



UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION



World Small Hydropower Development Report 2016



Executive Summary

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Suggested citation:

The World Small Hydropower Development Report 2016: United Nations Industrial Development Organization, Vienna, and International Center on Small Hydro Power, Hangzhou.

The digital copy is available on www.smallhydropower.org

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Foreword

CHEN Lei, Minister of Water Resources, People's Republic of China and Honorary Chairman, INSHP

Hydropower is an internationally recognized source of clean and green energy, which has played an important role for the global energy supply. Driven by the increasing demand for energy and global climate change, many countries have given priority to hydropower development in the expansion of their energy sectors. Small hydropower has unique benefits – it is a mature technology which is economically feasible and has minimal impact on the environment. Small hydropower has greatly contributed to solving the problem of rural electrification, improving living standards and production conditions, promoting rural economic development, alleviating poverty as well as reducing emissions. Moreover, small hydropower is an economically efficient technology, and as such, has been highly favoured by the international community, especially by developing countries.

China is the largest developing country in the world as well as the country endowed with the richest hydropower resources. The Government has promoted hydropower to a significant position. By the end of 2015, the total hydropower capacity of China reached 320 GW with an annual output of 1,100 TWh. Hydropower plays an essential role in the energy sector of China, contributing to the adjustment of the energy mix, emission reductions, as well as the economic development of the country, which has also promoted and led hydropower development worldwide. During the 12th Five-year Plan, the Government of China paid particular attention to the small hydropower sector, promoting the people's "well-being, and safe, green, and harmonious" small hydropower development. To date, 4,400 SHP plants (up to 50 MW) have been upgraded and refurbished; as a result, installed capacity and annual output have increased by more than 20 per cent and 40 per cent respectively. Furthermore, 300 counties completed the objectives of the New Hydropower Rural Electrification County Programme by developing 5,150 MW of newly installed SHP capacity, which accounted for 50 per cent of the total increase in SHP capacity. Additionally, through the national programme Replacing Firewood with SHP, 592,000 households, totalling 2.24 million people, have been provided with access to electricity and 733,333 hectares of forest have been saved. The total installed SHP capacity of China has exceeded 75 GW, with an annual output of 230 TWh, thus, meeting the target set by the Medium and Long-term Renewable Energy Development Plan five years ahead of schedule.

Currently, the Chinese economy has entered a "new normal" characterized by increasing energy demand, as well as ecological and environmental problems, and therefore faces the critical need to adjust the energy mix, improve energy efficiency and ensure energy security. The Government of China advocates for the development concepts of "Innovation, Coordination, Green Development, Opening Up and Sharing" and the energy strategy policy of "Conservation, Clean, and Safe"; it promotes a clean, highly efficient, safe, sustainable and modern energy sector, which is reflected in the Energy Development Strategy Action Plan 2014-2020. China has a great potential for hydropower, which is an important renewable energy source. The Government will actively promote further hydropower development while taking into consideration the environmental and resettlement issues. Meanwhile, SHP development will be incorporated into a poverty alleviation strategy, and will be adapted to local conditions. By 2020, the total installed hydropower capacity of China will have reached 350 GW, of which small hydropower will account for 81 GW.

The achievements of China in small hydropower development have received worldwide attention, representing a good example for other countries. Therefore, the establishment of the International Network on Small Hydro Power (INSHP) and the International Center on Small Hydro Power (ICSHP) in China, was a logical choice. INSHP is the first international organization headquartered in China. Following its mission of an international and non-profit organization and serving the host country, ICSHP is committed to South-South cooperation, global development of small hydropower and promotion of Chinese hydropower enterprises undertaking business activities abroad. The Center has made remarkable achievements in the past 20 years. It has created a unique triangular model of cooperation between international organizations, developing and developed countries. ICSHP has become the international hub for small hydropower, leading the development trend in the international small hydropower industry and disseminating the experience, knowledge and capability of China to countries all around the world.

As the host country of INSHP, the Government of China has always supported the initiatives of INSHP and ICSHP, including cooperation with other international organizations such as the United Nations Industrial

Development Organization (UNIDO), and independent experts and scholars, in order to share the successful experience of the Chinese small hydropower industry with other countries and regions, and to promote the development of small hydropower worldwide. In December 2013, the first English version of the *World Small Hydropower Development Report 2013 (WSHPDR 2013)* was published by ICSHP and UNIDO. The *WSHPDR 2013* was established with a global vision for small hydropower development: to provide baseline information and a strategic outlook for regional and international institutions as well as countries to develop their renewable energy plans and ensure integrated management of water resources. The report has become an important knowledge platform for global development of small hydropower.

As an update of the first edition of 2013, *WSHPDR 2016* comprises 160 national reports and 20 regional reports, with 11 new countries added compared to the previous edition. More than 230 experts and scholars in the field of small hydropower from related governmental institutions, research institutes, universities and colleges, as well as hydropower companies in those countries and regions, contributed to drafting country and regional reports. Analysis of the status of small hydropower development in each country included the following five aspects: electricity sector overview, small hydropower sector overview and potential, renewable energy policy and barriers to

small hydropower development. Other issues covered in country reports include information on the power grid structure, electricity tariffs, short-term projects planned by governments, incentives, policies and plans for renewable energy development. Every effort has been made by the authors, ICSHP and UNIDO to make *WSHPDR 2016* more comprehensive, practical and authoritative.

Today, the world is entering a new era—an era of low-carbon energy, characterized by dramatic changes in the energy supply-demand relationship. The Government of China is willing to share Chinese technological innovations in small hydropower with the international community, and to advocate the idea of green development of small hydropower, as well as to warmly welcome further exchange and cooperation in the field of small hydropower. To conclude, I would like to express my sincere hope that the publishing of *WSHPDR 2016* will help make international small hydropower development inclusive and sustainable and will contribute to creating a beautiful life for all of mankind.





Foreword

Li Yong, Director General, UNIDO

To address environmental challenges, energy security and volatile fuel prices, and to pursue inclusive and sustainable industrial and economic development, leaders are strategizing ways to shift the economies from relying on traditional energy sources to renewable ones. UNIDO, as a specialized agency of the United Nations, is promoting inclusive and sustainable development and realization of industry-related Sustainable Development Goals (SDGs), particularly SDG 9, on building resilient infrastructure, promoting inclusive and sustainable industrialization and fostering innovation. UNIDO understands that access to low-cost and reliable energy based on local renewable resources for productive uses can bring economic, social and environmental dividends, such as increasing industrial competitiveness, creating jobs for all and raising incomes.

In this regard, small hydropower is an excellent renewable energy solution to meet the needs of productive uses and to electrify rural areas. It is a mature technology, which can easily be designed, operated and maintained locally. It has the lowest electricity generation prices of all off-grid technologies, and the flexibility to be adapted to various geographical and infrastructural circumstances.

Despite these benefits, the potential of small hydropower in developing countries remains untapped.

It is therefore paramount for UNIDO to foster uptake of small hydropower through awareness building, information dissemination and experience sharing on the use of renewable energy, such as small hydropower, in industries and in small enterprises, in particular. This will boost productivity, industrialization and regional economic development.

This is in line with the objectives of the *World Small Hydropower Development Report*, namely, to promote the increase of the share of this valuable source of energy in the energy mix, through informing policy on energy planning and guiding investors in entering renewable energy markets, through information and knowledge sharing.

Towards this objective, UNIDO's Department of Energy collaborated with the International Center on Small Hydro Power (ICSHP) in 2013 to develop a small hydropower knowledge platform www.smallhydroworld.org and produce the *World Small Hydropower Development Report*. This flagship initiative of UNIDO is the first compilation of valuable information on global small hydropower. It serves as a crucial guide for policymakers and investors.

In 2016, UNIDO and ICSHP, along with partners, launched this updated version of the Report and Platform, continuing our mission to inform world leaders on the status and potential of small hydropower development, and encourage stakeholders in the sector to share and disseminate this knowledge.

I would like to congratulate the experts and institutions that have contributed to this Report, making it rich in content and accurate in presentation.

A handwritten signature in blue ink, appearing to be the name 'Li Yong' in Chinese characters (李勇).

Acknowledgements

The *World Small Hydropower Development Report 2016* was prepared under the overall guidance of Pradeep Monga, Director of the Department of Energy at the United Nations Industrial Development Organization (UNIDO), Cheng Xialei, Director General of the International Center on Small Hydro Power (ICSHP) and Liu Heng, Vice-President of Nanjing Hydraulic Research Institute. It is the result of two years of intense research efforts and close collaboration with the experts in the field of small hydropower.

The Report was headed by Rana Pratap Singh, Industrial Development Officer at UNIDO. This lengthy and at times arduous endeavour was coordinated by Sidney Yeelan Yap at UNIDO; Wang Xianlai and Eva Kremere at ICSHP. The Report was backed by a talented and indispensable team of researchers at ICSHP including Nathan Stedman, Tom Rennell, Marcis Galauska, Oxana Lopatina and Gonzalo Lopez.

The invaluable contributions and insightful comments received greatly enhanced the overall quality of the Report. These included authors and contributors: Fagan Abdurahmanov, Tcharabalo Abiyoun, Donald Adgidzi, Lia Aghekyan, Engku Ahmad, Dennis Akande, Sameer Sadoon Algburi, Mohammad Hassan Al Zoubi, Gabriel Anandarajah, Viktor Andonov, Darlene Arguelles, Fredrik Arnesen, John Kobbina Arthur, Engku Ahmad Azrulhisham, Attila Bagi, Johor Bahru, Betsy Bandy, Sendi Baptista, Kemal Baris, Stefano Basso, Alexis Baúles, Hannes Bauer, Madhu Prasad Bhetuwal, Mme Sow Aissatou Billy, Guillaume Binet, Alaeddin Bobat, Nebiyu Bogale, Edilbek Bogombaev, Carlos Bonifetti, Roger Limoko Bosomba, Paul Bryce, Thomas Buchsbaum, Alfredo Samaniego Burneo, Ejaz Hussain Butt, Rodolfo Caceres, Martin Camille Cange, Sonya Chaoui, Piseth Chea, Zivayi Chiguvare, Gift Chiwayula, Karim Choukri, Nouri Chtourou, Romao Grisi Cleber, Bill Clement, Fred Conning, Dione Constance, Jovan Cvijic, Manana Dadiani, Vassish Dassagne, Eric Davy, Denise Delvalle, Johanna D'Hernoncourt, Sinalou Diawara, Paulo Alexandre Diogo, Pirran Driver, Khalil Elahee, Sylla Elhadji, Hussein Elhag, Mohamedain E. Seif Elnasr, Lambert Engwanda, Cayetano Espejo, Daniela Espinoza, José Fábrega, Nimashi Fernando, Soukaina Fersi, Geraldo Lúcio Tiago Filho, Sione Foliaki, Fombong Matty Fru, Tokihiko Fujimoto, Camila Rocha Galhardo, Ramon Garcia, Rinayu Garini, Carlos González, Erickl Gonzalez, Toon Goormans, Johannes G.Grijnsen, Cleber Romao Grisi, Leo Guerrero, Mathias Gustavsson, Zvonimir Guzovic, Armin Hadzialic, Mohammad Hajilari, Randrianarivelo Jean de Dieu Luc Harisson, Eoin Heaney, Liu Heng, Deung-Yong Heo, Marcello Hernández, Sven Homscheid, Arian Hoxha,

M.R. Ibragimova, Janis Irbe, Agustín Irizarry-Rivera, Michela Izzo, Sherab Jamtsho, Frantisek Janicek, Sergio Armando Trelles Jasso, Rim Jemli, Edy Jiménez-Toribio, Kurt Johnson, Morsha Johnson-Francis, Rán Jónsdóttir, Aaron Yancho Kaah, Furkat Kadyrov, Ramiz Kalbiyev, J.K. Kaldellis, Papias Karanganwa, Bryan Karney, Raul Pablo Karpowicz, Egidijus Kasiulis, Fredrick Kazungu, Nguy Thi Khanh, Harald Kling, Wim Klunne, John Korinihona, Igor Kovacevic, Juraj Kubica, Arun Kumar, Gianluca Lazzaro, Disashi Nyama Lemba, Zenkevich Zhanna Leonidovna, Jean-Marc Lévy, Patricia Lewin, Stelios Liaros, Roger Limoko, Galina Livingstone, Casper Lundbak, Esmenio Isabel Joao Macassa, Ewa Malicka, Ghulam Mohd Malikyar, Sharon Mandair, Ariel Marcheniagi, Miroslav Marenc, Cayetano Espejo Marin, Ramon Garcia Marin, Rupeni Mario, Max Marten, Harrison Masiga, Petr Mastny, Anare Matakiviti, Leopoldo Mba, Nebiyu Bogale Mereke, Emmanuel Michael-Biririza, Lasten Mika, Jan Moravek, Conrado Moreno, Carine Mukashyaka, Tin Myint, Wimal Nadeera, N'guessan Pacôme N'Cho, Leonel Wagner Neto, Niels Nielsen, Robert Nyamvumba, Abdeen Mustafa Omer, Emna Omri, Efrain O'neil-Carrillo, Karim Osseiran, Daniel Paco, Milena Panic, Domingos Mosquito Patricio, Cláudio Moisés Paulo, Elsia Paz, Henrik Personn, Ana Milanovic Pešic, Mark Pickup, Vlad Florin Pîraianu, Jiri Pitron, Martina Prechtl-Grundnig, Nuwan Premadasa, Mairawesi Pulayasi, Peeter Raesaar, Faisal Rahadian, Mizanur Rahaman, Jorge Reyes, Lucas Rissatto, António Carmona Rodrigues, José Pablo Rojas, Irina Rotari, Vladimir Russo, Kamila Sakipova, Jorge Reyes Salazar, Alberto Sanchez, Sašo Šantl, Vahan Sargsyan, Ryspek Satylkanov, Martin Scarone, Ozturk Selvitop, Shamsuddin Shahid, Mahender Sharma, M. Hady Sherif, Manish Shrestha, Sangam Shrestha, Luciano José da Silva, Mundia Simainga, Christopher Simelum, Jérémie Sinzinkayo, Seming H. Skau, Paradis Someth, Eva Szabina Somossy, Marina Stariradeva, Janusz Steller, Phillip Stovold, Abdul-Ilah Younis Taha, Samiha Tahseen, Kati Takala, Ibrahim Ragab Mohamed Teaima, Stephan Theobold, Mikael Togeby, Petr Toman, Ernesto Torres, Bertrand Touaboy, Thierry Trouillet, Le Anh Tuan, Makhbal Tumenjargal, Eva Maate Tusiime, Philbert Tuyisenge, Jo Tyndall, Miranda Urbina, Marko Urošev, Peter Vail, Petro Vas'ko, Sandra Vatel, Carola Venegas, Akhomdeth Vongsay, David E. Weir, Harsha Wickramasinghe, Horace Williams, Mark Williams, Edmund D Wuseni, Kassius Klei Ximenes, Milena Yanuzova, Zhanna Zenkevich.

Other contributing experts were Liu Deyou, Hu Xiaobo and Lara Esser from ICSHP, Lin Ning and Li Zhiwu from the Hangzhou Regional Center (Asia-Pacific) for Small Hydro Power (HRC). Deepest gratitude is also due to Guillaume Binet, Johannes Geert Grijnsen, Sergio Armando Trelles Jasso, Kurt Johnson, Furkat Kadyrov, Bryan

Karney, Wim Klunne, Gianluca Lazara, Galina Livingstone, Miroslav Marenc, Niels Nielsen, Janusz Steller, Phillip Stovold, who thoroughly reviewed numerous drafts and significantly improved several sections of the Report.

The Report further benefited from constructive comments by members of the *WSHPDR* Editorial Board, specifically Linda Church-Ciucci, National Hydropower Association (NHA) and Hydro Research Foundation, Solomone Fifita, Secretariat of the Pacific Community (SPC), Motoyuki Inoue National Institute of Science and Technology Policy (NISTEP), Wim Jonker Klunne, Energy and Environment Partnership (EEP), Arun Kumar, Alternate Hydro Energy Center, Pradeep Monga, UNIDO, Hongpeng Liu, United Nations Economic and

Social Commission for Asia and the Pacific (UNESCAP), Liu Heng, Nanjing Hydraulic Research Institute, András Szöllösi-Nagy, Institute for Water Education (UNESCO-IHE), Tian Zhongxing, INSHP, Kuniyashi Takeuchi, International Centre for Water Hazard and Risk Management (ICHARM), Jeffrey Skeer, International Renewable Energy Agency (IRENA) and Geraldo Tiago Filho, Centro Nacional de referencia em Pequenas Centrais Hidreletricas (CERPCH); by members of the UNIDO Publications Committee - Augusto Luis Alcorta Silva Santisteban, Adnan Seric, Jacek Cukrowski, Steffen Kaeser, Frank Hartwich, Alois Mhlanga, Patrick Nussbaumer, Thouraya Benmokrane and Michele Clara, as well as other UNIDO colleagues at the Department of Energy.

Executive Summary

The *World Small Hydropower Development Report (WSHPDR) 2016* is the result of an enormous collaborative effort between the United Nations Industrial Development Organization (UNIDO), the International Center on Small Hydro Power (ICSHP) and over 230 local and regional small hydropower (SHP) experts, engineers, academics and government officials across the globe.

Prior to the *World Small Hydropower Development Report (WSHPDR) 2013*, it was clear that a comprehensive reference publication for decision makers, stakeholders and potential investors was needed to promote SHP as a renewable and rural energy source for sustainable development more effectively and to overcome the existing barriers to development. The 2016 edition aims to not only provide an update but also to greatly expand on the 2013 edition by providing improvements on data accuracy with enhanced analysis and a more comprehensive overview of the policy landscapes compiled from a larger number of countries.

