to 80 MW is generally considered as SHP in the country. According to this definition, there are six SHP plants with a combined capacity of 251 MW, of which only one is below 10 MW. According to the National Water Development Strategy, hydropower should be developed as a by-product of any new reservoir. However, since 2013, no new hydropower capacity has been added or announced. In general, the development of renewable energy has been progressing rather slowly, hindered by the conflict with the Islamic State in Iraq and the Levant (Da'esh) and other systemic factors. The Ministry of Energy announced grid power losses of over 8 GW since the Islamic State intervention in 2014. The Government of Iraq is attempting to revitalize investment in energy resources with tax exemptions and support during the licensing, approval, implementation and operation processes. Decentralized electricity generation that does not rely on fossil fuel transportation, such as SHP, wind and solar power, could be ideal sources of energy for conflict regions in Iraq.

Israel is the newest addition in the *WSHPDR 2019*. In 2014, there were reported to be seven hydropower facilities that contributed a combined 6 MW to the country's electrical grid. Several pumped storage hydropower facilities and new technologies were under development as of 2019, which may contribute to the potential for SHP in the northern parts of the country. There are limited surveys concerning the potential capacity for SHP in the country, which represents a potential growth area.

There are three SHP plants (up to 10 MW) in **Jordan** with a combined capacity of 12 MW. The potential of SHP is estimated at 58.15 MW, indicating that almost 21 per cent has been developed thus far. Compared to the results of the *WSHPDR 2016*, installed and potential capacity remain unchanged. Thus, the contribution of hydropower to the country's energy mix remains very small. At the same time, there are plans to develop SHP by utilizing the water flow of the Zarqa River, with a number of projects proposed to be installed at water treatment plants. By 2020, the Government aims to achieve a 10 per cent share of renewable energy in the country's energy mix, with particular focus given to wind and solar power.

Lebanon has seven small, mini- and micro-hydropower plants with a total capacity of 31.2 MW. However, one of them is currently out of service. The potential capacity for SHP in Lebanon is estimated to be 139.8 MW, indicating that slightly more than 22 per cent has been developed. Compared to the *WSHPDR 2016*, installed and potential capacities remain the same. Hydropower is a major contributor to the renewable energy mix in the country, with Lebanon enjoying relatively better access to water than its neighbouring countries. Lebanon also has a significant wind power potential, especially in the north.

Currently, there is no installed hydropower capacity in **Saudi Arabia**. However, there is potential for installing SHP plants at existing dams, which is estimated to be at least 130 MW. Even though Saudi Arabia does not use its renewable energy resources effectively (as almost all of its electricity is produced from the combustion of fossil fuels), the country is beginning to realize the benefits of curbing domestic oil consumption. The country has set a goal of producing almost half of its power from renewable energy sources by 2020.

The Syrian Arab Republic has four SHP plants with an overall installed capacity of 20.84 MW. There is no known SHP potential for further development. While the country relies on local oil and gas, there is a significant potential for the exploitation of renewable resources, such as wind and solar power. However, the geopolitical upheaval in the Syrian Arab Republic has led to instability in electricity generation and challenges to further deployment. Notably, prior to the outbreak of the civil war, the Syrian Arab Republic produced 50 TWh of electricity in 2011. However, in 2017, this number decreased to below 20 TWh.

Turkey is the leading country in the region in terms of SHP installed and potential capacity. The potential of SHP up to 10 MW capacity in Turkey is 6.5 GW, with nearly half already installed. As of April 2018, there were 300 hydropower plants with capacity up to 10 MW. SHP installed capacity has more than doubled compared to the *WSHPDR 2016*, which has been achieved thanks to SHP incentives and increased investment in the area. The Ministry of Energy and Natural Resources aims to have 30 per cent of the total electricity mix covered by renewable energy sources by 2023.

Four countries in the region have introduced **FIT** schemes: Armenia, Israel, the Syrian Arab Republic and Turkey. As opposed to the other three countries, FITs in Israel only apply to solar and wind power and do not cover SHP. Turkey also uses an auction system, which has led to record-low prices for deployment. Azerbaijan, Iraq and Lebanon do not have FITs but offer other financial mechanisms to support renewable energy projects.

Anming First Cascade in Songyang, Zhejiang Province, China.

Europe

Europe has a long history of SHP development, which has enabled the region to reach its highest level of installed capacity. Europe, with a wide variety of climates and landscapes, fluctuates according to each subregion in regards to SHP potential.

The overall installed capacity in the region is 19,699 MW, while the potential capacity is estimated at 37,554 MW. In comparison to the *WSHPDR 2013*, this represents an increase in installed capacity of 10 per cent (5 per cent in caparison to the *WSHPDR 2016*). As of 2019, Europe has developed nearly 52 per cent of its SHP potential, with Western Europe reaching the world's highest SHP development rate at 85 per cent. The greatest remaining potential lies in Southern Europe with 7,865 MW.

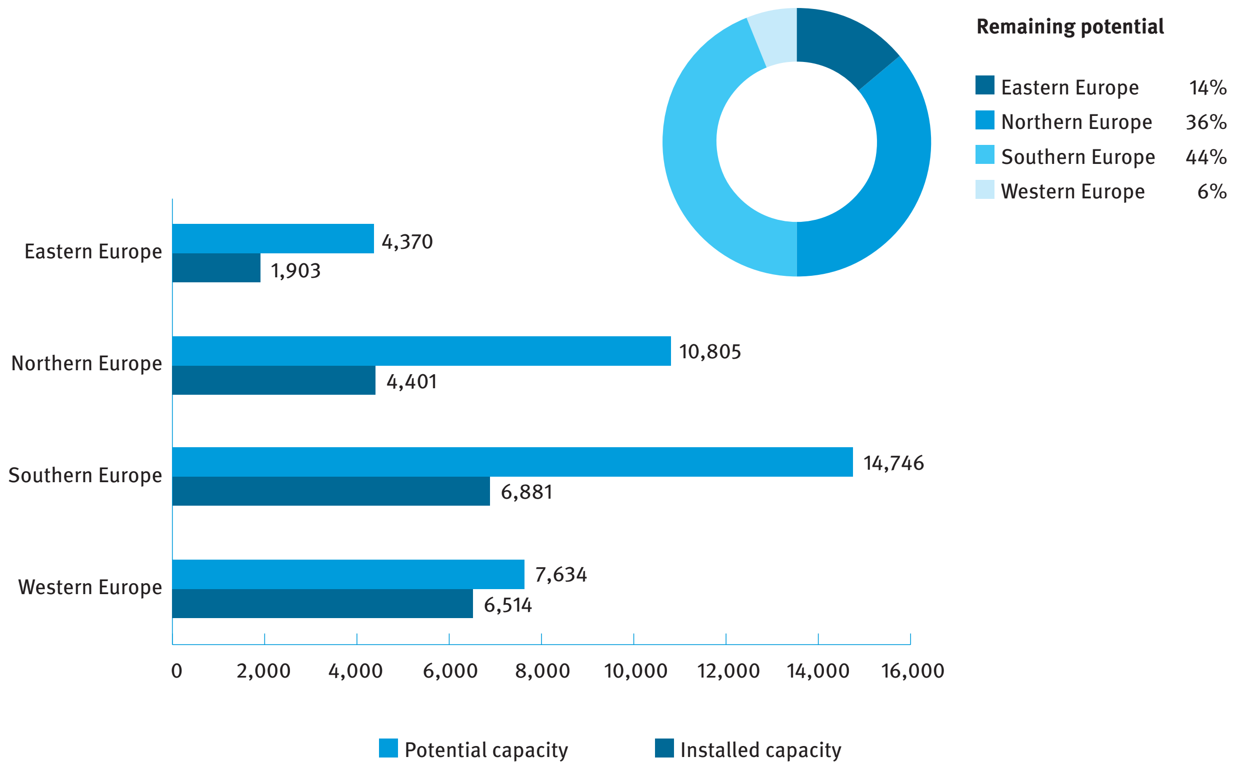
Europe has the largest number of countries with established FITs for SHP; 22 out of the 39 countries included in this Report already have FITs incorporated into their respective SHP policies.

The general challenges the region faces with regard to SHP development are the rigid environmental regulations that may hinder the development of SHP capacities in some countries. Many environmental organizations in Europe also have a negative view of hydropower systems in general, and thus promote policies and actions that do not differentiate between large hydropower and SHP.

