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INTERNATIONAL CENTER
ON SMALL HYDROPOWER

World Small Hydropower Development Report 2022

Global Overview

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Foreword

by **Gerd Müller, UNIDO Director General** for World Small Hydropower Development Report 2022 Executive Summary

The COVID-19 pandemic caught the world unprepared for a complex, systemic challenge of such a scale. Livelihoods, economic progress, and social stability have been severely impacted worldwide. The COVID-19 pandemic has also slowed progress towards sustainable energy goals. In such a critical moment when multiple crises are coming together, we need a decisive collective effort to follow through on the goals the world community agreed on to build sustainable energy systems. We must make sure that renewable energy development is a top priority at all levels of decision-making.

In the face of this challenge, it is especially critical to continue to collect and share knowledge about the various renewable energy technologies. Small hydropower is one of such solutions. It has long played a key part in providing access to sustainable and reliable electricity around the world. Small hydropower is a simple, adaptable and low-cost technology, which makes it particularly suitable for remote and marginalized communities. When planned with environmental and socio-economic aspects in mind, it provides access to sustainable renewable energy, the basis for any development which also empowers communities, improves livelihoods and is the basis for more development opportunities. Small hydropower offers one answer to many questions posed by the pandemic, climate crisis and energy transition for achieving the commitments under the Paris Agreement.

Over 60 per cent of global small hydropower potential remains untapped. There are still vast opportunities across the globe to use it for the benefit of local communities and the planet. In order to support policy-makers, communities, potential developers and other stakeholders interested in developing small hydropower projects, the United Nations Industrial Development Organization (UNIDO) partnered with the International Center on Small Hydro Power (ICSHP) to launch the fourth edition of the World Small Hydropower Development Report. The first three editions have shown that the report is a much-needed global knowledge product on small hydropower. I am proud that that this is already the fourth edition of the report and that UNIDO and ICSHP are continuing this important work of knowledge gathering and distribution. The valuable content of the current edition is an outcome of a collective effort of more than 200 experts and contributing organizations from all over the world. The production of this comprehensive report would not have been possible without generous support and intellectual leadership from the Ministry of Water Resources of the People's Republic of China and ICSHP.

I am confident that this report will contribute to the global effort to build sustainable energy systems that will help mitigate the climate crisis and empower communities.

Prologue

World today

Providing universal access to electricity remains one of the most critical economic, environmental and development challenges facing the world today, with over 700 million people, or 9.5 per cent of the global population, predominantly in rural areas, still lacking access to electricity in 2020.[1] The number of people gaining access to electricity every year has been increasing since 2010. However, progress has been uneven and must be accelerated if the United Nations Sustainable Development Goal (SDG) 7, targeting universal access to affordable, reliable, sustainable and modern energy, including universal access to electricity, is to be met by 2030. Meeting SDG 7 remains critical because access to reliable and affordable electricity has an immediate and transformative impact on the quality of life and is crucial to ensuring access to such basic services as healthcare and education. At the same time, in both developing and developed countries, the need for clean and sustainable sources of energy is becoming more acute in the face of the climate crisis and environmental degradation. Sustainable renewable energy is therefore a key building block towards both the broader development goals, including poverty eradication and public services provision, and climate crisis mitigation and prevention of environmental degradation.

Based on current policies, the share of renewable energy is expected to reach 22 per cent by 2030 (from 16.1 per cent in 2010 and 17.7 per cent in 2019), falling short of the significant increase required. It is estimated that approximately 670 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 2.1 billion people will continue to use wood and coal for cooking in 2030 (2.4 billion in 2020), which poses major health risks worldwide.[2]

Small hydropower and SDGs

As the lowest-cost renewable energy technology, hydropower remains integral to international efforts to fight the climate crisis and ensure a clean energy future. Overall, 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, 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).

Small hydropower (SHP), due to its adaptability to the local needs and conditions and suitability for remote rural areas with low-density energy demand, has been at the centre of development strategies worldwide, whilst helping reduce greenhouse gas emissions and promoting greater energy independence. If effectively and sensitively planned, SHP projects can also offer opportunities for the empowerment of local communities (SDG 11), including the usually disadvantaged groups such as women and youth, empowering them economically (SDGs 5 and 8), and contributing to progress towards greater equality (SDG 10).

Project financing

A lack of modern energy access is one of the key hindrances to economic development and poverty alleviation, particularly in rural communities. 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 averaging USD 2.7 trillion per year between 2020 and 2030, ramping up to USD 4 trillion by 2030, will be required if the goal of universal access to modern energy services is to be met by 2030, with the majority of these investments required in Sub-Saharan Africa.[2] Several mechanisms and strategies do exist to promote the financing of SHP projects, but much more still needs to be done to allow the available potential to be fully exploited. 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 Global Environment Facility (GEF), the World Bank and the African Development Bank (AfDB), to name just a few.

But many problems persist. 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.

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 the fee-for-service scheme in Zambia. The role of micro-finance institutions (MFIs) in financing SHP should also be investigated.

In many countries, community-owned SHP projects, operated to meet the electricity needs of the community itself, have proven a sustainable solution to rural electrification. For example, a large-scale community-owned SHP programme has been implemented in the Dominican Republic through a combination of government and GEF funding, and continues to expand. In Japan, community-owned SHP projects have been financed by local governments to revitalize rural communities at risk of long-term economic decline. Construction of such projects is typically financed by a combination of grants from the national government and international development agencies. Where successful, the costs of investment in these projects to local or national budgets are balanced by the reduced volume of financing required for subsidizing such communities in other spheres, funding relocation costs, or dealing with other negative economic externalities of rural flight.

Ultimately, better governance and policymaking is needed to catalyze 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, 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 6.9 million in 2019, mainly due to growth in Asia.[2]

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 small hydropower sector

Empowering women and girls and closing gender gaps are critical to realizing sustainable development goals (SDG) and ensuring a good quality of life for all. The energy sector, and in particular, decentralized systems such as SHP can facilitate the achievement of these targets. SHP can provide not only sustainable energy but also a steady baseload, which can facilitate positive changes to women's lives in the communities in which SHP plants are constructed and also beyond these communities.

In countries with low levels of access to electricity, benefits of access to electricity from SHP plants for women can include reduced time poverty and drudgery due to the use of electric appliances for household chores and economic activities. This immediately improves women's welfare but can also have knock-on benefits when such time is invested in studying, income generation and other life-enhancing activities. SHP development can also create direct and indirect jobs, provide power for productive uses and income generation and improve the delivery of critical social services including education and health services. Making the gender approach part of project design and implementation is critical to ensuring that SHP projects help empower women and girls across the globe, and close gender gaps. It is also crucial to identify and address barriers to women's participation in the SHP sector.

Youth and small hydropower

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.

Young people around the world can play a key role in creating the change required for the transformation of the global energy system, thus, contributing to regional and international development aims, while at the same time finding and creating opportunities for their own professional and personal development. While much of the world's SHP potential remains untapped, the SHP sector offers great opportunities for young professionals and entrepreneurs to get involved in providing clean energy to communities across the world. The active participation of youth in SHP can play a vital role in achieving a sustainable energy system because young people can bring the creative and forward-oriented thinking that is needed for a rapid energy transition. At the same time, young people continue to face multiple barriers in accessing the required skills to get involved in the sector as well often do not receive the needed policy, institutional and financial support. These barriers and inadequacies must be identified and addressed in order to realize the promise of SHP as a vehicle for social mobility, economic engagement and professional development for today's young people.

Small hydropower and climate change

Hydropower has a dual relationship with the climate crisis — it helps mitigate the impacts of changing climate but is also subject to vulnerability because of its dependence on the hydrological regime, which is affected by climatic conditions. Hydropower projects help displace fossil fuel energy sources (particularly, oil, coal and biomass in the case of SHP) and limit global warming. At the same time, changes in runoff due to climate change can have an effect in the short term (days, months) and the long run with significant implications for the productive uses of SHP plants. Climate change also induces effects in other sectors that can cascade to SHP plant operations, with competing water uses and different requirements from the grid also affecting the operations of SHP plants. However, climate change will impact hydropower generation in different ways depending on the region. Moreover, size influences the project's role in mitigation and adaptation to climate change. Due to limited capacity to store water and control floods, run-of-river SHP plants are particularly vulnerable to changing hydrological patterns.

It is therefore important to assess the ongoing and projected impacts of climate change on the SHP sector and identify solutions that would mitigate these impacts. It is additionally important understand the impacts of ongoing SHP use and development on the environment, local economies and communities in the context of shifts in the availability of water resources and competing water demand and within the overall framework of climate change-resilient SHP.

Innovation, modernization 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 benefit from digitalization through preventive monitoring and increased operational efficiency. Digitalized hydropower is an end-to-end solution that employs data, analytics and software applications together with hardware solutions. It can enhance efficiency, cybersecurity, reliability as well as the profitability of a hydropower plant over its lifetime. A fully digitalized plant could contain self-learning systems that intelligently support plant owners in strategic decisions and enable them to maximize the profit.

Unfortunately, hydropower somewhat lags behind other electricity generating sectors in the field of digitalization, due to many projects that were constructed decades ago and have aged equipment. Therefore, digitalization remains an important field to further researched and developed for improved SHP operation and development.

World Small Hydropower Development Report 2022

In order to more effectively promote SHP as a renewable and rural energy solution and overcome existing barriers, it is essential to identify the development status of the technology across regions and engage stakeholders to share existing knowledge and experience. Prior to the first edition of the *World Small Hydropower Development Report (WSHPDR)* published in 2013, it was clear that a comprehensive reference publication for decision-makers, stakeholders and potential investors was needed. Today, the *WSHPDR* is the only global publication dedicated to the dissemination of in-depth information on SHP development.

For the fourth time, the United Nations Industrial Development Organization (UNIDO) and the International Center on Small Hydro Power (ICSHP), as the global knowledge leaders in the SHP sector, are continuing their partnership for the new edition of the report, the *WSHPDR 2022*. The new edition contains 20 regional chapters, 166 country chapters, 12 case studies, 3 thematic publications as well as a global database of existing and planned SHP plants. The *WSHPDR 2022* is the result of an enormous collaborative effort between UNIDO, ICSHP and over 200 local and regional SHP experts from across the globe, including engineers, academics and government officials. The current edition of the Report aims not only to provide an update on the SHP status by country but also to expand on the first three editions by providing improvements in data accuracy with enhanced analysis and a more comprehensive overview of the sector by country.

What is new?

Compared to the previous editions, the *WSHPDR 2022* offers a more detailed analysis of the SHP status by country, covering such aspects as operational, planned and potential SHP projects, cost of SHP development, financial mechanisms available for SHP projects, effects of the climate crisis on SHP as well as factors favouring further SHP development. Furthermore, the new edition includes three thematic publications addressing the topics of gender equality, youth involvement and climate change from the perspective of SHP as well as the first global database of developed and planned SHP projects by country. Finally, the current edition includes a collection of new case studies illustrating successful examples of SHP implementation, focusing on the social benefits of SHP projects, new technological solutions available as well as green SHP.

Thematic publications

Compared to the previous editions, the *WSHPDR 2022* has been expanded with three thematic publications exploring three important aspects of SHP development: gender empowerment, youth involvement and climate change. The social and environmental aspects of SHP development often do not receive the needed attention and the particularities of the SHP technology can be lost in more general analyses devoted to renewable energy technologies or hydropower. These three publications aim to address this gap in the understanding of the SHP sector by exploring the specificity of the SHP technology in terms of how it both impacts and is impacted by gender dynamics, youth representation and climate change. The information gathered in these publications is based on literature reviews and expert and stakeholder interviews and is intended to highlight key themes within each topic as well as outline some of the most important directions for further research and analysis.

Global SHP Database

As part of the new edition of the *WSHPDR* and in collaboration with local experts, UNIDO and ICSHP have created the first Global SHP Database, which aims to gather in one place and make easily accessible detailed information on SHP projects worldwide. The database consists of two sections: (a) existing SHP plants and (b) planned and potential SHP projects. Currently, it includes data from 129 countries and territories across five continents, listing 6,249 existing SHP plants and 8,860 potential and planned plants. The database is intended to serve as a source of information on the current status of SHP development by country as well as on projects that are under development or are available for investment.

The database is based on the most accurate data available, however, the completeness of data varies from country to country. Moreover, some countries have legal restrictions on sharing data on power plants publicly and, hence, these countries were not included in the database. This indicates that further efforts are required both on a local and international level, where this is possible, to compile detailed information on SHP projects to have a more complete understanding of the sector. It is hoped that the database can be further expanded in future editions.

Case studies

The case study section of the *WSHPDR 2022* comprises 12 case studies. The case studies share the best practices and experiences from a range of countries, highlighting the potential of SHP for productive use and community development. They demonstrate that SHP plants, when carefully planned and developed respecting the needs of communities and with regard to local capacities, infrastructure and environment, can provide a reliable and affordable source of electricity, revolutionizing the daily lives of communities, in particular in rural areas.

The section aims to provide real-life examples of benefits that communities can receive from SHP as well as the challenges encountered and solutions found during the implementation of SHP projects. Each case study includes a list of lessons learnt summarizing the factors that should be kept in mind while planning, developing and implementing SHP projects in order to ensure their success. This information might be particularly useful for decision-makers, students, engineers and company managers.

The case studies are gathered under the following three themes.

SHP for social and community development: Many people in the world still live without access to affordable, reliable and clean electricity. Lack of electricity is a significant barrier to human, social and community development, specifically impacting vulnerable groups, including women and young people. The case studies presented in this group (Brazil, Ghana, Japan, Kenya, Tanzania and Zambia) demonstrate the benefits that SHP can offer target communities. In particular, the discussed projects created employment opportunities, increased the standard of public service provision, improved security and education conditions. In these cases, SHP helped communities become more autonomous, stimulated local business and entrepreneurship and considerably improved life quality.

Technological solutions for SHP: SHP development and operation can be influenced by different factors, such as market, weather, site location and strict environmental regulations. A range of technical solutions exist that can help adapt the SHP technology to the local conditions and improve the control over different factors, making the SHP management more efficient and predictable. These include retrofitting of existing civil structures (Italy case), developing a compact run-of-river low-head hydropower concept (Hydroshaft), using innovative software solutions such as HYDROGRID's automated data-driven optimization for SHP cascades, intelligent operation control and dispatching systems for complementary power plants (China case), or Fichtner's Hybrid Configurator that helps design hybrid power plants and analyze their technical and financial impact.

Green SHP: Lack of appropriate regulation and control over SHP development can result in significant ecological impact including river dehydration, changed river ecology, reduced river connectivity and affected migratory fish and other aquatic species. Lack of sustainable practices, can also increase the risk of socio-environmental conflicts. 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. The Ukraine case study outlines the importance of SHP construction and operation in line with the principles of ecological sustainability.

Introduction to the World Small Hydropower Development Report 2022

According to the *WSHPDR 2022*, the global installed SHP capacity for plants of up to 10 MW is estimated at approximately 79.0 GW and the total known potential for SHP up to 10 MW (including developed capacities) is estimated at 221.7 GW. Thus, despite the appeal and benefits of SHP solutions, much of the world's SHP potential remains untapped (64 per cent). It should be noted that for a number of countries, including those with very developed SHP sectors (for example, India), data on SHP of up to 10 MW are not available due to the use of different local definitions. Therefore, the global installed and potential capacity can be assumed to be somewhat higher than the reported totals.

Compared to the *WSHPDR 2019*, SHP installed capacity (up to 10 MW) increased by 1 per cent (Figure 1). At the same time, the estimated SHP potential decreased by 3 per cent (Figure 2) based on more accurate data obtained for a number of countries, including Norway, Turkey and the Philippines, as well as due to the lack of data on SHP of up to 10 MW for some other countries.

Figure 1. **Global Installed Capacity of Small Hydropower of ≤10 MW in the WSHPDR 2013/2016/2019/2022 (GW)**

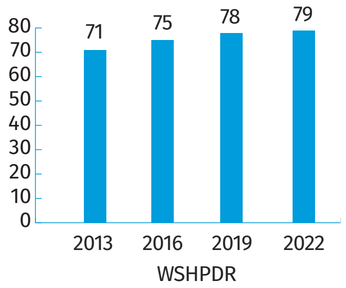
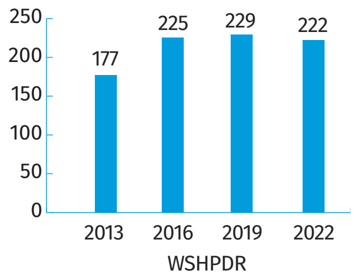
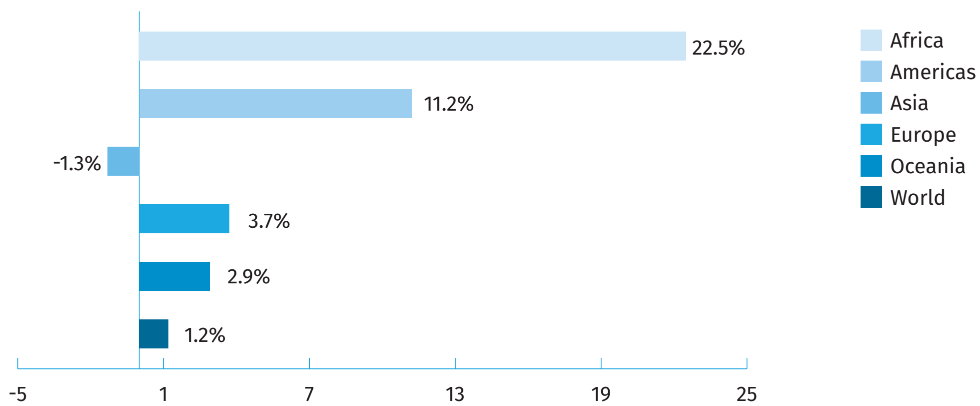


Figure 2. **Global Potential Capacity of Small Hydropower of ≤10 MW in the WSHPDR 2013/2016/2019/2022 (GW)**



The greatest relative increase in installed SHP capacity compared to the *WSHPDR 2019* is reported for Africa with an increase of almost 23 per cent (Figure 3). The Americas, Europe and Oceania have also seen an increase in installed SHP capacity of approximately 11 per cent, 4 per cent and 3 per cent, respectively, compared to the previous edition of the Report. In absolute terms, the largest increase in installed capacity is reported for Europe at 734 MW, followed by the Americas with 698 MW and Africa with 134 MW of new capacity. Conversely, the reported SHP installed capacity of Asia decreased by approximately 1 per cent, as a result of an updated estimation for Turkey as well as a lack of data for the 10 MW definition for some countries.

Figure 3. **Change in Installed Small Hydropower Capacity between the *WSHPDR 2019* and the *WSHPDR 2022* by Continent (%)**



SHP (of up to 10 MW) represents approximately 1 per cent of the total electricity installed capacity of the countries included in this Report and 6 per cent of their total installed hydropower capacity. Asia continues to have the largest installed capacity and potential for SHP of up to 10 MW, accounting 64 per cent and 63 per cent of the global total, respectively. Europe has the highest percentage of SHP development (52 per cent for SHP up to 10 MW), with Western Europe having 83 per cent of its known potential already developed (Figures 4 and 7).

Figure 4. **Small Hydropower Capacities of up to 10 MW by Continent (MW)**

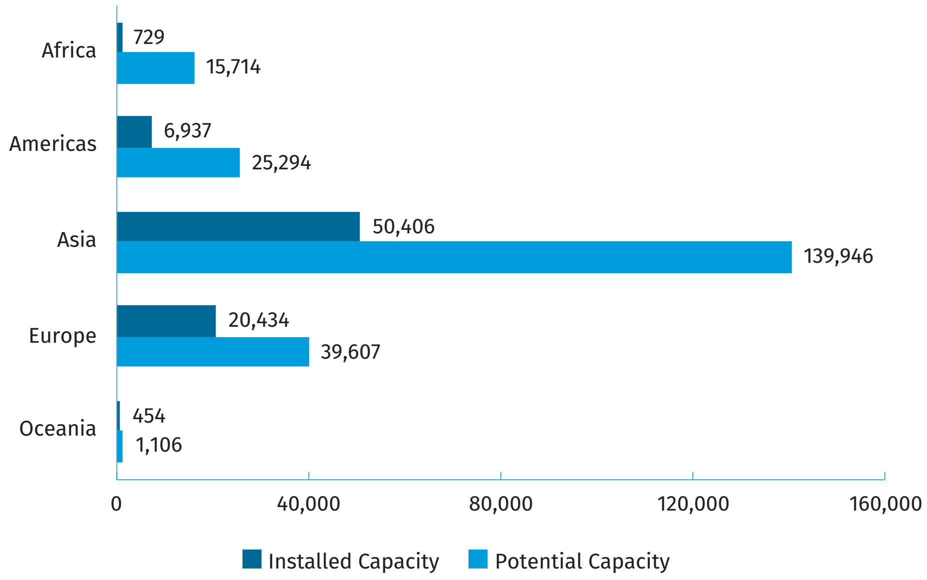
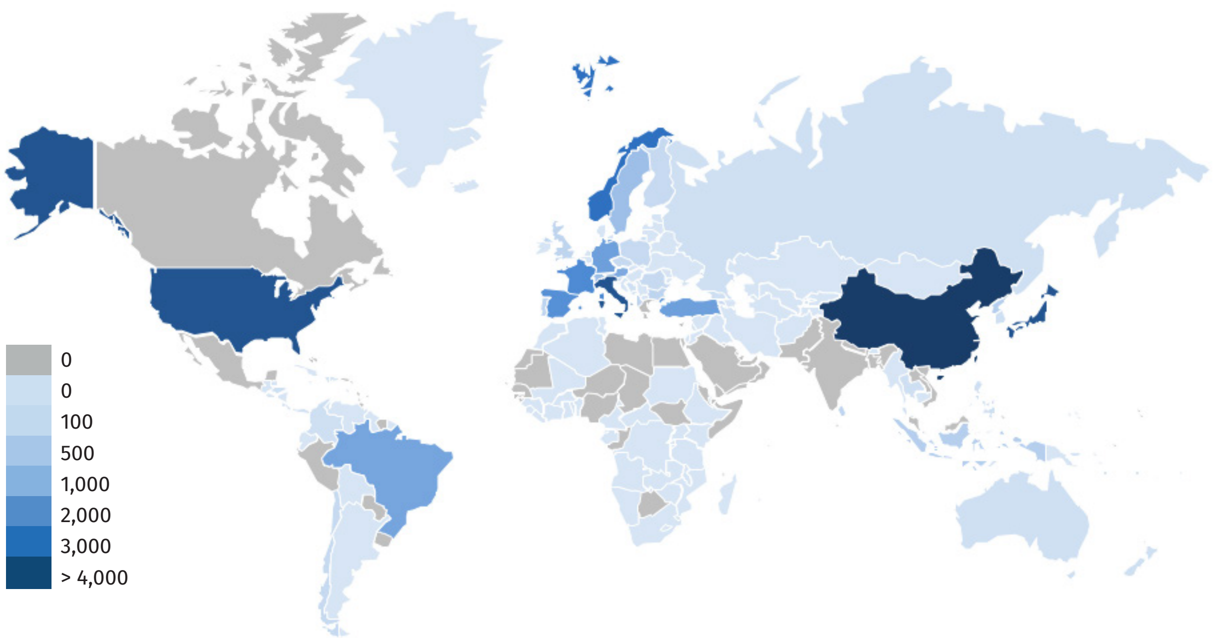
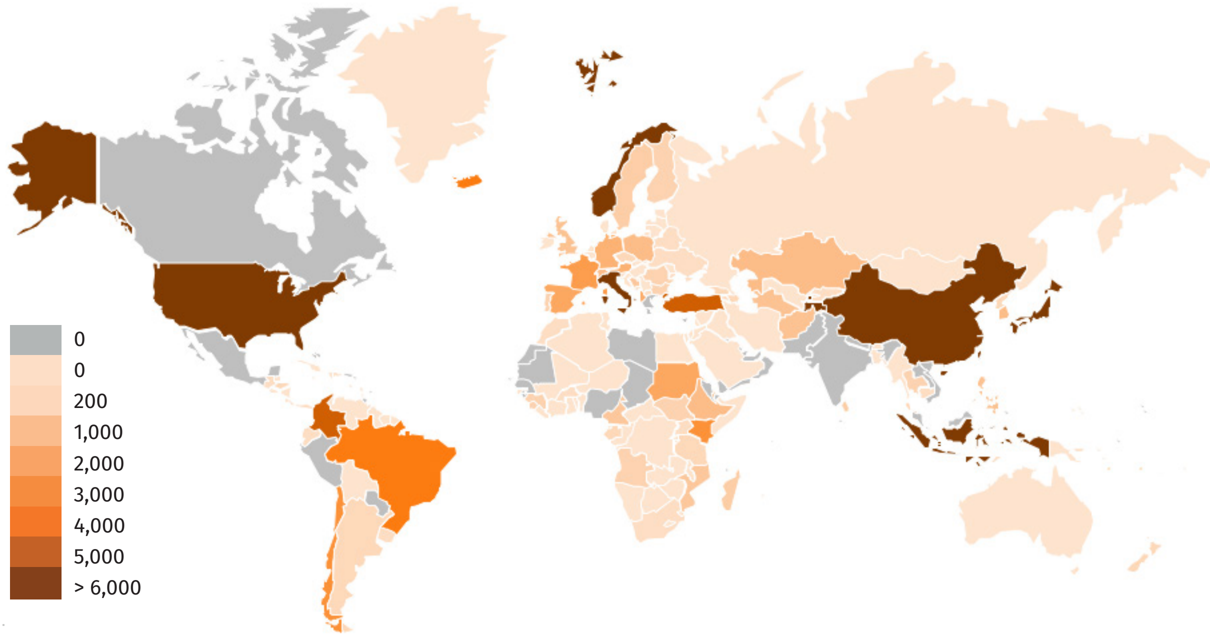


Figure 5. **Small Hydropower Installed Capacity of ≤10 MW by Country (MW)**



Note: Highlighted in grey are countries without data on SHP of ≤10 MW or no SHP plants installed.