Energy remains one of the most critical economic, environmental and development issues facing the world

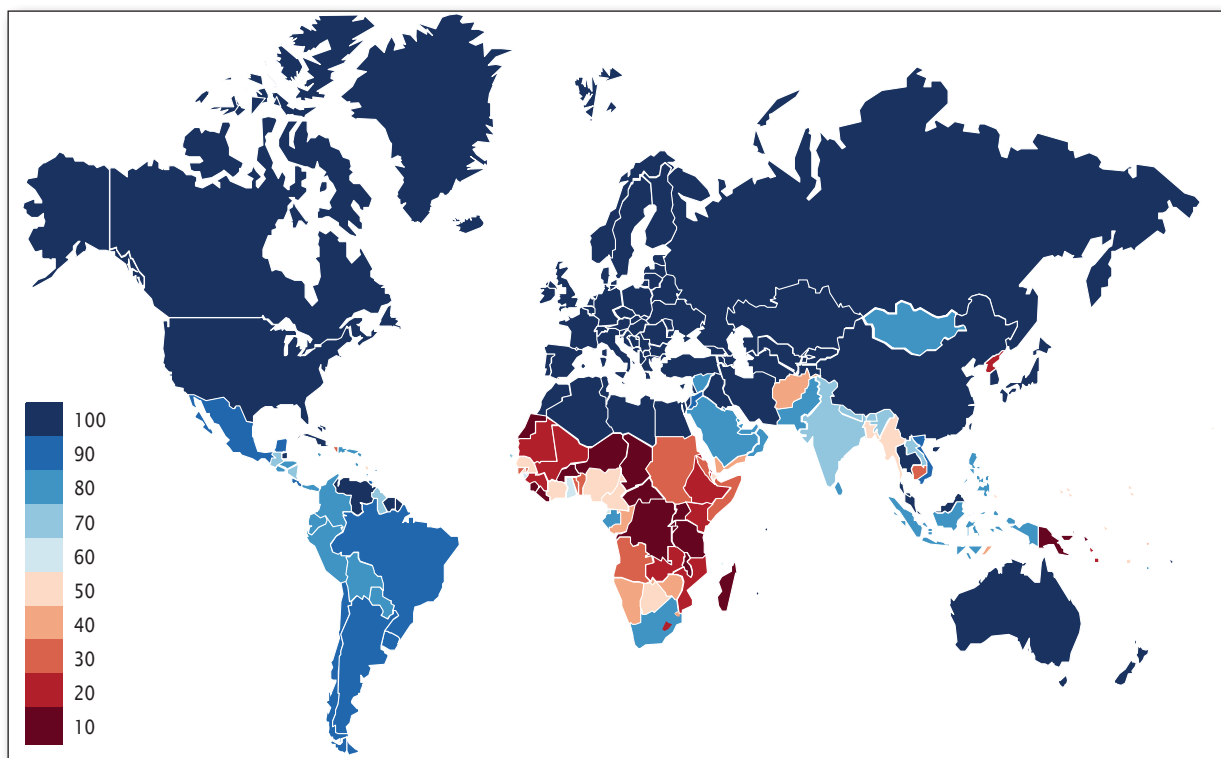
today with some 1.2 billion people—about 17 per cent of the world's population—still lacking access to electricity (Figure 1). Clean energy and access to electricity have been recognized by the United Nations as key to development. As such, energy access is the seventh Sustainable Development Goal (SDG). Yet clean energy exists with other SDGs, including alleviating poverty, education, improving environmental conditions and combating climate change.

In both developing and developed countries, the need for clean and sustainable sources of energy is growing more acute in the face of climate change while geopolitical and economic uncertainty over traditional fossil-fuel markets highlights the importance of energy diversification and independence.

On a global scale, hydropower is the most widely utilized form of renewable energy, with over 1.2 TW of installed capacity spanning six continents. However, inadequate design and planning of hydropower projects can have a negative effect on the environment. In order to ensure sustainable development and operation of hydropower,

FIGURE 1

Electrification rates by country (%)



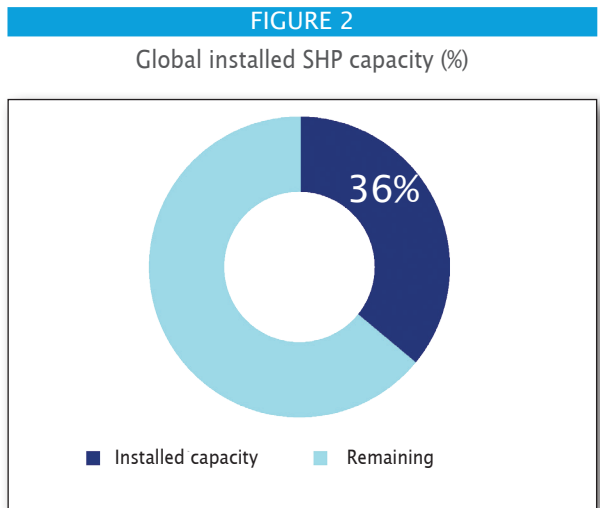
Source: Statistics from the World Bank

‘green hydropower’ as a concept has been developed. This is based on the principle of balancing economic and social development and environmental protection.

When supported by environmental protection policies and concrete supervision from the regulatory authorities, SHP can be an important renewable energy technology, contributing to rural electrification, socially inclusive sustainable industrial development as well as reduction of greenhouse gas emissions and deforestation. Therefore, it should be considered in national plans globally for development of sustainable green energy.

Global overview

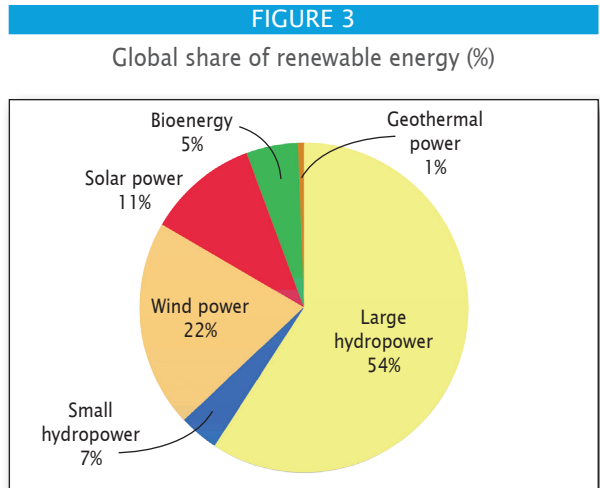
The globally installed SHP capacity is estimated at 78 GW in 2016, an increase of approximately 4 per cent compared to data from *WSHPDR 2013*. The total estimated SHP potential has also increased since publishing *WSHPDR 2013* to 217 GW, an increase of over 24 per cent. Overall, approximately 36 per cent of the total global SHP potential has been developed as of 2016 (Figure 2).



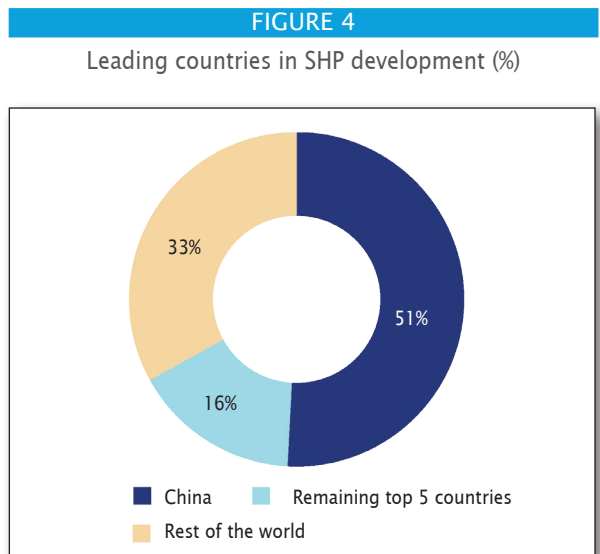
Source: ICSHP

SHP represents approximately 1.9 per cent of the world’s total power capacity, 7 per cent of the total renewable energy capacity and 6.5 per cent (< 10 MW) of the total hydropower capacity (including pumped storage). As one of the world’s most important renewable energy sources, SHP is fifth in development, with large hydropower having the highest installed capacity to date, followed by wind and solar power (Figure 3).

China continues to dominate the SHP landscape. Fifty-one per cent of the world’s total installed capacity (definition of below 10 MW) and approximately 29 per cent of the world’s total SHP potential are located in China. It has more than four times the SHP installed capacity of Italy, Japan, Norway and the United States of America (USA) combined. Together, the top five countries—China, Italy, Japan, Norway and the USA account for 67 per cent of the world’s total installed capacity (Figure 4).



Source: World Bank



Source: ICSHP

While the USA has developed a majority of its potential, reaching 57 per cent of its developed potential in 2016, Brazil has much of its SHP potential undeveloped, reaching only 30 per cent in 2016. Nevertheless, since the publishing of *WSHPDR 2013*, Brazil has increased its installed capacity by 34 per cent (up to 30 MW). The USA,

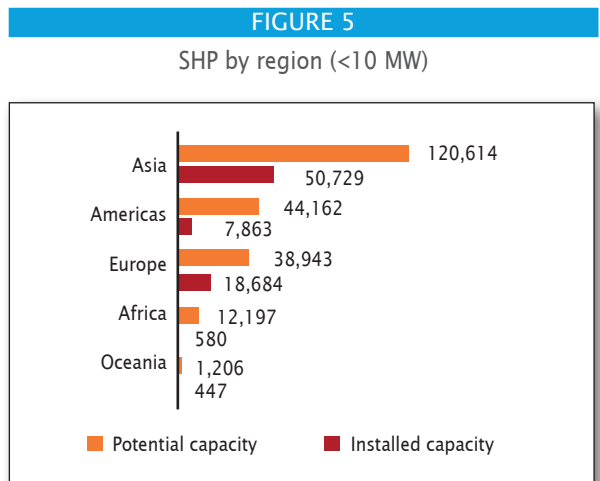


TABLE 1

Top 5 regions, sub-regions and countries in SHP development (< 10 MW)

| Regions/rankings | 1 | 2 | 3 | 4 | 5 |
|--|----------------|------------------|-----------------|--------------------|--------------------|
| Regions by installed capacity (MW) | Asia | Europe | Americas | Africa | Oceania |
| Regions by potential capacity (MW) | Asia | Americas | Europe | Africa | Oceania |
| Regions by undeveloped potential (MW) | Asia | Americas | Europe | Africa | Oceania |
| Regions by percentage of potential developed | Europe | Asia | Oceania | Americas | Africa |
| Sub-regions/rankings | | | | | |
| Sub-regions by installed capacity (MW) | Eastern Asia | Southern Europe | Western Europe | Northern America | Northern Europe |
| Sub-regions by total potential capacity (MW) | Eastern Asia | South America | Southern Asia | Southern Europe | South-Eastern Asia |
| Sub-regions by undeveloped potential (MW) | South America | Eastern Asia | Southern Asia | South-Eastern Asia | Southern Europe |
| Sub-regions by % developed | Western Europe | Northern America | Northern Africa | Eastern Asia | Central America |
| Countries/rankings | | | | | |
| Countries by installed capacity (MW) | China | USA | Japan | Italy | Norway |
| Countries by total potential capacity (MW) | China | Colombia | India | Japan | Norway |
| Countries by undeveloped potential (MW) | Colombia | China | India | Chile | Japan |

however, had decreased 46 per cent in installed capacity based on more accurate data in 2015. Europe has the highest SHP development rate, with nearly 48 per cent of the overall potential already installed (Figure 5).

Japan and India also have a less developed SHP sector, reaching only 35 and 18 per cent of developed potential

in 2016 respectively. Compared to *WSHPDR 2013*, India's total installed capacity has increased by 18.6 per cent (up to 25 MW). Japan, however, has increased 0.8 per cent.

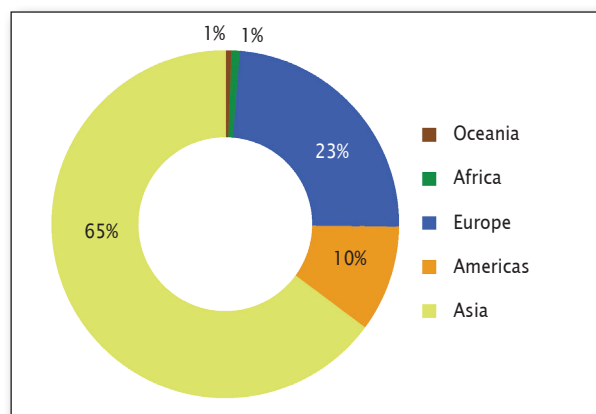
Largely due to the dominance of China in SHP, Asia has the highest share of installed SHP capacity, with 50,729 MW, constituting approximately 65 per cent of the total share. Oceania, on the other hand, has the lowest share, with approximately 1 per cent of the total global installed SHP capacity (Figure 6).

While Asia continues to have the largest installed capacity and potential for SHP up to 10 MW, Europe has the highest percentage of SHP development, with Western Europe having 85 per cent of its potential already developed.

The Americas and Africa have the third- and fourth-highest installed capacity and potential of all five regions. In the Americas, most of the SHP is concentrated in Northern America and South America. However, the two smaller regions—the Caribbean and Central America—have yet to carry out conclusive assessments to determine their actual SHP potentials. In 2016, the Americas reached a developed SHP rate of 18 per cent. Nonetheless, Africa

FIGURE 6

Installed SHP capacity by region (%)



has a larger gap to fill as its SHP development rate is at less than 5 per cent. Eastern Africa, in particular, is the sub-region that has the most SHP potential, but also the least to be developed (Figures 7, 8 and Table 2).

FIGURE 7

Potential SHP capacity by region (%)

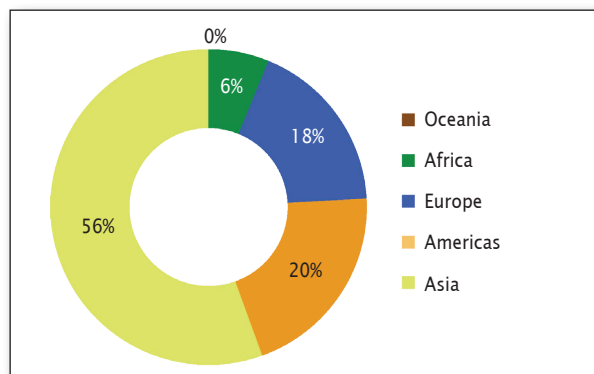
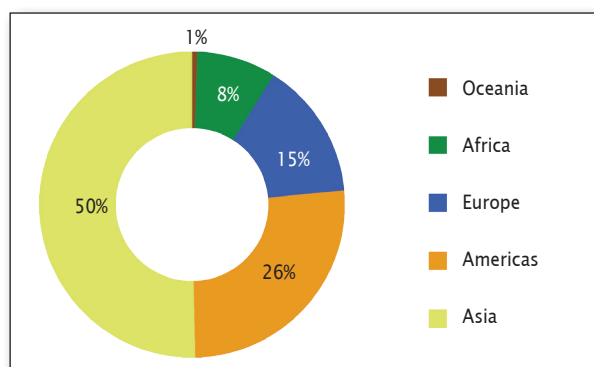


FIGURE 8

Share of remaining SHP potential by region (%)



Regionally, Asia has shown the highest increase in installed capacity, expanding its capacities by 33 per cent as compared to data from *WSHPDR 2013*. Africa has the second largest increase, by 10 per cent. However, due to the region's initial low levels of SHP installed capacity, the increase actually translates to a mere 54 MW. Thus the number is relatively little when compared to the 4,462 MW increase in Asia.

Of the 160 countries studied, approximately half of them have established national or local feed-in tariffs (FITs) or other similar fiscal incentives for SHP generators. A number of countries, such as Egypt and the Dominican Republic, have established FITs for renewable energy, but not specifically for hydropower. In other cases, such as in Mozambique and Ethiopia, FITs have been drafted and are pending for implementation. In Gambia the establishment of FITs has been declared mandatory as a part of the new energy law. However, it has not been implemented yet.

TABLE 2

SHP by region (< 10 MW)

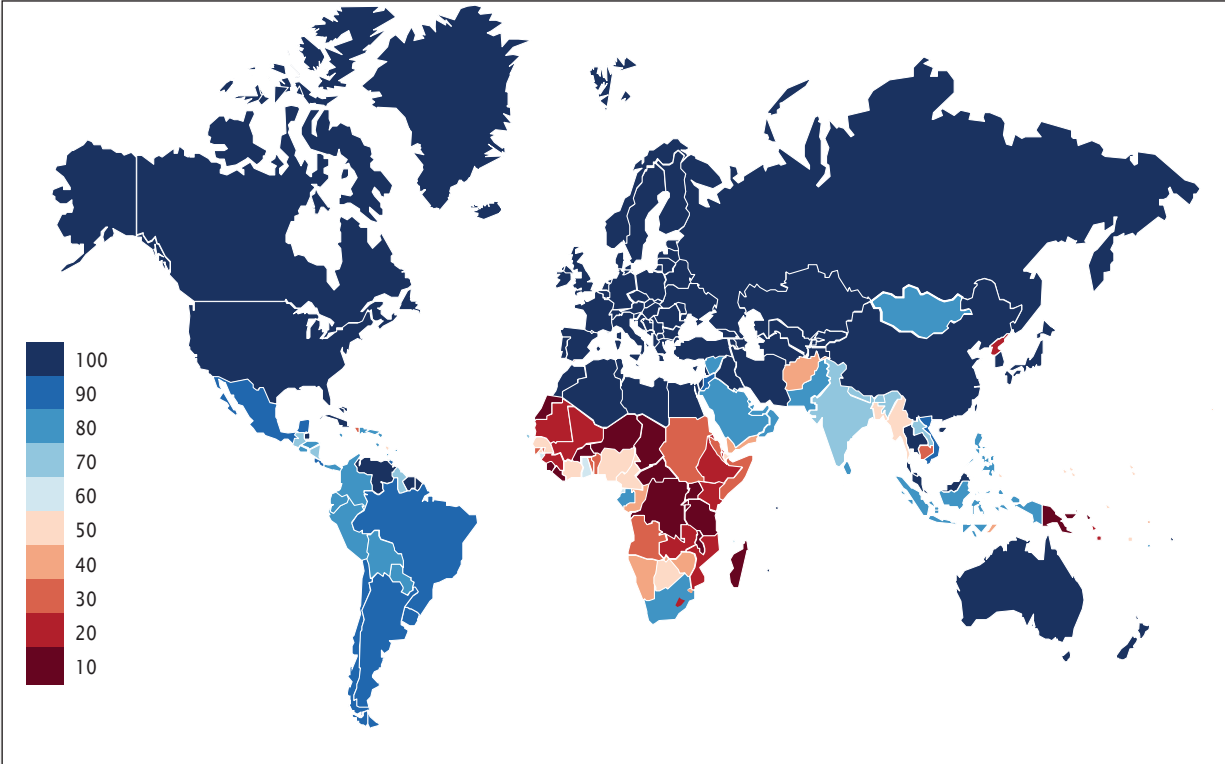
| | | Installed SHP capacity | Potential SHP capacity |
|-----------------|---------------------------|------------------------|------------------------|
| Africa | Middle Africa | 104 | 1,745 |
| | Eastern Africa | 216 | 6,759 |
| | Northern Africa | 111 | 189 |
| | Southern Africa | 63 | 392 |
| | Western Africa | 86 | 3,113 |
| Americas | Caribbean | 172 | 349 |
| | Central America | 855 | 1,512 |
| | Northern America | 4,798 | 7,662 |
| | South America | 2,039 | 34,638 |
| Asia | Central Asia | 221 | 6,087 |
| | Eastern Asia | 43,542 | 75,335 |
| | Southern Asia | 2,974 | 17,824 |
| | South-Eastern Asia | 2,340 | 13,642 |
| | Western Asia | 1,653 | 7,700 |
| | | | |
| Europe | Eastern Europe | 1,924 | 4,470 |
| | Northern Europe | 4,292 | 10,920 |
| | Southern Europe | 6,286 | 16,310 |
| | Western Europe | 6,183 | 7,243 |
| Oceania | Australia and New Zealand | 335 | 794 |
| | PICT | 112 | 412 |

Note: All data presented in this section are referenced in the respective regional summaries and country reports; electrification rate data available from the World Bank from <http://data.worldbank.org/indicator/EG.ELC.ACCS.ZS>.