Country	*Local SHP definition*	*Installed capacity (local def.)*	*Potential capacity (local def.)*	*Installed (<10 MW)*	*Potential (<10 MW)*
Albania	up to 15	330.2	-	240.2	1,963.0
Austria	up to 10	1,523.0	1,780.0	1,523.0	1,780.0
Belarus	up to 10	18.0	250.0	18.0	250.0
Belgium	up to 10	72.8	103.4	72.8	103.4
Bosnia and Herzegovina	up to 10	90.0	1,005.0	90.0	1,005.0
Bulgaria	up to 1	-	-	486.0	580.7
Croatia	up to 10	33.0	192.0	33.0	192.0
Czech Republic	up to 10	337.0	465.0	337.0	465.0
Denmark	up to 10	9.8	9.8	9.8	9.8
Estonia	up to 10	6.5	10.0	6.5	10.0
Finland	up to 10	312.0	600.0	312.0	600.0
France	up to 10	2,200.0	2,615.0	2,200.0	2,615.0
Germany	up to 1	-	-	1,731.0	1,830.0
Greece	up to 15	232.0	2,000.0	232.0	600.0
Hungary	up to 5	16.5	55.0	-	-
Iceland	up to 10	54.8	-	54.8	-
Ireland	up to 5	-	-	41.0	60.0
Italy	up to 10	3,395.0	7,073.0	3,395.0	7,073.0

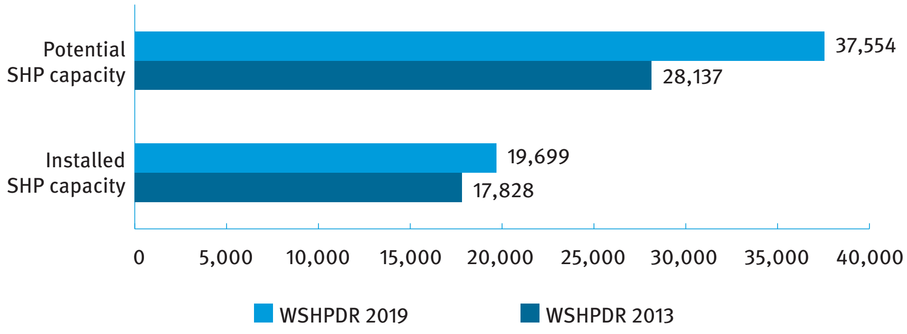
Latvia	up to 10	28.0	75.0	28.0	75.0
Lithuania	up to 10	26.9	51.9	26.9	51.9
Luxembourg	up to 10	34.0	44.0	34.0	44.0
Moldova	up to 10	0.4	3.0	0.4	3.0
Montenegro	up to 10	25.3	97.5	25.3	97.5
Netherlands	up to 10	3.0	12.0	3.0	12.0
North Macedonia	up to 10	130.0	260.0	130.0	260.0
Norway	up to 10	2,571.0	7,803.0	2,571.0	7,803.0
Poland	-	-	-	294.8	1,500.0
Portugal	up to 10	414.0	750.0	414.0	750.0
Romania	up to 10	404.0	730.0	404.0	730.0
Russia	up to 30	826.5	825,845.0	169.6	-
Serbia	up to 30	87.6	-	87.6	467.2
Slovakia	up to 10	81.6	241.4	81.6	241.4
Slovenia	up to 10	155.0	180.0	155.0	180.0
Spain	up to 10	2,079.0	2,158.0	2,079.0	2,158.0
Sweden	up to 10	961.0	-	961.0	-
Switzerland	up to 10	950.0	1,250.0	950.0	1,250.0
UK	up to 10	390.0	1,179.0	390.0	1,179.0
Ukraine	up to 10	95.0	375.0	95.0	375.0

Figure 32.
Installed and potential capacity in Europe's regions for SHP up to 10 MW (MW)



Source: *WSHPDR 2019*

Figure 33.
Comparison of installed and potential capacity in Europe regions for SHP up to 10 MW (MW)

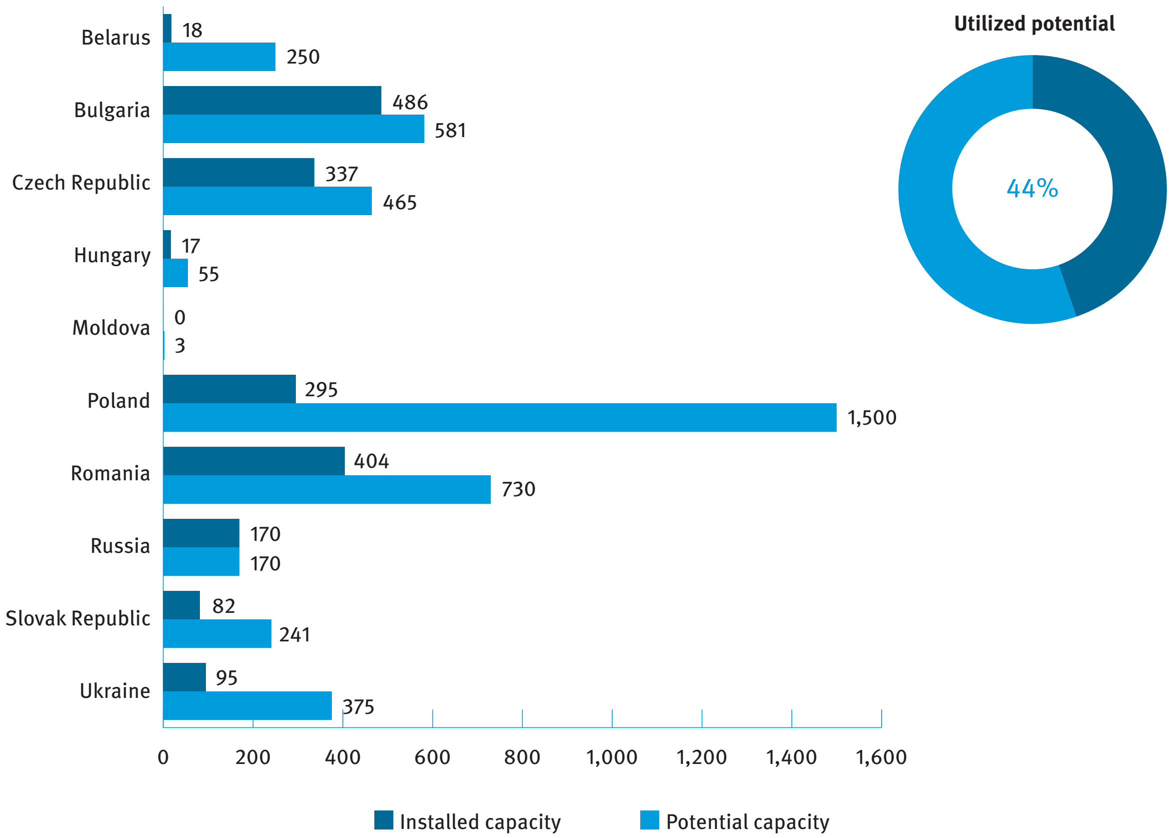


Source: *WSHPDR 2019*

Eastern Europe SHP overview

Belarus, Bulgaria, Czechia, Hungary, Republic of Moldova, Poland, Romania, Russian Federation, Slovakia and Ukraine

Figure 34.
Installed and potential capacity in Eastern Europe for SHP up to 10 MW (MW)



Source: *WSHPDR 2019*

An overview of SHP in the countries of Eastern Europe is outlined below. The information used in this section is extracted from the country profiles, which provide detailed information on SHP capacity and potential, along with other energy-related information.

The installed capacity of SHP up to 10 MW in **Belarus** stands at 18 MW, while the potential is estimated at 250 MW. The 2 MW increase in installed capacity, compared to the *WSHPDR 2016*, has been achieved due to the introduction of new capacities in the private sector.

Bulgaria currently has 237 SHP plants up to 10 MW with a combined installed capacity of 486 MW. Multiple attempts have been made to encourage investment in the country's SHP sector, with 84 per cent of the estimated potential developed to date. Since the *WSHPDR 2016*, the installed capacity has increased by nearly 200 MW.

In the **Czech Republic**, the installed capacity of SHP up to 10 MW is 337 MW with the generation of 1,053 GWh per year. The economically feasible potential of SHP is estimated at 465 MW, indicating that approximately 72 per cent has been developed. The National Renewable Energy Action Plan (NREAP) foresees an increase in the capacity of SHP to 344 MW by 2020.

According to the most recent data available, the number of SHP plants up to 5 MW in operation in **Hungary** is 28, with a combined installed capacity of 16.5 MW and the annual generation of 68.7 GWh in 2016. Due to relatively unfavourable natural conditions, the total hydropower potential in Hungary is rather modest. The technical potential of smaller rivers (up to 5 MW) is estimated at approximately 55 MW with annual generation of 300 GWh. Compared to the results of *the WSHPDR 2016*, the installed capacity has decreased by almost 15 per cent and potential capacity has increased by 96 per cent – both due to access to more accurate data.

During the Soviet Union period, there were 17 SHP plants in the **Republic of Moldova**. At present, there is only one functional small-scale hydropower plant, which has a capacity of 254 kW and a maximum annual contribution of 81 MWh. In addition, there are six micro-hydropower plants with a combined capacity of 141 kW, which are not, however, functional. The increase in installed capacity compared to the *WSHPDR 2016* is due to data recently made available. After assessing all potential sites, only 3 MW of potential was discovered for plants up to 10 MW.

Poland has 756 SHP plants with capacity up to 10 MW. Their combined installed capacity is 294.8 MW, representing 29.8 per cent of the country's total hydropower installed capacity and indicating an increase of 2.2 per cent since the *WSHPDR 2016*. In 2016, electricity generation from these SHP plants amounted to 908 GWh. In addition to the developed capacity, 162 SHP projects (up to 10 MW) with a total capacity of 55.97 MW and an expected annual generation of 252 GWh, are reported to be under construction or in the process of obtaining permits. It is estimated that these projects could be finalized by 2030. The total technical hydropower potential for SHP plants (up to 10 MW) in Poland is estimated to be approximately 5 TWh/year, corresponding to at least 1,500 MW of potential installed capacity.

The installed capacity of SHP up to 10 MW in **Romania** is 404 MW, while the potential capacity is estimated to be 730 MW, indicating that approximately 55 per cent has been developed. Since the *WSHPDR 2016*, the installed capacity has decreased by 194 MW due to a more accurate assessment.