Figure 6. **Small Hydropower Potential Capacity of up to 10 MW by Country (MW)**



Note: Highlighted in grey are countries without data on SHP of up to 10 MW or no SHP plants installed.

China continues to dominate the global SHP landscape, with 53 per cent of the world's total SHP installed capacity (definition of up to 10 MW) and approximately 29 per cent of the world's total known SHP potential. In terms of installed capacity, China is followed by the United States of America (USA), Italy, Japan and Norway. Together, these five countries account for almost 71 per cent of the world's total installed capacity of SHP up to 10 MW (Figure 8). The majority of the world's remaining undeveloped SHP potential is located in Asia (Figure 9). The largest known undeveloped SHP potentials are concentrated in Central Asia, Eastern Asia and South-Eastern Asia. (Figure 10).

Figure 7. **Share of Total Installed Small Hydropower Capacity by Continent (%)**

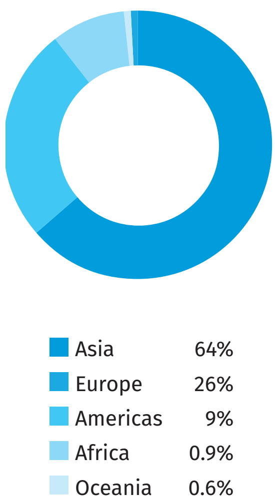


Figure 8. **Share of Total Installed Small Hydropower Capacity of Top 5 Countries Compared to the Rest of the World (%)**

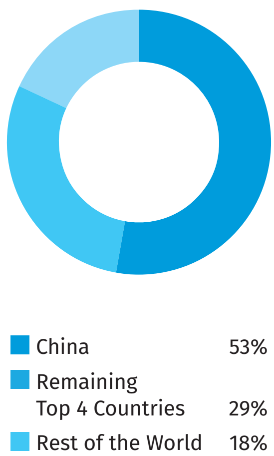


Figure 9. **Share of Total Remaining Small Hydropower Potential by Continent (%)**

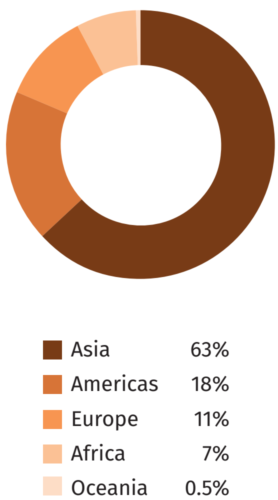
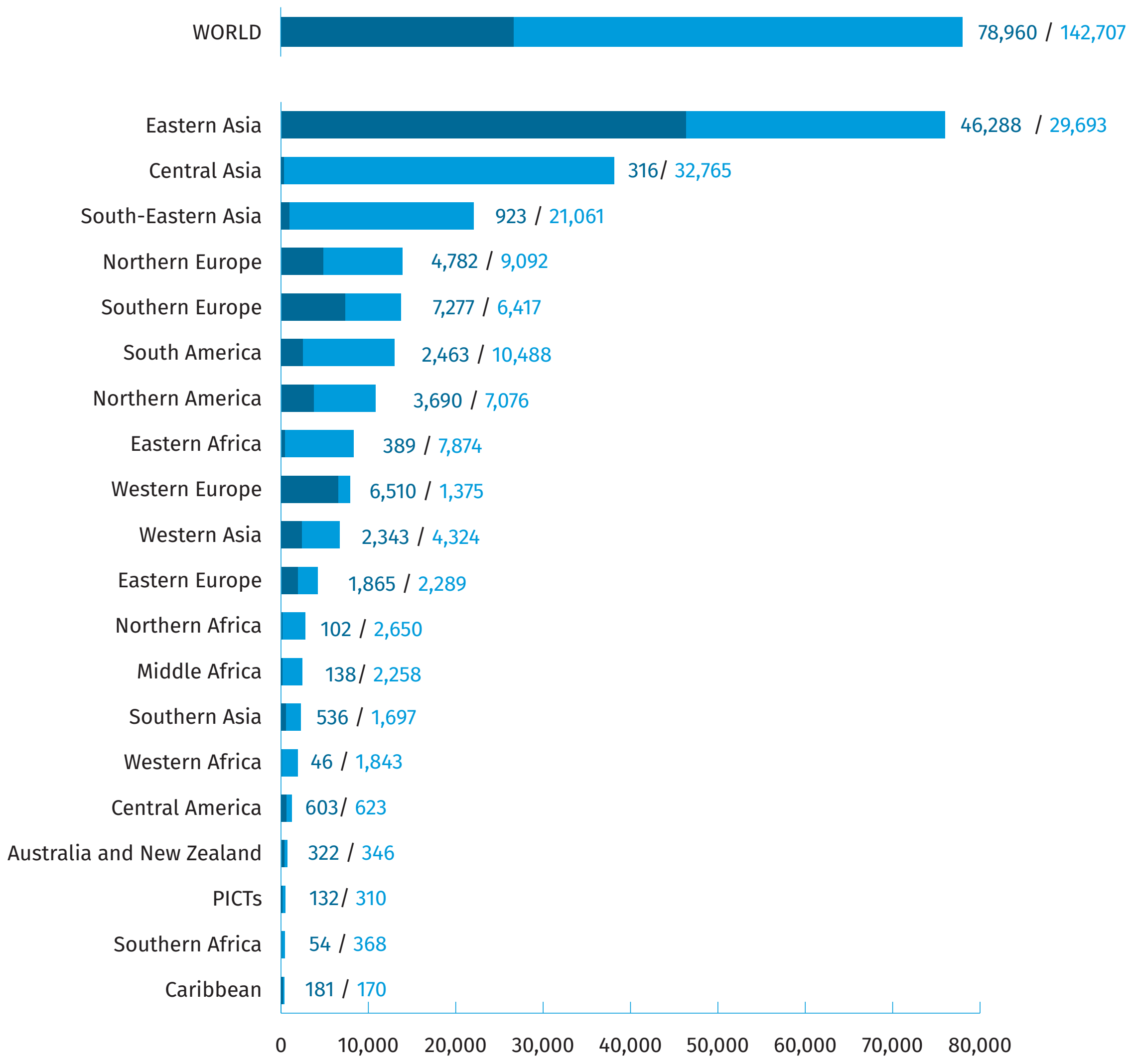


Figure 10. **Developed and Remaining Small Hydropower Potential of up to 10 MW by Region (MW)**



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 across the continent, resulting in a large variance in SHP potential in the north and south as compared to the east and west. The total installed capacity of SHP up to 10 MW in Africa is 729 MW and the total estimated potential is 15,714 MW. This indicates that less than 5 per cent of the known SHP potential of up to 10 MW has been developed so far.

Eastern Africa has the highest installed capacity of SHP of up to 10 MW on the continent (53 per cent of the continental total), followed by the Middle and Northern Africa regions. The highest known SHP potential is also found in Eastern Africa (also 53 per cent of the continental total), while the lowest potential is found in Southern Africa. Of all the countries in Africa, Uganda has the highest installed capacity of SHP of up to 10 MW (108 MW), whereas Kenya has the highest estimated potential for SHP of up to 10 MW (3,000 MW).

Country	*Local SHP definition*	*Installed capacity (local def.)*	*Potential capacity (local def.)*	*Installed (≤10 MW)*	*Potential (≤10 MW)*
Algeria	≤10 MW	47.1	N/A	47.1	N/A
Angola	≤10 MW	46.1	600.0	46.1	600.0
Benin	≤30 MW	0.5	95.0	0.5	N/A
Botswana	N/A	0.0	N/A	0.0	1.0
Burkina Faso	N/A	N/A	N/A	5.0	246.0
Burundi	≤1 MW	2.2	30.5	17.4	61.0
Cameroon	≤5 MW	1.5	N/A	1.5	970.0
Central Africa Republic	≤10 MW	18.8	41.0	18.8	41.0
Congo	N/A	N/A	N/A	0.0	70.5
Côte d'Ivoire	≤10 MW	5.0	45.7	5.0	45.7
Democratic Republic of the Congo	≤10 MW	56.0	101.0	56.0	101.0
Egypt	N/A	N/A	N/A	0.0	120.0
Equatorial Guinea	N/A	N/A	N/A	7.5	31.9
Eswatini	N/A	8.2	16.2	8.2	16.2
Ethiopia	≤10 MW	12.9	1,500.0	12.9	1,500.0
Gabon	N/A	N/A	N/A	6.0	518.1
Gambia	≤30 MW	0.0	N/A	0.0	19.5
Ghana	≤1 MW	0.1	9.9	0.1	17.4
Guinea	≤1.5 MW	N/A	N/A	11.2	751.8
Kenya	≤3 MW	N/A	N/A	66.3	3,000.0
Lesotho	≤10 MW	3.8	38.2	3.8	38.2
Liberia	≤30 MW	4.9	592.0	4.9	N/A
Madagascar	N/A	N/A	N/A	37.0	836.0
Malawi	≤5 MW	4.7	150.0	12.9	N/A
Mali	≤30 MW	5.7	154.7	5.7	N/A
Mauritania	N/A	0.0	N/A	0.0	N/A
Mauritius	N/A	N/A	N/A	19.7	19.7
Morocco	≤10 MW	30.5	300.0	30.5	300.0
Mozambique	≤10 MW	4.8	1,000.0	4.8	1,000.0
Namibia	N/A	0.1	120.0	0.1	120.0
Niger	N/A	0.0	N/A	0.0	8.0
Nigeria	≤30 MW	57.2	734.3	N/A	N/A
Réunion	≤10 MW	10.6	16.6	10.6	16.6
Rwanda	≤5 MW	34.4	111.1	N/A	N/A
Sao Tome and Principe	≤10 MW	1.9	63.8	1.9	63.8
Senegal	≤10 MW	0.0	0.0	0.0	0.0
Sierra Leone	≤30 MW	12.2	N/A	12.2	639.0
Somalia	N/A	N/A	N/A	0.0	4.6
South Africa	≤40 MW	N/A	N/A	42.0	247.0
South Sudan	N/A	N/A	N/A	0.0	688.1
Sudan	≤5 MW	N/A	N/A	7.2	2,228.6
Tanzania	≤10 MW	30.5	480.0	30.5	480.0
Togo	N/A	N/A	N/A	1.6	137.0
Tunisia	N/A	N/A	N/A	17.0	56.0
Uganda	≤20 MW	186.0	400.0	107.9	214.1
Zambia	≤20 MW	N/A	N/A	18.7	62.0
Zimbabwe	≤30 MW	31.4	N/A	16.1	120.0

Figure 11. **Installed and Potential Small Hydropower Capacity up to 10 MW in Africa (MW)**

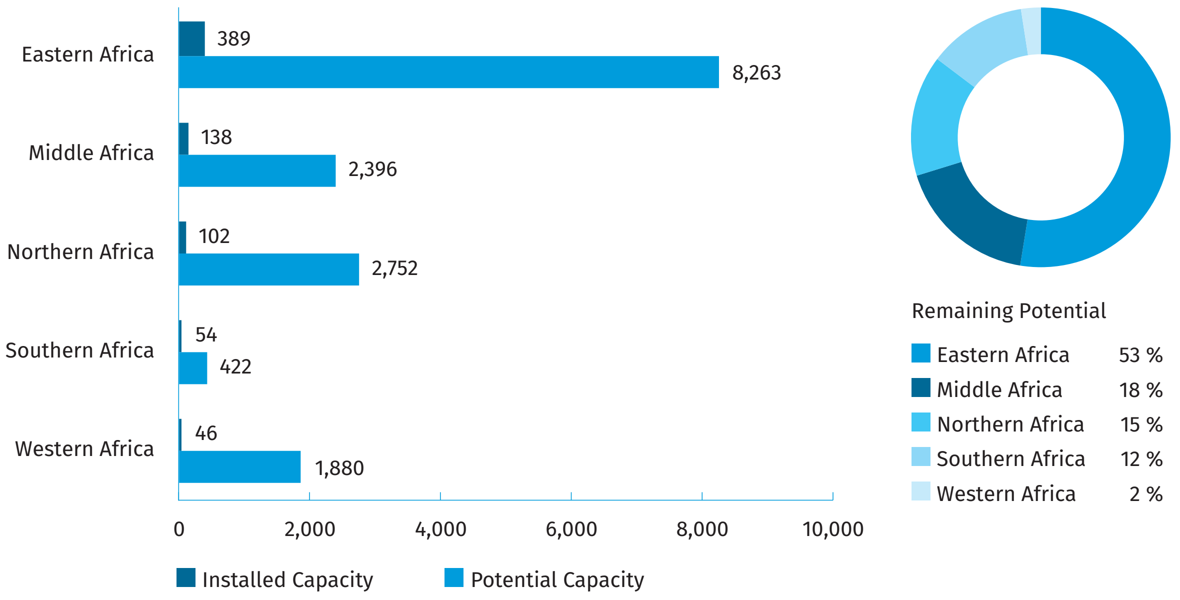
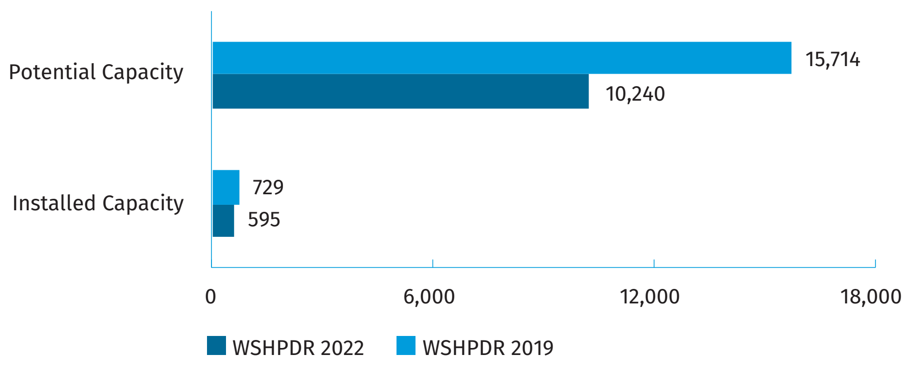


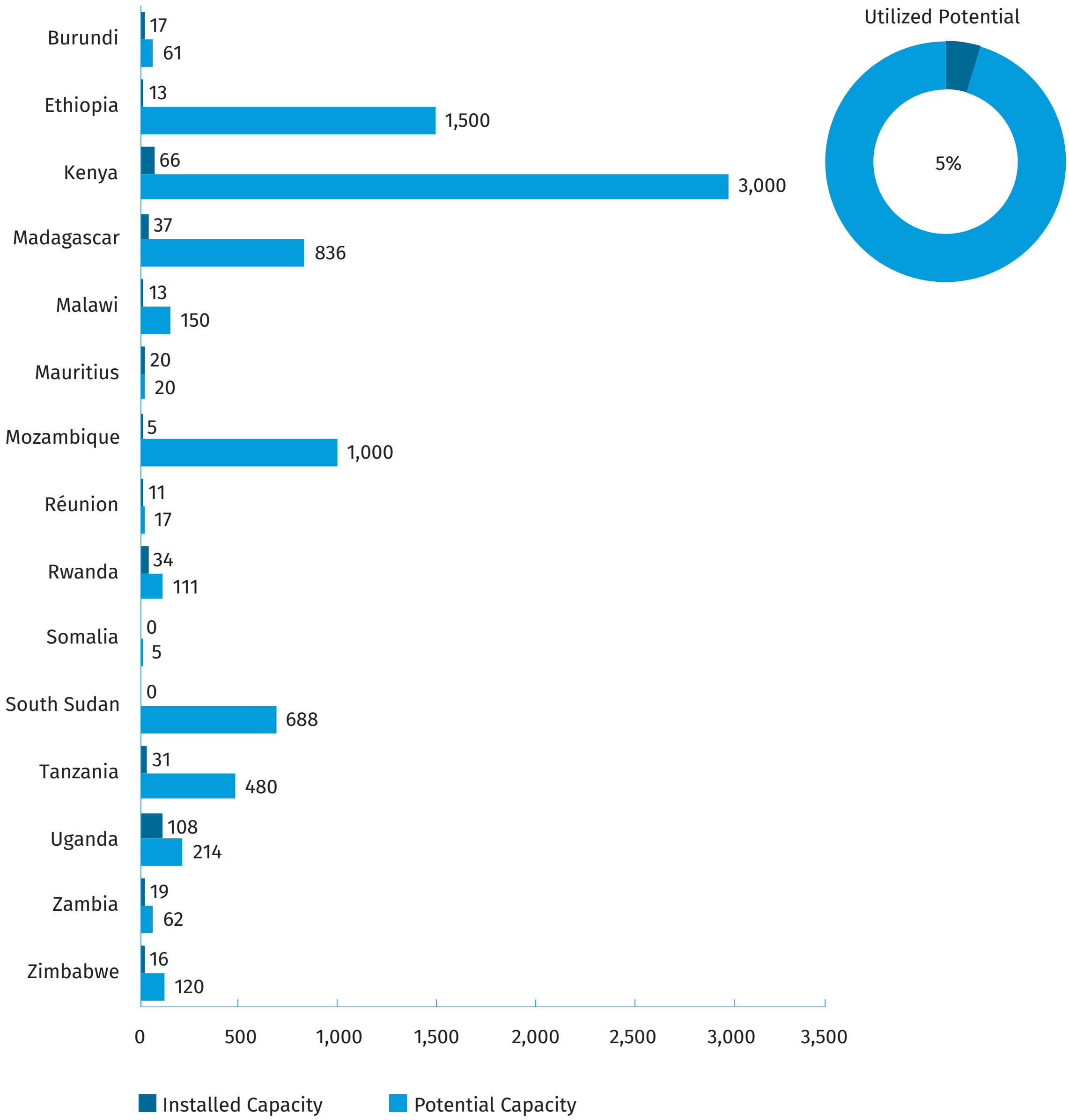
Figure 12. **Comparison of Installed and Potential Small Hydropower Capacity up to 10 MW in Africa in the *WSHPDR 2019* and *WSHPDR 2022* (MW)**



Eastern Africa SHP Overview

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

Figure 13. **Installed and Potential Small Hydropower Capacity up to 10 MW in Eastern Africa (MW)**



An overview of SHP in the countries of 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.

The installed SHP capacity up to 1 MW in **Burundi** is 2.2 MW, while the estimated potential capacity is 30.5 MW, indicating that 7 per cent has been developed. For SHP up to 10 MW, installed and estimated potential capacities are 17.4 MW and 60 MW, respectively, indicating that 29 per cent has been developed. While no new SHP plants have been commissioned in recent years, two SHP projects with a cumulative capacity of 9.1 MW were in the planning stages as of 2021.

In **Ethiopia**, the installed capacity of SHP up to 10 MW is 12.9 MW, while potential capacity is estimated at 1,500 MW, indicating that less than 1 per cent has been developed. While Ethiopia is in the process of expanding its already considerable large hydropower capacity, the SHP sector in the country has seen little development in the last few years and there are no plans for the construction of any additional SHP plants in the near future.

The installed capacity for SHP up to 10 MW in **Kenya** is 66.3 MW, while potential capacity has been estimated at 3,000 MW, indicating that approximately 2 per cent has been developed. The country has actively pursued SHP development, with a large number of plants operated by the Kenya Tea Development Authority (KTDA) to support the operation of tea processing facilities. More than 260 potential SHP sites have been identified in studies carried out over the last decade, with the highest concentration of potential sites located in the Tana River basin. Many new SHP projects are either under construction or in the planning stages, with the KTDA continuing to play a key role in SHP development in the country.

The installed capacity of SHP up to 10 MW in **Madagascar** is 37 MW. The estimate of potential capacity, updated on the basis of a 2017 study, is 836 MW, suggesting that 4 per cent has been developed. SHP development in the country is actively ongoing, with several new plants commissioned between 2019 and 2021 and three SHP projects under development as of 2021.

In **Malawi**, the installed capacity for SHP up to 5 MW is 4.7 MW, while potential capacity is estimated at 150 MW, indicating that 3 per cent has been developed. Recent activity in the SHP sector has included major reconstruction of existing SHP plants, with the total installed capacity of SHP up to 5 MW actually decreasing as several ageing plants were replaced by a newer SHP plant with an installed capacity of 8.25 MW in 2020. Consequently, the installed capacity for SHP up to 10 MW in the country reached 12.9 MW. Two additional ongoing SHP projects with a total capacity of 9.5 MW have passed the feasibility study stage.

Mauritius has an installed capacity of 19.69 MW for SHP up to 10 MW. No additional undeveloped potential has been identified, suggesting that the country's SHP potential is fully utilized. The most recently-constructed SHP plant was commissioned in 2019, but most of the country's SHP fleet is old and requires refurbishment. A government study has been launched to assess the existence of additional undeveloped potential.

The installed capacity for SHP up to 10 MW in **Mozambique** is 4.8 MW, while potential is estimated at 1,000 MW, indicating that less than 1 per cent has been developed. Little SHP development has taken place in the country over the last decade, as activity in the hydropower sector has been focused on large hydropower projects. The largest concentration of SHP plants in Mozambique is located in the central parts of the country and most existing plants have an installed capacity under 1 MW. Recent in-depth studies have identified hundreds of potential SHP sites across the country with a combined potential capacity of over 672 MW.

The installed capacity for SHP up to 10 MW in **Réunion** is 10.6 MW, with an additional 6 MW of untapped potential. The total estimated potential capacity in the country is thus 16.6 MW, of which 64 per cent has been developed. The last SHP plant in the country was commissioned in 2018. A number of additional SHP projects are in the planning stage, all with capacities under 1 MW.

In **Rwanda**, the installed capacity for SHP up to 5 MW is 34.4 MW, while the potential capacity is estimated at 111.1 MW, indicating that 31 per cent has been developed. The country has seen active SHP development in recent years, with several new plants commissioned between 2017 and 2020. Likewise, 10 additional plants are expected to become operational by 2024.

Somalia has no operational SHP capacity, although the existence of one previously operational SHP plant suggests a potential capacity of at least 4.6 MW if the plant were to be refurbished or rebuilt. The SHP sector in the country is stagnant, although plans to rehabilitate the existing SHP infrastructure in the country have been announced by the Government in a 2016 report.

South Sudan likewise has no operational SHP capacity. However, the potential capacity for SHP up to 10 MW is considerable, estimated at 688.1 MW in a 2018 study. There are no known plans for SHP development in the country on the national level and the country overall lacks a comprehensive renewable energy framework. Existing plans for renewable energy development focus on solar power projects and large hydropower.

The installed capacity for SHP up to 10 MW in **Tanzania** is 30.5 MW, while potential is estimated at 480 MW, indicating that approximately 6 per cent has been developed. The country has over 1,600 SHP plants, most of which are operated by faith-based groups for the provision of power to community facilities and health centres. Several SHP plants with capacities below 1 MW were commissioned between 2017 and 2019 and at least four different studies have identified hundreds of potential SHP sites across the country.

Uganda leads the Eastern Africa region in installed SHP capacity. The installed capacity of SHP up to 20 MW in the country is 186 MW, while estimated potential is 400 MW, indicating that 47 per cent has been developed. For SHP up to 10 MW, the installed capacity is 107.9 MW and estimated potential is 214.1, indicating that 50 per cent has been developed. SHP development in the country is very active, with over a dozen SHP plants up to 20 MW constructed between 2017 and 2022. Seventeen additional SHP projects were under construction as of 2022 and 20 potential SHP sites have been identified in various parts of the country.

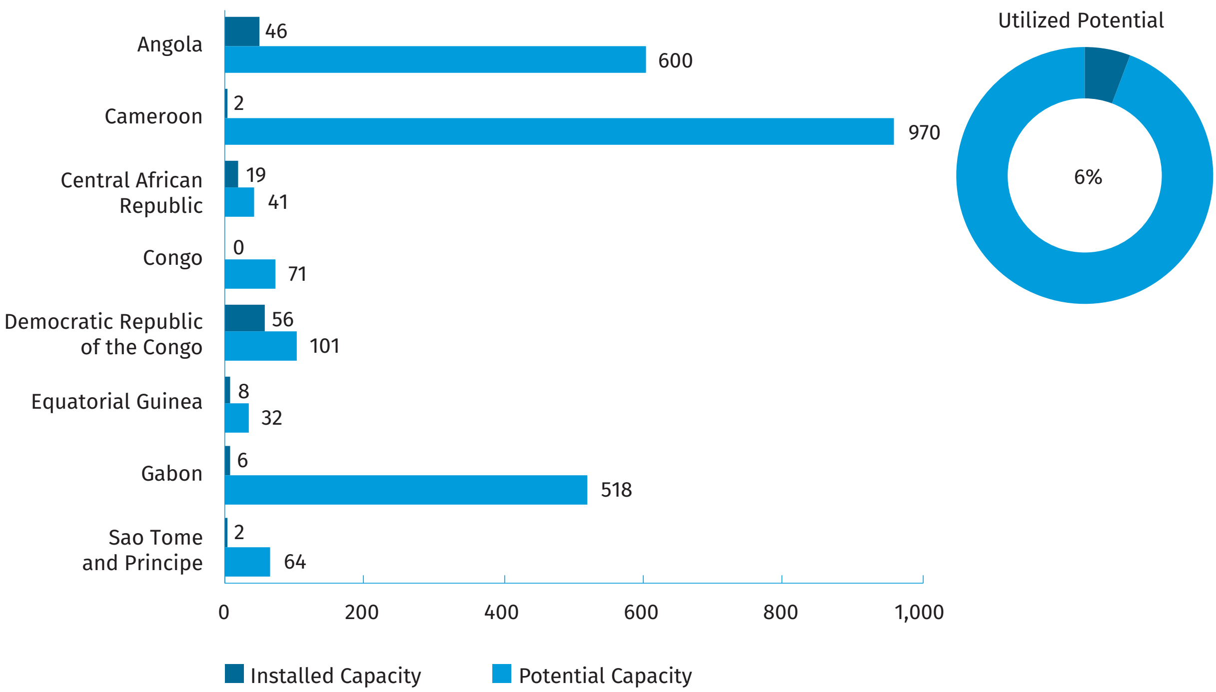
The installed capacity of SHP up to 10 MW in **Zambia** is 18.7 MW, while the potential capacity is estimated at 62 MW, indicating that 30 per cent has been developed. The installed SHP capacity of the country has increased substantially due to the commissioning of two new SHP plants in 2020 with a combined capacity of 10.6 MW. In addition to new stream development, older SHP plants have either undergone refurbishment and capacity upgrades or have been decommissioned and replaced with new plants. Several SHP projects were in various stages of development as of 2020.