The world at a glance

FIGURE 9

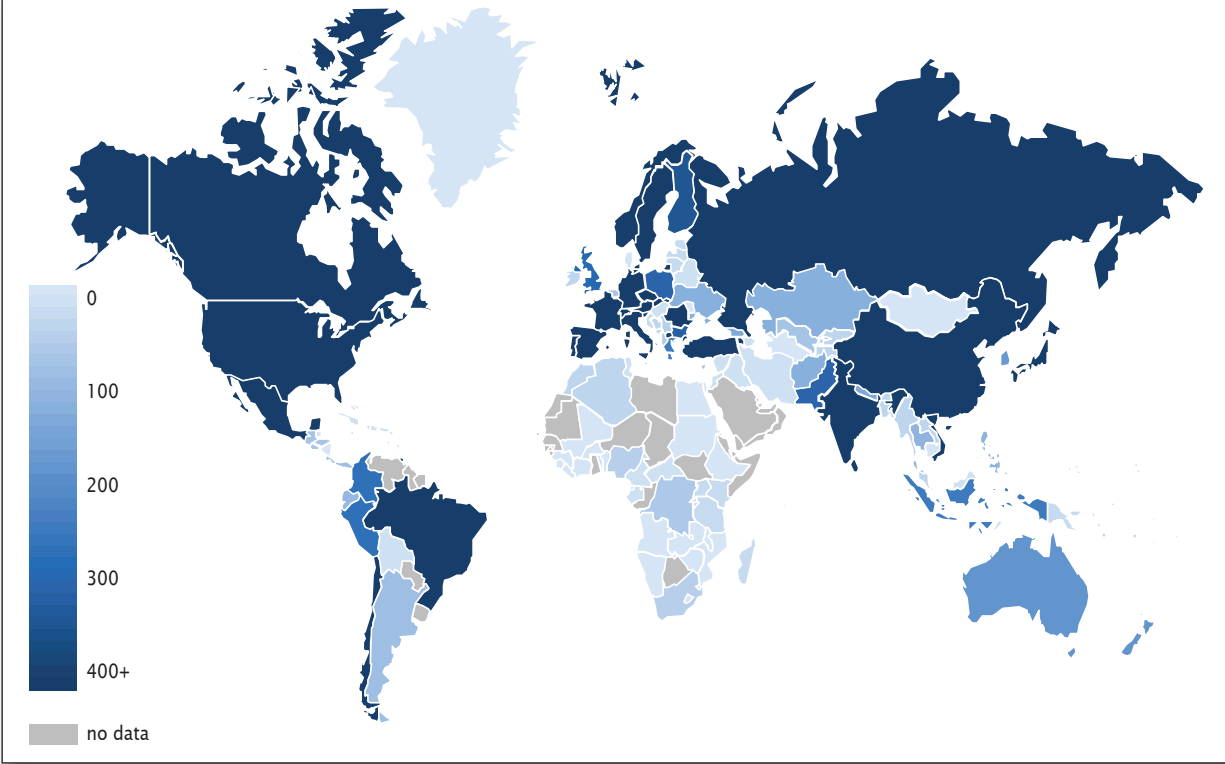
Electrification rates by country (%)



Source: Statistics from the World Bank

FIGURE 10

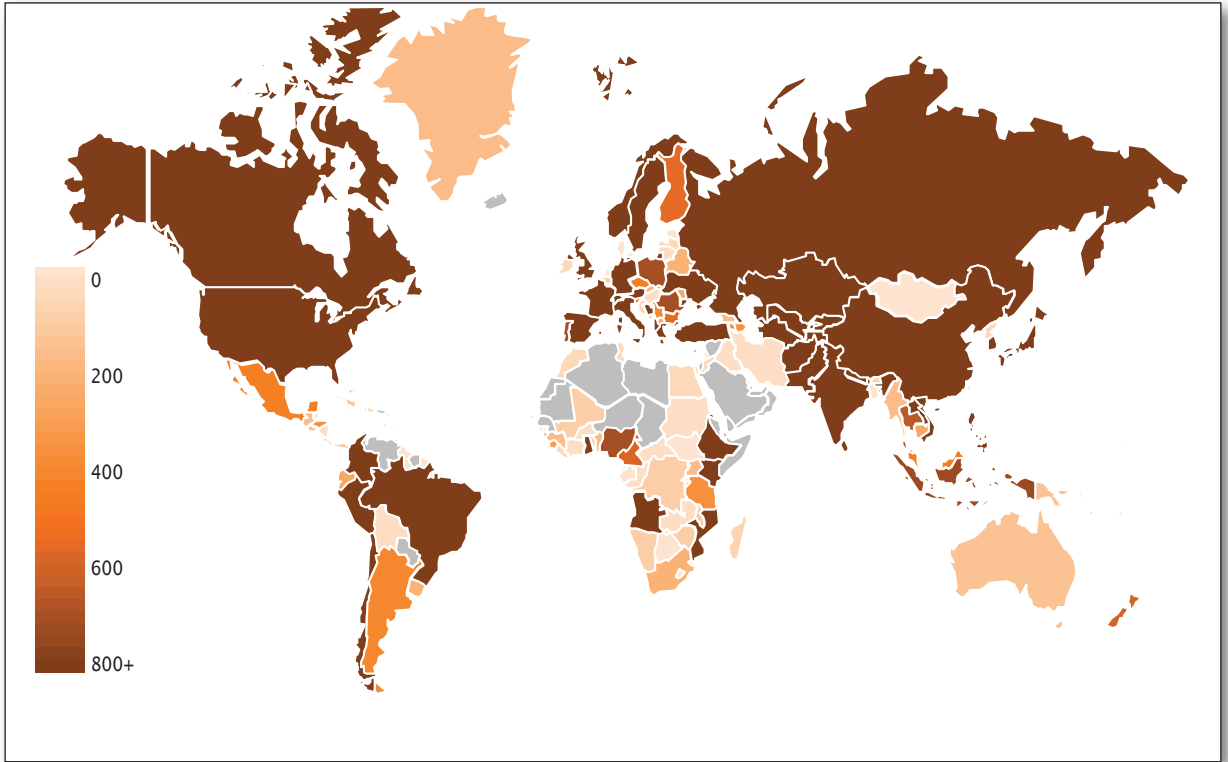
SHP installed capacity by country (MW)



Source: ICSHP

FIGURE 11

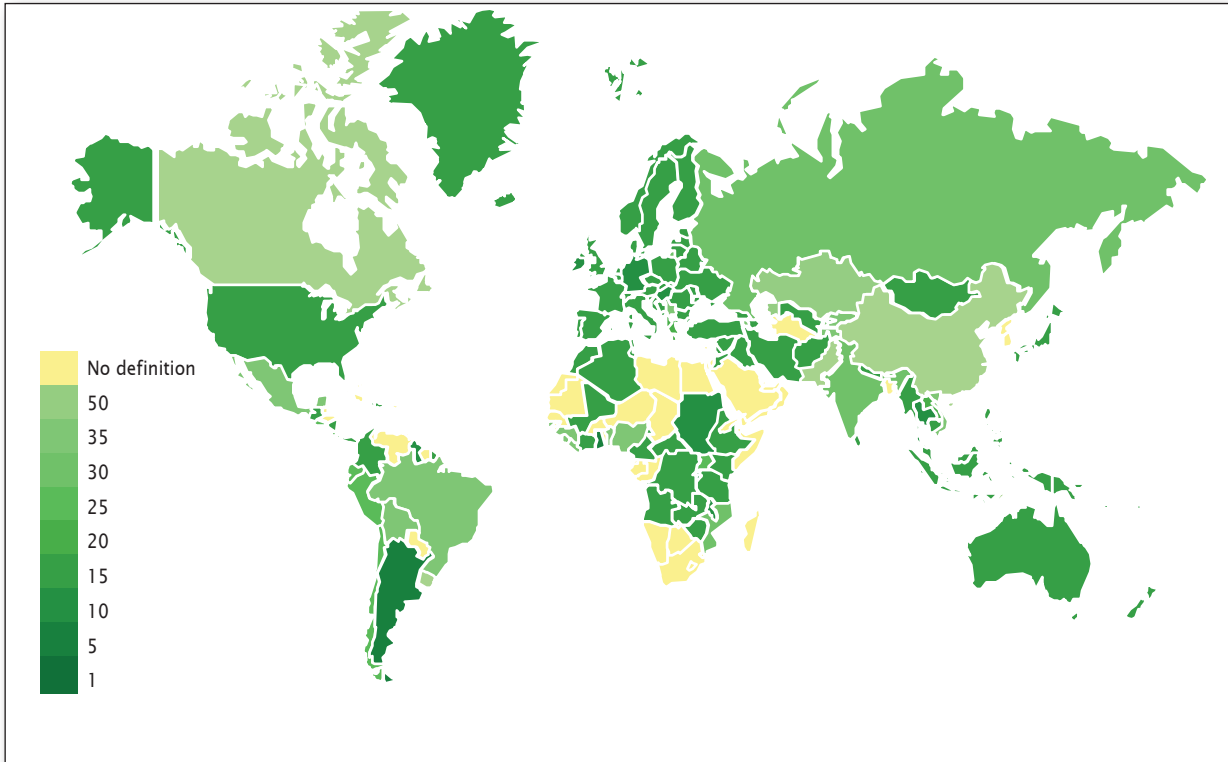
Identified SHP potential by country (MW)



Source: ICSHP

FIGURE 12

Definition of SHP by country (MW)



Source: ICSHP

Africa

SHP in Africa can be characterized as having a relatively low level of installed capacity but with considerable potential for development. Climatic and topographic characteristics vary tremendously, resulting in a large variance of SHP potential in the north and south as compared to the east and west of the continent (Figure 15).

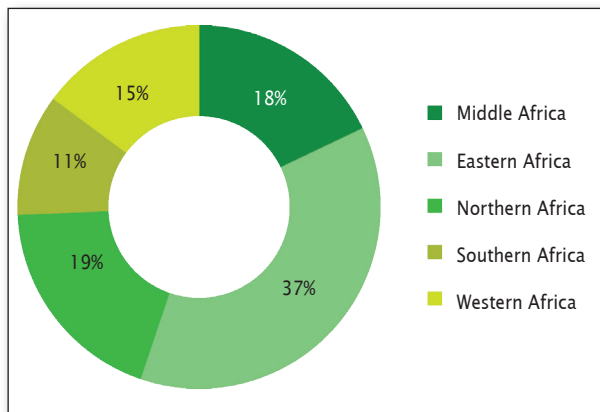
The total SHP installed capacity for Africa is 580 MW and the total estimated potential is 12,197 MW. This indicates that approximately 5 per cent has so far been developed.

Western and Middle Africa regions. Northern Africa has the highest electrification rate, but due to climatic conditions, it has low potential for hydropower. Southern Africa has the lowest installed capacity, the vast majority of which is located in South Africa.

Of the 45 countries in the region, many have some form of renewable energy policy, while 10 countries have established FITs relating to SHP.

FIGURE 13

Share of installed SHP capacity in Africa (%)



Eastern Africa has the highest installed capacity and potential for SHP in the continent, followed by the

FIGURE 14

Installed SHP capacity by country in Africa (MW)

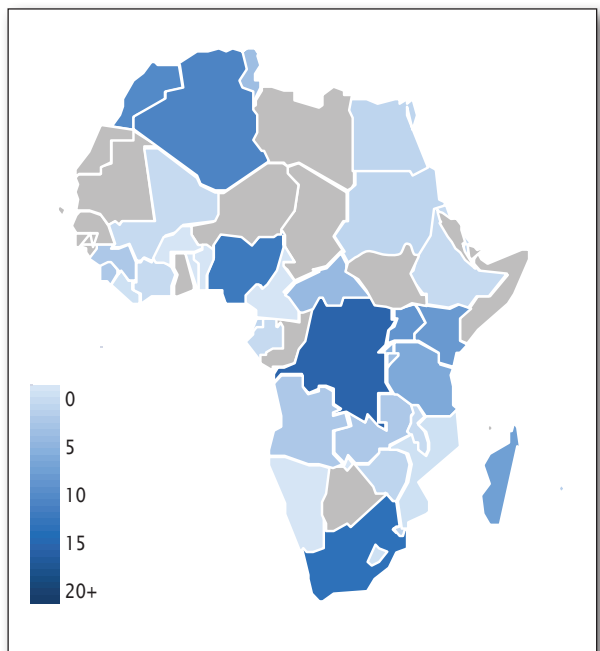


FIGURE 15

Potential SHP capacity by country in Africa (MW)

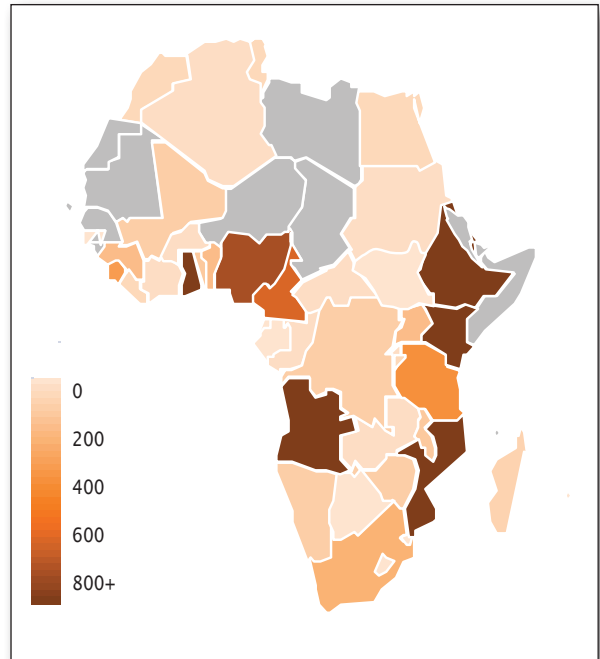
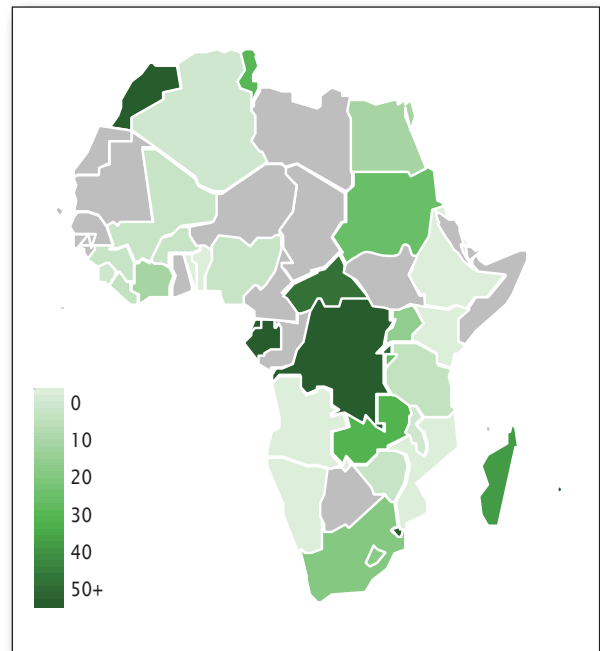


FIGURE 16

Developed SHP by country in Africa (%)



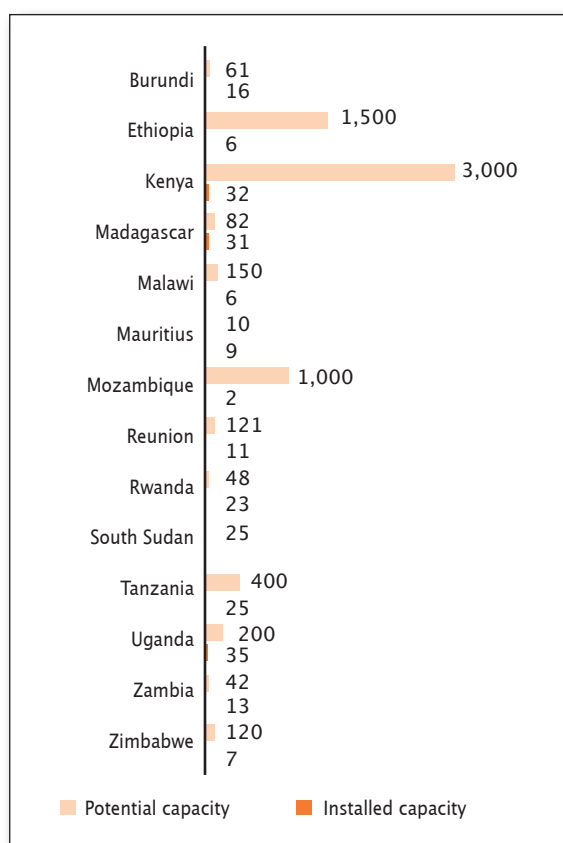
Eastern Africa

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

The Eastern Africa region has the highest overall potential for SHP in the African continent. It is home to the Great Lakes region as well as the White Nile basin, the Congo River basin, among others. In Burundi, Ethiopia, Malawi, Mozambique, Uganda and Zambia, large hydropower provides the vast majority of national electricity generation.