In the **Russian Federation**, the installed capacity of SHP plants up to 10 MW is 169.6 MW, and up to 30 MW is 826.5 MW, while the technically feasible potential for SHP up to 30 MW is estimated to be 826 GW, indicating that only about 0.1 per cent has been developed. Since the *WSHPDR 2016*, the number of operating SHP plants up to 30 MW has increased from 134 to 139. However, only two new SHP plants were actually constructed during this period, while other SHP plants were identified from the historic data. There are twelve SHP plants currently under construction across the country with a total installed capacity of about 170 MW. In addition, there are several SHP development plans and opportunities for new SHP projects are being explored.

Slovakia has a total SHP (up to 10 MW) installed capacity of 81.6 MW from 217 plants with annual generation of 281.8 GWh. The potential is estimated to be at least 241.4 MW, indicating that approximately one-third of the total potential has been developed. Compared to the *WSHPDR 2016*, both the installed capacity and the estimated potential capacity are unchanged.

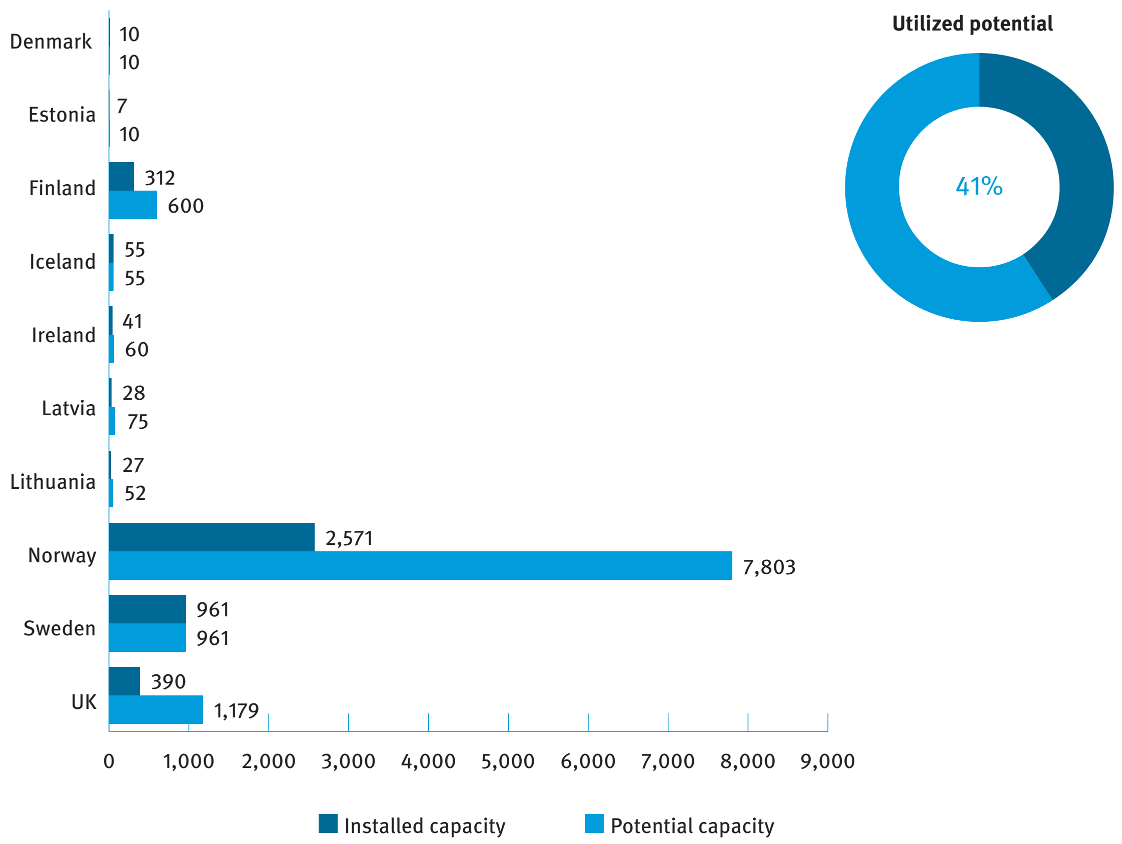
The total installed capacity of SHP up to 10 MW in **Ukraine** stands at 95 MW, coming from about 150 plants. The SHP potential capacity is estimated at 375 MW with an annual electricity generation of 1.27 TWh/year. This estimate is based on the 10 MW definition of SHP, as opposed to the 30 MW threshold on which the previous estimates were based. It also takes into account the national laws and programmes as well as the international agreements, conventions and additional protocols on the protection, conservation and sustainable use of natural resources, which define restrictions on the use of small river resources. The country's electricity is currently influenced by the complex political situation, with the ongoing conflict deepening the economic crisis. Nonetheless, Ukraine still remains a significant local exporter of electricity, and the Ukrainian authorities have also declared their commitment to continue developing the national hydropower sector – mainly in order to increase its power system flexibility, security and independence.

After bad experiences with green certificates in several European countries, FIT and feed-in-premium systems have been introduced for the smallest installations. For larger ones, the auction system is often applied. In most cases, the duration of support under auction systems and stipulated tariffs is 15 years. The support period is almost twice as short in the Russian Federation where higher pay-back rates are assumed. Generally, the support package also includes the obligation for public electricity providers to acquire electricity generated from renewable energy, although this obligation may be subject to limitations. FITs have been introduced in the all countries in the region, except Romania, while the Russian Federation offers some compensation for investment costs to renewable energy projects selected on a competitive basis. Some other support measures, such as tax exemptions and access to support funds are also available locally.

Northern Europe SHP overview

Denmark, Estonia, Finland, Iceland, Ireland, Latvia, Lithuania, Norway, Sweden and the United Kingdom of Great Britain and Northern Ireland (UK)

Figure 35.
Installed and potential capacity in Northern Europe for SHP up to 10 MW (MW)



Source: *WSHPDR 2019*

An overview of SHP in the countries of Northern Europe is outlined below. The information used in this section is extracted from the country profiles, which provide detailed information on SHP capacity and potential, along with other energy-related information.

In **Denmark**, since the year 2000, the generation from renewable energy increased by 2.5 times. As Denmark is topographically unsuited for hydropower and because of existing environment constrains, the optimum hydropower capacity in the country has already been developed. All the installed hydropower capacity in Denmark comes from SHP plants, stands at 9.8 MW and has remained unchanged since 2013.

Estonia is another country in the region in which all the hydropower capacity comes solely from SHP plants. It is also a country with one of the lowest hydropower potentials in the region. In addition, a list of 112 rivers and their reaches was introduced as protected areas for fish populations. After the year 2020, no growth in the hydropower sector is foreseen in Estonia's renewable energy policy. Due to the strict environmental requirements, some SHP plants in Estonia have been decommissioned since 2016. As a result, compared to the *WSHPDR 2016*, the country's installed SHP capacity decreased by almost 19 per cent. This indicates that in the future SHP will play a marginal role amongst other renewable energy sources.

According to the most recent data available, **Finland** has 167 SHP plants with a combined capacity of 312 MW. The decrease of 2 MW compared to the *WSHPDR 2016* is due to the recent refurbishment at one of the plants that led to an increase in its installed capacity beyond the 10 MW threshold. The Government of Finland offers grants for research and investment in SHP projects. However, these grants do not include the acquisition of ownership licences and feasibility studies, which makes them unfeasible for small projects where installed capacity is planned to be less than 1 MW. However, even though these grants could be used for larger projects, there has not been any data on new SHP capacities installed since the *WSHPDR 2016*.

Iceland has access to significant amounts of renewable energy sources, which means that the country not only has one of the cheapest prices for electricity in Europe, but having this amount of untapped renewable energy also means that none of the renewable sources are given priority for grid connection or special subsidies. This makes SHP development difficult, as priority is given to medium or large hydropower plants because they could be more profitable. No additional data is available regarding potential capacity for SHP, as feasibility studies and research currently focus on power plants larger than 10 MW. The installed SHP capacity is reported to have decreased to 54.8 MW since the *WSHPDR 2016* as a result of the upgrading of some plants.

The main incentive for the development of renewable energy in **Ireland** is the Renewable Energy Feed-In Tariff (REFIT). The REFIT 2 scheme covering onshore wind, SHP and landfill gas was started in March 2012. In Ireland, there are approximately 600 old mill sites that could be restored and up to 10 potential high-head sites suitable for hydropower. Still, the installed capacity of SHP in Ireland has not increased since the *WSHPDR 2016* and is reported to stand at 41 MW (for SHP up to 10 MW).

Latvia has 147 SHP plants with a total installed capacity of 28 MW, which indicates an 8 per cent increase compared to the *WSHPDR 2016*. Only one of these SHP plants has an installed capacity greater than 1 MW. Taking into account the environmental restrictions, it is estimated that the untapped SHP potential in Latvia is up to 300 GWh. The best opportunities for development could be old water mill sites. In the late 19th century, Latvia had more than 700 water mills, but in the Soviet era SHP started to be unprofitable and by 1977 all such plants had been eliminated.

Lithuania is reported to have 26.9 MW of SHP installed capacity, coming from 98 plants. The theoretical potential of SHP is estimated at 183 MW, while the undeveloped potential, excluding protected areas is only 25 MW. Following the creation of no-go areas for the construction of hydropower plants in 2004, the development of hydropower in the country has almost stopped. Between 2015 and 2017, only two new SHP plants have started operation in Lithuania. Compared to the *WSHPDR 2016*, the installed capacity of SHP increased by 1.5 per cent. It is difficult to expect more rapid development of SHP in the near future unless the list of environmentally and culturally valuable rivers is revised.