The installed capacity of SHP up to 10 MW in **Zimbabwe** is 16.1 MW, while the estimated potential capacity is 120 MW, indicating that approximately 12 per cent has been developed. For SHP up to 30 MW, the installed capacity is 31.4 MW, although no estimate of potential capacity is available. SHP plants in Zimbabwe are employed either as grid-connected facilities, which are operated by private companies, or as off-grid systems owned by communities and supported by non-governmental organizations (NGOs). One new SHP plant was commissioned in Zimbabwe in 2018 and several additional SHP projects are under construction.

Middle Africa SHP Overview

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

Figure 14. **Installed and Potential Small Hydropower Capacity up to 10 MW in Middle Africa (MW)**



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 up to 10 MW in **Angola** is 46.1 MW, while the potential capacity is estimated at 600 MW, indicating that nearly 8 per cent has been developed. The identified potential is contained in 100 different sites identified in 2015 as part of the country's Energy Strategy to 2025. Of these, at least six have been selected for priority investment by 2025.

In **Cameroon**, the installed capacity of SHP up to 10 MW is 1.5 MW, accounted for by a single SHP plant. The country's SHP potential is estimated at 970 MW, indicating that less than 1 per cent has been developed, but no detailed assessment of existing sites is available. One SHP project with an installed capacity of 2.9 MW is under development, but its commissioning was stopped due to the civil war.

The **Central African Republic** has an installed capacity of 18.8 MW for SHP of up to 10 MW, while estimated potential capacity is 41 MW, indicating that 46 per cent has been developed. The country has two SHP plants in operation, while construction of a third plant with a capacity of 10 MW was suspended due to political instability, and the plant is in need of rehabilitation. At least 15 sites suitable for SHP development have been identified in the country, and the construction of one additional SHP project is ongoing as of 2021.

There is no installed SHP capacity in **Congo**. The potential capacity for SHP has been most recently estimated at 75 MW and is entirely undeveloped. At least 27 potential SHP sites have been identified throughout the country, with capacities ranging between 6 kW and 10 MW. Several feasibility studies of potential SHP sites supported by various international institutions have been recently completed, and a number of additional studies were either ongoing or in the planning stages as of 2021.

In **the Democratic Republic of the Congo**, the installed capacity for SHP of up to 10 MW is 56 MW, while potential capacity is estimated at 100.9 MW, indicating that 55 per cent has been developed. No new SHP construction has taken place in the country in the last several years, although five new SHP projects were in the planning stages as of 2021.

The installed capacity for SHP of up to 10 MW in **Equatorial Guinea** is 7.5 MW, while potential capacity is estimated at 31.9 MW, indicating that nearly 24 per cent has been developed. There are three operational SHP plants in the country, with the largest one, the 3.8 MW Riaba SHP plant, operating at only a fraction of its installed capacity and in need of extensive repairs and upgrades. At least 36 potential SHP sites have been identified in the country and detailed evaluations of the sites are ongoing.

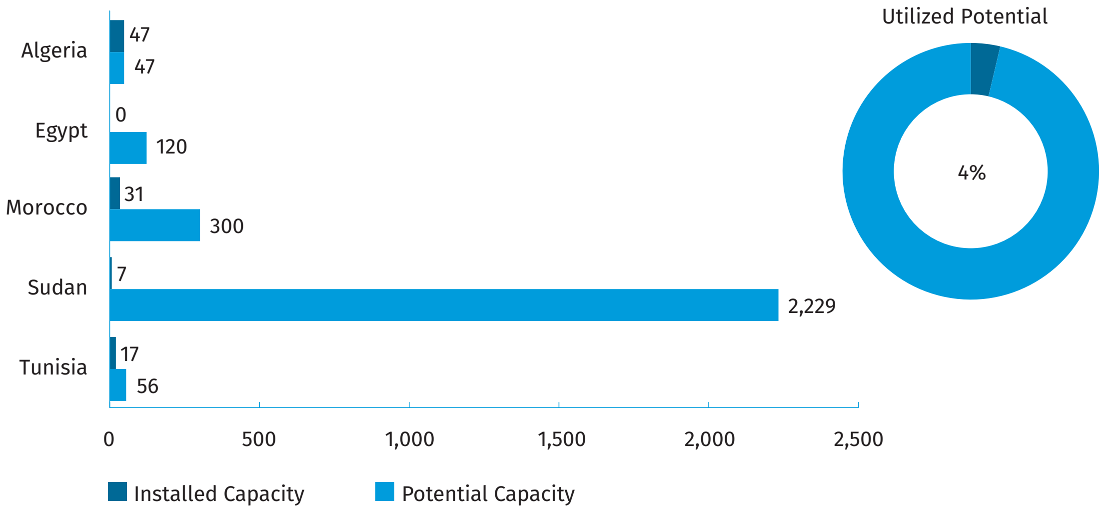
Gabon has an installed capacity of 6 MW for SHP of up to 10 MW, provided by three SHP plants. The potential capacity is estimated at 518.1 MW, indicating that approximately 1 per cent has been developed. Recent activity in the SHP sector in the country has been limited to the refurbishment of existing plants and updated studies of the country's SHP potential.

In **Sao Tome and Principe**, the installed capacity for SHP up to 10 MW is 1.9 MW while potential is estimated at 63.8 MW, indicating that approximately 3 per cent has been developed. There is only one operational SHP plant in the country, while three others have been decommissioned and are in need of extensive refurbishment or reconstruction. Thirty-four potential SHP sites have been identified in the country, but no new SHP projects are currently planned.

Northern Africa SHP Overview

Algeria, Egypt, Morocco, Sudan and Tunisia

Figure 15. **Installed and Potential Small Hydropower Capacity up to 10 MW in Northern Africa (MW)**



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, among other energy-related information.

In Algeria, the total installed capacity for SHP up to 10 MW is 47.1 MW. As there are no reliable estimates of the country's potential capacity, it is currently assumed that all SHP potential in Algeria is fully utilized. The installed capacity of Algeria increased relative to that reported in the *WSHPDR 2019* due to the inclusion of the previously unreported Ighzerouftis SHP plant in the country's SHP total. However, no SHP development has taken place in the country in recent years. Furthermore, the Government of Algeria has indicated its intention to phase out hydropower in order to redirect available water for irrigation and drinking water supply, and hydropower development has been entirely excluded from the country's New National Programme for Renewable Energy Development 2015–2030.

There were no operational SHP plants up to 10 MW in **Egypt** as of 2021, although several plants were in operation in the country in previous years. The potential capacity of SHP up to 10 MW has been recently revised from 51.7 MW to 120 MW. The country plans to develop several SHP sites with capacities ranging between 2 MW and 5 MW, although the project has not yet been confirmed due to concerns over its environmental and social impact.

Morocco has 30.5 MW of installed capacity for SHP up to 10 MW, while the potential capacity is estimated at approximately 300 MW, indicating that approximately 10 per cent of the SHP potential has been developed. As part of the Government's strategy to promote renewable energy sources by 2030, a number of hydropower projects have been approved for development by the private sector, of which 11 projects with a total capacity of 61.5 MW are under construction.

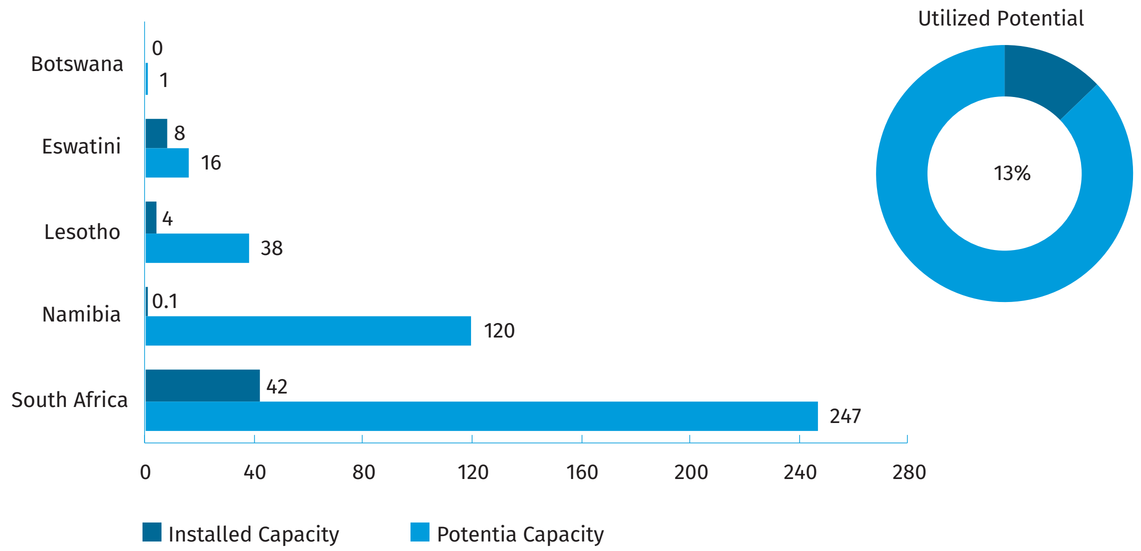
In **Sudan**, the installed capacity of SHP up to 10 MW is 7.2 MW, while the latest estimates put the country's SHP potential at 2,228.6 MW, indicating that less than 1 per cent has been developed. Although Sudan does not have an integrated renewable energy policy document, the country has been making efforts to develop its renewable energy potential and aims to reach at least a 50 per cent share of total electricity generation produced by renewable energy sources by 2031.

The total installed capacity for SHP up to 10 MW in **Tunisia** is 17 MW, while the estimated potential capacity stands at 56 MW, indicating that 30 per cent of the known potential has been developed. There has been no change in either installed SHP capacity or estimated potential capacity of the country since the *WSHPDR 2019*. The renewable energy strategy in Tunisia is focused primarily on solar and wind power. By contrast, the development of SHP has received relatively little interest in recent years, although in 2019 the National Company for the Exploitation and Distribution of Water of Tunisia invited bids for the construction of two micro-hydropower plants. The status of these two projects is currently unknown.

Southern Africa SHP Overview

Botswana, Eswatini, Lesotho, Namibia and South Africa

Figure 16. **Installed and Potential Small Hydropower Capacity up to 10 MW in Southern Africa (MW)**



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, among other energy-related information.

There are no SHP plants in **Botswana**. Hydropower potential in the country is low due to prevailing topographical features and climatic conditions. One study has identified an SHP potential of approximately 1 MW in the northern part of the country, while a more recent, continent-scale study suggested a significantly higher theoretical potential of 1,289 MW for SHP up to 10 MW. However, this latter figure is likely an overestimate and further detailed studies are necessary that account for current climatic conditions and economic constraints.

The installed capacity of SHP up to 10 MW in **Eswatini** is 8.2 MW from four SHP plants, of which one has been decommissioned but is still technically operational. Most of the existing plants were constructed between 1950 and 1990 and no new SHP plants have been commissioned in recent years, with hydropower development focusing on larger projects. Undeveloped SHP potential was estimated at 8 MW in 2001, with an array of potential micro-, mini- and small hydropower sites identified in subsequent studies. The total SHP potential of the country following the up to 10 MW definition, including existing capacities, is thus estimated at 16.2 MW, indicating that approximately 51 per cent has been developed.

Lesotho has an installed SHP capacity of 3.8 MW from five SHP plants, of which only two plants with a total capacity of 2.2 MW are operational. The potential capacity of the country, including existing plants, is estimated at 38.2 MW, indicating that 10 per cent of SHP potential up to 10 MW has been developed. No new SHP plants have been built in the last two decades, but plans for the rehabilitation of currently non-operational plants are in place.

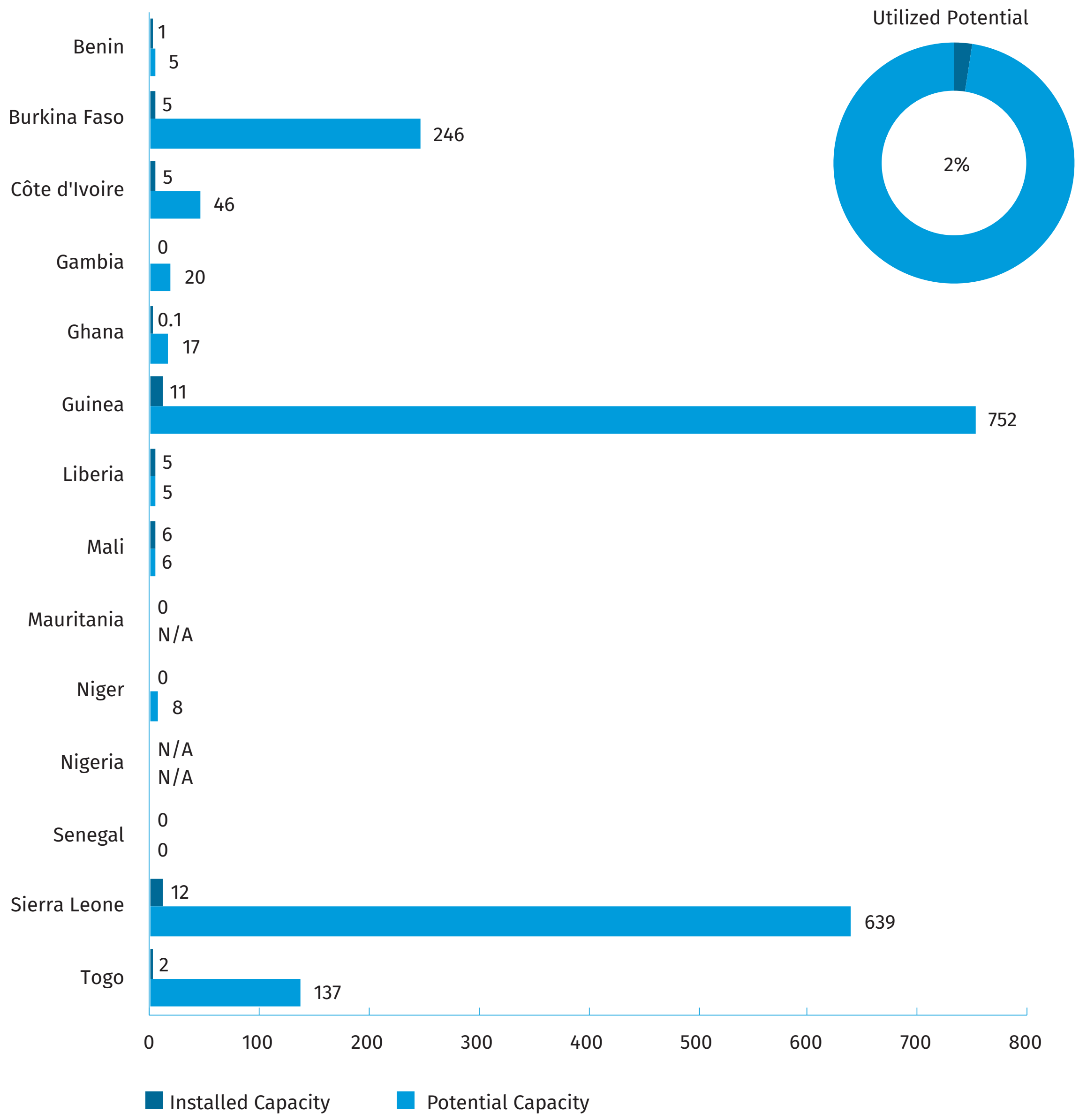
Namibia has a single SHP plant with an installed capacity of 0.05 MW. The role of SHP in the country's electricity sector is negligible. Namibia has several perennial rivers, one of which hosts a large hydropower plant, but smaller streams appropriate for SHP development are rare as the country is one of the driest and water-stressed in the region and globally. Plans have been proposed to develop 13 SHP plants on the Orange River with a total capacity of 120 MW.

In **South Africa**, the installed capacity of SHP up to 10 MW stood at 42 MW as of 2021, while potential capacity was estimated at 247 MW, indicating that 17 per cent of the known potential is currently utilized. A large number of SHP plants exists throughout the country, but the operational capacity has fluctuated considerably over the past 60–70 years as old plants have been decommissioned and new ones constructed in their place. Many operational plants are located on private land and are not connected to any private grid, supplying power for self-consumption to commercial entities such as mines and resorts. The SHP sector in the country has seen an increase in activity starting with 2009 following decades of neglect, in part due to the promotion of renewable energy sources under the REIPPP programme implemented by the Government. Several new SHP plants have been constructed in recent years.

Western Africa SHP Overview

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

Figure 17. **Installed and Potential Small Hydropower Capacity up to 10 MW in Western Africa (MW)**



Note: "N/A" refers to cases where data on installed and/or potential capacity for SHP of up to 10 MW are not available.

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, among other energy-related information.

Benin has a single hydropower plant with an installed capacity of 0.5 MW. The potential capacity for SHP up to 30 MW is estimated at 95 MW, of which less than 1 per cent has been developed. Additionally, at least 5 MW of capacity for SHP up to 10 MW has been identified, of which 10 per cent has been developed. No recent activity in the country's SHP sector has taken place, although an upgrade to the existing SHP plant to raise its installed capacity to 1 MW has been considered.

The installed capacity of SHP up to 10 MW in **Burkina Faso** is 4.6 MW, provided by three SHP plants. The country's installed SHP capacity has recently doubled with the commissioning of a third plant in 2019. The potential capacity of SHP up to 10 MW is estimated at 246 MW on the basis of a recent study published in 2018, which identified a total of 80 potential SHP sites in the country. Specific plans exist outlining the construction of three additional SHP plants over the next several years.

The installed capacity of SHP up to 10 MW in **Côte d'Ivoire** is 5 MW, provided by a single SHP plant built in 1983, while the estimated potential SHP capacity is 45.7 MW, indicating that nearly 11 per cent has been developed. The country's installed SHP capacity has not changed in several decades. Additionally, the single existing SHP plant is non-operational and in need of refurbishment. No new projects in the SHP sector are under consideration, although some preliminary studies are planned.

There is no installed hydropower capacity in **Gambia** of any kind. The potential capacity for SHP up to 10 MW is estimated at 19.5 MW and remains entirely undeveloped. There are no SHP projects planned and recent activity in the SHP sector has been limited to updated studies of SHP potential, which have identified four potential SHP sites of up to 10 MW.

Ghana has a single SHP plant with an installed capacity of 0.045 MW. The potential capacity for SHP up to 10 MW is estimated at 17.42 MW, and at 9.9 MW for SHP up to 1 MW. Less than 1 per cent of SHP capacity under either definition has been developed. The sole operational SHP plant in the country was commissioned in 2020, and one earlier project has been on hold and requires extensive refurbishment. Sixty-nine potential sites up to 2 MW and another 12 sites up to 1 MW have been identified in the country, but there are no specific plans for new SHP construction.

The installed capacity of SHP up to 10 MW in **Guinea** is 11.2 MW, while the potential capacity has recently been estimated at 751.8 MW, indicating that approximately 1 per cent has been developed. There are five SHP plants in Guinea, with two undergoing renovation. As of 2021, feasibility studies were ongoing for the construction of four additional SHP plants with the support of the French Development Agency, and additional feasibility studies on several other potential sites are planned.

There are two operational SHP plants in **Liberia** with a total installed capacity of 4.86 MW. The potential capacity for SHP up to 30 MW in the country is estimated at 592 MW based on a study published in 2017, indicating that less than 1 per cent has been developed. No new construction in the SHP sector has taken place in recent years and there are currently no plans for additional SHP projects.

The installed capacity of SHP up to 30 MW in **Mali** is 5.7 MW, provided by a single plant. The potential capacity is estimated at 154.7 MW, indicating that nearly 4 per cent has been developed. Two new SHP plants are under development in the country through the Mini-Hydropower Plants and Related Distribution Networks Development Project, with environmental and social audits ongoing as of 2022. One additional SHP project has been initiated with the assistance of international development institutions.

There is no installed hydropower capacity of any kind in **Mauritania**, and no potential hydropower capacity has been documented. However, some limited SHP potential may exist in the southern part of the country.

There is likewise no installed hydropower capacity of any kind in **Niger**. A potential capacity of 8 MW for SHP of up to 10 MW has been identified but remains entirely undeveloped. There are no ongoing projects or plans for SHP development in Niger, although a large hydropower project of 130 MW is under construction.

The installed capacity of **Nigeria** for SHP up to 30 MW is estimated at 57.2 MW, with the decrease relative to the *WSHPDR 2019* reflecting more accurate data on existing SHP plants. There are 14 SHP plants operating in the country. The economically feasible potential capacity has been assessed at 734.3 MW from 278 potential sites, indicating that nearly 8 per cent has been developed, while the theoretical potential capacity is estimated at 3,500 MW. Several new SHP projects have been initiated in Nigeria over the last decade, but their status and stage of completion are unclear.

There is no installed hydropower capacity of any kind in **Senegal**, and no potential SHP capacity has been identified due to the flat topography of the country.

There are eight SHP plants of up to 30 MW in **Sierra Leone** with a total installed capacity of 12.15 MW. Potential capacity for SHP up to 30 MW is estimated at 639 MW, indicating that approximately 2 per cent has been developed. One new SHP plant with a capacity of 15.4 MW has been in development since 2016.

There is one SHP plant in **Togo** with an installed capacity of 1.6 MW. Potential capacity for SHP up to 10 MW is estimated at 137 MW, indicating that approximately 1 per cent has been developed, while potential for SHP up to 30 MW is estimated at 206 MW, of which less than 1 per cent has been developed. There are no ongoing SHP projects in the country, although the Government has identified seven potential sites for priority development.

Americas

Northern America and South America dominate the SHP landscape in all of the Americas, with Brazil and the USA being leaders in terms of installed capacity and the USA also dominating in terms of known SHP potential. Countries in the Caribbean region have significantly smaller estimated potential. However, further studies could reveal a greater potential in the region as well as in other countries in the continent.

The total SHP capacity in the Americas is 6,937 MW, while the total potential is estimated at 25,294 MW for SHP of 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 yet. At the same time, in the current edition, the continent's reported potential significantly decreased compared to the previous edition, which is primarily due to the re-estimation of the potential of Colombia. According to the available data, approximately 27 per cent of the known SHP potential capacity in the Americas has been developed.