FIGURE 17

SHP capacities in Eastern Africa (MW)



Of the total SHP potential of 6,759 MW, the combined SHP installed capacity in the region is only 216 MW. Uganda has the highest installed capacity, with 35 MW, while South Sudan currently has no installed capacity. With only 3 per cent of SHP potential having been developed, countries such as Kenya and Ethiopia have significant potential estimated at 3,000 MW and 1,500 MW respectively.

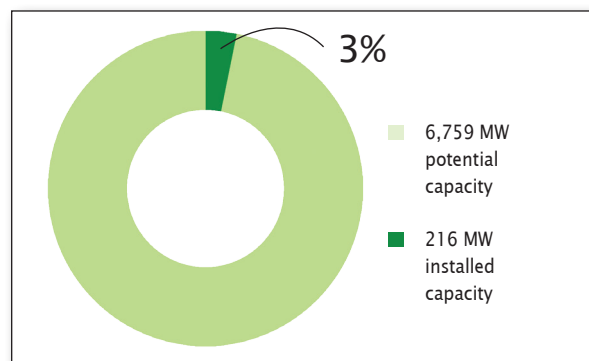
Most countries in the region are member states of the Common Market for Eastern and Southern Africa (COMESA), several are participating members of the East African Power Pool (EAPP). Renewable energy policies are either already in place or being implemented in the near future. Ethiopia and Malawi are expected to implement FITs while Kenya, Mauritius, Rwanda, Tanzania and Uganda have FITs in place, marking Eastern Africa as the sub-region with the most FIT policies.

SHP development has been relatively slow. So far, Madagascar, Mauritius, Mozambique, Tanzania, Uganda and Zimbabwe have moderately increased their share of SHP in the generation mix.

More extensive hydrological data and feasibility studies are needed in several countries, including Burundi, Tanzania and Zambia. In collaboration with the World Bank, Madagascar will publish a hydropower atlas by the end of 2016.

FIGURE 18

Developed SHP potential in Eastern Africa (%)



Barriers to SHP development include the costs of infrastructure development, including transmission lines and roads to SHP sites; lack of long-term financial solutions from local banks; and a need for capacity building in regards to maintenance and operation of SHP plants.

Middle Africa

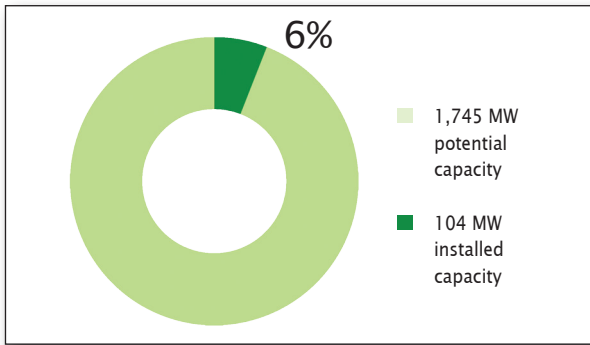
Angola, Cameroon, Central African Republic (CAR), Democratic Republic of the Congo (DRC), Congo, Equatorial Guinea, Gabon and Sao Tome and Principe

Like much of the African continent, the Middle Africa region has a large amount of undeveloped SHP potential. The Democratic Republic of the Congo has the highest installed SHP capacity at 56 MW, or over half of its potential, although further feasibility studies should reflect the increase of the number of potential sites. Angola has the highest SHP potential at approximately 860 MW, yet less than 2 per cent has been developed. While Equatorial Guinea and Gabon are likely to have considerable potential, accurate data are unavailable, giving the false impression that there is no SHP left to develop in the country. Overall, about 6 per cent of the regional SHP has been developed, marking a decrease in percentage from *WSHPDR 2013*, largely due to the increase in SHP potential in Angola.

The overall hydropower resources of Middle Africa are enough to supply the entire continent, and progress is being made to develop large-scale hydropower resources in several countries.

FIGURE 19

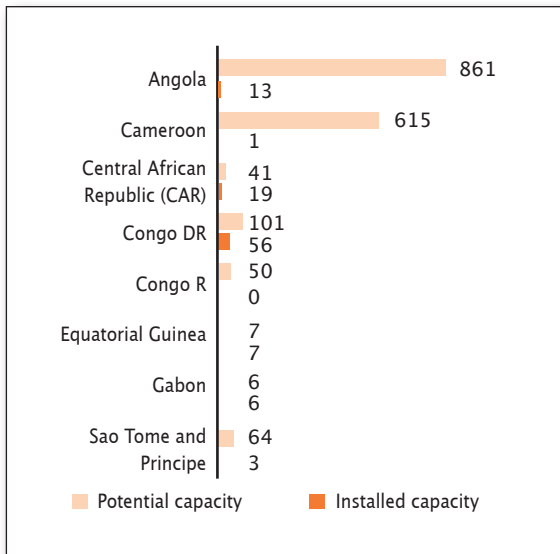
Developed SHP potential in Middle Africa (%)



However, all the countries in the region have very low electrification rates, which are significantly lower in the rural areas, with inefficient transmission networks compounding the issue. Moreover, most countries in the region lack formal policies for developing the SHP sector, hindering not only the construction of SHP projects but also progress in rural electrification.

FIGURE 20

SHP capacities in Middle Africa (MW)



More data are needed for the Central African Republic, Congo, Equatorial Guinea and Gabon to accurately determine their SHP potentials. More crucial to the overall renewable energy development is the need to establish transparent legal frameworks for investment in the energy sectors of most countries in the region.

Northern Africa

[Algeria, Egypt, Morocco, Sudan and Tunisia](#)

Partly attributable to the dry climate and limited water resources in Northern Africa, hydropower in general is not a primary source for generation, particularly in Algeria and Tunisia, where hydropower represents about 1 per cent of overall generation. The estimated SHP potential in

Northern Africa is limited at 225 MW, one of the lowest in the world, with 112 MW already developed. This indicates that approximately half of the potential is considered developed. It should be noted that this percentage is lower than that indicated in the *WSHPDR 2013*, due to the SHP potential increases in Egypt and Sudan.

FIGURE 21

Developed SHP potential in Northern Africa (%)

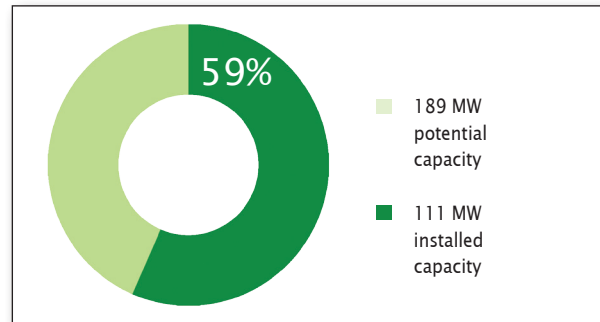
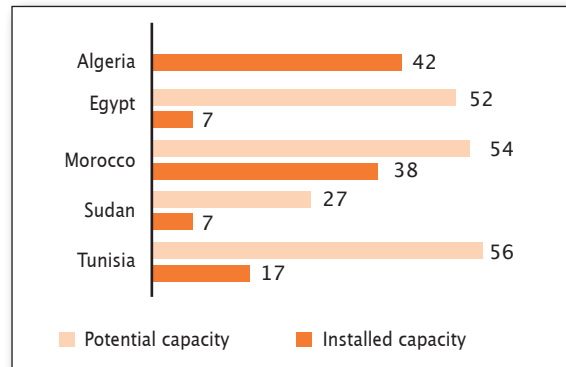


FIGURE 22

SHP capacities in Northern Africa (MW)



Morocco is the only country in the region with robust policies regarding SHP development and is currently constructing an SHP project of 15 MW. Conversely, due to climatic conditions and water shortages, Algeria has planned to cease hydroelectric generation in favour of utilizing all water resources for irrigation and water supply. Most countries of the region have opted for wind and solar power as alternatives to fossil fuels.

Southern Africa

[Botswana, Lesotho, Namibia, South Africa and Swaziland](#)

SHP in Southern Africa is dominated by South Africa, which comprises 80 per cent of the region's combined installed capacity and 63 per cent of the estimated potential. Aside from South Africa, which has had a considerable effect on the regional development of the sector, SHP potential is rather limited.

The combined installed capacity of the region is 62.5 MW and potential is 392 MW. This indicates that 16 per

cent has so far been developed. Swaziland has so far developed half of its SHP potential. In doing so, it had the largest increase in installed capacity, while Botswana still has no SHP. In Lesotho and Namibia, SHP capacity has remained unchanged.

FIGURE 23

SHP capacities in Southern Africa (MW)

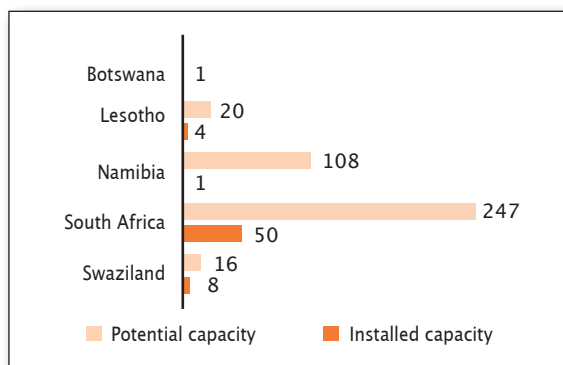
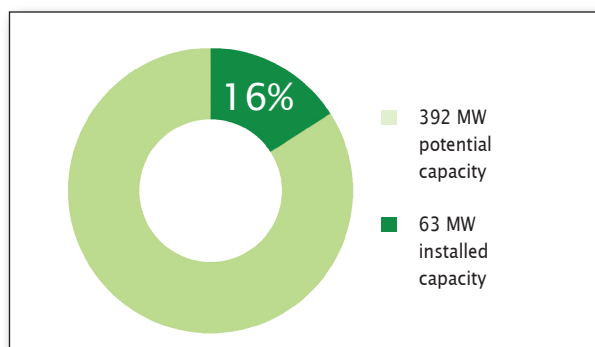


FIGURE 24

Developed SHP potential in Southern Africa (%)



Coal and large hydropower remain the chief sources of electricity generation in the region, while solar has the most abundant potential of small-scale renewable sources. Renewable energy policies and national plans reflect this, and large hydropower and solar power will continue to be dominant renewable energy sources for several of the countries in the region. As such, the SHP sector is relatively underdeveloped with the exception of South Africa.

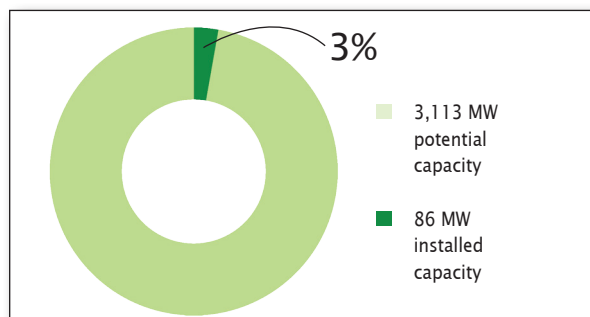
Western Africa

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

As with much of the African continent, Western Africa can be characterized as having considerable SHP potential but with limited development. Ghana and Nigeria, for example, have estimated potential capacities of 1,245 MW and 735 MW respectively. However, only 6 per cent of the potential in Nigeria has so far been developed, and there is currently no SHP in Ghana.

FIGURE 25

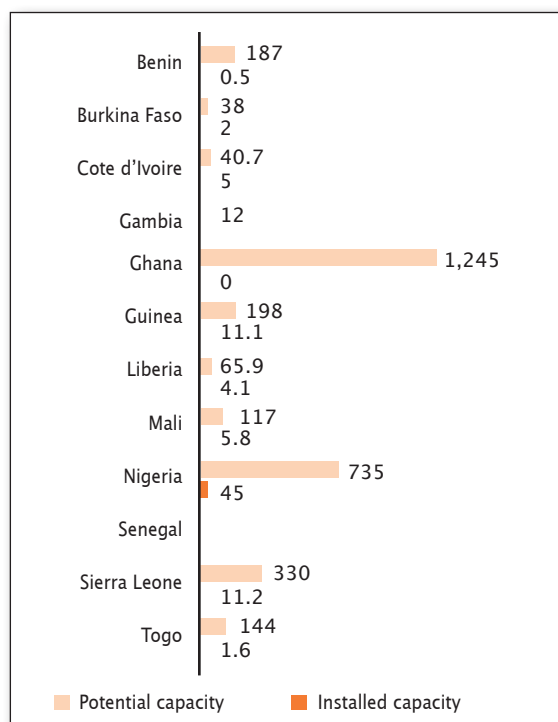
Developed SHP potential in Western Africa (%)



The region has the second-highest SHP potential in the continent, at 3,113 MW. Yet the installed capacity is the second lowest, with only 86.1 MW in operation. This indicates that 3 per cent of the total potential has been developed overall.

FIGURE 26

SHP capacities in Western Africa (MW)



Nigeria has the highest installed capacity, at 45 MW, while Sierra Leone has demonstrated the largest increase. If current long-term SHP projects are carried out, the region stands to triple its installed capacity of SHP.

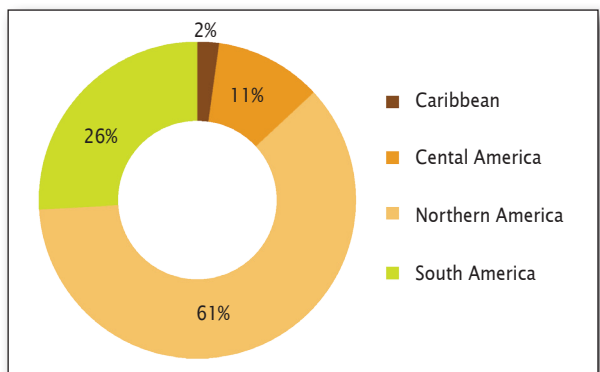
Although the region has witnessed slower growth in the SHP sector compared with other regions in Africa, Western Africa has the second-largest potential in Africa. Combined with the planned projects and development goals set forth by the Economic Community of West African States (ECOWAS), the region could very well see an upswing in SHP development.

Sources: All data for this region are referenced in the respective regional summaries and country chapters.

Americas

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

FIGURE 27
Installed SHP capacity in Americas (MW)



The total SHP capacity in the Americas is 14,702 MW while the total estimated potential is at least 86,868 MW for up to 50 MW. For capacities less than 10 MW, the installed capacity is 7,863 MW and potential is 44,162 MW. Some countries with enormous expected SHP potential have not had feasibility studies to determine their exact potential capacity. Mexico, for example, is a country that is suspected to have a large SHP potential but there have been no studies conducted to determine the country's true SHP potential. According to the available data, at least 17 per cent of the SHP potential capacities has been developed in the Americas.

Of the 30 countries in the region, four have established FITs relating to SHP. These four countries are Canada, the United States of America (though in the USA FITs are implemented only by some states), the Dominican Republic and Grenada.

The Caribbean, Central America and South America have experienced growth within the SHP sector, with their total installed capacities increased by 38 per cent, 43 per cent and 18 per cent respectively, since *WSHPDR 2013*. Many of the countries in these four regions have also established policies that incentivise the SHP sector. The Americas as a whole, however, still face barriers to developing SHP. This is mainly due to the high upfront costs of SHP plants, lack of regulatory policies in many of its 30 countries and social resistance to hydropower as it is perceived by

FIGURE 28
Installed SHP capacity by country in the Americas (MW)

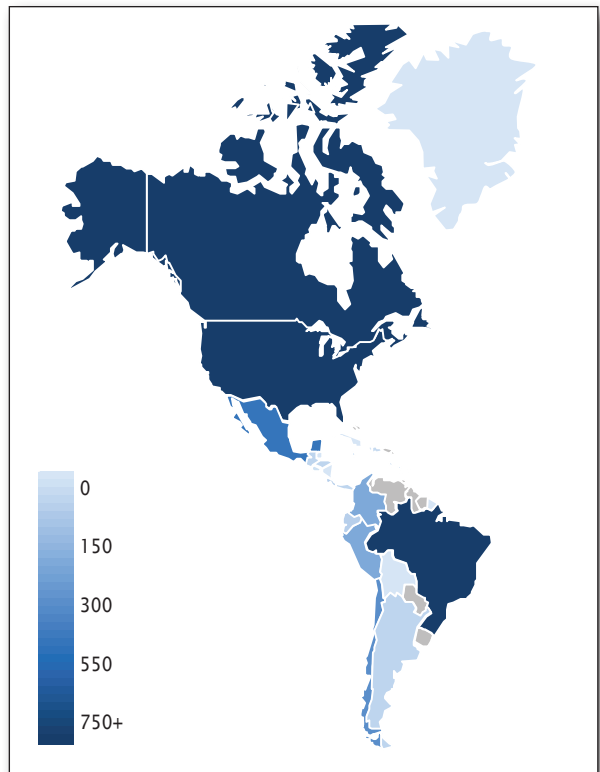
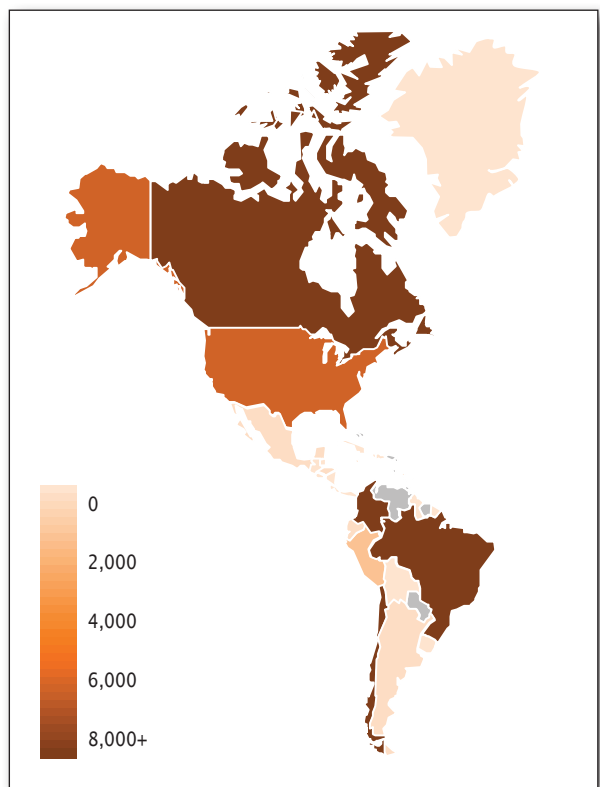


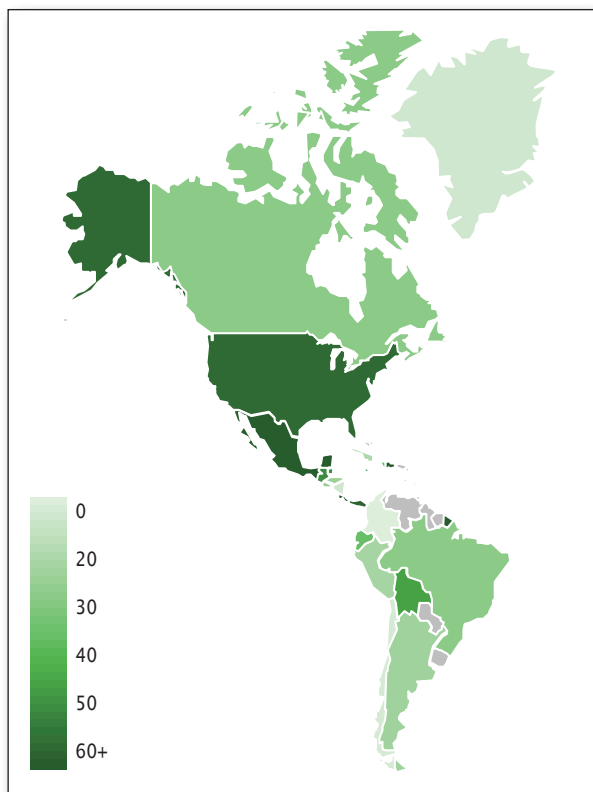
FIGURE 29
Potential SHP capacity by country in the Americas (MW)



many local populations as a technology that degrades the environment and destroys ecosystems.