There are 1,259 SHP plants in **Norway** with a combined capacity of 2,571 MW, which contribute approximately 78 per cent of the installed hydropower capacity in the country. Compared to the *WSHPDR 2016*, the installed SHP capacity increased by roughly 15 per cent. There is still significant interest in developing new SHP plants in Norway, as there are 429 licensed projects that have not yet expired or been realized, although some investments in Norway have been held back either due to the project funding and budget, the lack of grid access or both.

The installed capacity of SHP in **Sweden** is 961 MW, while the potential is unknown. Compared to the *WSHPDR 2016*, the installed SHP capacity increased by 25 per cent based on more accurate data. There are at present no specific targets related to increasing the capacity of SHP but there is also no limitation on expansion as long as it is aligned with the environmental regulations as well as other legislation, including dam safety and construction regulations. However, it is clear that the development of SHP in Sweden is limited, and increasing capacity is mainly possible through the refurbishment of old power plants.

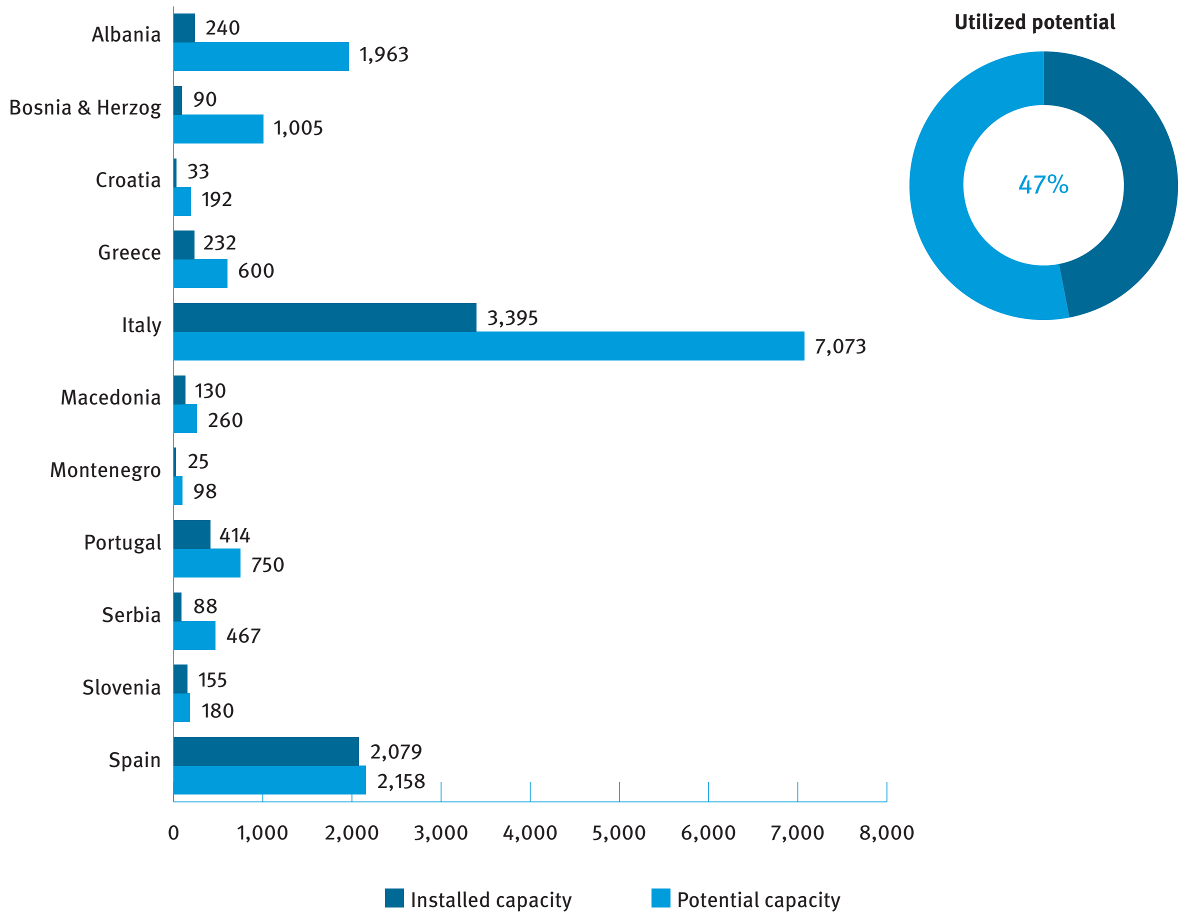
Due to the costs and concerns about its environmental impact, further large-scale development potential in the **United Kingdom of Great Britain and Northern Ireland** is limited, however, there is a scope for exploiting the remaining SHP resources in a sustainable way. Recent studies have revealed that there are a considerable amount of financially feasible SHP sites in the country. However, the development of SHP is slow due to environmental requirements and decreasing government support. The current installed capacity of SHP is 390 MW, which accounts for 33 per cent of the known economically feasible potential. In comparison to data from the *WSHPDR 2016*, installed capacity has increased by approximately 42 per cent.

FITs or premiums for renewable energy projects have been introduced in Denmark, Estonia, Finland, Ireland, Latvia, Lithuania and the UK. For plants greater than 5 MW, the UK offers the Renewable Obligation scheme. Although FITs exist in Finland, they do not apply to hydropower. Renewable energy plants in Norway and Sweden are supported by a joint green electricity certificate scheme. In general, the region is moving towards auction-based systems to promote renewable energy development.

Southern Europe SHP overview

Albania, Bosnia and Herzegovina, Croatia, Greece, Italy, North Macedonia, Montenegro, Portugal, Serbia, Slovenia and Spain

Figure 36.
Installed and potential capacity in Southern Europe for SHP up to 10 MW (MW)



Source: *WSHPDR 2019*

An overview of SHP in the countries of Southern Europe is outlined below. The information used in this section is extracted from the country profiles, which provide detailed information on SHP capacity and potential, along with other energy-related information.

Due to its topography, **Albania** is quite rich in hydropower resources, with an estimated potential for SHP up to 10 MW standing at 1,963 MW. The installed capacity of SHP up to 10 MW is 240.2 MW, indicating that 12 per cent has been developed. For SHP plants up to 15 MW the installed capacity is 330.2 MW. Since the *WSHPDR 2016*, the installed capacity has nearly tripled due to the construction of new plants. The Government has set the development of the energy sector among its priorities, focusing on the development of renewable energy resources and hydropower, in particular. The country's total hydropower reserves could enable annual generation of up to 16 TWh.

In **Bosnia and Herzegovina**, there are 74 SHP plants with a total installed capacity of approximately 90 MW. The potential is estimated at 1,005 MW or 3,520 GWh. Compared to the *WSHPDR 2016*, installed capacity has increased by 150 per cent, which is mainly due to access to more accurate data. In 2016, renewable energy accounted for more than 50 per cent of the country's energy mix but less than 36 per cent of electricity generation. According to the National Renewable Energy Action Plan (NREAP), the share of renewable energy should reach 52.4 per cent by 2050 in the country's electricity sector, 56.9 per cent in heating and cooling and 10 per cent in the transportation sector.

Croatia has 31 SHP plants with a total installed capacity of nearly 33 MW. Thus, the installed capacity of Croatia has remained unchanged since the *WSHPDR 2016*. The SHP potential is estimated at 192 MW, indicating that 83 per cent remains untapped. The tariff system introduced in 2014 set a quota of 35 MW for SHP until 2020, and 744 MW for wind power plants connected to the grid. To reach the hydropower target, 11 plants with a combined capacity of 3.9 MW have been installed. There are also pending contracts with an installed capacity of roughly 4.2 MW. In addition, there are plans to develop a number of large-scale hydropower projects, including two plants of 300 MW and 138 MW.

The installed capacity of SHP in **Greece** is 232 MW from 115 SHP stations of around 2 MW each. The economic potential for SHP up to 15 MW is estimated to be 2,000 MW, indicating that approximately 11 per cent has been developed. Since the *WSHPDR 2016*, the installed capacity has increased by 9 MW. Additionally, approximately 60 projects, reaching a total of 200 MW, have obtained binding connection offers, while more than 300 MW are under approval. The current strategy for reducing fossil fuel dependence has predominantly focused on the large-scale installation of wind farms and solar PV panels, while hydropower has experienced a lack of political interest.

Italy has 2,745 micro- and mini- hydropower plants with an installed capacity of 769 MW, and 872 SHP plants with a capacity of 2,626 MW. Compared to the *WSHPDR 2016*, installed capacity has increased by 7 per cent. The country's SHP potential for plants up to 10 MW exceeds 7 GW. SHP growth has been driven by comprehensive FITs, which have strongly promoted new SHP plants. However, the Government is still paying the cost of this strategy and has recently started a gradual reduction of FITs for SHP. The National Energy Strategy forecasts that overall hydropower production will reach 50 TWh by 2030 through the revamping of large hydropower plants and the construction of new SHP plants.

With a total installed SHP capacity of 25 MW, **Montenegro** has 16 SHP plants, of which seven are 30 or more years old, and nine have been built in the last three years. Compared to the *WSHPDR 2016*, installed capacity has increased by 42 per cent. The potential is estimated at 97.5 MW, indicating that 26 per cent has been developed. In 2007, the Government started offering concessions to private investors for SHP construction. As of 2015, 46 new privately-owned SHP plants were approved with an overall capacity of nearly 91 MW. While hydropower is expected to remain the dominant energy source, the country's energy development strategy aims to diversify the energy mix with wind, solar and biomass energy and other renewable energy sources.