Country	*Local SHP definition*	*Installed capacity (local def.)*	*Potential capacity (local def.)*	*Installed (≤10 MW)*	*Potential (≤10 MW)*
Argentina	≤50 MW	510.0	N/A	97.0	430.0
Belize	N/A	N/A	N/A	10.3	21.7
Bolivia	≤5 MW	N/A	N/A	99.1	N/A
Brazil	≤30 MW	6,324.6	35,765.0	1,608.2	3,737.8
Canada	≤50 MW	4,504.0	15,000.0	N/A	N/A
Chile	≤20 MW	618.0	5,145.0	304.0	2,995.0
Colombia	≤20 MW	900.8	N/A	234.6	4,946.0
Costa Rica	N/A	N/A	N/A	126.5	N/A
Cuba	N/A	N/A	N/A	21.0	77.0
Dominica	≤10 MW	6.6	N/A	6.6	N/A
Dominican Republic	≤10 MW	59.7	N/A	59.7	N/A
Ecuador	≤10 MW	112.7	356.3	112.7	356.3
El Salvador	≤5 MW	21.7	N/A	21.7	119.6
French Guiana	≤10 MW	5.5	34.5	5.5	34.5
Greenland	≤5 MW	N/A	N/A	9.0	183.1
Grenada	N/A	N/A	N/A	0.0	7.0
Guadeloupe	≤10 MW	11.6	33.0	11.6	33.0
Guatemala	≤5 MW	123.0	204.9	N/A	N/A
Guyana	≤5 MW	0.02	24.2	0.02	92.0
Haiti	N/A	N/A	N/A	6.8	37.6
Honduras	≤30 MW	288.6	N/A	148.0	385.0
Jamaica	N/A	N/A	N/A	30.6	76.2
Mexico	≤30 MW	699.3	N/A	N/A	N/A
Nicaragua	≤10 MW	26.6	104.7	26.6	104.7
Panama	N/A	N/A	N/A	147.2	263.5
Paraguay	≤50 MW	0.0	116.3	0.0	N/A
Peru	≤20 MW	503.8	3,500.0	N/A	N/A
Puerto Rico	N/A	N/A	N/A	39.3	43.9
Saint Lucia	N/A	N/A	N/A	0.0	2.7
Saint Vincent and the Grenadines	≤10 MW	5.7	7.5	5.7	7.5
Suriname	N/A	N/A	N/A	0.0	2.7
USA	N/A	N/A	N/A	3,681.0	10,583.0
Uruguay	≤50 MW	0.0	231.5	0.0	208.0
Venezuela	N/A	N/A	N/A	1.4	49.7

Figure 18. **Installed and Potential Small Hydropower Capacity up to 10 MW in the Americas (MW)**

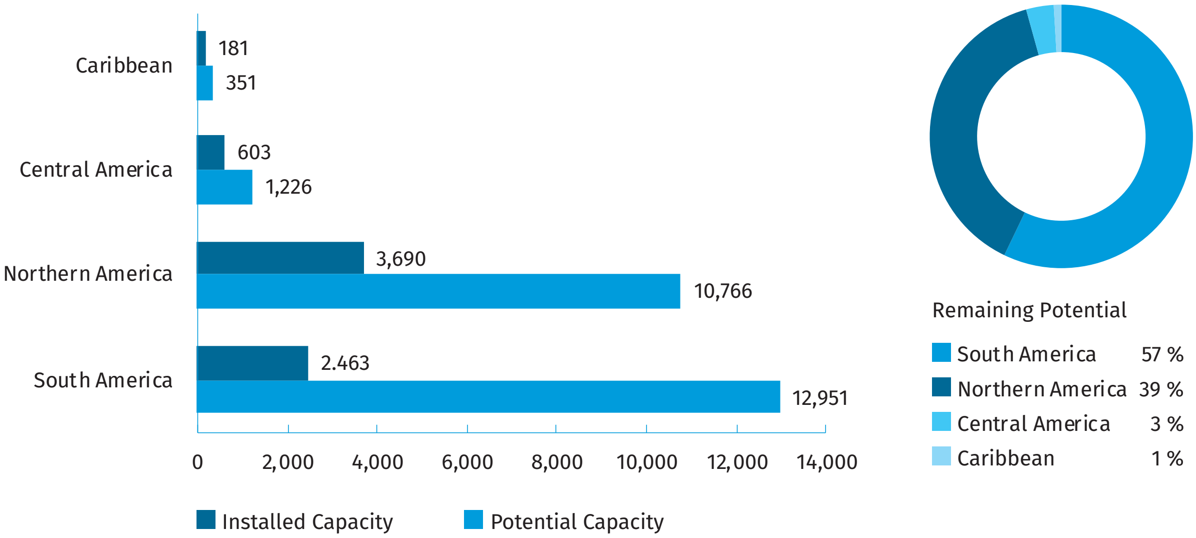
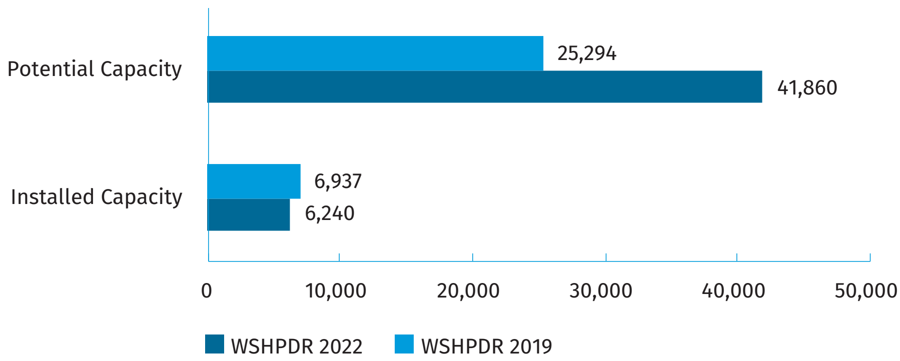


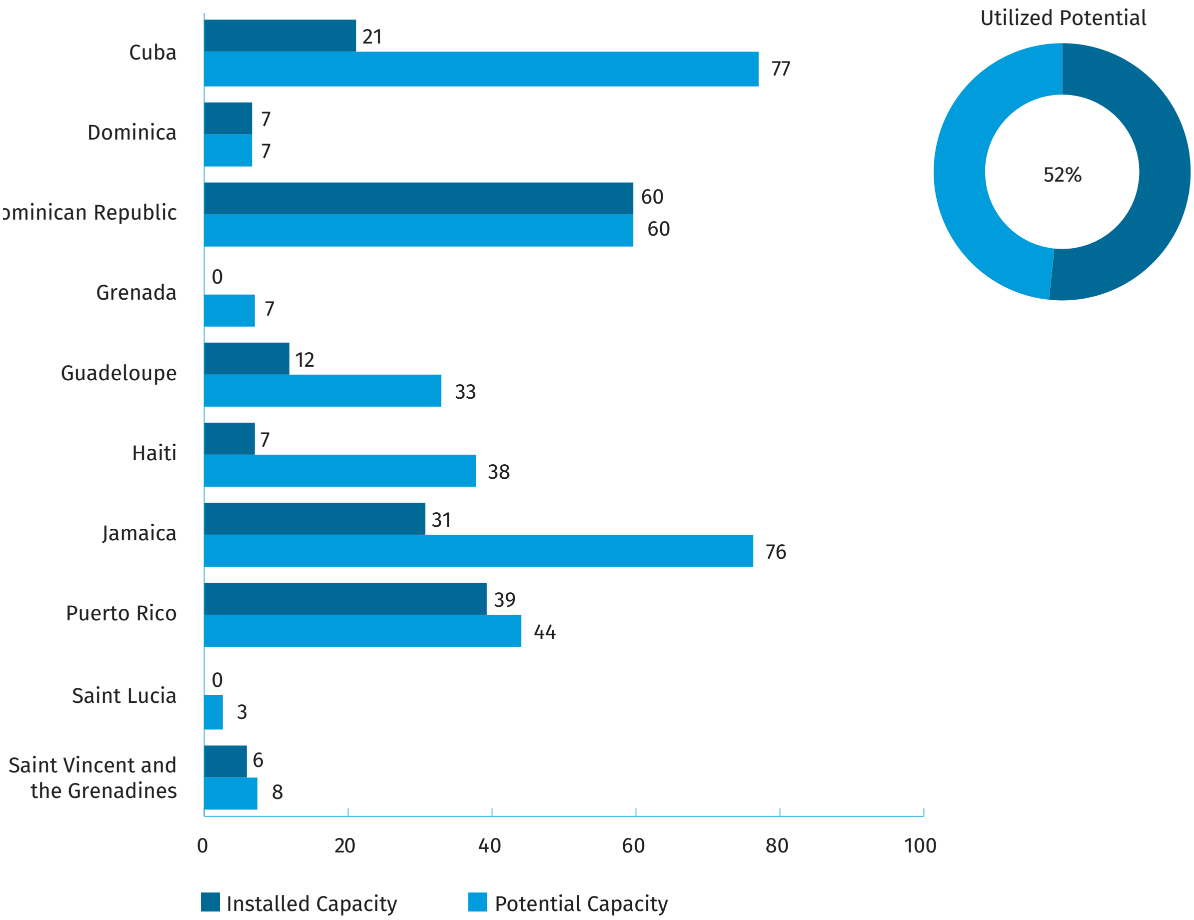
Figure 19. **Comparison of Installed and Potential Small Hydropower Capacity up to 10 MW in the Americas in the *WSHPDR 2019* and *WSHPDR 2022* (MW)**



Caribbean SHP Overview

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

Figure 20. **Installed and Potential Small Hydropower Capacity up to 10 MW in the Caribbean (MW)**



An overview of SHP for selected countries in 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, among other energy-related information.

Cuba has an installed capacity of 21 MW for SHP up to 10 MW, while potential capacity is estimated at 77 MW, indicating that 27 per cent has been developed. Cuba has over 170 SHP plants, of which 32 are currently non-operational due to water supply issues or disrepair. The most recent new SHP plant was commissioned in 2018, while another plant was refurbished in 2019. There were two additional SHP projects under construction as of 2021.

There are three SHP plants of up to 10 MW in **Dominica**, with a total installed capacity of 6.64 MW. The potential capacity of Dominica has not been assessed, so all known capacity is fully developed. One of the SHP plants in the country has been out of operation since 2017 as a result of hurricane damage, and the bidding process for its rehabilitation was launched in early 2022.

The installed capacity of SHP of up to 10 MW in the **Dominican Republic** is 59.7 MW provided by 16 state-owned SHP plants equipped with 22 individual power blocks, and 60 community-owned micro-hydropower plants. There is no reliable estimate of SHP potential in the country, thus, all known potential is considered fully developed. Recent SHP development in the country has been mainly carried out with the support of the Global Environmental Facility (GEF) Small Grants Programme and has focused on the construction of micro-scale plants for the benefit of rural communities. Ten additional micro-scale SHP projects are under construction.

Grenada has no hydropower capacity of any kind. The potential capacity of SHP up to 10 MW is estimated at 7 MW, although the estimate is based on a study conducted in 1981. Several SHP projects have been initiated in recent years but have not been completed and their current status is unknown.

Guadeloupe has a total installed capacity of 11.6 MW for SHP of up to 10 MW, provided by 16 plants. The potential SHP capacity is estimated at 33 MW, indicating that 35 per cent has been developed. However, the development of remaining untapped potential capacities is constrained by environmental considerations and the location of many potential sites inside protected areas. No new SHP construction has taken place in the country since 2016.

The installed capacity of SHP up to 10 MW in **Haiti** is 6.81 MW, provided by eight plants, while potential capacity is estimated at 37.6 MW, indicating that 18 per cent has been developed. No new SHP construction has taken place in the country in recent years and installed capacity has gradually decreased due to ageing equipment and lack of maintenance. Thirty-six potential SHP sites have been identified in the country.

Jamaica has an installed capacity of 30.6 MW for SHP of up to 10 MW, provided by eight SHP plants. The potential capacity for SHP of up to 10 MW is estimated at 76.2 MW, indicating that 40 per cent has been developed. The country's SHP fleet is fairly old and no new additions have been made since 2014, with the recent reported increase in installed capacity being a result of the inclusion of previously excluded plants. Thirteen potential SHP sites have been identified and the country has explicitly adopted a policy of exploring options for SHP construction at locations with the potential to host large hydropower plants.

The installed capacity of SHP of up to 10 MW in **Puerto Rico** is 39.3 MW, while potential is estimated at 43.9 MW, indicating that 89 per cent has been developed. There are seven operational SHP plants in the country, although with four of these plants inactive as of 2021, the available capacity has been reduced to 23.8 MW. The main potential opportunities for further SHP development are in micro-scale hydropower projects, as other potential hydropower sites have been largely developed.

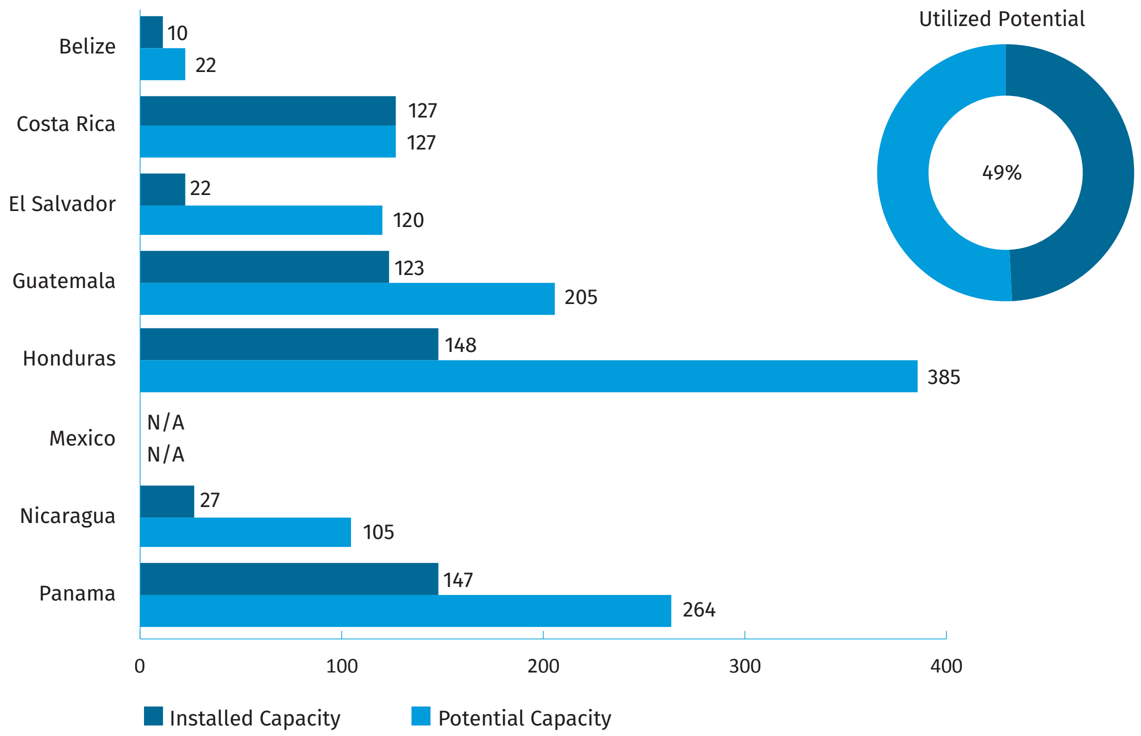
Saint Lucia has no hydropower capacity of any kind, as the country's only formerly-operational mini-hydropower plant is in a state of severe disrepair following damage from extreme weather. A potential capacity of 2.68 MW has been identified in previous studies, but there are no ongoing SHP projects in the country or any specific plans for the development of the SHP sector.

In **Saint Vincent and the Grenadines**, the installed capacity of SHP of up to 10 MW is 5.7 MW, while estimated potential capacity is 7.5 MW, indicating that 76 per cent has been developed. There are three SHP plants in the country, but their available capacity fluctuates considerably during the dry season. Refurbishment of two plants was carried out in 2016 and 2018. There are proposals for the construction of an additional SHP plant of 1.2 MW, but no concrete progress has been made.

Central America SHP Overview

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

Figure 21. **Installed and Potential Small Hydropower Capacity up to 10 MW in Central America (MW)**



Note: "N/A" refers to cases where data on installed and/or potential capacity for SHP of up to 10 MW are not available.

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, among other energy-related information.

The installed capacity of SHP up to 10 MW in **Belize** is 10.3 MW, provided by two SHP plants, and has not changed since the commissioning of the second plant in 2005. The potential capacity is estimated at 21.7 MW, indicating that approximately 47 per cent has been developed. The most recent study of SHP potential was carried out in 2006. Since then, no additional activity related to the SHP sector has taken place.

In **Costa Rica**, the installed capacity of SHP up to 10 MW is 126.5 MW, while the estimate of potential capacity is 7,373.5 MW, indicating that approximately 2 per cent has been developed. No new SHP construction has taken place in the country in recent years, although the assessed installed capacity has been revised upwards due to access to better data on existing SHP plants. The estimate of potential SHP capacity in the country is provided on the basis of a 2017 study assessing worldwide hydropower potential.

In **El Salvador**, there are 17 operational SHP plants with a total installed capacity of 21.7 MW, in addition to two plants with a capacity of 0.63 MW that are likely decommissioned or in need of extensive repairs. All existing SHP plants in the country have an installed capacity under 5 MW, and there are no plants in the 5–10 MW capacity range. The potential capacity for SHP up to 10 MW has been estimated at 119.6 MW, of which 18 per cent has been developed. There are two ongoing SHP projects on the San Simon River.

There are 65 operational SHP plants of up to 5 MW in **Guatemala** with a total installed capacity of 123 MW. An additional 33 plants with a total capacity of 80 MW are registered with the Government but are not operational, and one SHP plant with a capacity of 1.9 MW is pending registration. On the basis of these capacities, total potential SHP capacity of up to 5 MW in Guatemala is estimated at 204.9 MW, of which 60 per cent has reached operational status. The undeveloped SHP potential of the country is likely to be higher but no reliable estimate is available.

In **Honduras**, the installed capacity of SHP of up to 30 MW is 288.6 MW provided by 45 plants, of which 37 are plants of up to 10 MW and with a combined capacity of 148 MW. Potential capacity for SHP up to 10 MW is estimated at 385 MW, indicating that 38 per cent has been developed. The installed SHP capacity of the country has been growing steadily over the last decade due to the construction of new plants, but no data on ongoing SHP projects are available.

The installed capacity of SHP up to 30 MW in **Mexico** is 699.3 MW, provided by 69 plants. There is no reliable estimate of potential SHP capacity in the country. A large number of studies of SHP potential have been carried out over the last few decades in different parts of the country, producing estimates that differed by a wide margin. At the high end, one study suggested the existence of over 3,000 potential micro-, mini- and small hydropower sites across the country. In addition to existing SHP plants, 41 SHP plants were under construction across the country as of 2021, with a combined planned capacity of 452.5 MW.

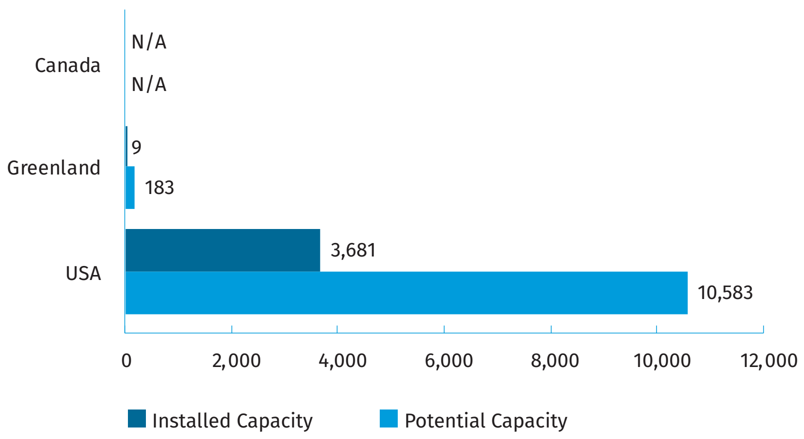
There are 17 operational SHP plants of up to 10 MW in **Nicaragua** with a total installed capacity of 26.6 MW. Based on an inventory of 20 potential SHP sites, potential capacity for SHP of up to 10 MW is estimated at 104.7 MW, indicating that 25 per cent has been developed. Three new SHP plants have been constructed in the country in recent years and several additional potential sites have been identified.

The installed capacity of SHP of up to 10 MW in **Panama** is 147.2 MW provided by 24 operational SHP plants, while potential capacity is estimated at 263.5 MW, indicating that 56 per cent has been developed. The installed SHP capacity of the country has expanded considerably over the last few years. There were 9 additional plants under construction as of 2021 and 13 other potential SHP sites have been identified.

Northern America SHP Overview

Canada, Greenland and United States of America

Figure 22. **Installed and Potential Small Hydropower Capacity up to 10 MW in Northern America (MW)**



Note: “N/A” refers to cases where data on installed and/or potential capacity for SHP of up to 10 MW are not available.

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, among other energy-related information.

The total installed capacity of SHP in **Canada** was 4,504 MW for SHP up to 50 MW as of 2020, with a corresponding potential capacity of 15,000, indicating that 30 per cent has been developed. However, the estimate of SHP potential in the country is rather dated and based on unclear methodology, with an updated estimate currently under preparation. SHP construction in the country is very active, with several new plants commissioned every year. SHP development is spurred by the exhaustion of large hydropower potential in several provinces and ambitious decarbonization goals set by the national Government, particularly with regard to the phasing out of coal-fired power plants.

The total installed capacity of SHP up to 10 MW in **Greenland** is 9 MW, provided by two larger SHP plants as well as by a collection of micro-hydropower plants with a combined capacity of 200 kW. The SHP potential in the country is assessed at

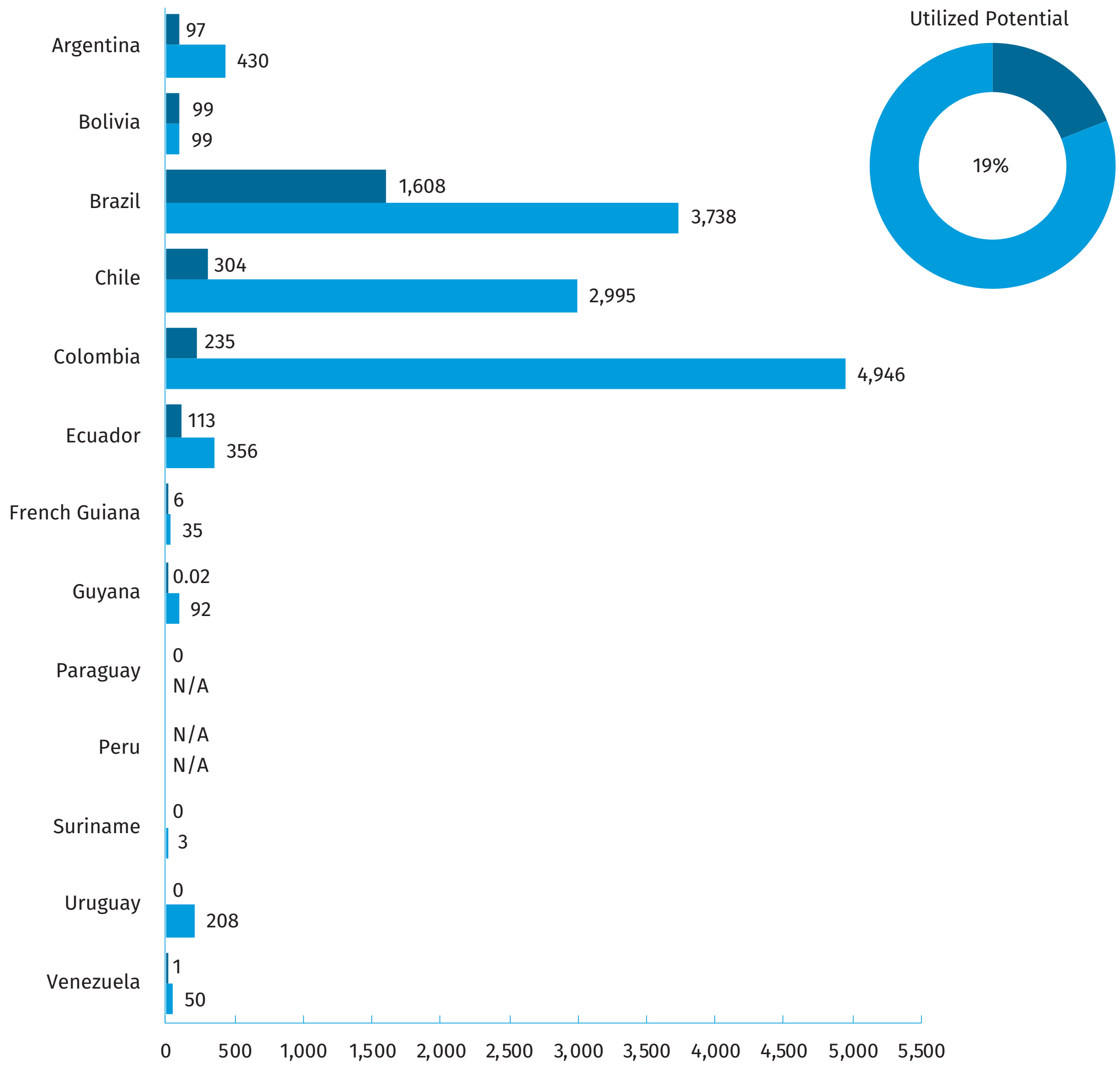
183.1 MW, indicating that approximately 5 per cent has been developed. No new SHP construction has taken place since 2008, but one ongoing SHP project is planned to launch in 2023. Additional interest in SHP development in the country is mainly focused on micro-scale hydropower.

In the **USA**, the total installed capacity for SHP up to 10 MW was 3,681 MW as of 2021, provided by 1,679 SHP plants. The potential capacity of SHP up to 10 MW in the country is estimated at 10,583 MW, indicating that nearly 35 per cent has been developed so far. SHP development in the USA is actively ongoing as part of a general trend towards the development of renewable energy sources, as the federal, state and municipal governments have adopted clean energy targets and renewable portfolio standards (RPS), with several new SHP plants commissioned every year. Development of SHP in the country has focused on the construction of SHP plants on non-powered dams and water conduits, rather than new stream reaches. Private companies account for the majority of planned and proposed SHP projects, while public companies active in the sector are frequently municipalities interested in adding SHP capacity to non-powered water infrastructure they already own or operate.

South America SHP Overview

Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, French Guiana, Guyana, Paraguay, Peru, Suriname, Uruguay and Venezuela

Figure 23. **Installed and Potential Small Hydropower Capacity up to 10 MW in South America (MW)**



Note: "N/A" refers to cases where data on installed and/or potential capacity for SHP of up to 10 MW are not available.

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, among other energy-related information.

The installed capacity of SHP of up to 10 MW in **Argentina** is 97 MW, provided by 24 plants. The potential capacity is estimated at 430 MW, indicating that nearly 23 per cent has been developed. The SHP sector in the country has not seen any recent development and many existing SHP facilities are in need of modernization. However, several SHP projects are in the planning stages and 116 potential SHP sites have been identified.

The installed capacity of SHP of up to 10 MW in **Bolivia** is 99.1 MW. There is no reliable estimate of potential for SHP off up to 10 MW, although potential for SHP of up to 30 MW has been estimated at 200 MW. There are 13 registered SHP plants in the country, in addition to dozens of unregistered plants operating on isolated grids. Unregistered off-grid SHP plants are particularly widespread in the country's private mining sector. The Government plans to expand SHP capacity by an additional 50 MW, but suitable sites have not been comprehensively catalogued. One additional SHP plant was under construction as of 2019.

In **Brazil**, the installed capacity of SHP under the local definition of up to 30 MW is 6,324.6 MW, while the estimated potential capacity is 35,765 MW, indicating that 18 per cent has been developed. For SHP of up to 10 MW, the installed capacity is 1,608.2 MW, while potential capacity is estimated at 3,737.8 MW, indicating that 43 per cent has been developed. Development of SHP in the country is actively ongoing, with over 20 new plants commissioned in 2020 alone. Construction of new plants is carried out in accordance with targets established by the Ten-Year Plan for Energy Expansion 2029. By 2029, the Government intends to expand the country's total capacity of SHP of up to 30 MW to 9,045 MW.

The installed capacity of SHP of up to 20 MW in **Chile** is 618 MW and estimated potential capacity is 5,145 MW, indicating that 12 per cent has been developed. For SHP of up to 10 MW, the installed capacity is 304 MW and estimated potential capacity is 2,995 MW, indicating that 10 per cent has been developed. SHP development in the country is ongoing, with several new plants commissioned on average every year. Several SHP projects were ongoing as of 2021 and a number of additional projects are in the planning stages.