FIGURE 30

Developed SHP by country in the Americas (%)



Caribbean

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

The Caribbean has one of the lowest levels of installed capacity in the world, placing it the sixth region with the lowest SHP installed capacity, with just 172 MW installed. There is at least a total potential of 349 MW in the region. However, it should be noted that this Report was not able to access the SHP potential for the Dominican Republic and Dominica. Therefore, the installed capacity of these two countries was used as the minimum threshold for the potential capacity. In the regional report, the potential capacities of the Dominican Republic and Dominica were recorded as not available and thus the total potential in the region was calculated as 290 MW. Nonetheless, the installed and potential capacities estimates indicate that at least 49 per cent of SHP has so far been developed in the Caribbean. Of the 10 countries in the region, two have established FITs—the Dominican Republic and Grenada.

All countries in the region are dealing with high costs and environmental degradation linked to their heavy reliance on fossil fuels. The cost of electricity imports and/or fossil fuels for the electricity sector is far too high for the countries to sustain. Thus, all countries have a national plan aimed at diversifying their energy mix. Within those national plans, which have set a timeline of a number of years to minimize their dependence on fossil fuel, there is a large focus

FIGURE 31

Developed SHP potential in the Caribbean

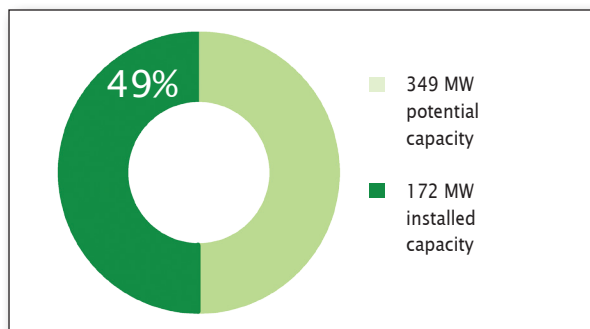
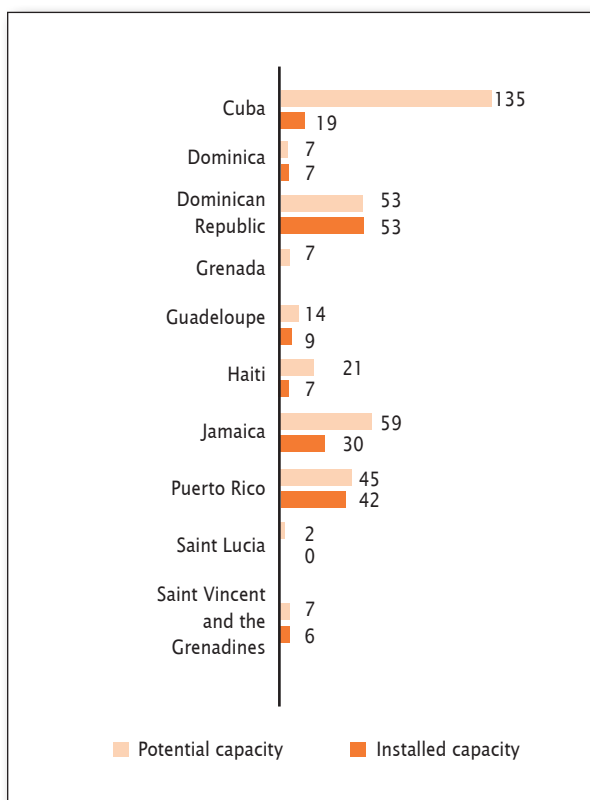


FIGURE 32

SHP capacities in Caribbean (MW)



on developing wind, solar, geothermal and biofuel power plants. Only a few countries have SHP policies within their national framework—Cuba, Dominica, the Dominican Republic, Jamaica, and Saint Vincent and Grenadines.

The Caribbean has seen development of the SHP sector in the form of feasibility studies—mainly studies on existing SHP plants. The countries that have conducted these feasibility studies are Jamaica, Haiti, Dominica, the Dominican Republic and Cuba. The Dominican Republic is the only country that has significantly increased its SHP capacity since *WSHPDR 2013*, from a total installed capacity of 15.4 MW to 52.5 MW.

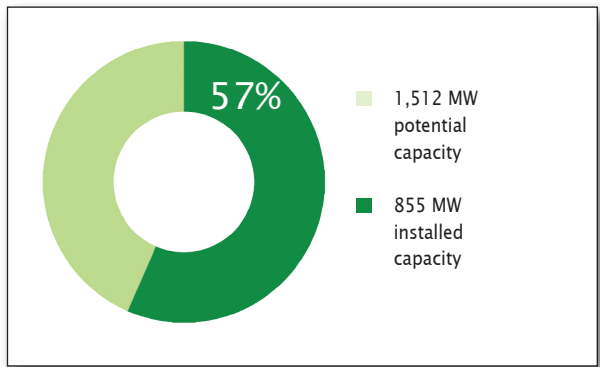
Overall, the region’s greatest challenge within the SHP sector is the lack of environmental conditions needed for efficient SHP plants and/or the lack of field studies needed to establish the true SHP potential of the islands. The Caribbean also generally lacks a systematic framework needed for the SHP sector. Mainly, these institutional problems arise from the lack of FITs and other incentives and/or supporting mechanisms, difficulties in land acquisition, energy generation monopolies and the absence of appropriate protocols to facilitate contracts.

Central America

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

Mexico dominates Central America’s SHP landscape, with approximately 55 per cent of the total installed capacity. In total there is 855 MW of installed SHP capacity, with a total potential of at least 1,512 MW. It should be noted that the potential of SHP for Mexico is so far unknown but it is believed to be vast. The region has developed at least 57 per cent of its SHP potential. However, it has done this without the use of FITs, as none of the eight countries have established FITs for SHP. It should be noted that the percentage of developed SHP does not include potential for Mexico, indicating a higher rate than what was reported in *WSHPDR 2013*.

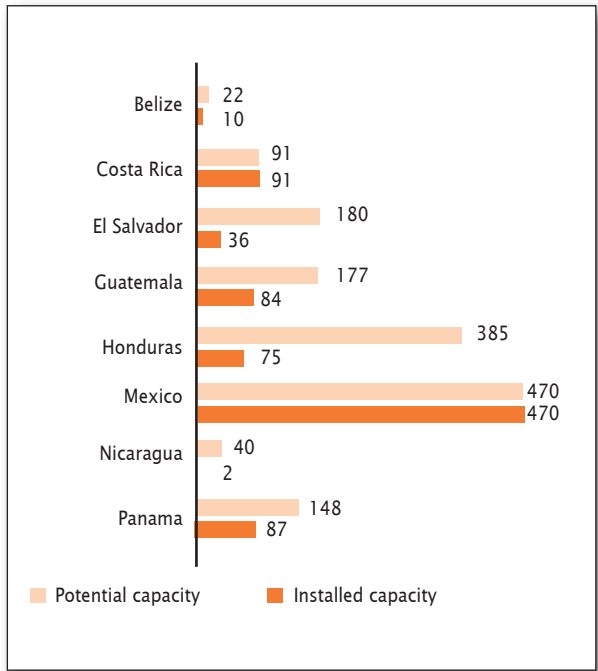
FIGURE 33
Developed SHP potential in Central America (%)



The countries of Central America have taken great steps to improve their renewable energy sector, which includes SHP. Specifically, Mexico and Honduras have taken measures to liberalize their electricity sectors, allowing for private investment to take place, while promoting investment in renewable energy resources such as SHP.

All eight countries have also established some sort of national framework to reduce carbon emission in the region, with Mexico and Costa Rica taking the most proactive steps. In 2015, Mexico presented to the United Nations Framework Convention on Climate Change (UNFCCC) its goals to reduce greenhouse

FIGURE 34
SHP capacities in Central America (MW)



gases by 22 per cent by 2030, while Costa Rica has committed to focusing on becoming carbon neutral by 2021.

Despite Central America taking proactive steps to improve its SHP sector, the countries still have a number of barriers that have to be addressed in order for SHP to fully develop its potential in the region. These barriers include the lack of FITs, which are essential to attracting financial investment for SHP, and the lack of concrete policies specifically designed for the development of SHP.

More specifically, Belize has unregulated markets and absence of energy and electricity standards; Guatemala constantly faces land-right issues with its population; and Costa Rica has limits on private investor participation in energy generation. Lastly, there is also the lack of reliable river flow data and detailed hydropower potential inventories that are essential for developing the SHP sector.

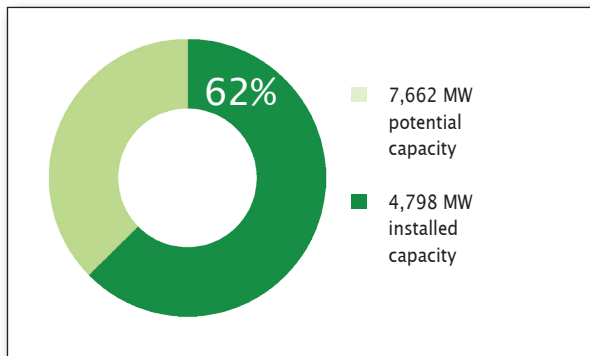
Northern America

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

Greenland has some SHP installed capacity and potential but it is dwarfed in comparison to the two largest countries in the region—Canada and the United States of America (USA). Despite only these three countries in the region possessing SHP capacity and potential, the region boasts the fourth-highest estimated SHP potential capacity in the world (up to 50 MW). However, it has developed 62 per cent of its less than 10 MW potential, with a total SHP installed capacity of 4,798 MW and potential capacity of 7,662 MW.

FIGURE 35

Developed SHP potential in Northern America (%)

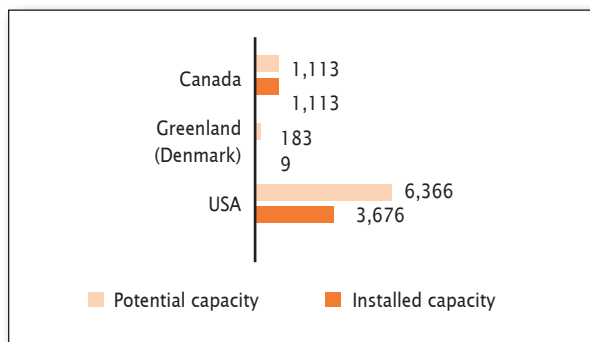


It should be noted that the definition of SHP by Canada includes all plants with an installed capacity of 50 MW or less. Therefore some reporting might include higher statistics for regional and country capacities. The less-than-10 MW potential for Canada was derived from the currently installed SHP; it is expected to be far higher, but it is at least 1,113 MW.

Both the USA and Canada have introduced FITs for SHP. However, due to the bureaucratic structure of the two countries, the tariffs are not nationwide, making their application variable according to state regulations.

FIGURE 36

SHP capacities in Northern America (<10 MW)



While the USA has implemented policies that promote SHP development, Canada and Greenland have yet to customize their policies towards SHP development. The lack of policies in Canada has much to do with its unique national strategy, which allows its provinces to develop policies with autonomy. This means that SHP development varies across jurisdictions. Greenland, on the other hand, can attribute its lack of policies to its focus on developing large hydropower as opposed to SHP. The USA, however, has had the Department of Energy (DOE) driving research and development efforts for SHP as part of its Water Power Program. The DOE also supports the National Hydropower Asset Assessment Program (NHAAP), which is an integrated water infrastructure information platform for the management and policy planning of sustainable hydroelectricity generation.

The region still faces many barriers to SHP development. In general, the greatest barriers are the high upfront costs of SHP and the technical requirements of grid interconnection. Furthermore, each country has its own set of challenges when it comes to SHP development. In Greenland, the main obstacles come from the transportation costs of electricity and SHP equipment. This is mostly due to the country's landscape, as many of the towns and settlements in Greenland are not connected by road. In Canada, the obstacles have been attributed to the lack of transboundary cooperation between upstream and downstream jurisdictions. The unique national strategy that allows its provinces to develop policies with autonomy has also led to a fragmented approach in almost all aspects of the energy sector due to the electricity policy and renewable energy targets of individual provinces. However, despite this systematic barrier, a hydro renaissance is possible in Canada, with hydro resources playing a larger role in the quest for a more renewable, sustainable, stable and economical power system. Lastly, barriers in the USA include a lack of comprehensive information regarding suitable sites and conduit hydropower opportunities, a lack of standardized technology, and state and local regulatory challenges, including regulatory issues associated with water quality certifications and environmental requirements.

South America

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

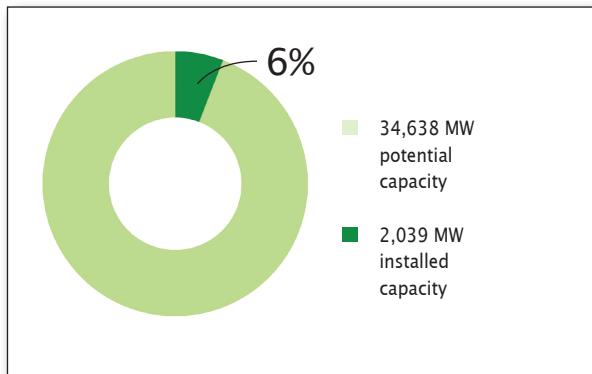
South America has the second-highest level of installed SHP capacity in the world. Brazil, Chile and Colombia combined account for 96 per cent of the region's total potential. However, due to the comparatively limited installed capacities, the region has the second-highest level of undeveloped potential in the world, with 63,463 MW of potential up to 50 MW, but only 6,783 MW of it being the total installed capacity (including plants up to 30 MW in Brazil). This indicates that only about 10 per cent has been developed. For SHP of less than 10 MW, the numbers are significantly reduced, except for the potential for Brazil being unknown, South America has at least 2,039 MW regional installed capacity and at least 34,638 MW potential capacity.

South America has experienced a significant increase in the total SHP installed capacity and has accomplished the increase without FITs, as no country in the region has established FITs for SHP.

South America began developing SHP in 1970 with the purpose of increasing the electrification rate in small towns and feeding the national grids. The countries in South America that have actually developed specialized policies for SHP are Argentina, Bolivia, Brazil, Chile, Colombia and Ecuador. Each of those countries has renewable energy policies that encourage and provide benefits for developing renewable energy projects that

FIGURE 37

Developed SHP potential in South America (%)

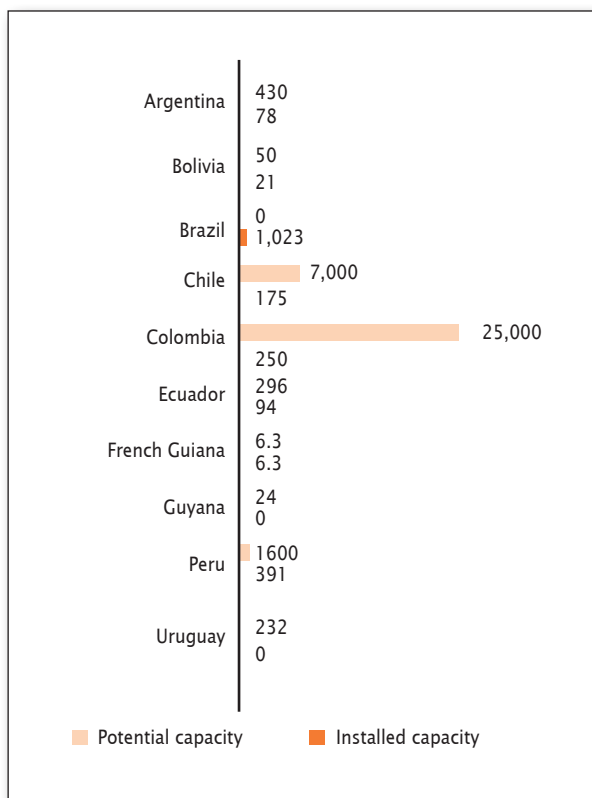


include small hydro schemes. Some of the benefits the countries have offered to incentivise SHP include exemption or reduction of taxes for importing SHP equipment or building SHP plants as well as power purchase agreements that secure the energy purchase price in a mid- or long-term agreement. This allows investors to pay for the generation costs and receive an acceptable investment return rate.