North Macedonia has approximately 90.6 MW of SHP, which annually generates 389 GWh. Compared to data from the *WSHPDR 2016*, installed capacity has increased by 43 per cent. Currently, SHP accounts for approximately 15.5 per cent of the total installed hydropower capacity and approximately 4.4 per cent of the country's total installed capacity. However, it is estimated that SHP could potentially meet up to 16 per cent of the country's current electricity demand. The country's total potential capacity is estimated at 260 MW.

The installed capacity of SHP in **Portugal** is 414 MW, indicating a 11 per cent increase compared to the *WSHPDR 2016*. There have not been any comprehensive studies of SHP potential, however, the NREAP is aiming for a total of 750 MW from 250 SHP plants by 2020, indicating that at least this potential exists. A key challenge for the Portuguese energy sector is to reduce energy dependence, a goal which can only be achieved by developing renewable energy sources. By 2030, a further 7,100 MW of installed capacity from renewable sources is expected to be added to the country's energy mix.

There are 131 SHP plants operating in **Serbia**, which range in capacity from 10.7 kW to 7 MW. Their combined installed capacity is 87.6 MW. Since the *WSHPDR 2016*, installed capacity has almost doubled due to the commissioning of new plants. Over 70 of these plants have been commissioned since 2016. The potential for SHP development (up to 10 MW) in the country is estimated at approximately 467 MW from a total of 856 sites. Thus, 19 per cent of the potential has been developed to date. The Energy Sector Development Strategy adopted in 2016 encourages investment in renewable energy and sets the goal for the total installed capacity of new renewable energy plants to reach 1,835 MW by 2030.

The installed capacity of SHP plants in **Slovenia** is 155 MW, coming from 424 plants. Compared to the results of the *WSHPDR 2016*, the installed capacity has decreased by approximately 1 per cent. The technically and economically-feasible potential is estimated to be around 180 MW. However, taking into consideration the environmental, legal and spatial limitations, the exploitable potential should be more limited. From 2015 to 2017, 40 new water permits for SHP plants were issued. The NREAP 2010-2020 set the target to increase the installed capacity of SHP plants with capacity of 1-10 MW by 16 MW. In general, support for hydropower in Slovenia is mixed, and comprehensive studies are necessary to prepare a Master Plan defining potential sites while considering the environmental objectives.

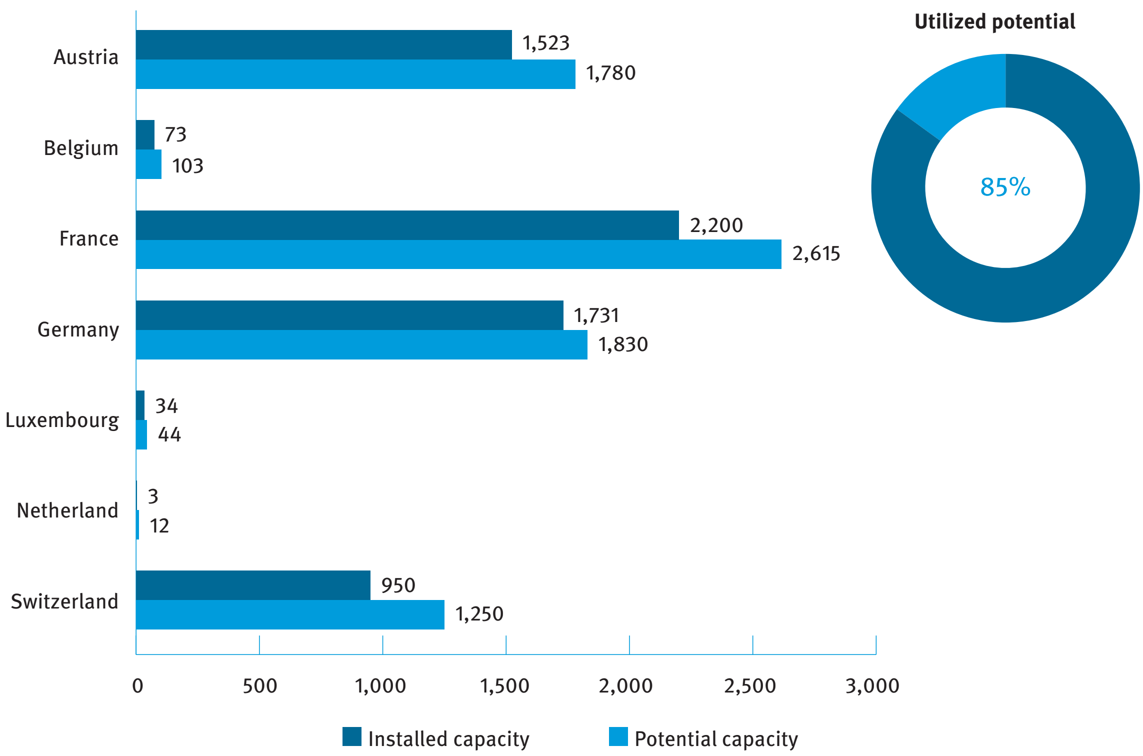
Spain has 1,078 SHP plants with a combined installed capacity of 2,079 MW, whereas the SHP potential is estimated at 2,185 MW. Between the *WSHPDR 2016* and *WSHPDR 2019*, installed capacity decreased by 25 MW. The decrease in installed capacity is due to the crisis that the country's SHP sector is currently undergoing, with a number of plants having been closed. SHP generation is highly dependent on water availability. Thus, in 2017, as a result of low rainfall, electricity generation from SHP plants fell by 33 per cent compared to 2016.

In order to promote the development of renewable energy, all the countries in the region have implemented economic incentives, which have also driven the growth of SHP. Thus, suppliers of electricity from renewable sources have received a range of benefits, which include **FIT** and premiums, priority connection to the grid, guaranteed purchase of electricity, preferential access to the network and subsidies. Greece recently abandoned the FIT system in favour of a new feed-in premium (FIP) scheme. Since 2012, new plants in Portugal do not receive support in the form of FITs. In 2012, Spain also suspended FIT pre-allocation and eliminated economic incentives for new power generation.

Western Europe SHP overview

Austria, Belgium, France, Germany, Luxembourg, Netherlands and Switzerland

Figure 37.
Installed and potential capacity in Western Europe for SHP up to 10 MW (MW)



Source: *WSHPDR 2019*

An overview of SHP in the countries of Western Europe is outlined below. The information used in this section is extracted from the country profiles, which provide detailed information on SHP capacity and potential, along with other energy-related information.

Austria has 3,262 SHP plants with a total installed capacity of 1,523 MW and a production of 6,853.8 GWh per year. While there is no reliable data on the SHP potential, the Austrian Government has set the target of achieving 1,780 MW of SHP capacity, implying that at least this potential is available, 86 per cent of which has already been developed. Compared to the results of the *WSHPDR 2016*, the installed capacity has increased by 11 per cent.

The installed capacity of SHP in **Belgium** is 72.8 MW from 154 sites, while the economic potential is estimated to be 103.4 MW, indicating that more than 70 per cent has been developed. The change in installed capacity compared to the *WSHPDR 2016* is due to refurbishments and new installations. In particular, as a result of refurbishment work, the capacity of the 10 MW Lixhe plant has been reduced by 7 MW and the capacity of the Andenne plant has been reduced by 1.9 MW. Another 7 MW from six plants was installed on navigable waterways, with the remainder coming from very small installations or refurbishments below 100 kW.

France is the regional leader in terms of SHP with an installed capacity of 2,200 MW. The potential is estimated at 2,615 MW, indicating that 84 per cent has been developed. Since the *WSHPDR 2016*, the installed capacity has increased by 8.9 per cent. In April 2016, the Government launched the first call for SHP projects to promote the construction of new green fields and to upgrade the equipment on existing dams, with 19 projects with a combined capacity of 27 MW selected. A new call for tenders for 105 MW of SHP was announced in April 2017.

The installed capacity of SHP up to 10 MW in **Germany** amounts to 1,730.8 MW. It is estimated that there are 7,110 operational hydropower plants with capacity less than 10 MW. However, since many micro- and pico-hydropower plants are used for self-consumption and are difficult to identify, it is likely that there could be a further 300-400 very small-scale plants in operation. Compared to the *WSHPDR 2016*, the installed capacity has decreased by 5.2 per cent, while potential capacity has remained unchanged at 1,830 MW.

Both installed and potential capacities of SHP in **Luxembourg** have remained unchanged, standing at 34 MW and 44 MW, respectively. Thus, 77.3 per cent of the currently known potential has been developed. However, this estimate of the potential is based on the 2020 target, according to which at least a further 10 MW should be developed, while the total available potential remains unknown. Both the public and the private sector are planning to conduct further feasibility studies and to disseminate SHP.

The topography of the **Netherlands** is dominated by lowlands and reclaimed land (polders). As a result, hydropower potential is low and is mostly derived from the existing water management works needed for flood control and navigation measures. Total installed hydropower capacity in the Netherlands is 38 MW, of which SHP accounts for 3 MW. SHP potential in the country is estimated at 12 MW. Since the *WSHPDR 2016*, both the installed and potential capacities have remained unchanged.