Colombia has an installed capacity of 900.8 MW for SHP of up to 20 MW and of 234.6 MW for SHP of up to 10 MW. The potential capacity of SHP of up to 10 MW is estimated at 4,946 MW, indicating that nearly 5 per cent has been developed. A large number of new SHP plants have been commissioned in recent years, and 43 prospective SHP projects of up to 10 MW are under review. The reported estimate of the country's SHP potential has been drastically reduced on the basis of updated, more detailed data on regional SHP potential.

The installed capacity for SHP of up to 10 MW in **Ecuador** is 112.7 MW, provided by 43 plants. Potential capacity is estimated at 356.3 MW, indicating that approximately 32 per cent has been developed. Several new SHP plants were constructed in the country between 2016 and 2020, with six additional plants expected to be completed by 2024.

French Guiana has an installed capacity of 5.5 MW for SHP of up to 10 MW, provided by two plants. The estimated potential capacity, based on plans issued by the Government for expansion of the SHP sector to 2030, is 34.5 MW, indicating that 16 per cent has been developed. Despite the established targets, little SHP development has taken place in the country in recent years, although two SHP projects are in the early planning stages.

Guyana has a single micro-hydropower plant with an installed capacity of approximately 0.02 MW. Potential SHP capacity in the country for SHP of up to 10 MW is estimated at 92 MW, which remains almost fully undeveloped. The existing SHP plant was launched in 2019 and is the first operational SHP plant in the country in over 20 years. Five projects involving the rehabilitation of non-operational SHP plants as well as the construction of new plants are in various stages of planning.

Paraguay has no installed SHP capacity, as the country's entire hydropower fleet consist of plants with installed capacities of over 50 MW. The potential capacity for SHP of up to 50 MW is estimated at 116.3 MW and remains fully undeveloped. The estimate of potential capacity is based on the total planned capacity of 18 SHP projects intended to enter into operation between 2029 and 2036.

Peru has an installed capacity of 503.8 MW for SHP of up to 20 MW, while potential capacity is estimated at 3,500 MW, indicating that over 14 per cent has been developed. The country's SHP capacity has increased dramatically in recent years, and at least 11 new plants have been commissioned between 2016 and 2019. There were 24 ongoing SHP projects in Peru as of 2021, with construction to be completed by 2024.

Suriname has no operational SHP capacity, although 2.7 MW of potential for SHP of up to 10 MW has been identified. Several formerly operational SHP plants exist in the country, but there are no known plans for their rehabilitation or for the construction of any new SHP plants.

Uruguay likewise has no installed SHP capacity. Potential capacity for SHP of up to 50 MW is estimated at 231.5 MW, while for SHP of up to 10 MW it is estimated at 208 MW, and remains fully undeveloped. Several studies have been carried out over the last decade assessing the technical and economic feasibility of multiple potential SHP sites, but there are no specific plans for any new SHP construction.

The installed capacity of SHP of up to 10 MW in **Venezuela** is 1.4 MW, provided by seven SHP plants, of which the most recent one was built in 1994. Potential capacity for SHP of up to 10 MW is estimated at 49.7 MW, indicating that 3 per cent has been developed. Ten potential SHP sites have been identified, but there has been little SHP development in recent years and there are no planned or ongoing SHP projects in the country.

Asia

Asia has vast SHP resources, which are, however, unevenly distributed across the continent. The total installed SHP capacity of Asia is 50,406 MW and the total estimated potential is 139,946 MW (for SHP of up to 10 MW). This indicates that approximately 36 per cent has so far been developed. The decrease in reported SHP installed capacity in comparison with the *WSHPDR 2019* is primarily due to the re-estimation of the installed capacity data for Turkey.

China dominates not only the SHP landscape in Asia but also globally, accounting for over 83 per cent of the continent's installed capacity and 45 per cent of the known potential for SHP of up to 10 MW. SHP development is one of the major priorities for countries in Asia. The key motives for SHP development on the continent are to decrease dependence on energy imports and fossil fuels and to improve access to electricity, especially in rural areas.

Country	*Local SHP definition*	*Installed capacity (local def.)*	*Potential capacity (local def.)*	*Installed (≤10 MW)*	*Potential (≤10 MW)*
Afghanistan	≤25 MW	N/A	N/A	83.2	1,200.0
Armenia	≤30 MW	382.0	431.0	340.0	N/A
Azerbaijan	≤10 MW	49.5	520.0	49.5	520.0
Bangladesh	N/A	N/A	N/A	0.0	60
Bhutan	≤25 MW	32.4	23,296.0	8.4	8.9
Cambodia	≤10 MW	1.7	300.0	1.7	300
China	≤50 MW	81,300.0	128,000.0	41,985.0	63,500.0
DPRK	N/A	N/A	N/A	522.1	N/A
Georgia	≤15 MW	263.0	723.9	212.2	491.8
India	≤25 MW	4,787.0	21,134.0	N/A	N/A
Indonesia	≤10 MW	543.0	19,385.0	543.0	19,385.0
Iran	≤10 MW	19.5	90.8	19.5	90.8
Iraq	N/A	N/A	N/A	6.0	62.4
Israel	N/A	N/A	N/A	7.0	N/A
Japan	≤10 MW	3,577.0	10,330.0	3,577.0	10,330.0
Jordan	≤10 MW	12.0	N/A	12.0	N/A
Kazakhstan	≤35 MW	255.0	2,354.4	118.0	1,380.9
Kyrgyzstan	≤30 MW	53.8	N/A	53.8	311.8
Lao PDR	≤15 MW	162.0	2,287.0	N/A	N/A
Lebanon	≤10 MW	31.2	144.8	31.2	144.8
Malaysia	≤30 MW	296.0	1,500.0	N/A	N/A
Mongolia	≤10 MW	4.7	129.5	4.7	129.5

Country	*Local SHP definition*	*Installed capacity (local def.)*	*Potential capacity (local def.)*	*Installed (≤10 MW)*	*Potential (≤10 MW)*
Myanmar	≤10 MW	42.9	114.0	42.9	114.0
Nepal	≤25 MW	662.5	4,000.0	N/A	N/A
Pakistan	≤50 MW	445.0	3,190.0	N/A	N/A
Philippines	≤10 MW	145.0	1,265.0	145.0	1,265.0
Republic of Korea	≤5 MW	N/A	N/A	199.5	1,500.0
Saudi Arabia	N/A	N/A	N/A	0.0	130.0
Sri Lanka	≤10 MW	425.0	873.0	425.0	873.0
Syria	≤10 MW	23.0	67.6	23.0	67.6
Tajikistan	≤30 MW	142.1	N/A	54.7	30,000.0
Thailand	≤6 MW	190.4	700.0	N/A	N/A
Timor-Leste	≤50 MW	0.4	N/A	0.4	219.8
Turkey	≤10 MW	1,662.2	4,891.5	1,662.2	4,891.5
Turkmenistan	N/A	N/A	N/A	1.2	1,300.0
Uzbekistan	≤30 MW	303.6	1,392.0	87.8	N/A
Viet Nam	≤30 MW	3,600.0	7,200.0	N/A	N/A

Figure 24. **Installed and Potential Small Hydropower Capacity up to 10 MW in Asia (MW)**

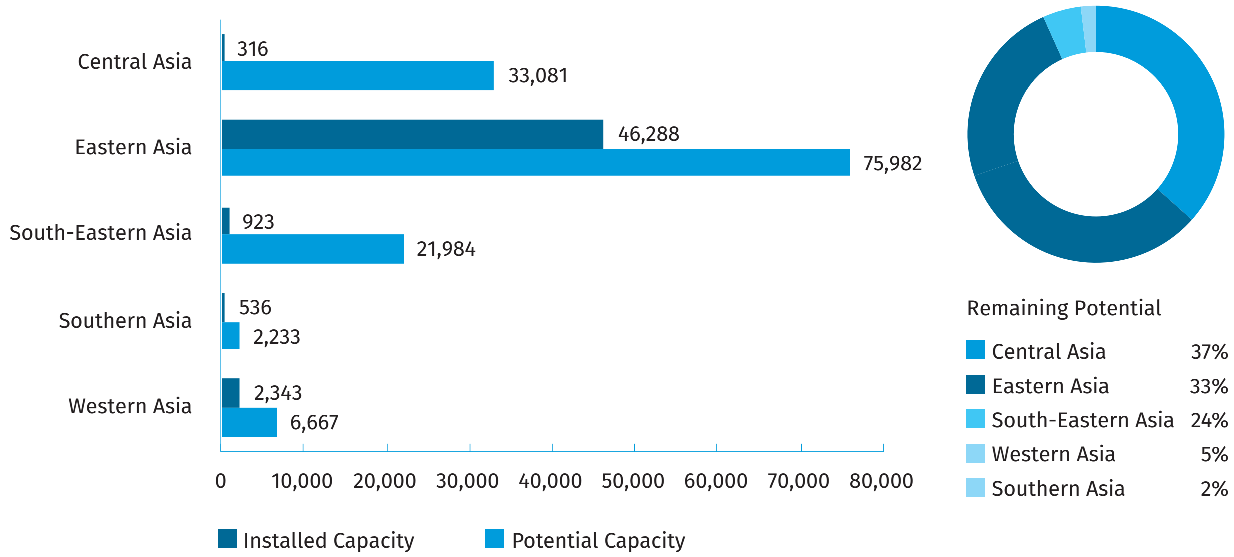
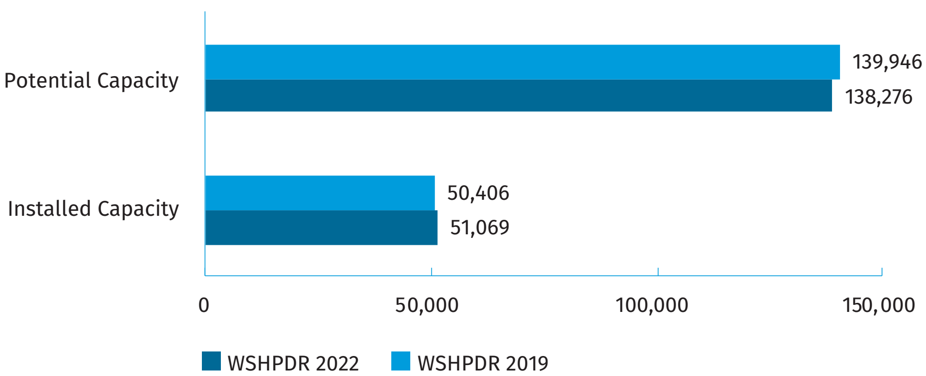


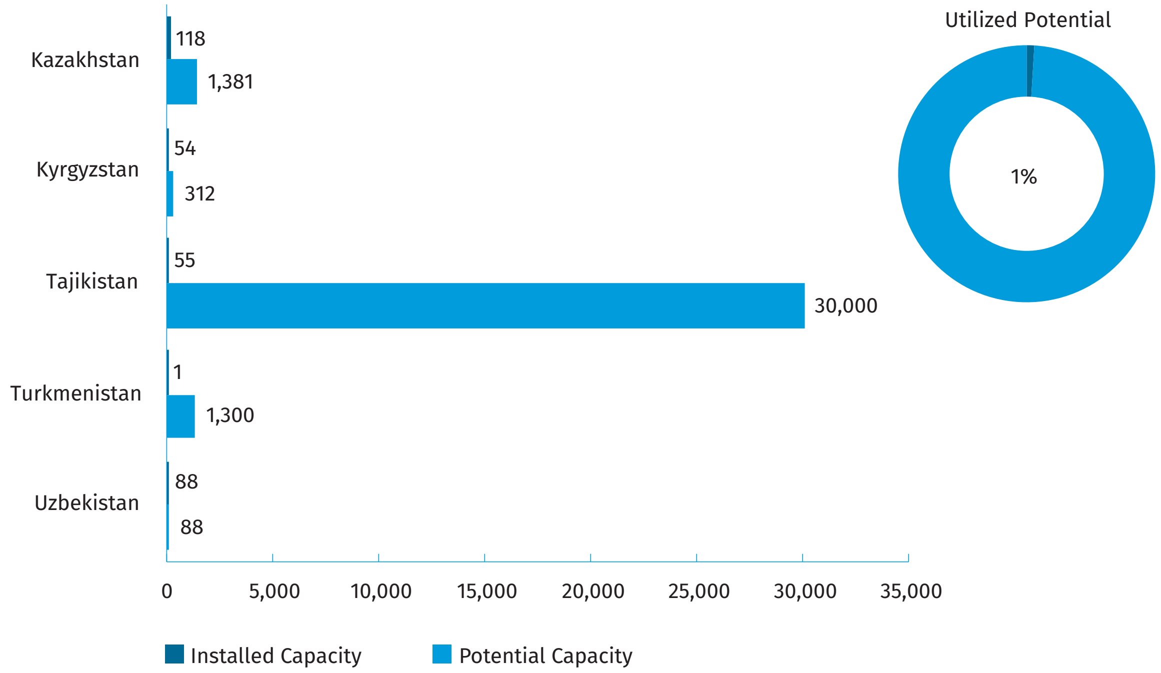
Figure 25. **Comparison of Installed and Potential Small Hydropower Capacity up to 10 MW in Asia in the *WSHPDR 2019* and *WSHPDR 2022* (MW)**



Central Asia SHP Overview

Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan

Figure 26. **Installed and Potential Small Hydropower Capacity up to 10 MW in Central Asia (MW)**



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, among other energy-related information.

The installed SHP capacity of **Kazakhstan** for SHP plants up to 35 MW was 255 MW as of mid-2021, while potential capacity is estimated at 2,354.4 MW, indicating that approximately 11 per cent has been developed so far. For SHP up to 10 MW, installed and potential capacity is 118 MW and 1,380.9 MW, respectively, indicating that approximately 9 per cent has been developed. As in Uzbekistan, a large number of SHP plants were constructed in Kazakhstan during the Soviet period and many have since fallen into disuse or require extensive rehabilitation. The country aims to add up to 1,500 MW of SHP capacity by 2030.

In **Kyrgyzstan**, there were a total of 18 SHP up to 10 MW plants operating as of 2020, with an installed capacity of 53.8 MW. Although the national definition of SHP includes plants up to 30 MW, in practice, there are no hydropower plants with a capacity of between 10 MW and 30 MW in the country. Potential capacity for SHP up to 10 MW is estimated at 311.8 MW, indicating that 17 per cent of the known potential has been developed. The construction of new SHP plants in Kyrgyzstan in recent years has been carried out solely by private sector developers. A number of government initiatives targeted the addition of 41 new SHP plants with a total capacity of 178 MW by 2025, but the pace of development has lagged due to issues with funding, project delays, as well as institutional, legal and technical obstacles.

Although the definition of SHP in **Tajikistan** includes plants up to 30 MW, in practice, the SHP fleet of the country is largely composed of hundreds of very small plants with capacities ranging from several hundred kilowatts to several megawatts. The total installed capacity of SHP up to 30 MW in Tajikistan as of 2021 was 142.1 MW, of which 44.8 MW was operated by the private-public company Pamir Energy to supply electricity to the semi-isolated Gorno-Badakhshan Autonomous Region, powered solely by SHP. The installed capacity of SHP up to 10 MW in 2021 was 54.7 MW, while the potential SHP capacity up to 10 MW is estimated at 30,000 MW, suggesting that only a small fraction of this potential has been developed so far. Extensive plans for the construction of SHP in Tajikistan were drawn up during the Soviet period but only partially realized. The construction of SHP plants picked up again after 1995, with 155 plants constructed between 1995 and 2021 with a cumulative capacity of 12.5 MW.

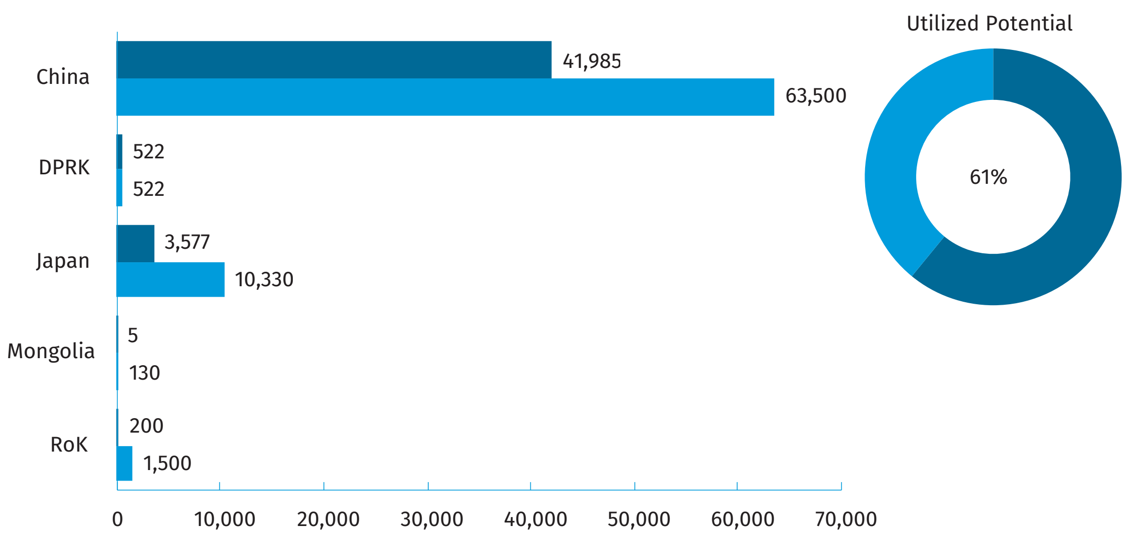
The only operational SHP plant of **Turkmenistan**, the Hindigush hydropower plant on the Murgab River, was built in 1913 with a capacity of 1.2 MW and remains in use to this day. The country's SHP potential is estimated at 1,300 MW, indicating that less than 1 per cent has been developed. Plans for the refurbishment of several previously operational SHP plants as well as the construction of new plants have been proposed since 2011 but have not been realized.

The installed SHP capacity of **Uzbekistan** is estimated at 303.6 MW for SHP up to 30 MW and at 87.8 MW for SHP up to 10 MW. Potential capacity for SHP up to 30 MW is estimated at 1,392 MW, indicating that approximately 22 per cent has been developed. No estimate of potential capacity for SHP up to 10 MW is available. During the mid-20th century, there were over 250 operational SHP plants in the country, but most of these are no longer in use. In recent years, the Government has actively pursued SHP development, launching an ambitious programme of SHP construction and refurbishment in 2017. The programme includes specific plans to add an additional 35 new SHP plants with a total installed capacity of 349 MW and to increase the installed capacity of 23 existing plants to 251.4 MW by 2030. Several new SHP plants were commissioned and one plant was refurbished in 2019.

Eastern Asia SHP Overview

China, Democratic People's Republic of Korea, Japan, Mongolia and the Republic of Korea

Figure 27. **Installed and Potential Small Hydropower Capacity up to 10 MW in Eastern Asia (MW)**



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, among other energy-related information.

In **China**, SHP is a mature technology and is widely adopted all over the country, with 43,957 SHP plants up to 50 MW in operation as of 2020. China has added approximately 2,000 MW of SHP up to 50 MW since the publication of the *WSHPDR 2019*. As of 2020, the installed capacity for SHP up to 50 MW in China was approximately 81,300 MW and potential capacity is estimated at 128,000 MW, indicating that nearly 64 per cent of SHP potential up to 50 MW has been developed. For SHP up to 10 MW, the installed capacity was 41,985 MW as of 2020 while potential capacity is estimated at 63,500 MW, indicating that approximately 66 per cent of the potential for SHP up to 10 MW has been developed. China has set ambitious targets for hydropower development, including building an additional 70,000 MW of hydropower capacity by 2030 and another 70,000 MW by 2050, with SHP intended to account for a share of this additional capacity. Responsibility for SHP development in the country has gradually been shifting towards the private sector.

The estimated total installed capacity of SHP up to 10 MW in the **DPRK** is 522.1 MW. Of this total, 470.9 MW is accounted for by plants constructed prior to 2005, while the remaining 51.2 MW was added between 2016 and 2019. In 2015, the construction of new hydropower projects was announced at six different sites, but no specific data on the potential SHP capacity or current status of these projects are available. Likewise, there is no reliable estimate of the existing SHP potential in the country beyond that which has already been developed. Circumstantial evidence including the topography and hydrological conditions of the DPRK suggest that untapped hydropower potential in the country is considerable. Additionally, many of the previously installed SHP plants, particularly those in the micro- and mini-hydropower capacity range, may no longer be operational or are in need of extensive refurbishment.

In **Japan**, the total installed capacity of SHP under 10 MW is 3,577 MW, while potential capacity is estimated at 10,330 MW, indicating that approximately 35 per cent of the SHP potential in the country has been developed. Japan has a long history of hydropower development, but opportunities for construction of additional large-scale hydropower plants are limited. Consequently, construction of SHP plants represents the most active subsector of hydropower development in the country and is promoted by national government policy as well as by non-governmental organizations, agricultural cooperatives and other local organizations.

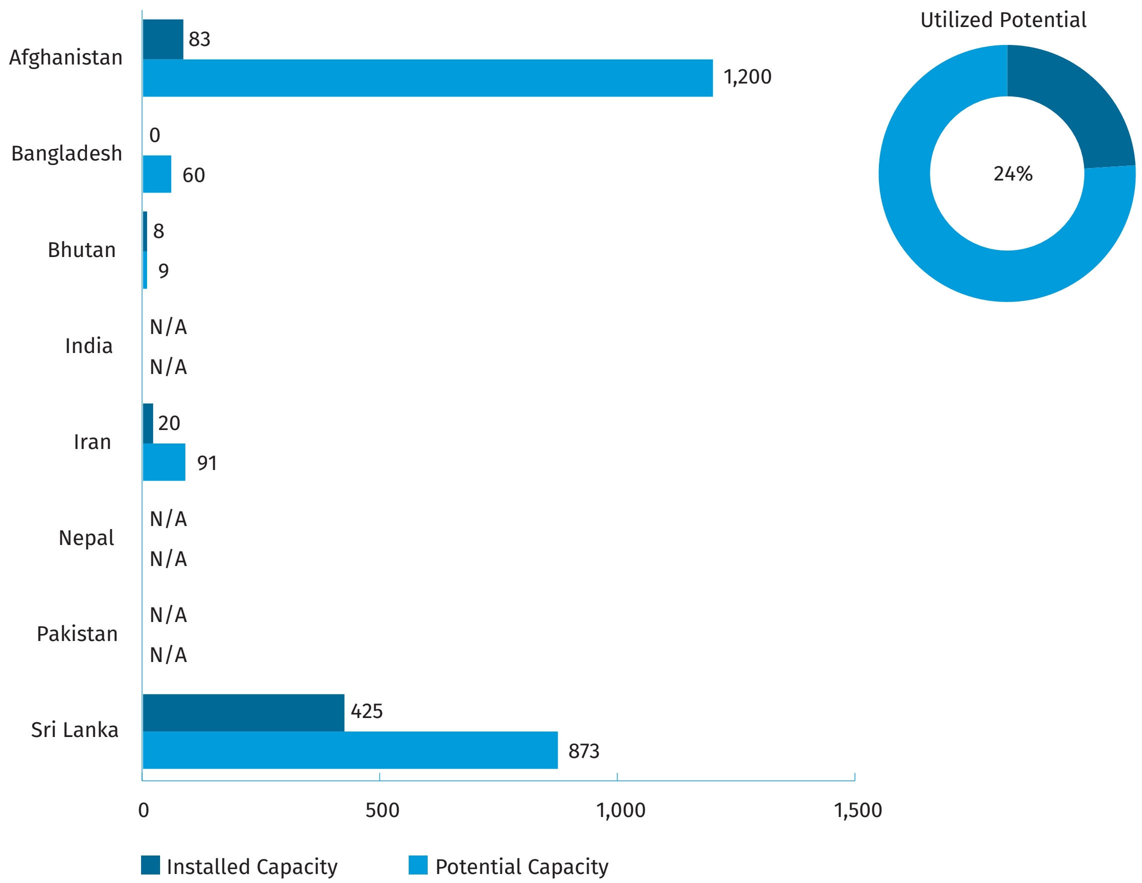
Mongolia has 10 SHP plants up to 10 MW with a total installed capacity of 4.7 MW. The potential capacity of SHP up to 10 MW in Mongolia is estimated at 129.5 MW, indicating that approximately 3 per cent has been developed. However, five of the existing SHP plants require major restoration work and are currently out of operation, while the other five only operate during the summer. Consequently, SHP in Mongolia is considered a seasonal energy source.

The **RoK** currently has 169 operating plants up to 10 MW with a combined installed capacity of 199.5 MW. Potential capacity for plants up to 10 MW in the RoK is estimated at 1,500 MW, indicating that over 10 per cent has been developed. The SHP sector in the country is undergoing active development, with 14 new plants commissioned in 2018–2019. Ongoing projects include several SHP plants being constructed as auxiliary facilities at the sites of existing thermal power plants.

Southern Asia SHP Overview

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

Figure 28. **Installed and Potential Small Hydropower Capacity up to 10 MW in Southern Asia (MW)**



Note: “N/A” refers to cases where data on installed and/or potential capacity for SHP of up to 10 MW are not available.

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, among other energy-related information.

In **Afghanistan**, the total installed capacity of SHP up to 25 MW was estimated at 83.2 MW as of 2022, while potential capacity is estimated at 1,200 MW, suggesting that approximately 7 per cent has been developed. One new major SHP plant was commissioned in 2021, with another project nearing completion. However, only SHP up to 3 MW is classified as renewable energy under existing legislation. Most SHP development in Afghanistan in recent years has taken the form of mini- and micro-hydropower projects installed on isolated grids and funded by various support programmes, with an estimated 5,000 of such projects in different parts of the country.