Despite such attractive incentives in some of the countries, the region still faces a number of barriers to SHP. Generally, the financial resource constraints due to limited availability of local finance institutions or local financial policies pose a huge barrier for the governments in the region.

FIGURE 38

SHP capacities in South America (MW)



There is also a social barrier related to the local population’s perception of hydropower—which tends to be negative—and a lack of information regarding the impacts and benefits of small hydro projects in particular. This hinders the governments’ ability to establish regulatory frameworks, which in turn may lead to cancellation of projects. Lastly, the region has poor quality of hydrological, climate and statistical data, especially for remote areas far from the main cities where the locations are suitable for SHP projects.

Sources: All data for this region are referenced in the respective regional chapters.

Asia

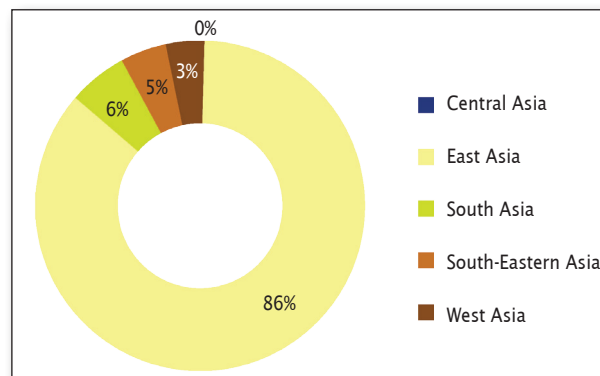
Asia has vast SHP resources. However, they are unevenly distributed across the continent (Figure 41). Almost 80 per cent of the discovered SHP potential is concentrated in just three countries of the continent—China, Tajikistan and India (using data for local definitions of SHP). The countries with the lowest SHP potential are Bangladesh, Timor-Leste and Saudi Arabia.

The total installed SHP capacity of Asia is 50,729 MW and the total estimated potential is 120,614 MW (for up to 10 MW). This indicates that approximately 42 per cent has so far been developed. SHP accounts for 16 per cent of the continent’s total installed hydropower capacity and 3 per cent of total electricity generating capacity. The installed SHP capacity of the continent has been increasing over the past few years.

As already noted, China dominates not only the Asian SHP landscape but also in the world. Within Asia, China accounts for approximately 78 per cent of the installed capacity and 53 per cent of the total potential capacity.

FIGURE 39

Share of installed SHP capacity in Asia (%)



Eastern Asia has the highest installed capacity and potential for SHP in the continent. Central Asia has the lowest installed and potential capacities in the continent.

FIGURE 40

Installed SHP capacity by country in Asia (MW)

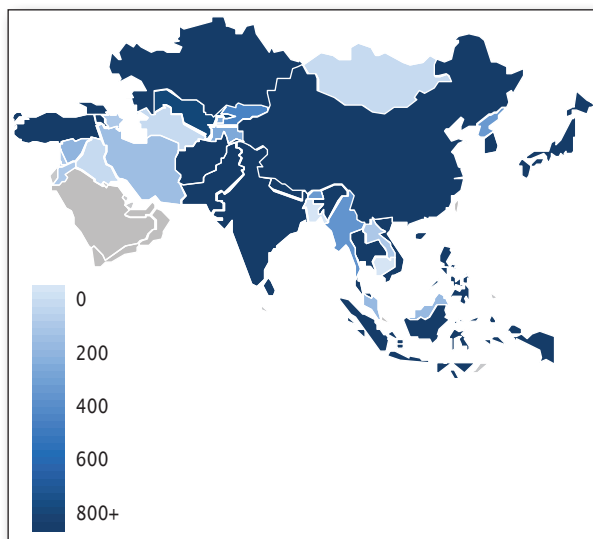


FIGURE 42

Developed SHP by country in Asia (MW)

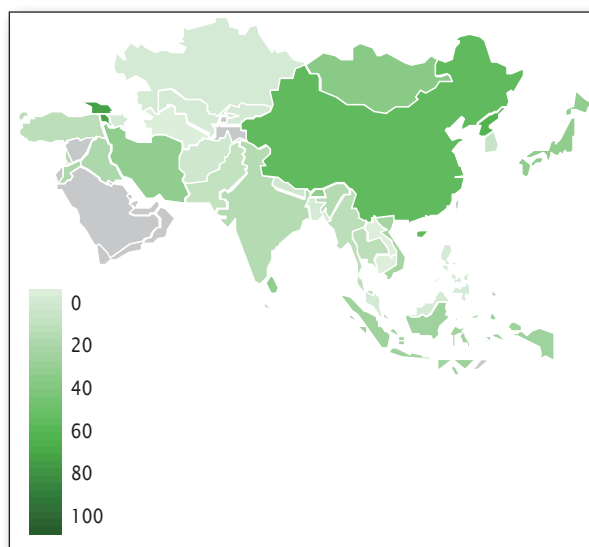
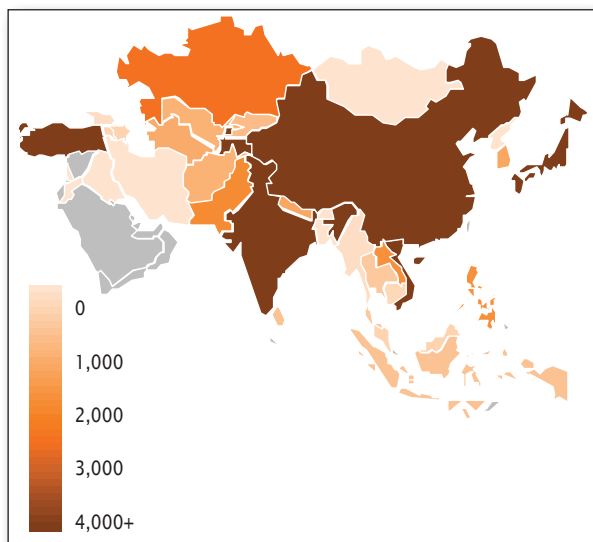


FIGURE 41

Potential SHP capacity by country in Asia (MW)

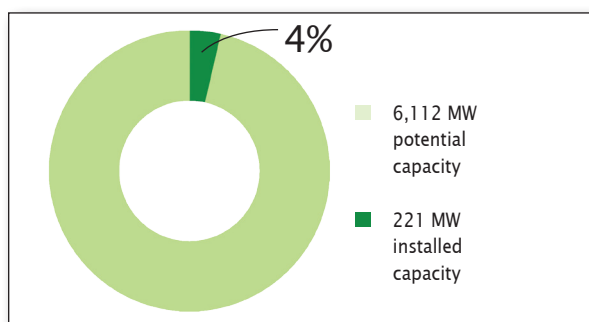


Central Asia
Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan

Installed capacity in Central Asia is relatively low. However, there remains a large amount of potential capacity available to be developed. Kazakhstan has the highest installed capacity, with 78 MW, whereas Tajikistan has the highest potential capacity, with 30,000 MW (up to 30 MW). Total installed capacity in the region is just 221 MW, while potential is considerable with an estimated 6,112 MW, indicating that just 4 per cent has so far been developed.

FIGURE 43

Developed SHP potential in Central Asia (%)



SHP development is one of the priorities for countries in Asia that possess potential for further development. The key motives for developing SHP in the continent are to decrease dependence on fossil fuels, thus mitigating environmental problems; decrease dependence on energy imports; and improve access to electricity, especially in rural areas.

Of the 36 countries in the continent covered in this Report, many have some form of renewable energy policy while 22 have established FITs related to SHP.

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

Hydropower resources are unevenly distributed among the countries, which were compensated during the Soviet era through the Central Asia Integrated Power System that connected all the countries into one single power system. After the collapse of the Soviet Union, each country established its own electricity system. However, the countries agreed to maintain parallel operations.

While Kazakhstan, Turkmenistan and Uzbekistan depend heavily on thermal power, hydropower is the main source

FIGURE 44

SHP in Central Asia (MW)

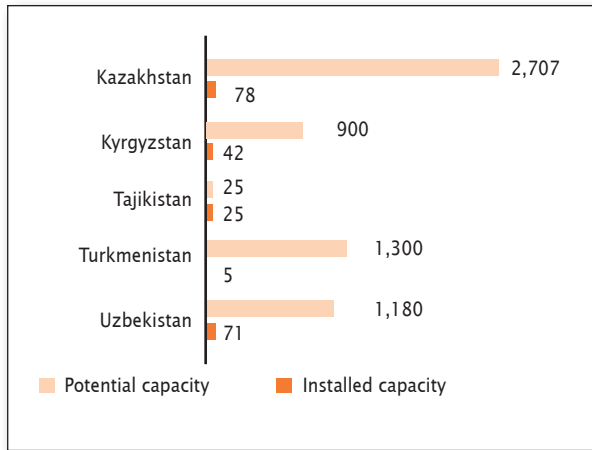
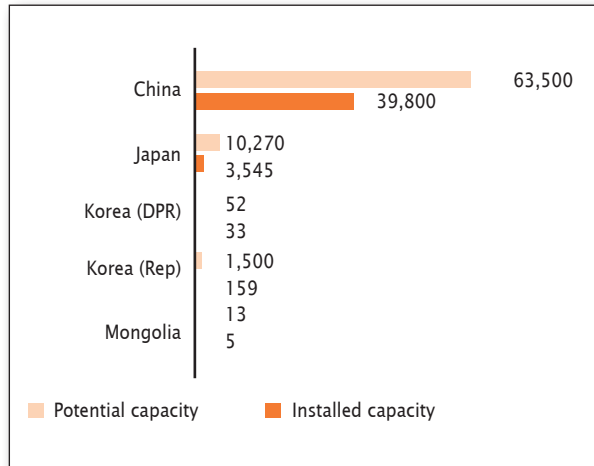


FIGURE 45

SHP in Eastern Asia (< 10 MW)



of electricity generation for Kyrgyzstan and Tajikistan. In general, the region has focused on the development of large-scale hydropower, with the share of SHP remaining rather low at 2 per cent of total hydropower installed capacity. Recently, SHP has attracted more attention of investors and governments, in particular for electrification of remote rural areas. According to the governments' plans, in the near future, 1,065 MW will be added to the regional SHP capacity, of which 51 per cent will be built in Kazakhstan.

A number of positive developments in sustainable energy have been observed in the region, with governments supporting renewable energy and energy efficiency through legislative and institutional reforms. All countries of the region, except Turkmenistan, have adopted legislation on renewable energy and have introduced FITs. The region demonstrates a growing interest in energy efficiency measures, which can be seen in Tajikistan and Kyrgyzstan by way of reducing their dependence on energy imports. Uzbekistan and Turkmenistan see it as a way to increase their fossil-fuel exports.

Barriers to SHP development in the region include the lack of affordable financial solutions from local banks, low awareness of the potential and possible applications of SHP, limited data on SHP potential, low electricity tariffs and low prices of traditional energy.

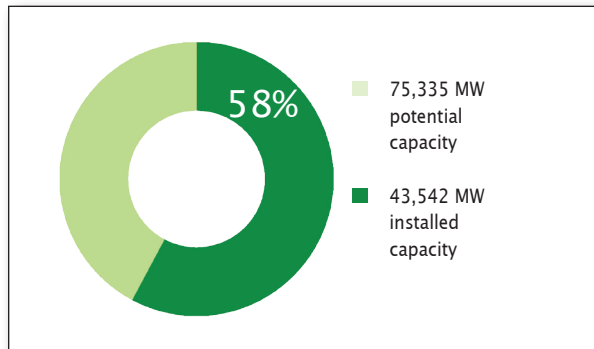
Eastern Asia

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

SHP in Eastern Asia is dominated by China, which constitutes 91 per cent of the region's total SHP installed capacity and 84 per cent of the potential. Japan and the Republic of Korea have comparatively smaller but still considerable SHP sectors. The total installed SHP capacity of Eastern Asia is 43,542 MW, whereas the potential is estimated at 75 GW, indicating that 58 per cent has been developed.

FIGURE 46

Developed SHP potential in Eastern Asia (%)



Fossil fuels remain the main source of energy in the region and nuclear power has a significant share in the energy mix of China, Japan and the Democratic People's Republic of Korea. This, combined with the escalating energy demand due to rapid economic growth and increasing population, contributes to the ever-growing emission of greenhouse gases and other air pollutants, which have a significant effect on air quality.

The countries in the region are trying to mitigate the environmental problems and encourage the development of renewable energies, including SHP. Besides, SHP is already being used by the governments in Eastern Asia to provide electricity to the rural population, contributing to rural development.

The region has a long history of SHP development. Currently, SHP accounts for 20 per cent of the region's total installed hydropower capacity and 4 per cent of the total installed electrical capacity. However, most countries in the region have limited expertise and manufacturing capacities for SHP. But China, on the contrary, possesses rich experience and expertise, which can be shared with its neighbouring countries.

SHP will see further growth in the region, with major developments planned in China and some projects in the Democratic People’s Republic of Korea, Japan and the Republic of Korea. Mongolia, on the contrary, has no plans for further SHP development at present.

Three countries in the region—China, Japan and Mongolia—have introduced FITs, and all five countries in the region have adopted legislation on renewable energy.

The barriers to SHP development vary among the countries of the region. SHP development in Mongolia, the Democratic People’s Republic of Korea, Japan and the Republic of Korea is hindered by the lack of skilled personnel and local technology. Mongolia and the Democratic People’s Republic also lack financial resources required for SHP development. Moreover, more data are needed for an accurate assessment of their SHP potentials. Finally, SHP is not a priority for Mongolia and the Republic of Korea, which are focusing instead on large hydropower or solar and wind energy. China, on the other hand, experiences environmental difficulties as well as constraints associated with land compensation, labour cost and resettlement.

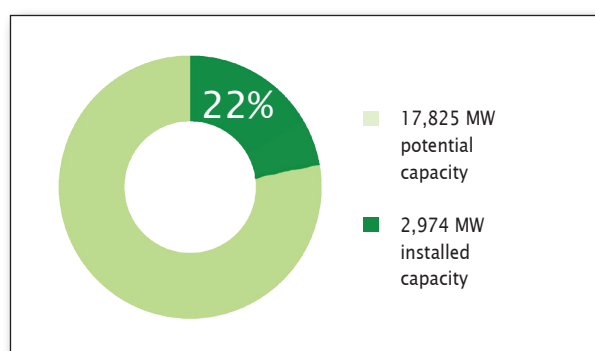
Southern Asia

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

India dominates the SHP sector in Southern Asia, with approximately 71 per cent of total capacity (2,119 MW) and 67 per cent of the discovered potential (11,914 MW), up to 10 MW. At the other end of the spectrum, Bangladesh has low installed SHP and very limited potential due to its flat terrain. The SHP potential of Bhutan is currently unknown, but based on its total hydropower potential, it is expected to be very high.

FIGURE 47

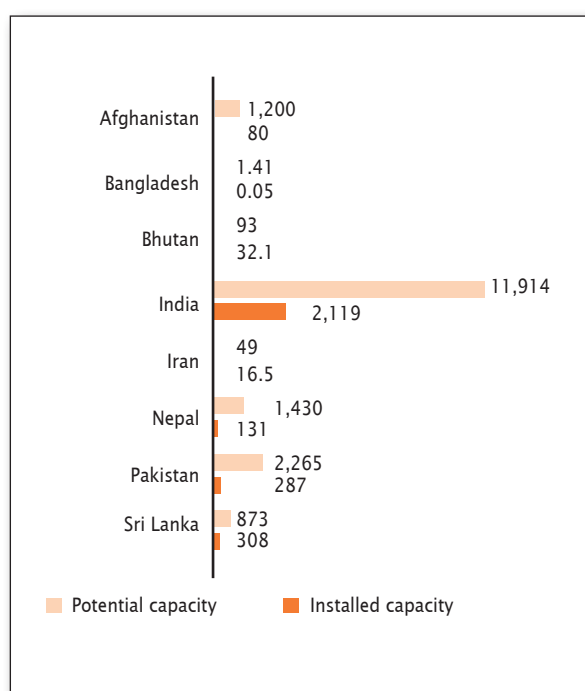
Developed SHP potential in Southern Asia (%)



The combined installed SHP capacity of the region is 2,974 MW and potential is 17,825 MW (less than 10 MW). This indicates that 17 per cent has so far been developed. The highest net increases in SHP installed capacity in recent years could be seen in Sri Lanka and Nepal.

FIGURE 48

SHP in Southern Asia (MW)



Hydropower is the main source of electricity generation in Afghanistan, Bhutan and Nepal. In particular, SHP accounts for 31 per cent of its total installed hydropower capacity in Afghanistan. In contrast, Bangladesh, India, Iran, Pakistan and Sri Lanka depend heavily on fossil fuels. However, hydropower still plays a significant role in the energy mixes of India, Iran, Pakistan and Sri Lanka. Overall, SHP in the region accounts for 8 per cent of total installed hydropower capacity and 1 per cent of total electrical capacity.

None of the countries in the region have reached 100 per cent electrification, with Afghanistan having the lowest rate in the region, at 43 per cent. Moreover, electricity grids have low efficiency and reliability with high losses and frequent blackouts. Therefore, providing universal access to electricity and reliable power supply remains an important challenge for countries in the region. SHP, including off-grid plants, has played an important role in the electrification of rural and remote areas and further development is planned for this purpose.

The Governments of India and Sri Lanka have put major focus on SHP development. Most countries in the region have developed regulatory frameworks to facilitate the development of renewable energies, including SHP. Five of them have introduced FITs.

Some barriers that hinder SHP development in the region are limited financial resources, lack of qualified specialists and technologies, limited studies on SHP potential and low electricity tariffs.