There are approximately 1,690 SHP plants in operation in **Switzerland**. Their combined installed capacity is approximately 950 MW and annual production is approximately 4,006 GWh. This represents roughly 12 per cent of the total hydropower capacity. The SHP potential is estimated at 1,250 MW, indicating that 76 per cent has been developed to date. The best sites have already been developed, while the exploitation of the remaining potential is under debate due to economic and ecological constraints.

SHP support mechanisms exist in all countries through tradable green certificates, investment support or subsidies, feed-in tariffs, market premium and premium tariffs. **FITs** are in place in Austria, France, Germany, Luxembourg and Switzerland.

Fish lift ensuring ecological continuity in Runserau, Austria.

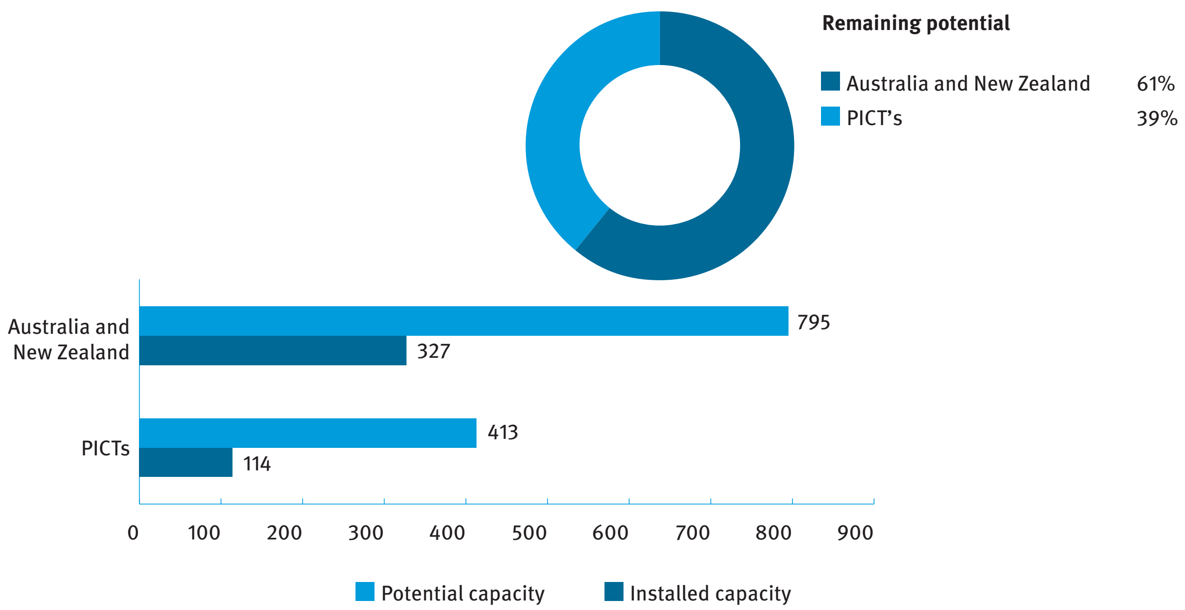
Oceania

Oceania is the smallest region in terms of the number of countries included in this Report as well as in installed and potential SHP capacity. The total installed capacity amounts to 441 MW, indicating an increase of 7 per cent in comparison to the *WSHPDR 2013*. The total estimated potential is 1,208 MW. The installed capacity and the newly assessed potential capacity indicate that approximately 37 per cent has so far been developed. Of the 10 countries in the region, only some regional governments in Australia have established FITs relating to SHP.

The Oceania region is very diverse in terms of SHP potential. While all the countries receive enough rainfall to merit constant SHP production, only a few of the islands have mountainous terrain, which is usually a key factor for SHP potential. The Australia and New Zealand region, which is found in the southernmost part of Oceania, is the richest area in regard to SHP potential, while the Pacific Island Countries and Territories (PICTs) are mostly flat islands and have little or no SHP potential. As a result, the greatest challenge for SHP development in Oceania is the topography.

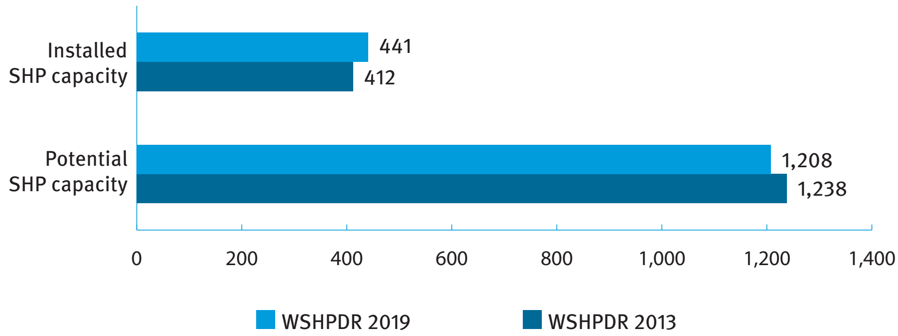
Country	*Local SHP definition*	*Installed capacity (local def.)*	*Potential capacity (local def.)*	*Installed capacity (local def.)*	*Potential capacity (local def.)*
Australia	up to 10	173.0	-	173.0	-
New Zealand	up to 10	154.0	622.0	154.0	622.0
Fiji	-	11.2	14.0	11.2	14.0
New Caledonia	up to 10	9.9	100.0	9.9	100.0
Papua New Guinea	up to 10	29.1	153.0	29.1	153.0
Solomon Islands	up to 10	0.3	11.0	0.3	11.0
Vanuatu	up to 10	1.3	6.0	1.3	6.0
Federated States of Micronesia	-	0.7	9.0	0.7	9.0
French Polynesia	up to 10	48.4	98.0	48.4	98.0
Samoa	-	13.5	22.0	13.5	22.0

Figure 38.
Installed and potential capacity in Oceania regions for SHP up to 10 MW (MW)



Source: *WSHPDR 2019*

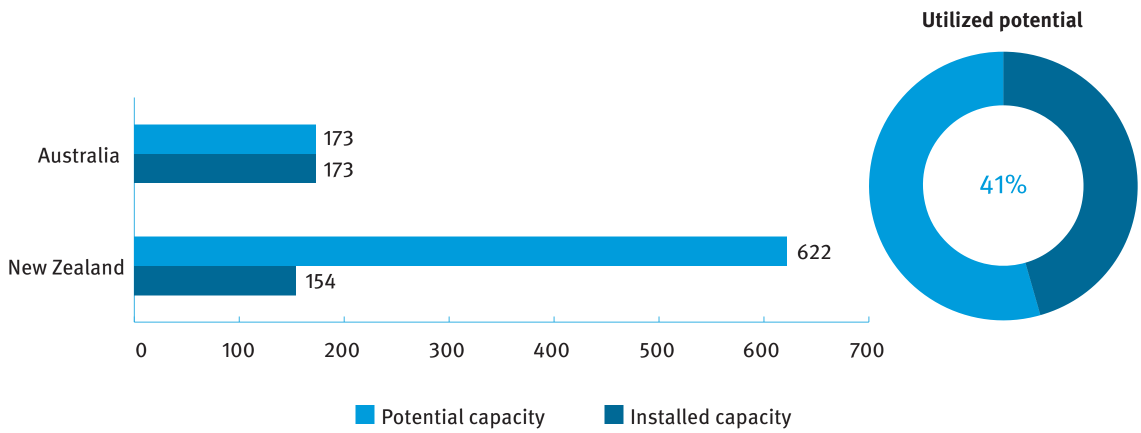
Figure 39.
Comparison of installed and potential capacity in Oceania regions for SHP up to 10 MW (MW)



Source: *WSHPDR 2019*

Australia and New Zealand SHP overview

Figure 40.
Installed and potential capacity in Australia and New Zealand for SHP up to 10 MW (MW)



Source: *WSHPDR 2019*

An overview of SHP in Australia and New Zealand is outlined below. The information used in this section is extracted from the country profiles, which provide detailed information on SHP capacity and potential, along with other energy-related information.

The installed capacity of SHP in **Australia** is 173 MW, which comes from 60 plants. This installed capacity has barely changed since the *WSHPDR 2016*. Some of the new additions include five plants installed by Melbourne Water in 2016-2017: Dandenong of 0.36 MW, Mt Waverley of 0.33 MW, Wantirna of 0.13 MW, Boronia of 0.11 MW and Cardinia Creek of 0.09 MW. There is no known statistical data on the potential SHP capacity in Australia. Australia is known for its aridity, but there are still many waterways and irrigation facilities that could be fitted with hydropower. Sewage treatment sites could also be considered for the installation of SHP systems.