There is no identified operational SHP capacity in **Bangladesh** as of 2022. The existence of several micro-scale SHP plants has been attested to in previous years, but they are no longer considered operational. The potential capacity for SHP up to 10 MW is estimated at 60 MW, with much of this potential concentrated in the hilly Chittagong region. Several recent studies have been carried out by national and international entities that identified a wide range of potential sites for new SHP construction as well as refurbishment of previously operational plants.

The total installed SHP capacity of **Bhutan** for SHP up to 25 MW was 32.4 MW in 2021, provided by 25 plants. With a single 24 MW plant providing most of this capacity. The total installed capacity for SHP up to 10 MW was 8.4 MW. Potential capacity for SHP up to 25 MW was estimated at 23,296 MW in 2017, indicating that significantly less than 1 per cent has been developed. There are no detailed data on the potential capacity for SHP up to 10 MW, but an estimate of 8.9 MW can be made on the basis of installed capacity and two additional projects under consideration as of 2021 with a total potential capacity of 0.5 MW. The overall installed SHP capacity of the country has changed little over the last decade, although several micro-scale plants have been commissioned. Several SHP projects with a total capacity of 83 MW are in the pipeline. Overall, existing plans for the development of hydropower resources in the country are focused on medium and large hydropower.

The total installed capacity of SHP up to 25 MW in **India** was 4,787 MW in 2021, while potential SHP capacity in the country is estimated at 21,134 MW, indicating that 22 per cent has been developed. The degree of SHP development varies considerably across different states, with Karnataka and Himachal Pradesh leading the country in both installed capacity and identified SHP potential. The SHP sector in India is actively expanding and a number of new SHP plants were commissioned in 2020. The Ministry of New and Renewable Energy is spearheading SHP development through support for SHP research and documentation of standards, while construction of new plants has been primarily carried out by the private sector.

The total installed capacity of **Iran** for SHP up to 10 MW was 19.5 MW as of 2021. There is a lack of clear data on potential SHP capacity in the country, but based on the sum of capacities for existing plants, planned project and identified potential sites, potential SHP capacity is estimated at 90.8 MW, indicating that over 21 per cent has been developed. Estimates of potential SHP capacity in the country have decreased following the cancellation of several planned projects in 2019. Little SHP development has taken place in the last decade, with the most recent utility-scale SHP plant commissioned in 2011.

The total installed capacity in **Nepal** for SHP up to 25 MW was 662.5 MW in 2021, with SHP up to 10 MW accounting for the bulk of this capacity. Potential capacity for SHP up to 25 MW is estimated at 4,000 MW, indicating that approximately 17 per cent has been developed. In addition to utility-scale SHP plants, some 3,000 micro-hydropower plants operate in the country, providing power to rural and isolated areas. Development in the SHP sector is actively ongoing. As of 2021, a large number of prospective SHP projects totalling several thousand megawatts have either been granted generation licences or licences in preparation for feasibility studies.

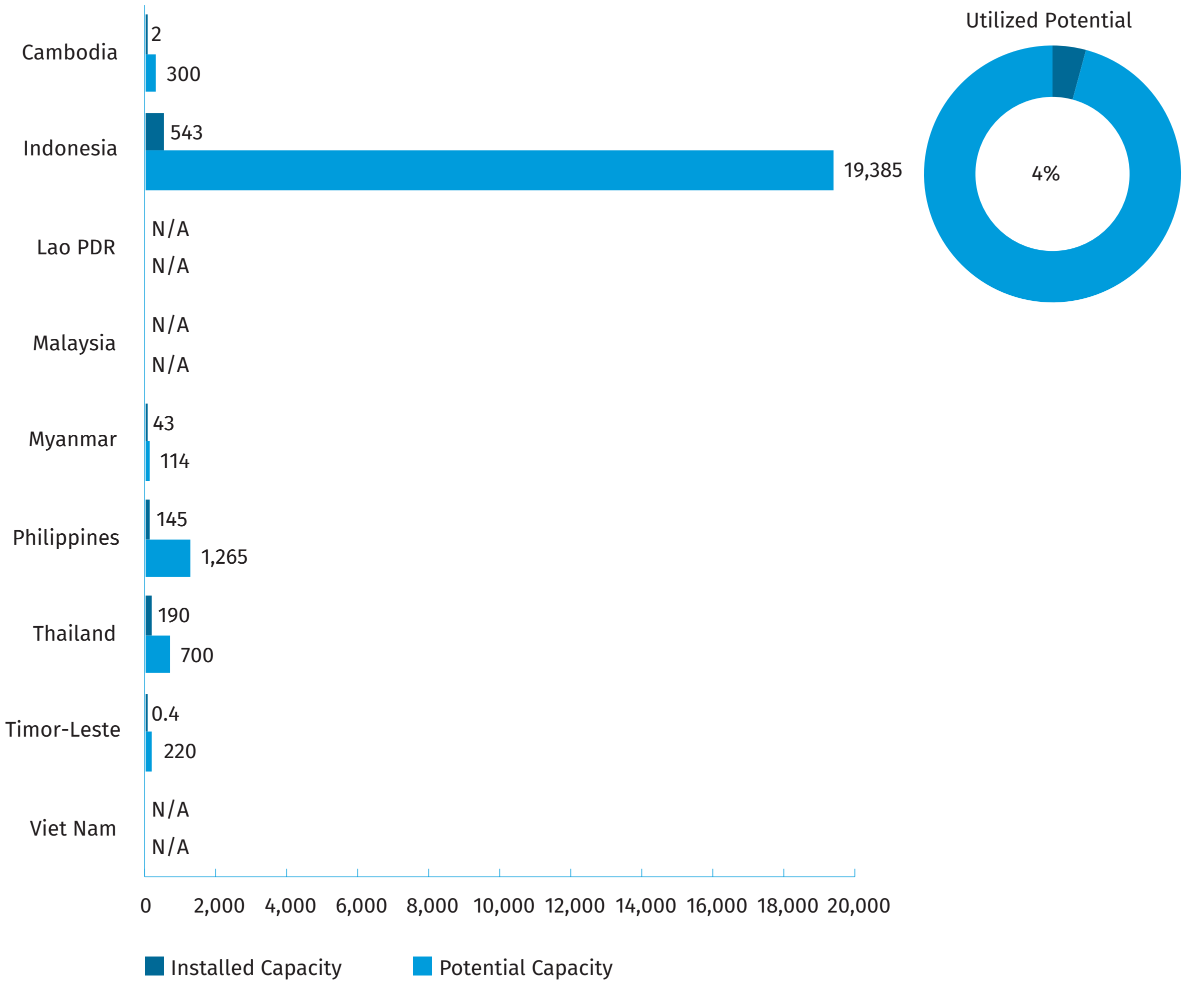
The total installed capacity in **Pakistan** for SHP up to 50 MW was 445 MW as of 2020, while potential capacity is estimated at 3,190 MW, indicating that approximately 14 per cent has been developed. The Gilgit-Baltistan province hosts the largest concentration of SHP in the country and also contains the greatest estimated SHP potential. Development of SHP in Pakistan is pursued by a variety of public, private and international actors, including the Alternative Energy Development Board and the Pakistan Council of Renewable Energy Technologies. Joint Pakistan–China research centres for SHP technologies have been established in Islamabad and Peshawar and international funding for SHP projects has been provided by the Asian Development Bank, Swiss Agency for Development and Cooperation and the Aga Khan Foundation. At least five SHP projects were under construction as of 2021.

The total installed capacity of SHP up to 10 MW in **Sri Lanka** was 424.6 MW in 2019, provided by 205 grid-connected SHP plants. The potential capacity for SHP up to 10 MW in the country is estimated at 873 MW, indicating that approximately 49 per cent has been developed. The Ratnapura and Nuwara Eliya districts lead the country in installed SHP capacity. SHP development is very active in the country with over 20 new plants launched in 2018–2019, although procurement bottlenecks have led to a backlog of planned projects with a cumulative capacity of 100 MW, and no new power purchase agreements have been signed with developers since 2015. SHP developers from Sri Lanka have been expanding their reach internationally and pursuing projects in other parts of Asia as well as in African countries.

South-Eastern Asia SHP Overview

Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, Philippines, Thailand, Timor-Leste and Viet Nam

Figure 29. **Installed and Potential Small Hydropower Capacity up to 10 MW in South-Eastern Asia (MW)**



Note: "N/A" refers to cases where data on installed and/or potential capacity for SHP up to 10 MW are not available.

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, among other energy-related information.

As of 2020, the installed SHP capacity of **Cambodia** consisted of four plants with a total installed capacity of 1.7 MW constructed under grant aid from the Government of Japan and managed by the country's public electricity company. Several additional private micro-hydropower plants exist in different parts of the country, but data on their installed capacity is lacking. The country's potential capacity for SHP up to 10 MW is estimated at 300 MW, indicating that less than 1 per cent has been developed. There were nine SHP projects in the country in advanced stages of study as of 2021, in addition to 39 identified potential sites.

Indonesia has the region's second-largest SHP capacity at 543 MW (for SHP up to 10 MW) and the largest SHP potential, estimated at 19,385 MW, indicating that approximately 3 per cent has been developed. The country is actively pursuing SHP development, adding over 200 MW of additional SHP capacity in 2019–2020. New SHP plants have included both larger plants in the 1–10 MW capacity range as well as mini-hydropower plants with capacities below 1 MW, and have been constructed for both on-grid and off-grid operations. Multiple feasibility studies have been published in recent years, with the latest estimate of the country's SHP capacity dating to 2019.

The installed capacity of SHP up to 15 MW in the **Lao PDR** was 162 MW as of 2019, while potential capacity is estimated at 2,287 MW, indicating that 7 per cent has been developed. The country saw a burst of activity in the SHP sector following deregulatory reforms adopted in 2011, which delegated the approval process for SHP plants to provincial authorities, while also limiting investment in the SHP sector to local entities. Subsequent reforms adopted in 2017, following a string of disasters in the hydropower sector, again tightened central Government oversight of all hydropower projects but opened the SHP sector to foreign investment. As of 2019, there was a total of 252 MW of SHP projects in the development pipeline.

In **Malaysia**, the total installed capacity of SHP up to 30 MW was 296 MW in 2019 and potential capacity is estimated at 1,500 MW, indicating that 20 per cent has been developed. SHP development in the country has been very active, with over a dozen SHP plants build in 2017–2020 with capacities ranging from 2.2 MW to 24.5 MW. The construction of SHP projects has been spurred by the adoption of feed-in tariffs (FITs) in 2011. At the end of 2020, a total of 530 MW of SHP projects were in various stages of implementation.

The verifiable installed capacity of SHP up to 10 MW in **Myanmar** was 42.9 MW as of 2021, provided by nearly 350 SHP plants operated by the Ministry of Electricity and Energy as well as other government ministries. Additionally, over 2,000 privately-run micro-hydropower plants are estimated to exist across the country, but data on their cumulative capacity is not available. The potential capacity of SHP up to 10 MW in the country is estimated at 114 MW based on existing plants and identified sites, indicating that nearly 38 per cent has been developed. Two new SHP plants were constructed in Myanmar in 2018 and several projects were in the early planning stages as of 2021.

The installed capacity of SHP up to 10 MW in **the Philippines** was 145 MW as of 2021, while potential capacity is estimated at 1,265 MW, indicating that over 11 per cent has been developed. While the SHP sector in the country has seen active development in recent years, the total installed capacity of the country has decreased by a small margin due to the exclusion of non-operational SHP plants from government databases. A total of 17 new hydropower projects, primarily within the category of SHP, were in the early planning stages as of 2021.

In **Thailand**, the installed capacity of SHP up to 6 MW was 190.4 MW as of 2020. The potential capacity for SHP up to 6 MW in the country is estimated at 700 MW, mostly concentrated in the northern part of the country, indicating that approximately 27 per cent has been developed. Several new plants have been constructed in recent years. The development of SHP in the country is promoted by the national Alternative Energy Development Plan (AEDP2018), which has set a goal of increasing the total installed capacity of SHP in the country to 376 MW by 2037. A total of 256 potential sites have been identified in the northern part of Thailand.

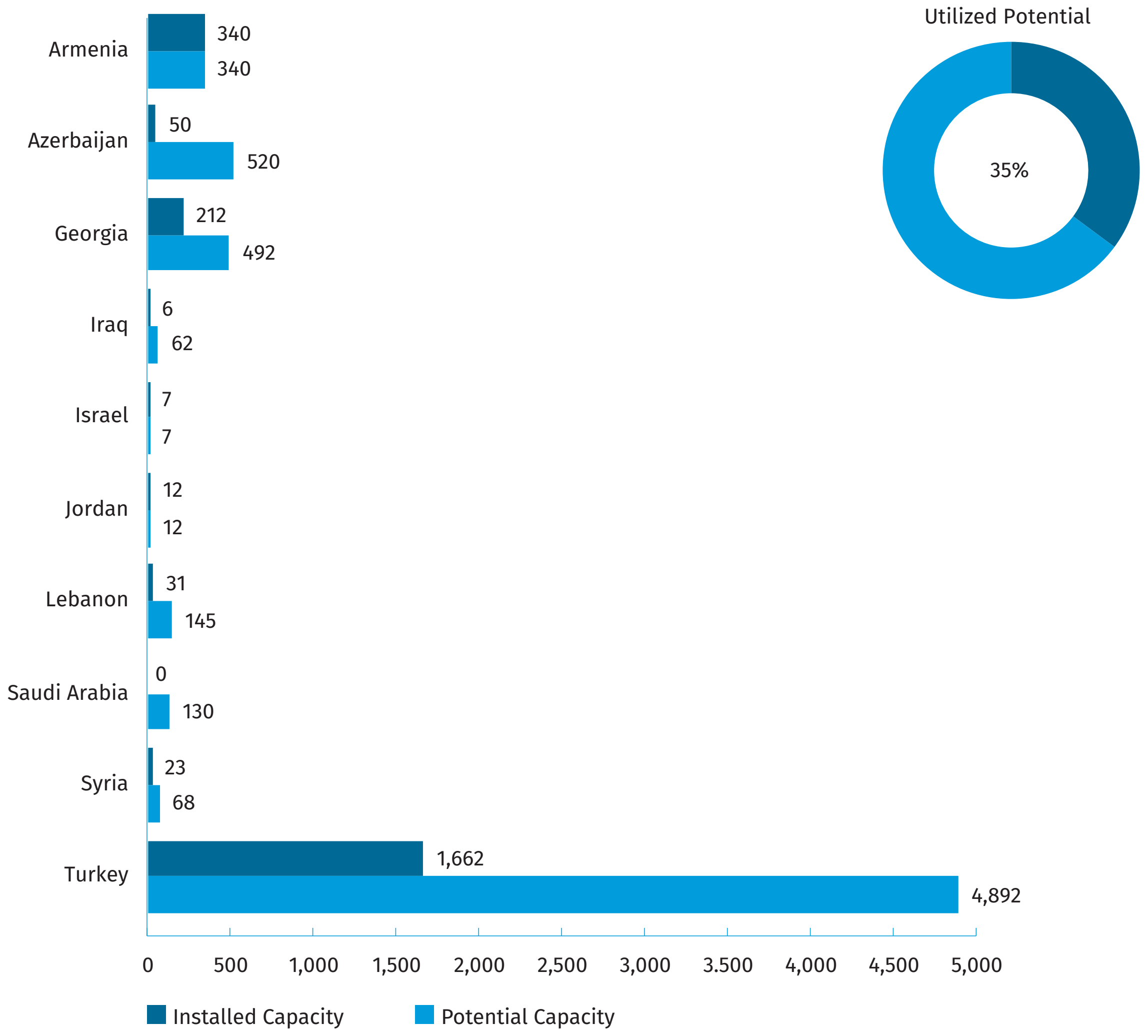
Timor-Leste has 0.4 MW of SHP capacity provided by three plants, which are all either fully inoperable or operating at significantly reduced capacity. The potential for SHP up to 10 MW in the country is estimated to be at least 219.8 MW, suggesting than 1 per cent has been developed. Potential SHP sites in the country have been inventoried by several detailed studies, but no concrete plans for further development of the SHP sector exist.

The total installed capacity of SHP up to 30 MW in **Viet Nam** was approximately 3,600 MW as of 2020, while potential capacity is estimated at 7,200 MW, indicating that 50 per cent has been developed. The SHP sector of Viet Nam has been growing at a rapid pace, more than doubling in installed capacity since the publication of the *WSHPDR 2019*. While the country's rapidly growing economy has led to ever-increasing electricity demand, its commitment to decarbonizing the electricity sector has led the Government to reduce targets for the expansion of thermal power while pursuing a radical expansion of hydropower, wind power and solar power over the next decade. With much of the country's potential large hydropower capacity nearing saturation, the development of SHP is expected to play an ever-increasing role in the overall growth of the hydropower sector. Under the draft Power Development Plan published in 2022, Viet Nam is aiming to increase its total SHP capacity to 5,000 MW by 2030 and to 5,900 MW by 2045. At the same time, accidents and environmental concerns have caused the Government to increase scrutiny of the SHP sector, leading to the cancellation of hundreds of planned and ongoing projects over the last decade.

Western Asia SHP Overview

Armenia, Azerbaijan, Georgia, Iraq, Israel, Jordan, Lebanon, Saudi Arabia, Syria and Turkey

Figure 30. **Installed and Potential Small Hydropower Capacity up to 10 MW in Western Asia (MW)**



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, among other energy-related information.

In **Armenia**, there were 188 SHP plants up to 30 MW as of 2021 with a total installed capacity of 382 MW, of which 186 plants were up to 10 MW with a total installed capacity of approximately 340 MW. The potential capacity for SHP up to 30 MW is estimated at 430.6 MW, indicating that approximately 89 per cent has been developed. Ongoing SHP development has included the commissioning of 11 new SHP plants in the last several years, and 24 SHP projects with a total capacity of nearly 49 MW were under construction as of early 2021.

The installed capacity of SHP up to 10 MW in **Azerbaijan** was estimated at 49.5 MW as of 2022 while potential capacity is approximately 520 MW, indicating that nearly 10 per cent has been developed. Several new SHP plants were constructed in the country between 2017 and 2020 and several additional plants formerly operated by the de-facto authorities in Nagorno-Karabakh were refurbished and recommissioned in 2021. In addition, a further 23 non-operational SHP plants are slated for refurbishment in the near future.

In **Georgia**, the total installed capacity for SHP up to 15 MW was approximately 263 MW as of 2021 and approximately 212 MW for SHP up to 10 MW. The official definition of SHP in the country was altered from up to 13 MW to up to 15 MW in 2019. Under the new definition, there were 72 SHP plants in operation as of 2021, of which 68 were plants up to 10 MW. Potential capacity for SHP up to 15 MW is estimated at 724 MW, indicating that 36 per cent has been developed, and for SHP up to 10 MW at nearly 492 MW, indicating that 43 per cent has been developed. A very large number of SHP plants have been constructed in the country between 2017 and 2020, with capacities ranging from 0.5 MW to 9.5 MW. As of December 2020, there were a total of 74 SHP projects under construction, applying for licences or undergoing feasibility studies.

The installed capacity of SHP in **Iraq** is 6 MW, provided by a single SHP plant. Potential capacity for SHP up to 10 MW is estimated to be at least 62 MW, suggesting that less than 10 per cent has been developed. Currently, there are no plans for SHP development as the country has prioritized solar power and wind power projects.

The total installed SHP capacity in **Israel** is estimated at 7 MW and has not changed over the last decade. Data on specific plants as well as on the total SHP potential in the country are not available. Studies on opportunities for SHP development in Israel as well as experimental projects on SHP installation on water supply infrastructure have been carried out over the last decade, but no specific plans for SHP development in the country have been proposed or implemented.

There are two operational SHP plants in **Jordan**, both constructed in the 1980s, with a total installed capacity of 12 MW, but only one plant is actively producing electricity. There is no reliable data on SHP potential in the country. As of 2021, there were no ongoing SHP projects or official plans for SHP development in the country.

The installed capacity of SHP up to 10 MW in **Lebanon** is 31.2 MW and has not changed in several decades, with the country's still-operational SHP plants constructed during the pre-civil war period. Potential for SHP up to 10 MW has been assessed by several detailed studies and is estimated at 144.8 MW, indicating that 22 per cent has been developed, but there are no plans for further SHP development in the country.

Saudi Arabia has no SHP sector and no plans for the development of SHP. However, untapped SHP potential is estimated to total approximately 130 MW. This potential is mainly accounted for by non-powered dams, including 6 dams with a potential capacity of between 45 MW and 51 MW and 51 smaller dams with a potential capacity of 82 MW.

Syria has three operational SHP plants up to 10 MW with a total installed capacity of approximately 23 MW. The total potential for SHP up to 10 MW in the country is estimated at 67.6 MW, suggesting that 34 per cent has been developed. No significant SHP development has taken place in the country since the 1960s. The Government of Syria has been exploring options for re-energizing the SHP sector as a means to offset the loss of electricity capacity caused by the ongoing conflict and sanctions. A government study commissioned in 2020 conducted a detailed investigation of the potential for SHP development in current conditions, with a particular focus on developing hidden SHP potential found in existing water supply infrastructure, outflow from industrial sites and non-powered dams.

The total installed capacity of SHP up to 10 MW in **Turkey** was 1,662.2 MW as of 2020. The potential capacity was estimated at 4,891.5 MW, indicating that 34 per cent has been developed. Both installed and potential capacity of SHP in the country have decreased considerably relative to the *WSHPDR 2019* following updates to databases of SHP plants and the cancellation of over 600 SHP projects. The causes of these cancellations included technical issues, environmental factors including drought and difficulty in obtaining licences. The private sector plays an important role in SHP development in the country, with 714 SHP plants put into operation under public-private partnerships.

Europe

Europe has a long history of SHP development, which has enabled it to reach a high level of installed capacity and potential development. The overall installed capacity of SHP of up to 10 MW in the region is 20,434 MW, while the potential capacity is estimated at 39,607 MW, indicating that 52 per cent of known potential has been developed. The increase in SHP installed capacity in comparison to the *WSHPDR 2019* is mainly due to the new capacities added in Norway, Italy and Albania.

With a wide variety of climates and landscapes in the continent, SHP potential varies across the regions. The greatest remaining potential is concentrated in Northern Europe, primarily in Norway. Italy is the leader in the continent in terms of installed capacity of SHP of up to 10 MW, followed by Norway and France.