South-Eastern Asia

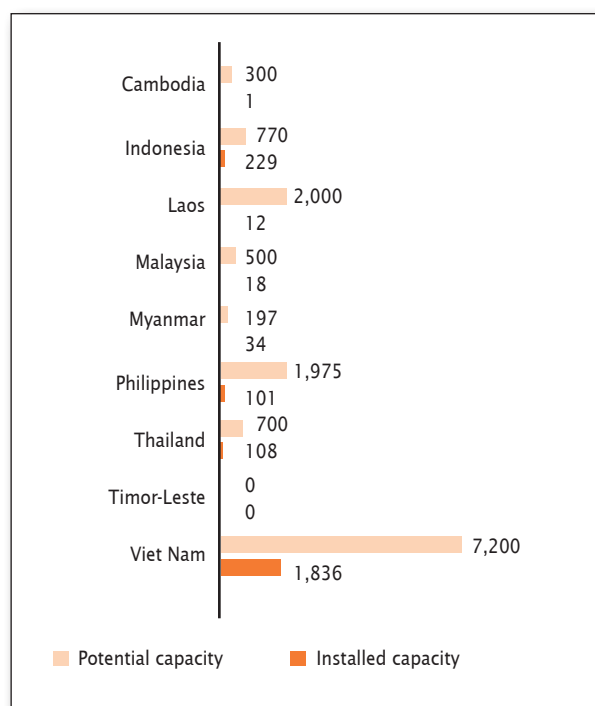
Cambodia, Indonesia, Lao People's Democratic Republic (Lao PDR), Malaysia, Myanmar, Philippines, Thailand, Timor-Leste, Viet Nam

The Report on South-Eastern Asia covers nine countries in the region. The combined total installed SHP capacity of these countries is 2,340 MW and estimated potential is 13,642 MW, indicating that 17 per cent has been developed. Viet Nam has the highest share of SHP capacity, at 78 per cent (1,836 MW), and also with the highest potential (7,200 MW).

The region has seen rapid economic and demographic growth in the last 25 years and, as a result, demand for electricity has increased substantially. The countries are faced with the need to develop their electric power capacities and infrastructure as well as to improve access to electricity, especially in rural areas. This creates an opportunity for SHP development in the region. Currently, SHP accounts for approximately 6 per cent of the region's total installed hydropower capacity and 1 per cent of total electricity generation capacity.

FIGURE 49

SHP capacities in South-Eastern Asia (MW)



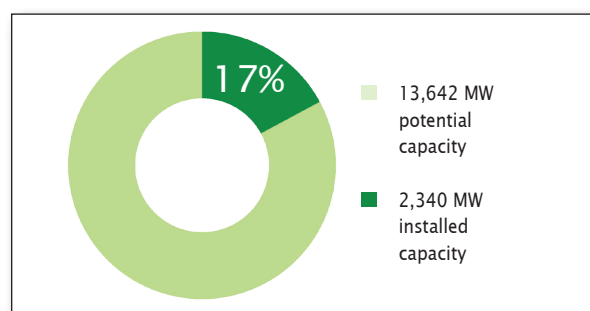
Fossil fuels still remain the chief source of electricity generation in the region. The countries in the region intend to decrease dependence on fossil fuels and develop renewable energies, which is reflected in their renewable energy policies and national plans. Lao PDR, Myanmar and Timor-Leste are currently without a law that would support the development of renewable energies. However, the Government of Lao PDR is in the process of drafting one, and Timor-Leste has a national programme

for the development of renewable energies.

Hydropower plays an important role in the energy mixes of Cambodia, Myanmar and Viet Nam, and in Lao PDR, hydropower is the only source of electricity generation. The installed capacity of SHP in the region has been increasing, with most developments observed in Indonesia and Viet Nam. Conversely, the Government of Viet Nam has recently cancelled a number of SHP projects due to high social and environmental risks caused by poor planning and construction.

FIGURE 50

Developed SHP potential in South-Eastern Asia (%)



The development of SHP in the region is often hampered by a number of factors, including the high cost of projects due to the location of potential sites in remote areas, whereas access to financial resources is limited. Furthermore, although most countries have introduced subsidies for electricity generated from renewable energy sources, Cambodia, Lao PDR and Timor-Leste still lack FITs. Other challenges are the lack of technical knowledge and operational skills, the lack of standardized procedures and standards, and limited available data.

Western Asia

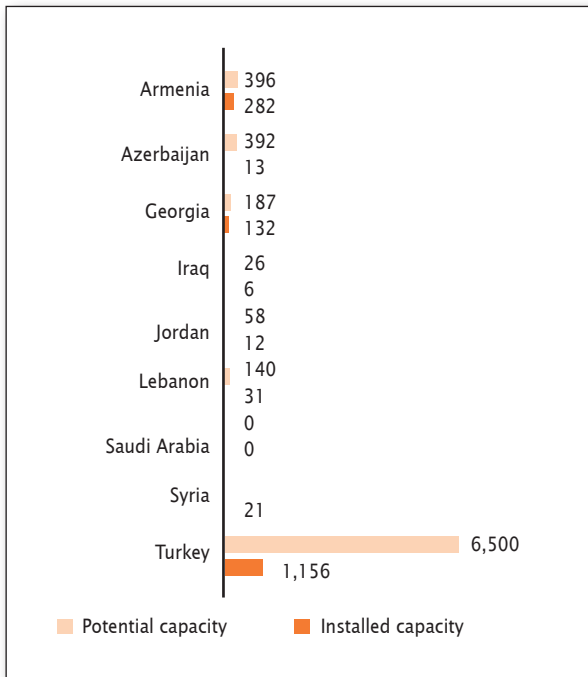
Armenia, Azerbaijan, Georgia, Iraq, Jordan, Lebanon, Saudi Arabia, Syrian Arab Republic, Turkey

The total installed SHP capacity of Western Asia is 1,653 MW and the estimated potential is 7,700 MW, indicating that 21 per cent has so far been developed, marking a significant increase from the figures reported in *WSHPDR 2013*, largely due to increases in installed capacities in Armenia and Turkey.

Much of Western Asia is located in a dry and desert climate. As a result, the region has the second-lowest SHP potential in the continent. Fairly considerable potential exists in the north-western parts, most notably in Turkey, which has an estimated potential of 6,500 MW or 84 per cent of the region's potential. Turkey is also the regional leader in terms of installed capacity with 1,156 MW, accounting for 70 per cent of the region's total.

FIGURE 51

SHP capacities in Western Asia (MW)

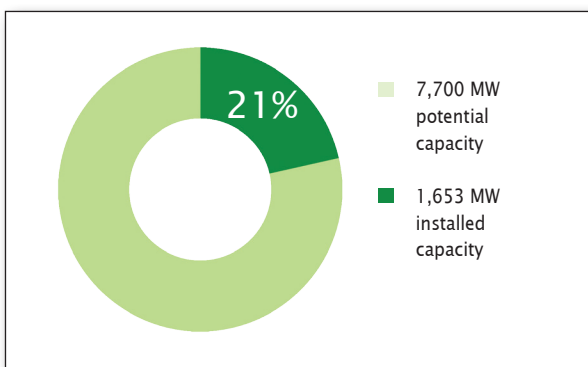


Most electricity in the region is generated from fossil fuels, with Georgia being the only country with the main share of hydropower in its energy mix. Armenia and Turkey are also highly dependent on hydropower. SHP accounts for 5 per cent of the region’s total installed hydropower capacity and 1 per cent of total installed electricity generating capacity.

Armenia and Georgia have relatively developed SHP sectors. However, hydropower plants in these countries are prone to unreliable operation due to significant annual rainfall fluctuations. Azerbaijan has a significant SHP potential as well. However, only 3 per cent has so far been developed. Nonetheless, further SHP development is among the priority projects of the Government. In the rest of the region, there is limited interest in SHP due to water scarcity. Thus, Lebanon, Jordan and Iraq have

FIGURE 52

Developed SHP potential in Western Asia (%)



relatively limited SHP potential, while Saudi Arabia has no SHP potential at all. The SHP potential of the Syrian Arab Republic is unknown.

The Caucasus countries and Turkey are seeking to further exploit their SHP potential, which is reflected in their policy frameworks. In other parts of the region, SHP development will remain rather limited due to water scarcity. Political instability is another major obstacle for SHP development in the region, especially in countries around the Middle East.

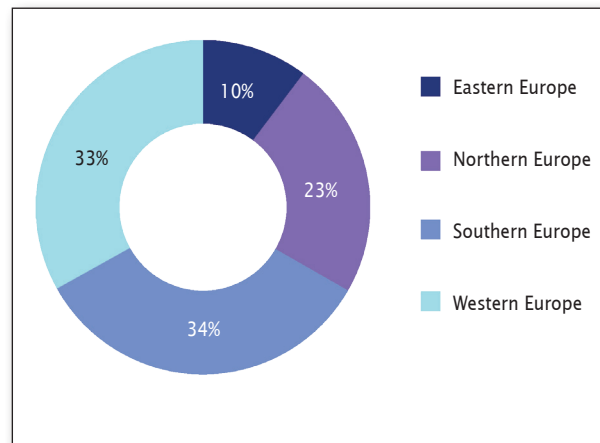
Sources: All data for this region are referenced in the respective regions.

Europe

Europe has a long history of SHP development, which has enabled the region to reach its highest rate of installed capacity. Europe, having a variety of climates and landscapes, fluctuates according to each sub-region in regards to SHP potential. Western Europe, for example, has great potential, with 85 per cent of its estimated potential already developed, while Northern Europe has very little SHP potential as much of it has already been fully developed.

FIGURE 53

Installed SHP capacity in Europe (MW)



The overall installed capacity in the region is 18,684 MW while the potential capacity is estimated at 38,943 MW. In comparison to *WSPDR 2013*, this represents an increase in installed capacity of 5 per cent and an increase in potential capacity of 38 per cent. As of 2016, Europe has developed nearly 48 per cent of its SHP potential, with Western Europe reaching the world’s highest SHP development rate, at 85 per cent.

Europe has the largest number of countries with established FITs for SHP; 28 out of the 39 countries

FIGURE 54

Installed SHP capacity by country (MW)

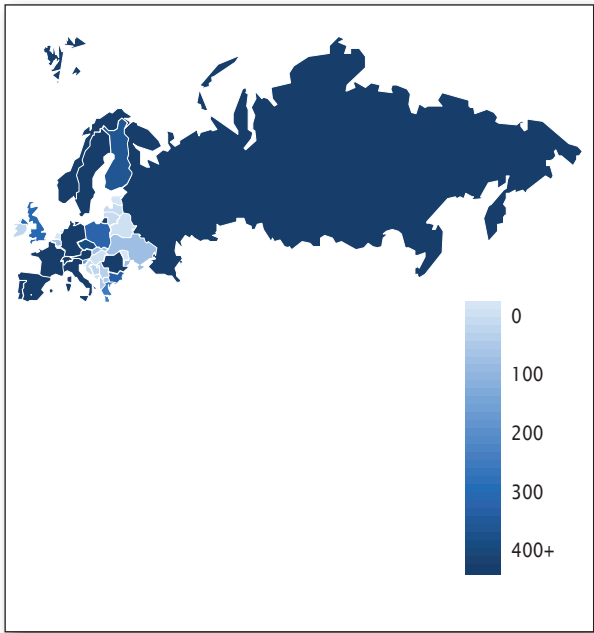
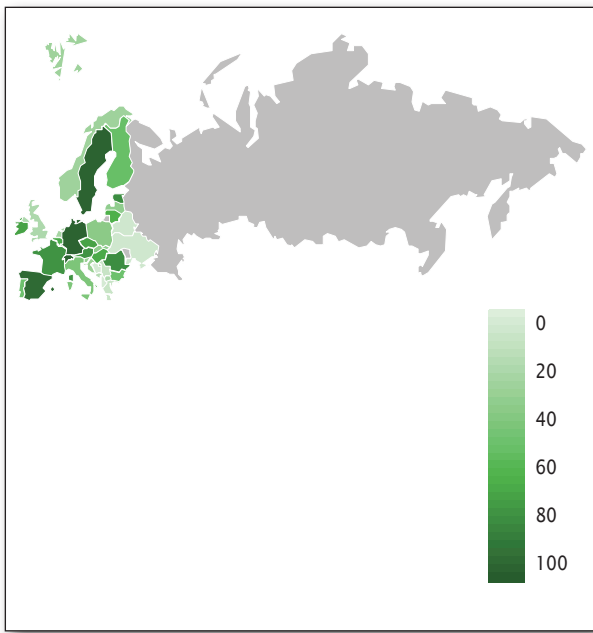


FIGURE 56

Developed SHP by country in Europe (%)



included in this Report already have FITs incorporated into their respective SHP policies.

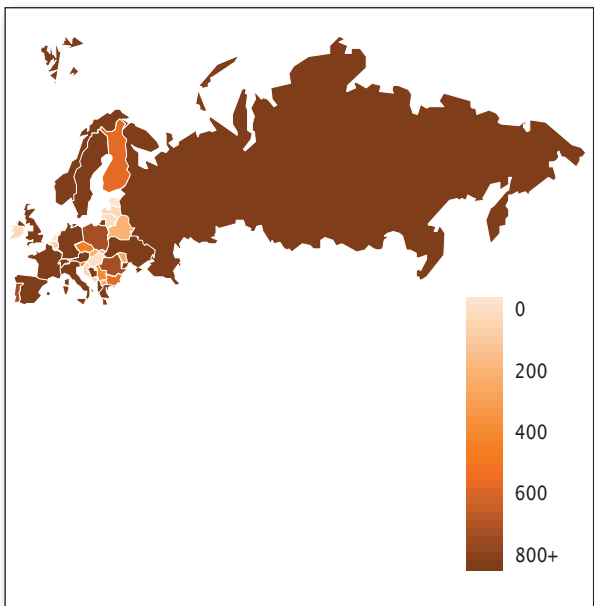
The general challenges the region faces with regard to SHP development are the rigid environmental regulations that may hinder the development of SHP capacities in some countries. Many environmental organizations in Europe also have a negative outlook

on hydropower systems in general, and thus promote policies and actions that do not differentiate between large hydropower and SHP.

The Russian Federation (Russia) provides a mechanism for ‘joint projects with third countries’ that incentivizes European Union (EU) Member States to support the construction of renewable energy installations, such as SHP plants, in non-EU countries. This supporting mechanism is relevant for the renewable energy projects in the north-west of Russia, from where Russia can export electric power to EU Member States.

FIGURE 55

Potential SHP capacity by country in Europe (MW)



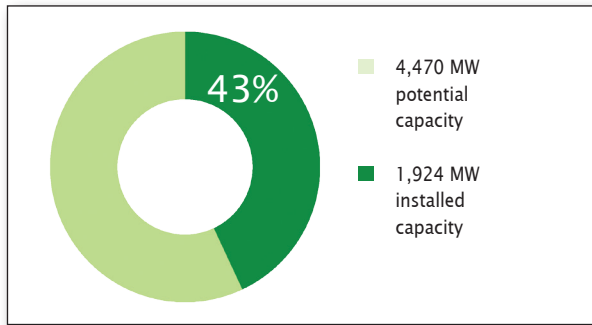
Eastern Europe

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

Eastern Europe has a considerable amount of installed SHP capacity at 1,924 MW, representing more than 43 per cent of the less than 10 MW potential of 4,470 MW. The percentage of developed SHP has decreased since the *WSHPDR 2013*, largely due to an increase in the SHP potential capacities of several countries. It should be noted that the potential does not include data for Russia; only data for less than 30 MW were available (some 825,845 MW).

FIGURE 57

Developed SHP potential in Eastern Europe (%)

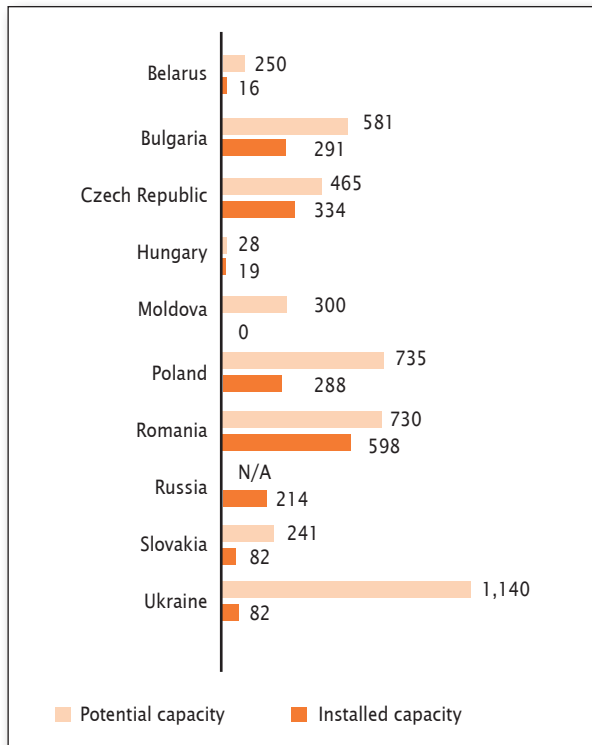


Nevertheless, there is still considerable SHP developed in some countries of the region, such as Bulgaria, Czechia and Poland. Significant potential has yet to be developed in countries such as Ukraine and Russia. Of the 10 countries, six have established FITs, namely, Bulgaria, Hungary, Poland, Romania, Czechia and Ukraine.

All the countries in the region have implemented policies aimed at promoting renewable energy sources (RES). However, as large hydropower encounters ever more barriers due to the environmental degradation that dams have caused, numerous countries have neglected the SHP sector altogether. Instead, the region has taken proactive steps to focus on the development of other renewable energy sources, primarily wind and solar power.

FIGURE 58

SHP capacities in Eastern Europe (MW)



Additionally, Eastern Europe faces many bureaucratic and financial barriers to SHP development. The lengthy administrative processes, for example, which are mostly aimed at safeguarding the environment, have unfortunately stalled the SHP sector and even lessened the significance of SHP, with environmental organizations perceiving it as a moderate source of green energy at best.

Lastly, many countries in the region also lack master development plans needed for a productive and sustainable SHP sector. As a result, investors usually have to take more risks to ensure the success of an SHP project, which often deters investors altogether.

Northern Europe

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

Northern Europe has the third-highest total SHP potential in Europe, with 10,920 MW. However, 70 per cent of this potential is found in Norway. Other countries, such as Denmark and Sweden, have fully developed their known viable SHP potential.