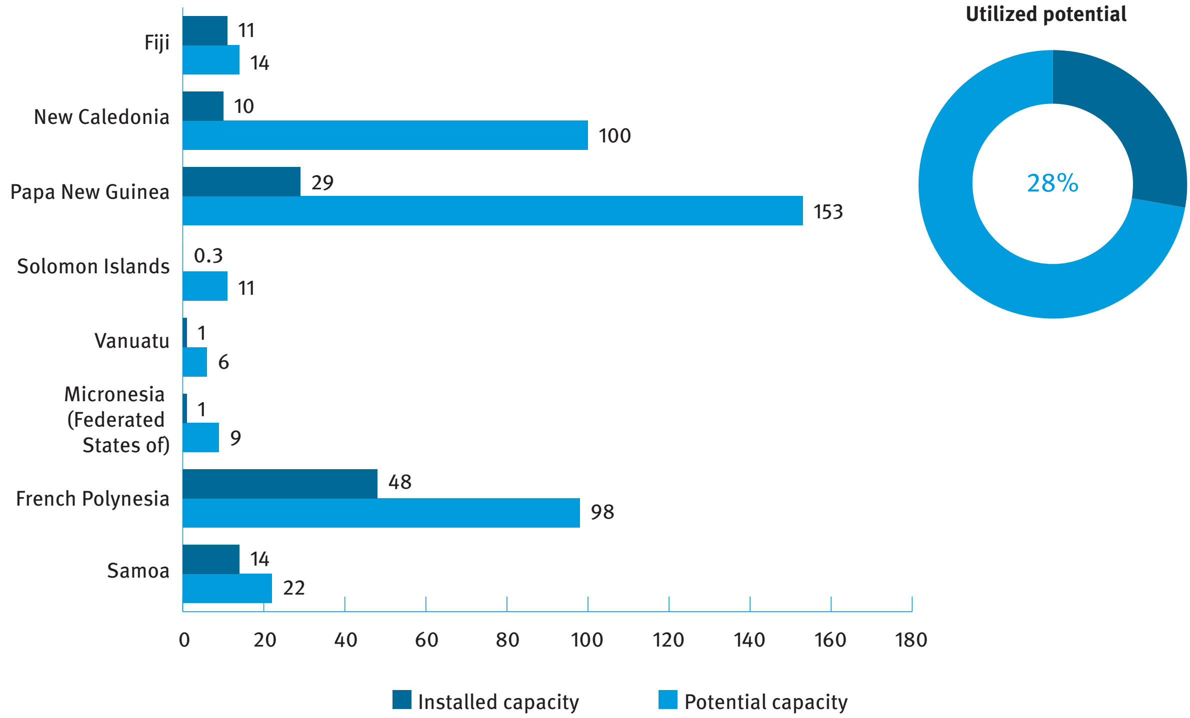
In **New Zealand**, the installed SHP capacity is approximately 154 MW. Its potential stands at 622 MW, indicating that 25 per cent of the known potential has been developed. Most viable mini-hydropower sites with capacities between 100 kW and 5 MW have already been developed, while a large number of projects remain technically feasible though not economically viable or environmentally licensable. As of August 2018, two SHP projects were planned for development by 2020: the 6.5 MW Upper Fraser SHP in the Otago region and the 6.5 MW Ruataniwha Plains in Hawkes Bay. However, large-scale development of SHP is not likely due to the low wholesale price of electricity and the lack of financial support mechanisms that make technically-feasible sites economically unsound. Many other potential sites cannot be licensed due to their location in environmentally-sensitive areas.

No **FIT** schemes have been introduced in New Zealand. In Australia, such schemes are enacted at the State level and have predominantly focused on providing support to small-scale solar photovoltaics.

Pacific Island Countries and Territories (PICTs) SHP overview

Fiji, New Caledonia, Papua New Guinea, Solomon Islands, Vanuatu, Federated States of Micronesia, French Polynesia and Samoa

Figure 41.
Installed and potential capacity in PICT's for SHP up to 10 MW (MW)



Source: *WSHPDR 2019*

An overview of SHP in the countries of the PICTs region is outlined below. The information below summarizes the content of each country report providing input on the SHP development status of those countries.

The SHP installed capacity in **Fiji** is 11.2 MW, representing a 7 per cent increase compared to the *WSHPDR 2016*. There are ten SHP plants in operation with the most recent having been commissioned in 2017 (700 kW Somosomo SHP). The available hydropower potential is about 14 MW, of which approximately 80 per cent has been developed. Small and micro-hydropower projects are also being considered for the development of rural electrification under the Rural Electrification Policy. The Government of Fiji supports renewable energy development as an alternative way to provide a cost-effective energy supply. In addition to hydropower, solar, wind power and biomass projects have been developed, with one of the most recent projects being the Nabou 12 MW biomass plant commissioned in 2017.

Since the *WSHPDR 2016*, the installed SHP capacity of **New Caledonia** has remained unchanged at 9.9 MW, provided by 11 plants ranging from 26 kW to 7.2 MW. The Yaté dam is the major hydropower plant in New Caledonia and the only large hydropower plant with a total capacity of 68 MW. The total potential of SHP is estimated to be between 100 MW and 250 MW. SHP development is currently under consideration, with an ongoing project of a 3 MW SHP plant in Pouébo that is planned to be commissioned in September 2019. Future hydropower development is recommended to focus on reservoir rather than the run-of-river type due to the relatively steep terrain and unsteady precipitation patterns. According to the Energy Transition Plan, the share of renewable energy in electricity generation in the country should reach 100 per cent by 2030. Among renewable energy sources, the efforts are focused on solar and wind power, with likely development of 95 MW and 20.4 MW respectively, by 2020.

The installed capacity of SHP in **Papua New Guinea** stands at 29.1 MW, which indicates a small increase compared to the *WSHPDR 2016*, mainly due to the availability of more accurate data. The SHP potential is estimated to be about 153 MW. This includes at least 6 MW of capacity in the capacity range of 1 MW to 10 MW as well as 500 micro-hydropower sites with an average capacity of 22 kW. The development of hydropower has been prioritized in the country's energy sector strategy as an important energy source to replace thermal power generation and reduce dependence on fossil fuel imports. The 2010-2030 Development Strategic Plan of PNG set the target of achieving 1,020 MW of hydropower installed capacity by 2030, while only 500 MW for all other renewable energy sources combined and 390 MW for gas. Currently, there is an SHP project of 3 MW under development at Popondetta, Oro.

The installed capacity of SHP in the **Solomon Islands** has remained unchanged since the *WSHPDR 2016* and stands at 285 kW. There are 14 hydropower plants with capacities up to 150 kW, six of which are currently in operation. The Government database of SHP sites comprises 100 potential locations of which 62 have an estimated overall capacity of 11 MW.

The installed capacity of SHP in **Vanuatu** has remained at 1.28 MW. The most significant plant in operation is the 1.2 MW Sarakata SHP. The country's estimated potential is about 5.98 MW, showing that 21.4 per cent has already been developed. At the time of the writing of this report, two hydropower projects were underway, the construction of a 600 kW Sakatra SHP extension and the bidding for the construction of the Brenwe SHP (<1.2 MW). Vanuatu's energy system is highly reliant on fossil fuel imports, exposing it to fuel price volatility and supply disruptions. However, the country is rich in renewable energy resources, including hydropower, wind, solar and geothermal power, which could help reduce the reliance on imported fuel.

The Federated States of Micronesia have one SHP plant in Pohnpei. The original installed capacity of this plant was 2.1 MW. However, during the rehabilitation in 2014, only 725 kW were reinstalled and are running to date. The potential of SHP in the country is estimated to be 9 MW, indicating that approximately 8 per cent has been developed. There is a plan to develop a 2.7 MW hydropower plant at Lehnmesi in Pohnpei by 2023.

The installed capacity of SHP in **French Polynesia** is 48 MW, indicating a slight increase compared to the *WSHPDR 2016*. The potential capacity is estimated at 98 MW, of which 49 per cent has been developed. Most of the installed capacity is located on the island of Tahiti (47.2 MW) and the capacity of the Marquesas Islands amounts to 1.2 MW. Studies have been carried out to expand the capacity of the existing ageing plants such as the Vaihiria and Vaite SHPs. In addition to hydropower, there is also significant potential for solar power. The Government aims to achieve 50 per cent of electricity generation from renewable energy sources by 2020 and 100 per cent by 2030. However, the development of renewable energy projects has been modest due to the lack of power regulations.

There are seven small-scale hydropower plants in **Samoa**. Their total installed capacity is 13.5 MW while the potential is around 22 MW. Compared to the *WSHPDR 2016*, installed capacity has increased by 13 per cent as a result of the commissioning of two new plants and the availability of more accurate data. In 2017, the rehabilitation of three plants damaged during Cyclone Evan in 2012 was completed. There are plans to continue the development of hydropower, including the installation of a third turbine at the Taelefaga SHP increasing its capacity to 6 MW, the installation of a 0.2 MW Faleata SHP and at Afiamalu a mixed generation plant with 10 MW of wind power and 10 MW of pumped-storage hydropower.

International finance plays an important role for SHP development in the PICTs region. **FITs** have only been introduced in Vanuatu, where the offered scheme is solely limited to solar power. However, the National Energy Policy of PNG set a target to outline incentives for renewable energy development such as FITs.

Conclusions

SHP is a mature and versatile technology, effective for providing access to clean and sustainable electricity in the developing world, particularly in rural areas. Through developing SHP, many countries have already taken steps—or are beginning to take steps— to alleviate poverty and increase access to electricity. SHP also helps developed nations achieve targets for advancing renewable energy and reducing greenhouse gas emissions.

The purpose of this Report is to illustrate the improvements achieved in the SHP sector across regions and the great positive impacts linked to SHP development. Since the publication of the first edition of the Report in 2013, the combined installed capacity of SHP in the world increased by 10 per cent reaching 78 GW. At the same time known SHP potential increased by 30 per cent to 229 GW. Thus, the data collected in the Report demonstrate that there is still room for improvement for the SHP sector in many parts of the world, with such regions as Central Asia and South America possessing around 30 GW of untapped SHP potential. Overall, despite the progress made in SHP development in the last few years, many of the barriers and, hence, recommendations for the further development of the sector remain similar to those listed in the previous editions of the Report.