Country	*Local SHP definition*	*Installed capacity (local def.)*	*Potential capacity (local def.)*	*Installed (≤10 MW)*	*Potential (≤10 MW)*
Austria	≤10 MW	1,521.6	1,780.0	1,521.6	1,780.0
Albania	≤15 MW	482.0	N/A	432.0	1,963.0
Belarus	≤10 MW	17.3	250.0	17.3	250.0
Belgium	≤10 MW	76.0	103.4	76.0	103.4
Bosnia & Herzegovina	≤10 MW	172.2	1,005.0	172.2	1,005.0
Bulgaria	N/A	N/A	N/A	494.7	580.7
Croatia	≤10 MW	45.7	100.0	45.7	100.0
Czech Republic	≤10 MW	353.0	465.0	353.0	465.0
Denmark	≤10 MW	7.0	9.8	7.0	9.8
Estonia	≤10 MW	8.0	10.0	8.0	10.0
Finland	≤10 MW	297.5	585.5	297.5	585.5
France	≤10 MW	2,200.0	2,615.0	2,200.0	2,615.0
Germany	N/A	N/A	N/A	1,674.0	1,830.0
Greece	≤15 MW	247.2	2,000.0	N/A	N/A
Hungary	≤5 MW	17.1	28.0	N/A	N/A
Iceland	≤10 MW	66.1	3,742.0	66.1	3,742.0
Ireland	≤10 MW	58.5	70.7	58.5	70.7
Italy	≤10 MW	3,648.4	7,073.0	3,648.4	7,073.0
Latvia	≤10 MW	28.0	96.0	28.0	96.0
Lithuania	≤10 MW	26.9	57.9	26.9	57.9
Luxembourg	≤10 MW	25.3	44.0	25.3	44.0
Moldova	N/A	N/A	N/A	0.3	7.2
Montenegro	≤10 MW	34.7	97.5	34.7	97.5
Netherlands	≤10 MW	13.0	N/A	13.0	N/A
North Macedonia	≤10 MW	111.4	258.0	111.4	258.0
Norway	≤10 MW	2,924.0	7,162.0	2,924.0	7,162.0
Poland	N/A	N/A	N/A	291.7	1,500.0
Portugal	≤10 MW	415.0	750.0	415.0	750.0
Romania	≤10 MW	321.0	730.0	321.0	730.0
Russia	≤30 MW	852.9	825,844.6	168.4	N/A
Serbia	≤30 MW	N/A	N/A	109.0	N/A
Slovakia	≤10 MW	81.6	145.0	81.6	145.0
Slovenia	≤1 MW	N/A	N/A	164.0	180.0
Spain	≤10 MW	2,145.0	2,158.0	2,145.0	2,158.0
Sweden	≤10 MW	961.0	N/A	961.0	N/A
Switzerland	≤10 MW	1,000.0	1,500.0	1,000.0	1,500.0
Ukraine	≤10 MW	119.6	280.0	119.6	280.0
United Kingdom	≤10 MW	405.0	1,179.0	405.0	1,179.0

Figure 31. **Installed and Potential Small Hydropower Capacity up to 10 MW in Europe (MW)**

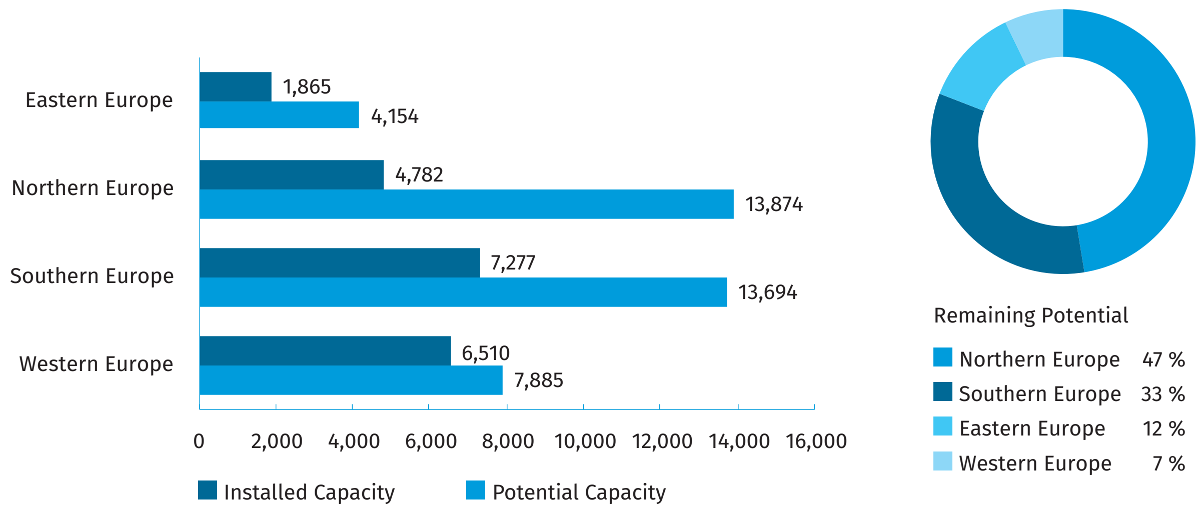
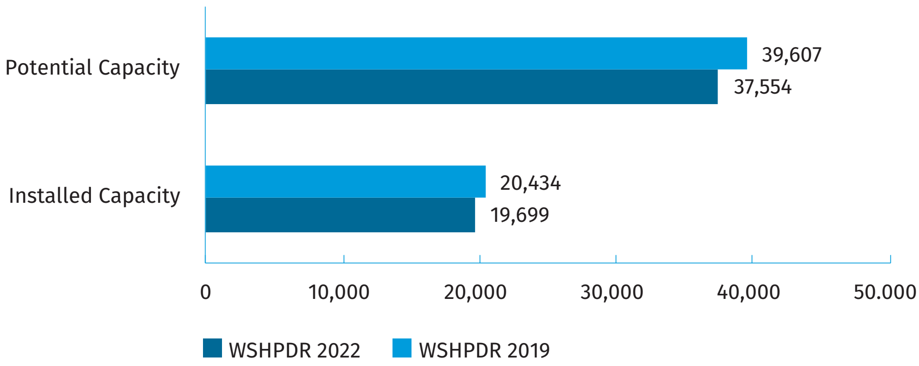


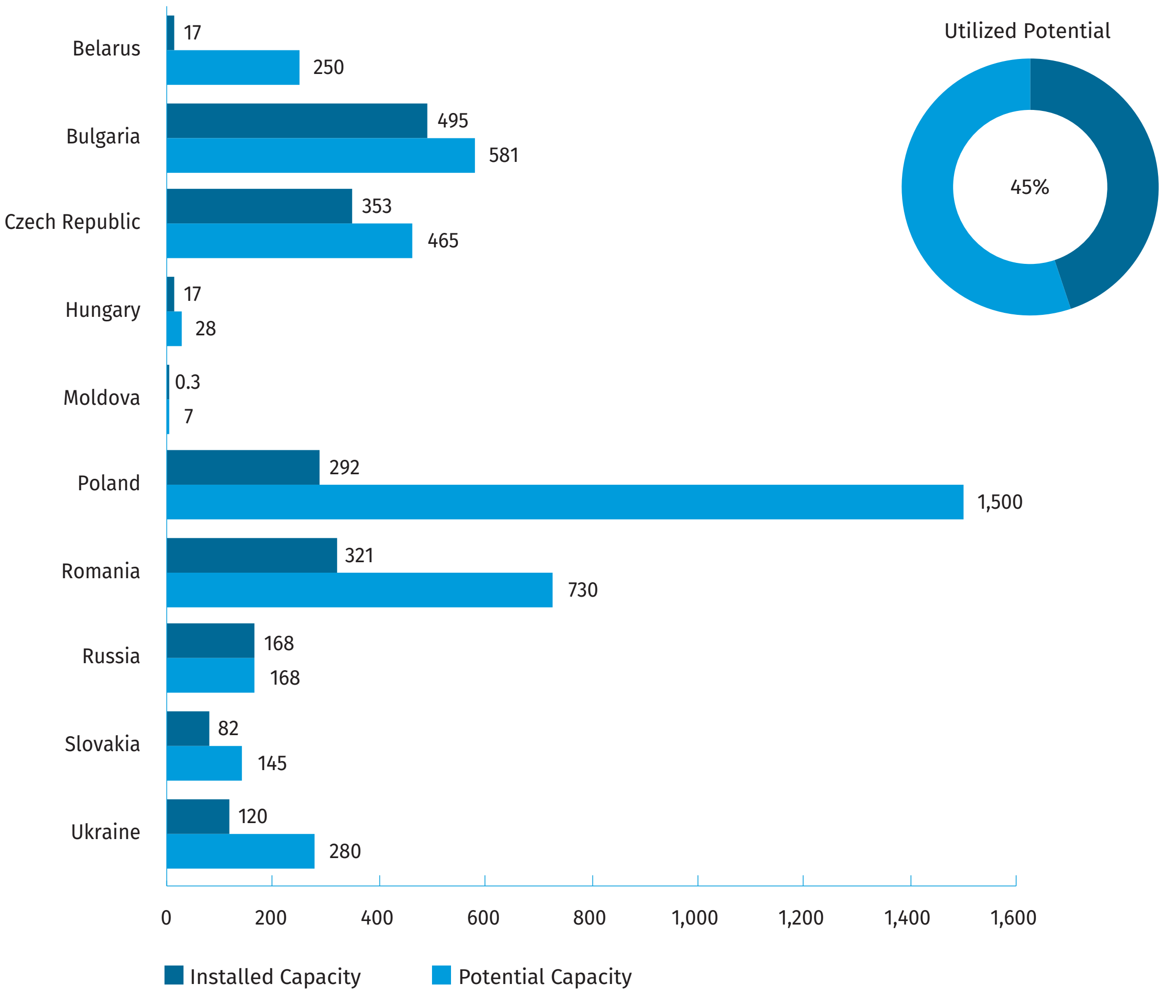
Figure 32. **Comparison of Installed and Potential Small Hydropower Capacity up to 10 MW in Europe in the *WSHPDR 2019* and *WSHPDR 2022* (MW)**



Eastern Europe SHP Overview

Belarus, Bulgaria, Czech Republic, Hungary, Moldova, Poland, Romania, Russia, Slovakia and Ukraine

Figure 33. **Installed and Potential Small Hydropower Capacity up to 10 MW in Eastern Europe (MW)**



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, among other energy-related information.

Belarus has an installed capacity of 17.3 MW for SHP of up to 10 MW, provided by 49 plants. Potential capacity is estimated at 250 MW, indicating that approximately 7 per cent has been developed. Although several new mini-hydropower plants have been commissioned over the last few years, the overall installed capacity of the country has not increased as the capacities of previously existing plants have been re-assessed downwards. Thirty-four potential SHP sites have been identified in the country.

The installed capacity for SHP of up to 10 MW in **Bulgaria** is 494.7 MW, while potential capacity is estimated at 580.7 MW, indicating that 85 per cent has been developed. Little new SHP construction has taken place in the country in recent years, although a number of restoration and rehabilitation projects have been carried out on existing plants. There were several ongoing SHP projects in the country as of 2021.

The **Czech Republic** has an installed capacity of 353 MW for SHP of up to 10 MW, while potential capacity is estimated at 465 MW, indicating that 76 per cent has been developed. There are 1,422 SHP plants in the country, of which 953 are micro-scale plants with a cumulative capacity of 38 MW. Such plants make up the bulk of new SHP development in the country, and, while many new plants have been commissioned in recent years, their individual capacities have generally not exceeded several hundred kilowatts. There is a lack of comprehensive information on ongoing or planned SHP projects in the Czech Republic due to a degree of unwillingness on the part of private investors to disclose such information.

The installed capacity for SHP of up to 5 MW in **Hungary** is 17.1 MW provided by 28 plants. Potential capacity for SHP of up to 5 MW is estimated at 28 MW, indicating that 61 per cent has been developed. The estimate of potential capacity in Hungary has been re-assessed on the basis of economic feasibility of potential sites. The most recent SHP plant in the country was commissioned in 2017 and one other SHP plant was recently refurbished. There are no ongoing SHP projects or concrete plans for any additional SHP development.

Moldova has one operational SHP plant with an installed capacity of 0.25 MW. Potential capacity is estimated at 7.2 MW, indicating that nearly 4 per cent has been developed. A large number of formerly operational plants and abandoned SHP sites exist in the country, with as many as 17 plants operational in the 1960s. A significant part of the country's identified potential capacity comes from these abandoned or non-operational plants rather than greenfield sites. However, there are no specific plans or ongoing projects for additional development or refurbishment of SHP in Moldova at this time.

In **Poland**, the installed capacity of SHP of up to 10 MW is 291.7 MW, while potential capacity is estimated at 1,500 MW, indicating that 19 per cent has been developed. SHP development in the country is actively ongoing, with multiple plants commissioned between 2018 and 2020. A very large number of identified potential sites exist in the country, including thousands of historical sites such as former water mills and abandoned hydropower plants that could host potential SHP projects. A number of SHP projects are in the planning stages, to be commissioned in 2023.

The installed capacity of SHP of up to 30 MW in **Russia** is 852.9 MW, while the technically-feasible potential capacity is estimated at 825,845 MW, indicating that less than 1 per cent has been developed. The installed capacity of SHP of up to 10 MW is 168.4 MW, although no reliable estimate of potential capacity for SHP of up to 10 MW is available. Regionally, the North-Western and North Caucasus regions lead the country in installed SHP capacity, while the largest potential capacity is located in the Far Eastern region. Several new SHP plants have been constructed in recent years and several existing plants have been refurbished. Major renovation of approximately 40 SHP plants is planned for 2025–2026.

Romania has an installed capacity of 321 MW for SHP of up to 10 MW, provided by 103 plants. Potential capacity is estimated at 730 MW, indicating that approximately 44 per cent has been developed. SHP development in the country is ongoing with several new plants commissioned between 2017 and 2021, although the reported installed capacity of the country has decreased due to a reassessment of the actual capacities of existing plants.

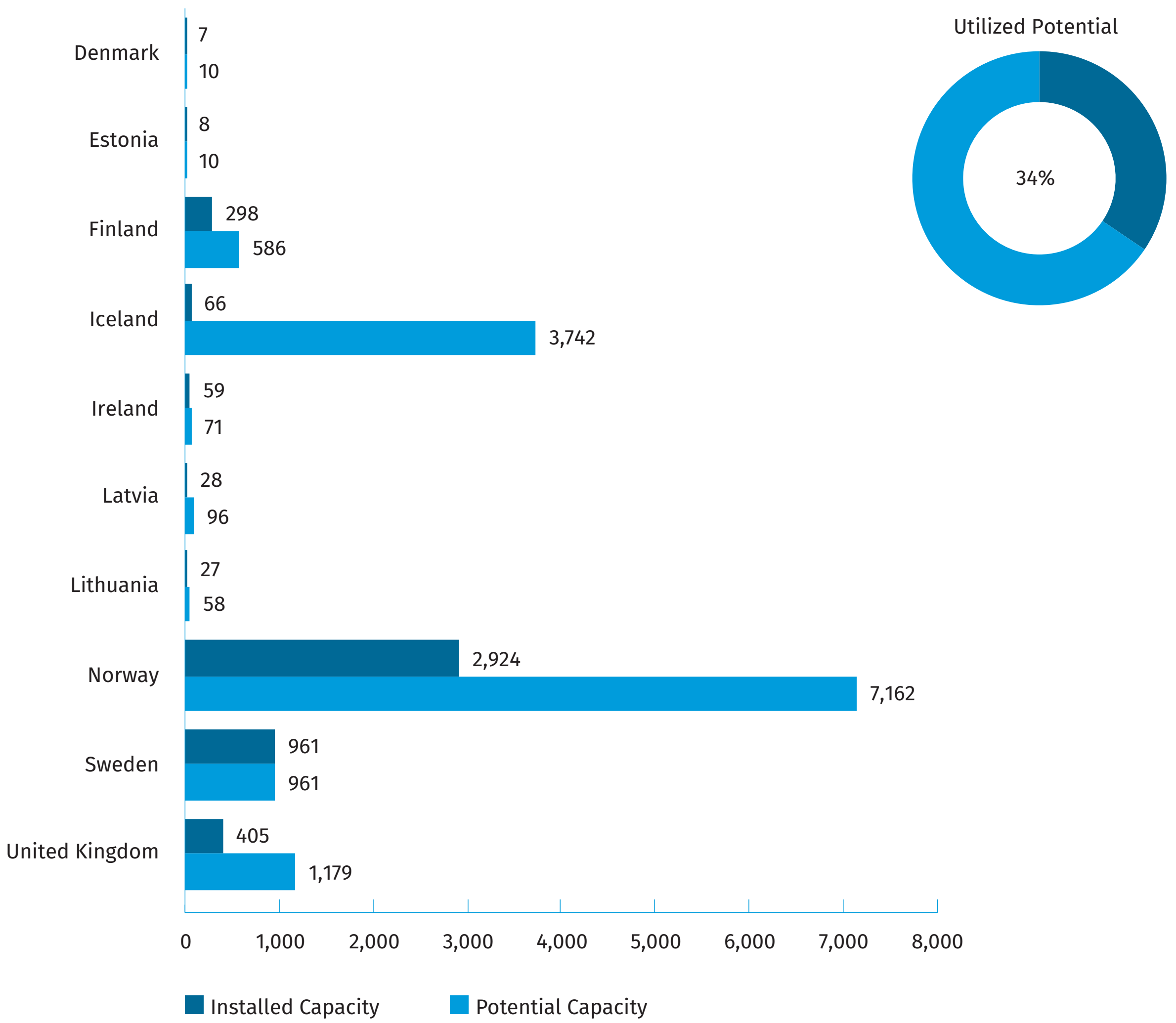
Slovakia has an installed capacity of 81.6 MW for SHP of up to 10 MW, while potential capacity is estimated at 145 MW, indicating that approximately 56 per cent has been developed. There are 217 SHP plants operating across the country. Little SHP development has taken place in Slovakia over the last decade, with the most recent plant commissioned in 2014. An ambitious plan to develop an additional 160 MW of SHP capacity by 2030, proposed in 2011, has stalled due to environmental considerations. A more recent plan published in 2019 envisions a total SHP capacity of 145 MW to be achieved by 2030.

The installed SHP capacity of up to 10 MW in **Ukraine** is 119.6 MW provided by 167 plants. Potential capacity is estimated at 280 MW, reflecting the latest published data and representing a major decrease from previous estimates. These figures indicate that approximately 43 per cent of the total potential has been developed. SHP development in the country has b een very active, with 15 new plants commissioned in 2019 alone. However, some of these projects were undertaken with insufficient oversight and have caused concern among locals and environmental activists. There are several ongoing and planned SHP projects in the country.

Northern Europe SHP Overview

Denmark, Estonia, Finland, Iceland, Ireland, Latvia, Lithuania, Norway, Sweden and the United Kingdom

Figure 34. **Installed and Potential Small Hydropower Capacity up to 10 MW in Northern Europe (MW)**



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, among other energy-related information.

The installed capacity of SHP of up to 10 MW in **Denmark** is 7 MW, provided by two operational SHP plants. A third SHP plant was undergoing restoration as of 2021. Potential SHP capacity in the country is estimated at 9.75 MW on the basis of the total installed capacity of the three plants. With one plant out of operation, approximately 72 per cent of the total potential capacity is being utilized. Further SHP development in the country is unlikely due to unfavourable topographic conditions.

Estonia has approximately 50 operational SHP plants of up to 10 MW with a total installed capacity of 8 MW. Potential SHP capacity in the country is estimated at 10 MW, indicating that 80 per cent has been developed. The potential for further SHP development in Estonia is limited and there are no ongoing projects or specific plans for the construction of additional SHP plants.

Finland has an installed capacity of 297.5 MW for SHP of up to 10 MW from approximately 80 plants, while potential capacity is estimated at 585.5 MW, suggesting that 51 per cent has been developed. Some activity has taken place in the SHP sector in the country recently, with one new plant commissioned in 2021. However, overall installed capacity for SHP of up to 10 MW has declined as some plants have been decommissioned and others refurbished to exceed the 10 MW threshold and therefore excluded from the total. Additional new stream development in Finland is unlikely, and much of the remaining unutilized potential capacity comes from existing but non-operational SHP sites.

The installed capacity of SHP of up to 10 MW in **Iceland** is 66.1 MW, while potential capacity has been recently estimated at 3,724 MW, indicating that approximately 2 per cent has been developed. However, the estimate of potential capacity is theoretical, and the technically and economically feasible SHP potential of the country is unknown. SHP construction in Iceland is actively ongoing, with six new SHP plants commissioned between 2018 and 2019, while several additional projects are in the planning stages.

Ireland has an installed capacity of 58.5 MW for SHP of up to 10 MW, while potential capacity is estimated at 70.7 MW, indicating that nearly 83 per cent has been developed. There are 66 operational SHP plants in addition to hundreds of identified potential SHP sites in the country. Three new SHP projects were under development as of 2021.

There are 147 SHP plants of up to 10 MW in **Latvia** with a total installed capacity of 28 MW. Potential SHP capacity in the country is estimated at 96 MW, indicating that 29 per cent has been developed. No new SHP development has taken place in Latvia in recent years, in part due to negative formal assessments of their environmental impact and public opposition. On the other hand, a total of 367 old water mill sites have been identified in the country that are suitable for the construction of SHP plants.

The installed capacity of SHP of up to 10 MW in **Lithuania** is 26.9 MW, provided by 97 plants. Potential capacity is estimated at 57.9 MW, indicating that 46 per cent has been developed. There has been no new SHP construction in Lithuania in recent years, and there are no ongoing or planned SHP projects in the country. However, a 2019 change in the country's Water Law has opened 170 rivers and streams that had been previously off limits to SHP development.

Norway has an installed capacity of 2,964 MW for SHP of up to 10 MW, accounting for 61 per cent of the region's total installed SHP capacity. The potential capacity is estimated at 7,162 MW, indicating that 41 per cent has been developed. The SHP sector of Norway has been expanding rapidly and consistently over the last two decades, with 70 per cent of the country's existing SHP plants constructed between 2000 and 2020. As of 2020, there were 64 SHP plants under construction in the country in addition to another 267 licensed projects.

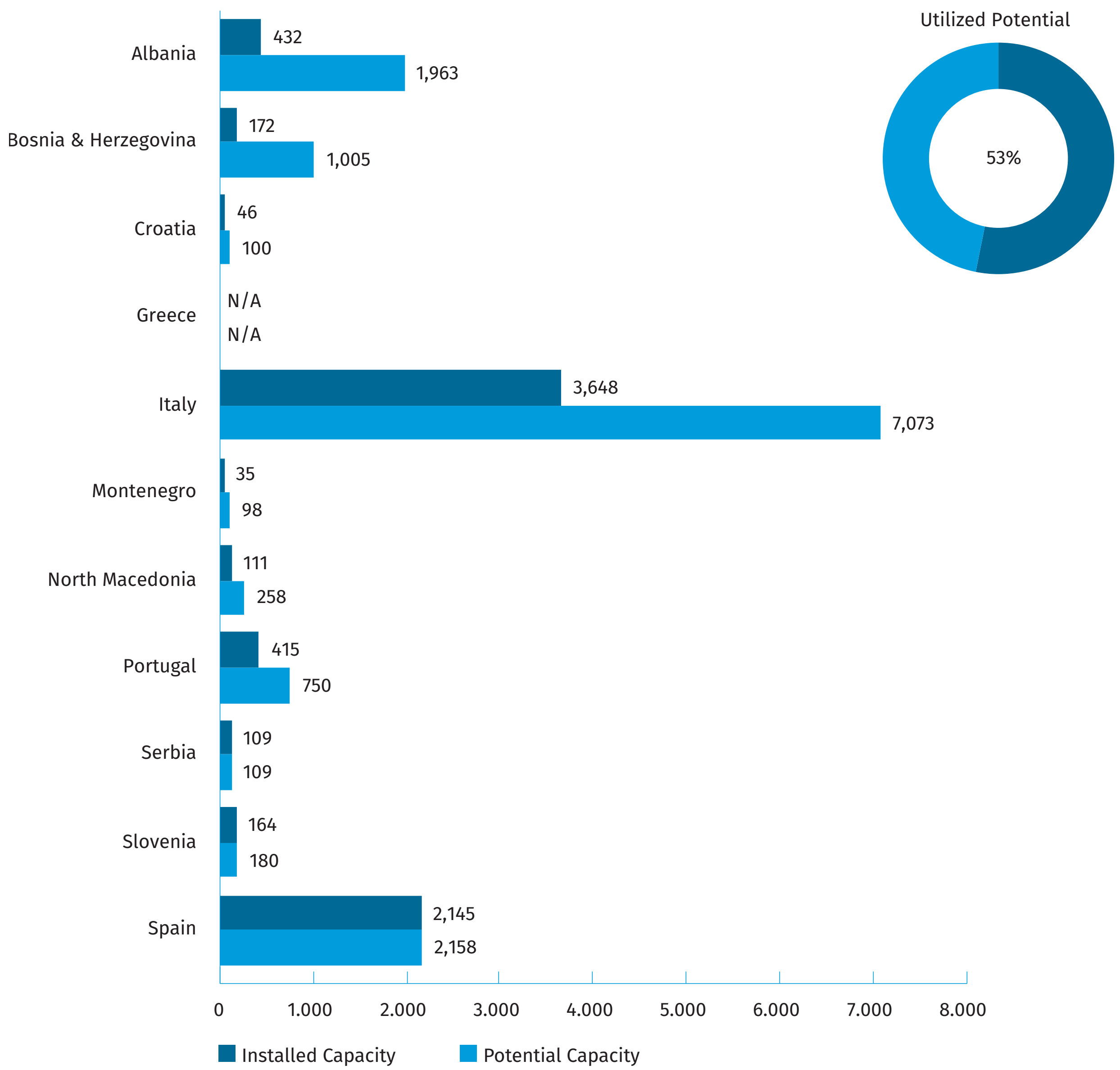
The installed capacity of **Sweden** for SHP of up to 10 MW is 961 MW. No reliable estimates of potential SHP capacity are available and it is assumed to be fully or almost fully developed, although some evidence suggests it may be double that of current installed capacity. The installed capacity of the country has not changed in several years and any further development is expected to focus on the modernization of existing plants.

The **United Kingdom** has an installed capacity of 405 MW for SHP of up to 10 MW, while the potential capacity is estimated at 1,179 MW, indicating that 34 per cent has been developed. The SHP sector in the country is actively growing with 1,216 new SHP plants commissioned between 2010 and 2019, although the pace of new construction has slowed in recent years. Tens of thousands of potential SHP sites have been identified across the country, with the large majority of potential sites as well as existing SHP plants located in Scotland.

Southern Europe SHP Overview

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

Figure 35. **Installed and Potential Small Hydropower Capacity up to 10 MW in Southern Europe (MW)**



Note: "N/A" refers to cases where data on installed and/or potential capacity for SHP up to 10 MW are not available.

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, among other energy-related information.

Albania has an installed capacity of 432 MW for SHP of up to 10 MW, while potential capacity is estimated at 1,965 MW, indicating that 22 per cent has been developed. The installed capacity for SHP of up to 15 MW is 482 MW, provided by 122 plants. The country has nearly doubled its installed capacity for SHP of up to 10 MW between 2017 and 2019, owing in part to strong support for the sector in the form of feed-in tariffs (FITs) and guaranteed off-take of electricity.

In **Bosnia and Herzegovina**, the installed capacity of SHP of up to 10 MW is 172.2 MW, while potential capacity is estimated at 1,005 MW, indicating that 17 per cent has been developed. The country is actively pursuing SHP development, nearly doubling its installed capacity in recent years. As of 2021, there were 115 SHP plants in operation and an additional 341 SHP projects in various stages of completion. However, generation of electricity from SHP decreased dramatically between 2019 and 2020 due to changing hydrological conditions.

The installed capacity of SHP of up to 10 MW in **Croatia** is 45.7 MW provided by 39 plants, while the feasible potential capacity is estimated at 100 MW, indicating that nearly 46 per cent has been developed. There were at least 29 additional SHP projects in the country as of 2019 in various stages of approval.

Greece has an installed capacity of 247.2 MW for SHP of up to 15 MW, while potential capacity is estimated at 2,000 MW, indicating that approximately 12 per cent has been developed. There are approximately 120 SHP plants operating in the country. Despite rising SHP capacity, generation from SHP has been steadily decreasing over the last several years due to prevailing dry climatic conditions. The country plans to increase its total SHP capacity to 350 MW by 2030, and 70 MW of new SHP projects were awaiting implementation as of 2020.

The installed capacity of SHP of up to 10 MW in **Italy** is 3,648.4 MW, provided by 3,271 plants of up to 1 MW and an additional 922 plants with installed capacities of 1–10 MW. Potential capacity is estimated at 7,073 MW, indicating that approximately 52 per cent has been developed. The SHP sector in the country has been growing at a rapid pace in recent years. New SHP projects have increasingly focused on utilizing existing water supply networks such as aqueducts, with 24 such projects authorized for construction in 2020 alone. Growth in the SHP sector of Italy is driven by comprehensive support schemes including FITs, auctions and other incentives.

Montenegro has an installed capacity of 34.7 MW for SHP of up to 10 MW, while potential capacity is estimated at 97.5 MW, indicating that approximately 36 per cent has been developed. Although SHP development in the country had stagnated for several decades, the sector has revitalized starting in 2013, and 16 new SHP plants were commissioned by 2019. Fifty-five new SHP projects are in various stages of development.

The installed capacity of SHP of up to 10 MW in **North Macedonia** is 111.4 MW, while potential capacity is estimated at 258 MW, indicating that 43 per cent has been developed. There are 101 SHP plants operating in the country. The recent pace of construction has been high, with several new SHP plants commissioned per year between 2017 and 2020.

Portugal has an installed capacity of 415 MW for SHP of up to 10 MW, while potential capacity is estimated at 750 MW, indicating that 55 per cent has been developed. Previous plans had aimed to achieve a total SHP capacity of 750 MW from 250 plants by 2020, but as of 2021 these plans had not been realized. The pace of construction of new SHP plants in the country has slowed significantly since 2017. There are no concrete plans for any additional SHP projects, with ongoing construction in the hydropower sector focusing on large plants.

There are 138 SHP plants of up to 10 MW operating in **Serbia**, with a total installed capacity of 109 MW. There are no reliable recent estimates of the country's potential SHP capacity, although previous estimates suggested a potential of several hundred megawatts. The latest estimate of potential was carried out in the 1980s and is no longer considered representative in light of the changing hydrological conditions in the country. Nevertheless, Serbia is actively developing its SHP sector, with many new plants commissioned in 2020–2021, and efforts to produce an updated database of potential SHP sites are also underway.

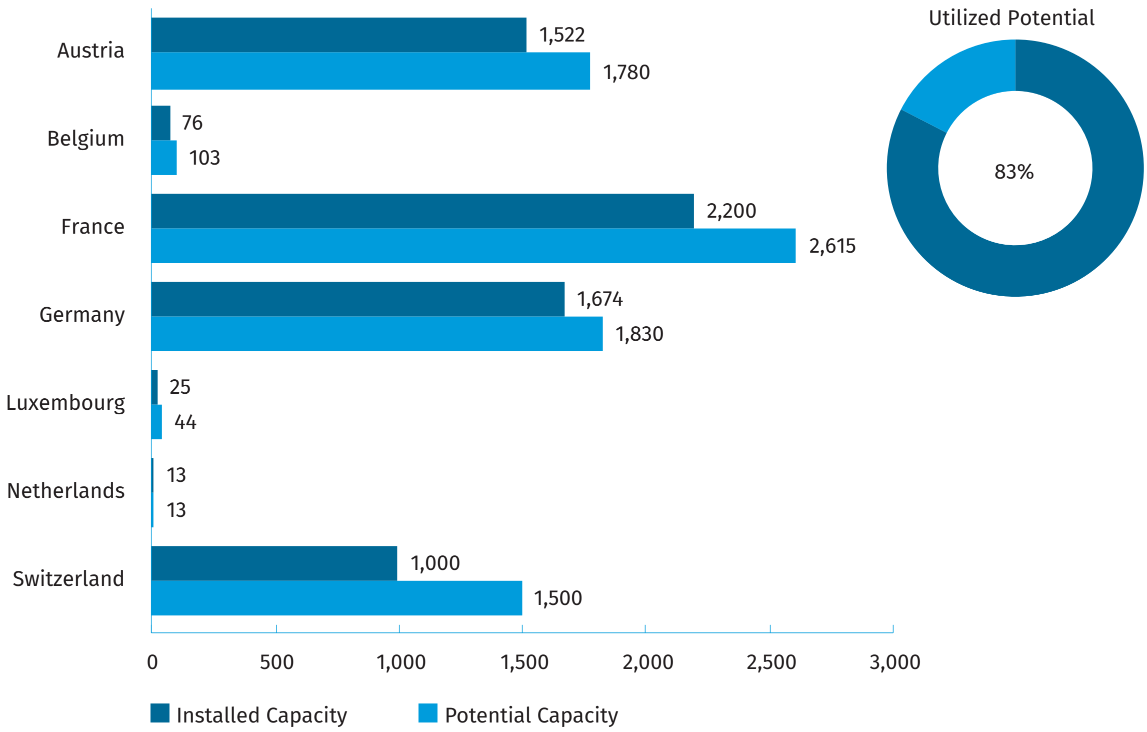
The installed capacity of SHP of up to 10 MW in **Slovenia** is 164 MW, while potential capacity is estimated at 180 MW, indicating that approximate 81 per cent has been developed. A moderate expansion of the country's SHP sector is planned, with total installed capacity expected to reach 177 MW by 2040. However, strategic development plans have emphasized the refurbishment and modernization of existing SHP plants rather than new construction.

Spain has 1,098 operating SHP plants of up to 10 MW, with a total installed capacity of 2,145 MW. Potential capacity for SHP of up to 10 MW is estimated at 2,158 MW, suggesting that nearly all potential has been developed. Active development of the SHP sector in the country has been continuous since the 1980s, but it remains unclear what additional SHP projects can be realized in light of the increasingly limited remaining undeveloped potential.

Western Europe SHP Overview

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

Figure 36. **Installed and Potential Small Hydropower Capacity up to 10 MW in Western Europe (MW)**



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, among other energy-related information.

The installed capacity of **Austria** for SHP of up to 10 MW was estimated at 1,521.6 MW at the end of 2017, provided by 3,307 SHP plants. The potential capacity is estimated at 1,780 MW, indicating that 85 per cent has been developed. The most current data on SHP capacity in Austria are difficult to acquire due to the decentralized and fragmentary nature of reporting on the SHP sector in the country. However, the overall number of registered SHP plants has increased in recent years even as total installed capacity has decreased slightly, due to changes in reporting standards by the relevant national authorities. Over 100 SHP projects were in various stages of planning as of 2021, with many suspended ones due to various obstacles.

Belgium has an installed capacity of 76 MW for SHP of up to 10 MW, which accounts for 43 per cent of the country's total hydropower capacity. Potential SHP capacity is estimated at 103.4 MW, indicating that nearly 74 per cent has been developed. Information on existing SHP plants in the country is incomplete and recent increases in installed capacities most likely reflect the inclusion of previously-unreported SHP capacities in official statistics rather than any new development. Confirmed activity in the sector includes one existing SHP plant undergoing rehabilitation as of 2022.

The total installed capacity of **France** for SHP of up to 10 MW is estimated at 2,200 MW, provided by approximately 2,270 SHP plants. However, comprehensive data on existing SHP plants are difficult to acquire due to legislation specifically limiting the public disclosure of SHP plants with an installed capacity under 0.035 MW. Potential capacity for SHP of up to 10 MW is estimated at 2,615 MW, indicating that 84 per cent has been developed. While the overall estimate of total installed capacity has not changed in the last few years, a large number of new SHP projects were commissioned between 2019 and 2020, with capacities ranging between 0.07 MW and 5.50 MW. Planned projects include the refurbishment of one 2.7 MW SHP plant.

The total reported installed capacity of SHP of up to 10 MW in **Germany** was 1,674 MW in 2020, representing a significant decrease from previous years. However, this figure is the result of changes in reporting standards and likely underrepresents the actual installed SHP capacity of the country. Potential SHP capacity is estimated at 1,830 MW. On the basis of the reported installed capacity data, this suggests that over 91 per cent of the potential has been developed, although data from previous years suggest a figure closer to 100 per cent. There has been no new SHP construction reported in the country in the last decade, as the country's SHP potential is considered to be almost fully developed.

Luxembourg has an installed capacity of 25.3 MW for SHP of up to 10 MW while potential capacity is estimated at 44 MW, indicating that nearly 57 per cent has been developed. The reported SHP capacity of the country decreased due to the exclusion of one previously-included plant with an installed capacity of 13 MW. One additional plant is still reported as part of the installed capacity total, but has functionally been out of operation since 2021 due to heavy flood damage. There has been no significant activity in the SHP sector of Luxembourg in recent years and no new projects are planned.

The installed capacity of SHP of up to 10 MW in the **Netherlands** is 13 MW, which is believed to account for the country's entire SHP potential, although a detailed assessment of SHP potential in the country is not available. Reported installed capacity has increased due to the inclusion of a 10 MW hydropower plant not previously recognized as an SHP plant, rather than any new development. In addition to traditional SHP, there is some potential in the Netherlands for tidal SHP applications and several such projects have been installed in 2008 and 2015.

Switzerland has approximately 1,400 SHP plants of up to 10 MW with an estimated total installed capacity of 1,000 MW. SHP potential in the country is estimated at 1,500 MW, suggesting that 66 per cent has been developed. Over the last few years, the country's SHP capacity has increased by approximately 50 MW, with many new plants commissioned between 2018 and 2020. Development is actively ongoing and several additional projects were under construction as of 2021.

Oceania

Oceania is the smallest region in terms of the number of countries included in this Report as well as in terms of installed and potential SHP capacity. The total installed capacity of SHP of up to 10 MW amounts to 454 MW, indicating an increase of 3 per cent in comparison to the *WSHPDR 2019*. The total estimated potential is 1,106 MW, thus, approximately 36 per cent has so far been developed.

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 is the richest area regarding SHP potential in Oceania, however, further SHP development is not foreseen in the region. On the other hand, the Pacific Island Countries and Territories (PICTs) are mostly flat islands and have little or no SHP potential, thus, making topography the key barrier.

Country	*Local SHP definition*	*Installed capacity (local def.)*	*Potential capacity (local def.)*	*Installed (≤10 MW)*	*Potential (≤10 MW)*
Australia	≤10 MW	175.0	N/A	175.0	N/A
Federated States of Micronesia	N/A	N/A	N/A	0.7	9.0
Fiji	≤10 MW	11.3	43.2	11.3	43.2
French Polynesia	≤10 MW	48.6	98.0	48.6	98.0
New Caledonia	≤10 MW	13.0	100.0	13.0	100.0
New Zealand	≤50 MW	475.0	N/A	146.8	489.8
Papua New Guinea	≤10 MW	41.0	153.0	41.0	153.0
Samoa	N/A	N/A	N/A	15.5	22.0
Solomon Islands	N/A	N/A	N/A	0.4	11.0
Vanuatu	N/A	N/A	N/A	1.3	5.4

Figure 37. **Installed and Potential Small Hydropower Capacity up to 10 MW in Oceania (MW)**

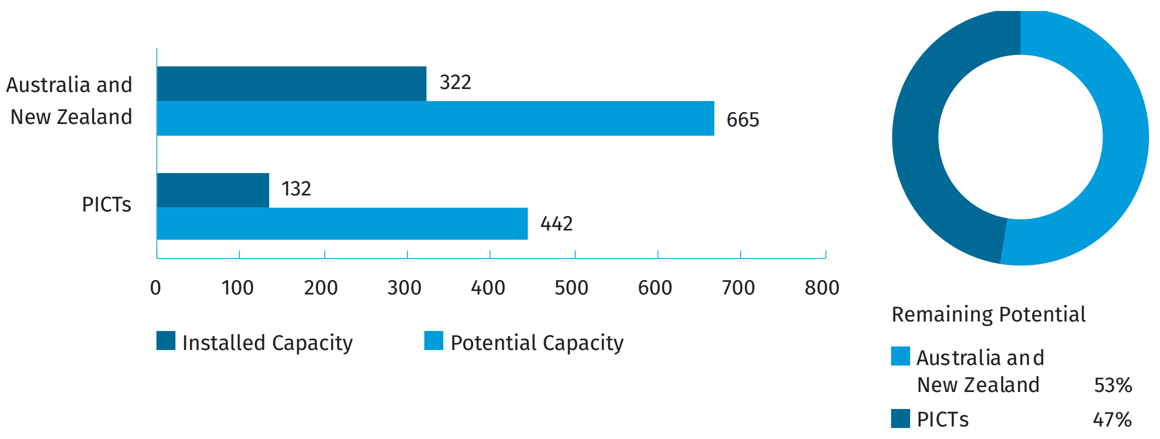
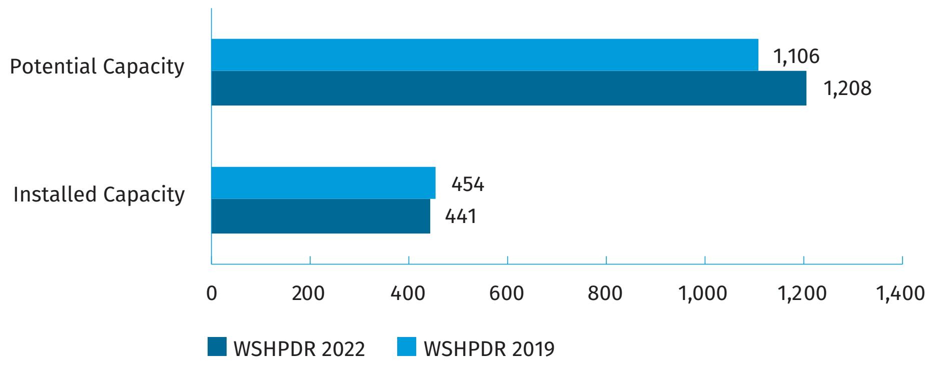


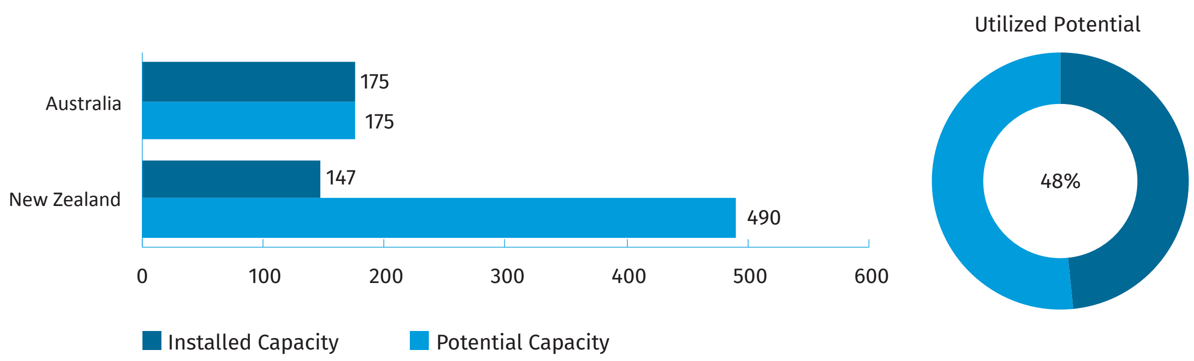
Figure 38. **Comparison of Installed and Potential Small Hydropower Capacity up to 10 MW in Oceania in the *WSHPDR 2019* and *WSHPDR 2022* (MW)**



Australia and New Zealand SHP Overview

Australia and New Zealand

Figure 39. **Installed and Potential Small Hydropower Capacity up to 10 MW in Australia and New Zealand (MW)**



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, among other energy-related information.

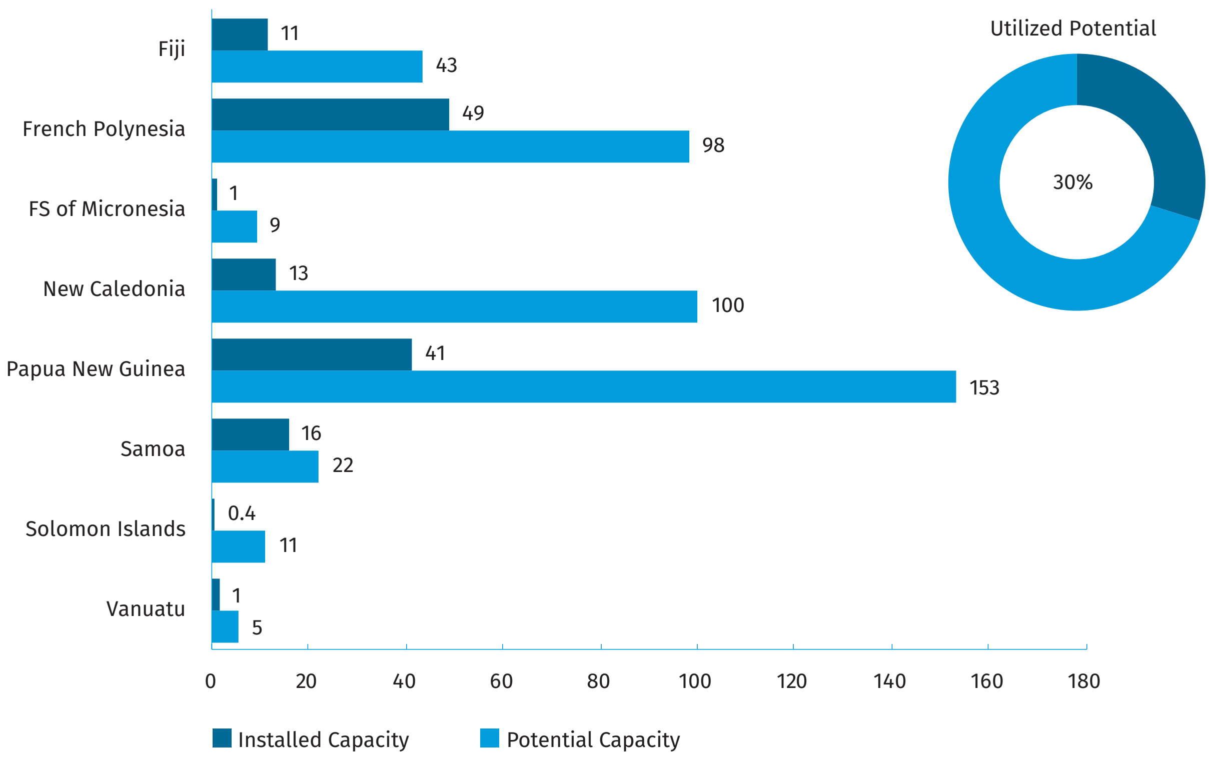
The total installed capacity of SHP up to 10 MW in **Australia** is 175 MW from approximately 65 plants. The installed capacity of SHP in the country has changed little since 2014, with different estimates contained in different editions of the *WSHPDR* reflecting differences in data quality rather than actual changes in installed capacity. No nationwide estimates of SHP potential in the country are available. Local inventories of hydropower potential on rivers undertaken by regional governments suggest a significant theoretical potential in parts of the country, for example, up to 1,000 MW in New South Wales. However, little or none of this potential is socially or environmentally feasible due to water scarcity issues and potential impacts on fish populations and the consequent social opposition to further hydropower development.

In **New Zealand**, the total installed capacity of SHP up to 10 MW is 146.8 MW, while under the local definition of SHP up to 50 MW, it is 475 MW. Undeveloped potential for SHP up to 10 MW has been estimated at 343 MW, bringing the total potential capacity to 489.8 MW if existing installed capacity is included. This suggest that approximately 30 per cent of the existing potential for SHP up to 10 MW has been developed so far. The SHP sector of New Zealand had once seen robust development, driven in part by the efforts of local communities to build and operate SHP plants for their own needs. However, in recent years, activity in the sector has been scarce and mostly focused on the renovation or reconstruction of existing SHP plants, with total installed capacity decreasing by approximately 10 per cent relative to the *WSHPDR 2016* as part of this process. In 2020, one new SHP plant with an installed capacity of 4 MW was commissioned and another 1.9 MW project was approved for construction.

PICTs SHP Overview

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

Figure 40. **Installed and Potential Small Hydropower Capacity up to 10 MW in the PICTs (MW)**



An overview of SHP in the countries of the PICTs region 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 total installed capacity for SHP up to 10 MW in **Fiji** was 11.3 MW in 2021, while potential capacity is estimated at 43.2 MW, indicating that 26 per cent has been developed. Little development of SHP has taken place in the country in recent years, with the last new plant commissioned in 2017 and ongoing projects focusing on the refurbishment of existing plants rather than the construction of new ones.

In **French Polynesia**, there are 16 SHP plants up to 10 MW with a total installed capacity of 48.6 MW. The potential capacity is estimated at 98 MW, indicating that French Polynesia has utilized approximately 50 per cent of its SHP potential. Although the country's SHP capacity has seen only slight increases over the last decade, the Hydromax Project, a 2018 government initiative to promote sustainable hydropower development, has led to the construction of a new SHP plant as well as upgrades to two previously-existing SHP plants.

The FS of Micronesia have 0.7 MW of installed capacity for SHP up to 10 MW, while the potential capacity is estimated at 9.0 MW, indicating that approximately 8 per cent has been developed. The country's installed SHP capacity has remained constant over the last decade. Most hydropower potential in the country is located in the state of Pohnpei, which also hosts the country's only SHP plant. The FS of Micronesia are building a new 2.5 MW SHP plant on the Lehnmesi River, scheduled to be completed by 2023.

In **New Caledonia**, the installed capacity of SHP up to 10 MW was approximately 13 MW at the end of 2020, while the potential capacity is estimated at approximately 100 MW. This indicates that 13 per cent of the known SHP potential has been developed so far. Recent developments in the SHP sector have included the completion of the 3 MW Paalo plant, the first new SHP plant in the country in three decades.

Papua New Guinea has 41 MW of installed capacity for SHP up to 10 MW, while the potential is estimated at 153 MW, indicating that approximately 27 per cent of existing SHP capacity has been developed. With the launch of two new SHP plants, the number of existing SHP plants in PNG had reached 11 as of 2020. Under the Town Electrification Investment Programme, Papua New Guinea is planning to rehabilitate and increase the capacity of some of its existing SHP plants. Ongoing SHP projects in the country include the 3 MW Ramazon plant scheduled to be completed by 2023 and another 10 MW project undergoing feasibility studies.

In **Samoa**, the installed capacity for SHP up to 10 MW is 15.5 MW, and the total potential capacity is estimated at 22 MW, indicating that approximately 71 per cent has been developed. SHP plants once supplied more than 85 per cent of the country's electricity, but the share of SHP in the country's energy mix has declined in parallel with growing electricity demand. In recent years, the Renewable Energy Development and Power Sector Rehabilitation Project, funded by multiple governments and international organizations, helped rehabilitate and reconnect 4.69 MW of SHP capacity to the grid. Despite the high financial costs incurred during the rehabilitation process, hydropower remains the most cost-effective source of electricity generation in Samoa.

In **Solomon Islands**, the installed capacity of SHP plants is 361 kW, whereas the potential capacity is estimated at 11 MW, indicating that approximately 3 per cent has been developed. There are 13 hydropower plants in the country, with capacities up to 150 kW. A number of SHP projects, including the 30 kW Beulah micro-hydropower plant, are under development or in the planning stages.

The installed capacity for SHP up to 10 MW in **Vanuatu** is 1.3 MW and the potential capacity is estimated at 5.4 MW, indicating that approximately 24 per cent has been developed. There are existing plans in the country to construct 13 new micro-hydropower plants with a total capacity of 1.5 MW. However, any potential SHP sites in Vanuatu require multi-year monitoring prior to construction to adequately assess both the hydropower potential of the site as well as the risk of flood damage.

Conclusions

SHP is a mature and versatile technology, effective for providing access to clean and sustainable electricity both in the developing and developed 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 edition of the *WSHPDR* 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 12 per cent reaching 79.0 GW. At the same time, known SHP potential is estimated at 221.7 GW. Thus, the data collected in the Report demonstrate that there is still room for development in the SHP sector in many parts of the world. Overall, despite the progress made in SHP development in the last few years, many of the barriers and enablers, hence, recommendations for the further development of the sector remain similar to those listed in the previous editions of the Report.

Barriers to SHP Development

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.

Enablers for SHP Development
At the same time, substantial opportunities exist across the globe for development of the SHP sector, particularly in light of the fact that 64 per cent of identified SHP potential remains unutilized. Demand for SHP development in many parts of the world is driven by a number of common factors, including the following:

Policies promoting renewable energy sources
Decarbonization efforts by governments around the world have led to the adoption of a wide array of policies promoting the development of renewable energy sources (RES). Although feed-in tariffs are being phased out in some countries, alternative forms of support including feed-in premiums, renewable energy auctions and carbon trading mechanisms are becoming widely available.

Rising cost of electricity generation from conventional sources
Rising costs of generation from hydrocarbons make renewable energy increasingly attractive to investors even in the absence of legislated incentives, and have been driving renewable energy development in countries with robust incentive programmes and also those typically lacking the financial means to subsidize RES.

Demand for electricity access
Lack of electricity access in remote regions drives demand for off-grid generation capacity provided by SHP. In many areas, SHP can supplement existing on-grid supply or provide an alternative, particularly when grid extension is complicated by geographic or economic factors.

Remaining undeveloped SHP potential
Several countries have an assessed SHP potential capacity far in excess of existing domestic demand. In such cases, SHP development represents an opportunity to expand electricity exports to neighbouring countries.

Development on existing infrastructure
In countries with little remaining SHP potential or where additional SHP development is inadvisable for environmental reasons, authorities and private developers have increasingly looked at tapping existing non-powered water infrastructure for SHP generation, including aqueducts, water mains and outflow from industrial sites.

Technological innovation
Sustainability in the SHP sector is also driven by technological innovation. Modernization of existing SHP plants with fish passes, high-efficiency turbines and smart operational control all reduce impact on wildlife and allow SHP plants to conform to stricter minimal flow requirements. As another example, hydrokinetic systems make SHP development possible in ultra-low-head applications without impounding streamflow.

Recommendations

The following recommendations for addressing the barriers to SHP development are provided as general recommendations and should not be considered comprehensive.

(a) *Undertake detailed resource assessments*

Developing countries should undertake detailed analyses of their SHP potential to lower development costs and encourage private investment. Developed countries would similarly benefit from undertaking 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.

(b) *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 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.

(c) *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 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 to improve the risk assessment and provide conducive loan conditions.

(d) *Facilitate access of the SHP industry to equipment and technology*

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

(e) *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 the generation, to raise the overall efficiency of SHP projects. Establishing microgrids with SHP providing base-load power can also offer a short to medium-term—or even permanent—solution for electrifying remote and inaccessible communities.

(f) *Improve local skills and expertise*

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

(g) *Strengthen international and regional cooperation*

The 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 the climate crisis 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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