The key barriers to SHP development, common for all regions of the world, include the following:

Lack of accurate and up-to-date data

The lack of accurate data on SHP potential is a common barrier for attracting private investment in the SHP sector in developing countries. When available, both in developed and developing countries, data on SHP potential are often based on outdated studies and fail to account for current policy frameworks, technological improvements and the potential arising from the rehabilitation of old sites or the development of existing waterways and dams.

Lack of political focus on SHP development

Primary or exclusive focus on other forms of renewable energy such as wind and solar power has, in some cases, hindered progress within the SHP sector, particularly when policies and financial incentives offered for renewable energy do not apply to SHP. In other cases, focus is overwhelmingly in favour of large hydropower, or SHP potential can be associated with large hydropower potential and consequently given less attention.

Difficulties in finding sustainable sources of financing

In spite of the medium- and long-term benefits outweighing the high levels of initial investment, SHP is still often perceived as high risk by private investors, notably in developing countries. As a result, SHP projects in developing countries are often realized through grants or soft loans from foreign development institutions or other countries, which does not represent a sustainable financing model.

Lack of policies and regulations supporting SHP development

While many countries have renewable energy targets, including targets specifically for SHP, many still lack appropriate and well-defined pathways to achieve these targets that would be aligned with the development plans of other sectors such as water and environment.

Lack of incentives for investors and developers

While financial incentives, such as FITs, are critical for attracting investment into the sector, increasing the confidence of banking institutions and facilitating longer-term loans at more affordable interest rates, many governments have not introduced such incentives for renewable energy or SHP more specifically. However, it is crucial that incentive policies should be tailored to the specific needs of the country as poorly selected and structured incentives can have a more negative-than-positive effect on SHP development.

Lack of local technology and skills

A lack of appropriate local technical skills and expertise hinders both construction of new and operation of existing SHP projects. A lack of local SHP technology makes the sector dependent on foreign imports, with duties and import taxes increasing the costs of SHP development and operation.

Lack of infrastructure and difficulties in providing grid access

Given the nature of SHP technology, appropriate sites are often located in remote areas without access to the local grid. Unless there is explicit government support in the form of policies that guarantee the cost of connection, the costs for some sites can be prohibitive.

Environmental regulations restricting SHP development
For several, mainly developed countries, new environmental protection regulations have placed strain on potential SHP sites because either the regulations require additional costs that make projects unfeasible or they prevent development entirely.

Bureaucratic barriers to SHP development
Cumbersome and lengthy administrative processes, with complicated permit requirements that cross numerous departments are costly, delay project implementation and discourage investors.

Negative public perception of SHP
While SHP does not incur the same environmental costs as large hydropower projects, it nonetheless tends to suffer from a similarly poor public image. The importance and advantages of SHP as a solution to rural electrification and inclusive sustainable industrial development also still remain underestimated.

Impacts of climate change on SHP
Climate change threatens the reliability of SHP. Erratic water supplies can also lead to competition between SHP plants and other sectors, most notably drinking water, leading to plants running less efficiently. However, far from reducing the need for SHP, the impacts of climate change only highlight the desperate need for countries to adopt this and other forms of renewable energy as quickly as possible.

Recommendations

The following recommendations for addressing the barriers outlined above are provided as general recommendations and should not be considered as comprehensive.

Undertake detailed resource assessments

Developing countries should undertake detailed analyses of their SHP potential in order to lower the development costs and encourage private investment. Developed countries should similarly undertake detailed re-assessments of their SHP potential accounting for new technologies, ecological conditions, regulations as well as the potential arising from the conversion of existing infrastructure and the rehabilitation of old sites.

Develop appropriate policies and regulations

Policies and financial incentives already established for other sources of renewable energy should be extended to cover SHP, particularly emphasizing green technology, and clear targets for SHP development should be set. Such policies and incentives should be properly designed to account for the local conditions and draw on a collaboration among agencies responsible for water resources, environment and electricity. Government agencies should also streamline the licensing process by creating a one-stop shop for standardized permits and contracts.

Facilitate access to sustainable sources of financing

An overall strategy aiming to reduce the financial risks for investors should be developed. High initial costs need to be overcome with easier and improved access in order for project developers to be able to successfully provide finance. One measure that can mitigate this is creating awareness of SHP among local banking institutions or microfinance institutions in order to improve the risk assessment and provide conducive loan conditions.

Facilitate access of the SHP industry to equipment and technology

Building or improving industries that serve as components to SHP will aid in the overall development of the SHP sector. In countries with insufficient local technology, access to foreign imports can be aided through the establishment of concessionary duties and reduced import taxes.

Provide reliable infrastructure

Developing robust grids with suitable capacity and coverage to accommodate new connections facilitates connecting SHP plants and is critical for attracting private investment. In countries with high distribution losses, investments in distribution systems should match those in generation, in order to raise overall efficiency of SHP projects. Establishing micro-grids with SHP providing base-load power can also offer a short- to medium-term—or even permanent—solution for electrifying remote and inaccessible communities.

Improve local skills and expertise

By increasing local capacities in conducting feasibility studies, construction, and operation and maintenance of SHP plants, the whole SHP sector can become more self-sufficient and long-lasting for countries.

Strengthen international and regional cooperation

Promotion of SHP by international and regional institutions is essential for mainstreaming SHP as a positive renewable energy solution. On a more specific level, more information is needed on such topics as new SHP technologies, sustainable models for financing and ownership of SHP projects, the effectiveness of financial incentives for SHP development and the impact of climate change on SHP. By developing South-South cooperation and triangular cooperation among developing countries, developed countries and international organizations, international and regional agencies can facilitate the transition of individual pilot SHP projects towards the successful implementation of full-scale SHP programmes.

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Kinetic hydropower is one of the innovative technological solutions that allows more communities to benefit from SHP.

List of abbreviations

ADB	Asian Development Bank
AfDB	African Development Bank
CER	Certified Emission Reduction
CSP	Concentrated solar power
EBRD	European Bank for Reconstruction and Development
ECOWAS	Economic Community of West African States
EIA	Environmental Impact Assessment
ESHA	European Small Hydropower Association
FIT	Feed-in tariff
GEF	Global Environment Facility
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
IEA	International Energy Agency
IRENA	International Renewable Energy Agency
JICA	Japan International Cooperation Agency
NEP	National Energy Policy
OLADE	Latina American Energy Organization (Organización Latinoamericana de Energía)
PICTs	Pacific Island Countries and Territories
PPA	Power Purchase Agreement
PPP	Public Private Partnership
RE	Renewable energy
RET	Renewable energy technology
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educations, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
VAT	Value Added Tax
WFD	Water Framework Directive

Technical abbreviations

Hz	Hertz
kW	Kilowatt
kWh	Kilowatt hour
GWh	Gigawatt hour
l/s	Litre per second
MVA	Mega Volt Ampere
MW	Megawatt
rpm	Rotation per minute
m3/s	Cubic metre per second
kWp	Kilowatt peak
CO_2	Carbon dioxide

Contributing organizations

Laboratoire de Génie Électrique d'Oran (LGEO)

Université des sciences et de la technologie d'Oran – Mohamed Boudiaf (USTO-MB)

Guakía Ambiente

Scientific Research Institute of Energy (SRIE)

Kleinwasserkraft Österreich

Pöyry

Jimma University

France Hydro Électricité

Ea Energy Analyses

Guyana Energy Agency (GEA)

La Asociación Hondureña de Energía Renovable (AHER)

The International Energy Agency Technology Cooperation Programme on Hydropower (IEA Hydro)

International Network on Small Hydro Power (INSHP)

Komite Nasional Indonesia untuk Bendungan Besar (KNI-BB) / National Committee on Large Dams (INACOLD)

Catalytic Innovations

Ministère de l'Energie, de l'Eau et des Hydrocarbures (MEEH) de Madagascar

Universiti Kuala Lumpur (UniKL)

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Agenția pentru Eficiență Energetică (AEE) / Agency for Energy Efficiency, Moldova

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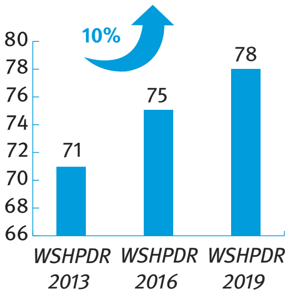
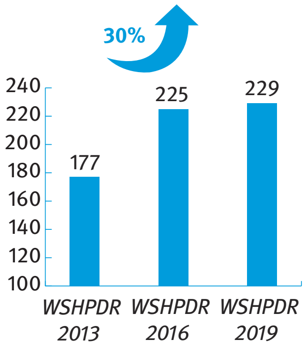
World Small Hydropower Development Report 2019

The ***World Small Hydropower Development Report (WSHPDR) 2019*** is an update of the Report's first two editions in 2013 and 2016. The *WSHPDR 2019* contains 166 national reports and 20 regional reports, with 21 new countries added since the first edition.

World SHP installed capacity (GW)



World SHP potential (GW)



- The Report is available on **www.smallhydroworld.org;**
- More than 230 experts and organizations have been involved;
- The Report covers **20 regions and 166 countries**;
- Every country report provides information on:
  a) Electricity sector;
  b) Small hydropower sector;
  c) Renewable energy policy and;
  d) Barriers to small hydropower development.

A special report with **Case Studies** is added to the *WSHPDR 2019*, showing the different roles small hydropower can play in achieving the SDGs.

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