SHP capacity has increased by 18 per cent compared to data from *WSHPDR 2013*, from 3,643 MW to 4,292 MW. The total estimated potential has also increased by 185 per cent, from 3,831 MW to 10,920 MW. This indicates that approximately 39 per cent has so far been developed. While *WSHPDR 2013* indicated over 90 per cent of SHP developed in the region, the percentage has decreased significantly with the addition of a more accurate and higher potential for Norway.

Of the 10 countries reviewed, six have established FITs for SHP, namely, Denmark, Estonia, Ireland, Latvia, Lithuania and the United Kingdom of Great Britain and Northern Ireland (United Kingdom). The notable exceptions are Norway and Sweden, both of which operate a shared

FIGURE 59

Developed SHP potential in Northern Europe (%)

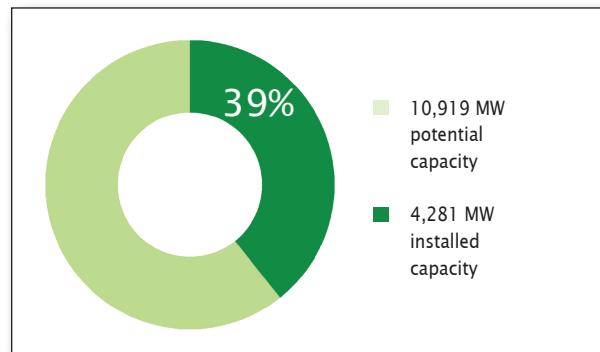
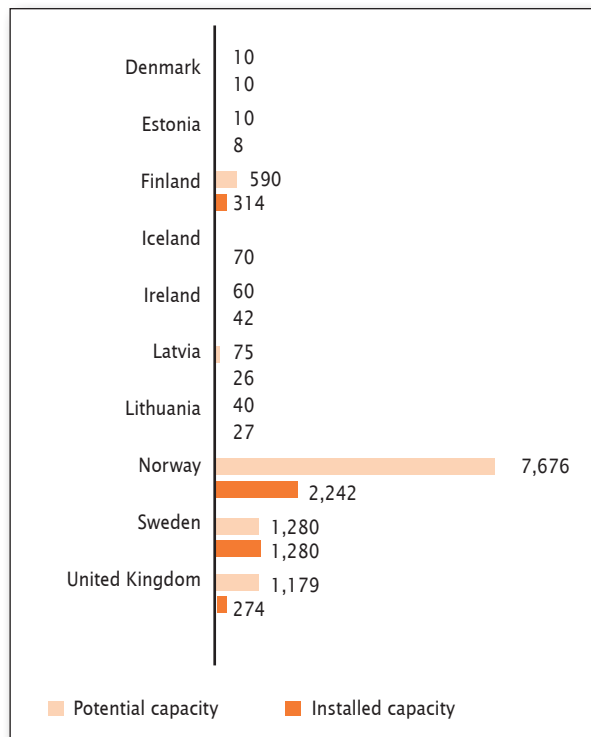


FIGURE 60

SHP capacities in Northern Europe (MW)



market with a green certificate scheme for renewable energy producers in place of guaranteed tariffs. Finland does not have FITs but has established other investment schemes that promote SHP.

Within the Northern European countries, the installed capacity and potential capacity vary dramatically—from values of over 1,000 MW in Norway and Sweden to under 10 MW in Denmark and Estonia. As a result, some countries, such as Norway, have a large interest in developing their substantial potential while others, such as Denmark, want to achieve 100 per cent power generation from renewable energy sources, but cannot do so with SHP.

The dramatic variations of SHP potential have undoubtedly been reflected in the developments of the SHP sector in the region. Norway, for example, has increased its SHP installed capacities by 26 per cent and the United Kingdom, by 19 per cent. Iceland has also increased its installed capacity by over 100 per cent, from 25 MW to 70 MW. However, the SHP potential in Iceland has not been thoroughly studied and is thus unknown. All the Northern European countries have introduced renewable energy policies supporting electricity generation from renewable energy sources, including support mechanisms for SHP. The overall goal of these renewable energy policies is to increase the share of renewable energy by 2020.

Northern Europe still faces some barriers to SHP development, mainly due to the exceptionally low electricity

costs in the region, which often has led to the need of extending payback periods for SHP investments. This also results in the investment costs of SHP development to be initially higher than expected and thus can deter investors from the region. Lastly, the SHP sector has been slowed down by the environmental requirements and legislation of many countries in the region.

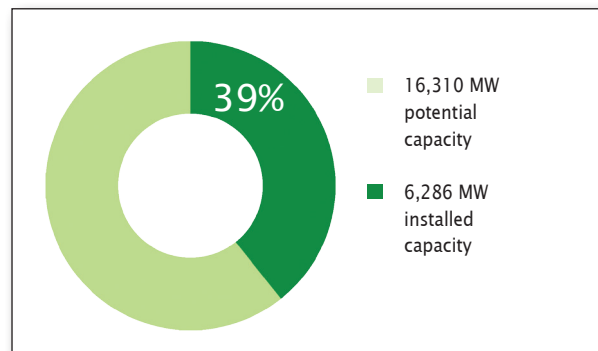
Southern Europe

Albania, Bosnia and Herzegovina, Croatia, Greece, Italy, the former Yugoslav Republic of Macedonia, Montenegro, Portugal, Serbia, Slovenia and Spain

The overall installed capacity in Southern Europe is 6,286 MW while the estimated potential is 16,310 MW. This indicates that approximately 39 per cent has so far been developed.

FIGURE 61

Developed SHP potential in Southern Europe (%)



Italy is the most viable country in the region for SHP development, taking up 50 per cent of Southern Europe's total installed capacity and 43 per cent of its total potential capacity.

The region has a significant amount of untapped SHP potential—estimated to be at least 16 GW—as well as other renewable energy sources. In order to promote the development of renewable energy, all countries of the region have implemented economic incentives. These incentives have also driven the growth of SHP and further promoted policies that allow suppliers of electricity from renewable sources to receive a range of benefits. The benefits include FITs, priority connection to the grid, guaranteed purchase of electricity, preferential access to the network and other government subsidies. Of the 11 countries covered in this Report, 10 have FITs for SHP in place, the exception being Spain, which suspended FIT pre-allocation in 2012.

Southern Europe still faces a few barriers when it comes to developing the SHP sector, mainly due to the long and complicated authorization and licensing process—a complication that exists in Greece, Italy, Montenegro, Portugal, Serbia and Spain. Other institutional and

FIGURE 62

SHP capacities in Southern Europe (MW)



regulatory barriers include corruption, disagreement between local and national regulations, and even frequent changes in SHP regulations.

Western Europe

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

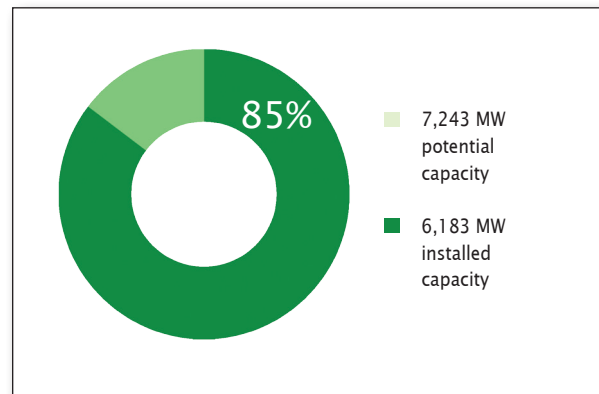
Western Europe has developed 85 per cent of its estimated potential, the highest SHP developed rate in the world. Countries such as Austria, France and Germany have developed significant shares of their relatively large SHP estimated potential. Nonetheless, additional studies are needed to ascertain the potential for applications of hydropower technology, such as in-conduit turbines, as well as the conversion or rehabilitation of existing waterways and dam structures.

The total installed capacity in the region is 6,183 MW, with an estimated potential of 7,243 MW. Aside from Belgium and Switzerland, all the countries have established FITs for SHP.

Western Europe has many SHP policies, with all countries enforcing some form of SHP mechanism. These mechanisms range from tradable green certificates, as seen in Belgium, to investment support or subsidies, as seen in the Netherlands and Austria.

FIGURE 63

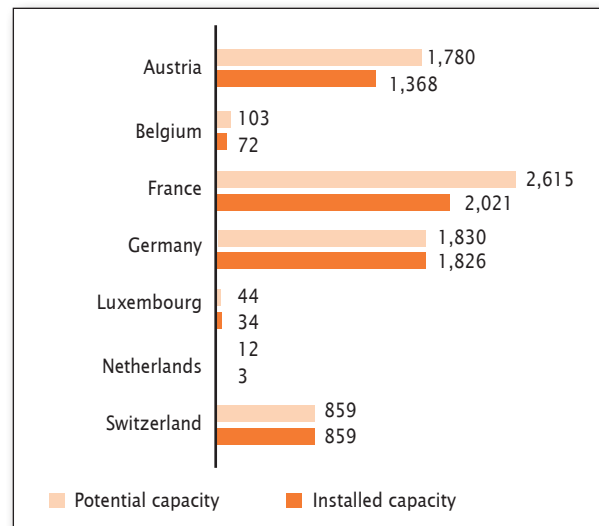
Developed SHP potential in Western Europe (%)



All the countries in the region, with the exception of Switzerland, also benefit from the Water Framework Directive, a European Union (EU) regulation on SHP and hydrology in general.

FIGURE 64

SHP capacities in Western Europe (MW)



Despite the exceptionally high SHP development rate in the region, Western Europe still endures several challenges in regards to further developing its SHP sector. The greatest obstacle involves the higher environmental expectations regarding hydro-morphology. For example, though the Water Framework Directive is a regulation aimed at establishing 'good status' on all water bodies within the EU's jurisdiction, it also imposes strict environmental conditions, which has restricted the energy production of SHP and jeopardized the economic viability of new and existing SHP projects. A modification of the EU environmental regulations is expected in 2017, which may relieve some of the strict conditions on SHP.

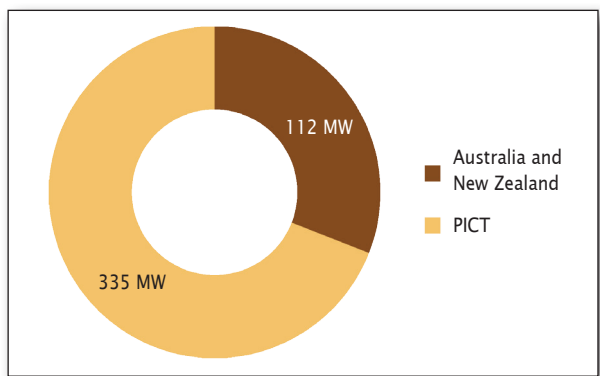
Sources: All data for this region are referenced in the respective chapters.

Oceania

Oceania is the smallest region in terms of the number of countries included in this Report as well as in installed and potential capacity. The total installed capacity amounts to 447 MW. The total estimated potential is at 1,206 MW, indicating a decrease of 2.6 per cent in comparison to *WSHPDR 2013*. This decrease is due to a reassessment of some sites in New Zealand that have been disqualified for development since 2013. The installed capacity and newly assessed potential capacity indicate that approximately 37 per cent has so far been developed. Of the 10 countries from the region, none has established FITs relating to SHP.

FIGURE 65

Installed SHP capacity in Oceania (MW)



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 a mountainous terrain, which is usually a key factor in prompting SHP potential. The Australia and New Zealand region, which is found in the southernmost part of Oceania, is the richest area in regards to SHP potential, while the Pacific Island Countries and Territories (PICT) are mostly flat islands and have little or no SHP potential. As a result, the greatest challenge for SHP development in Oceania is the topography.

FIGURE 66

Installed SHP capacity by country in Oceania (MW)



FIGURE 67

Potential SHP capacity by country in Oceania (M)

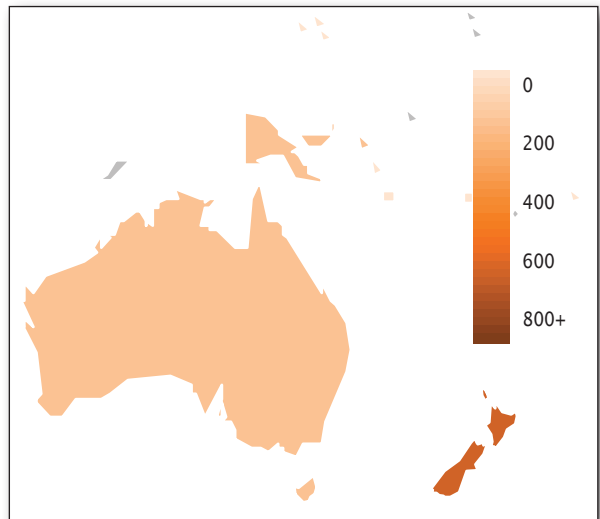
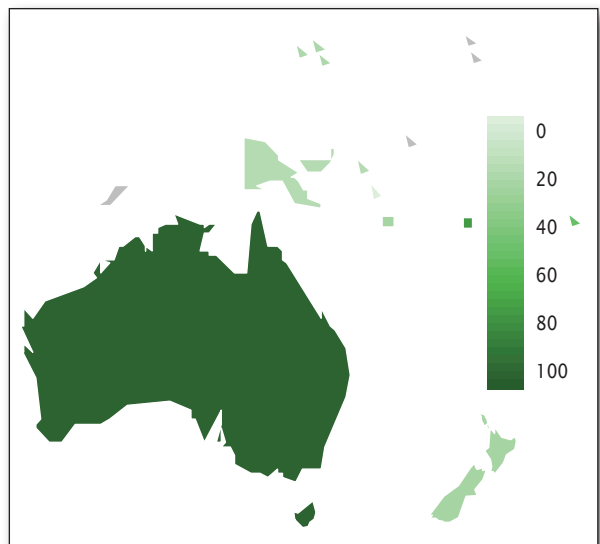


FIGURE 68

Developed SHP by country in Oceania (%)

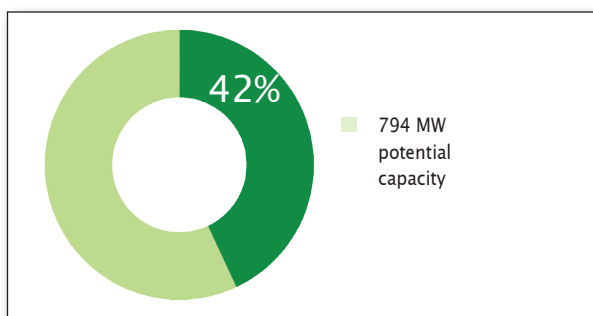


Australia and New Zealand

The region consists of just Australia and New Zealand and yet constitutes 75 per cent of the installed SHP capacity in Oceania and 66 per cent of the estimated potential. The total installed capacity is 335 MW, an increase of 8 per cent compared to data from *WSHPDR 2013*, and the potential is estimated to be at least 794 MW, a decrease of 15 per cent. It should be noted that there have been no comprehensive SHP studies in Australia and therefore the total SHP potential is not known. The Report uses the country's installed capacity as the minimum threshold for SHP potential. Moreover, the decrease of potential capacity in Australia and New Zealand is due to new data that appeared for New Zealand, which exclude sites in conservation zones and sites that are simply not economically feasible. This newly acquired data indicate that approximately 42 per cent has so far been developed.

FIGURE 69

Developed SHP potential in Australia and New Zealand (%)

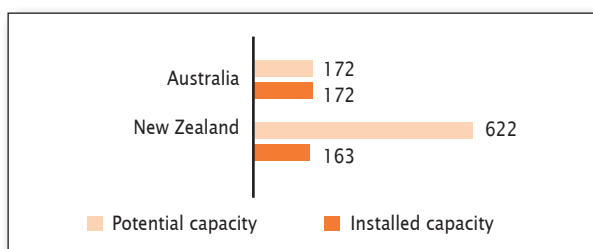


The Australia and New Zealand region did not have much development within the SHP sector, mostly due to the lack of policy in the two countries, which is generally needed to drive and implement SHP. While New Zealand has had some SHP plants installed since 2013, bringing its total capacity from 138 MW to 163 MW, Australia has had no development. It is believed that both countries will focus their efforts on other renewable energies, mostly wind and solar.

The region also faces two great challenges to developing SHP. The first is that many of the sites where SHP development is suitable are in protected areas or have significant potential environmental and social issues that require a long and expensive consenting process.

FIGURE 70

SHP capacities in Australia and New Zealand (MW)



The second challenge is that SHP development requires a lot of financial investment, with costs for new generation being higher than market prices, even with renewable energy credits. Therefore, the two countries often find difficulty in funding SHP projects.

Pacific Island Countries and Territories (PICT)
 Fiji, New Caledonia, Papua New Guinea, Solomon Islands, Vanuatu, Micronesia, French Polynesia and Samoa

The Pacific Island Countries and Territories (PICT) region is an amalgamation of the Melanesia, Micronesia and Polynesia regions and consists of Fiji, New Caledonia, Papua New Guinea, Solomon Islands, Vanuatu, Micronesia, French Polynesia and Samoa. A number of smaller island nations and territories are not covered in this Report as they do not have any known SHP capacity.

The PICT region has just 112 MW of installed SHP capacity and 412 MW of estimated potential capacity, indicating that only 27 per cent has been developed. In comparison to data from *WSPDR 2013*, the installed capacity has increased by 10 per cent while the estimated potential has increased by 35 per cent.

FIGURE 71

Developed SHP potential in the Pacific Island Countries and Territories (%)

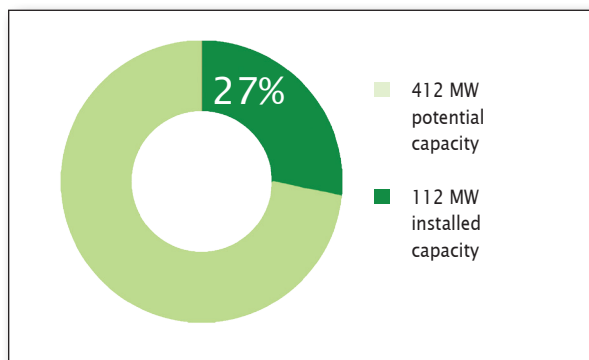
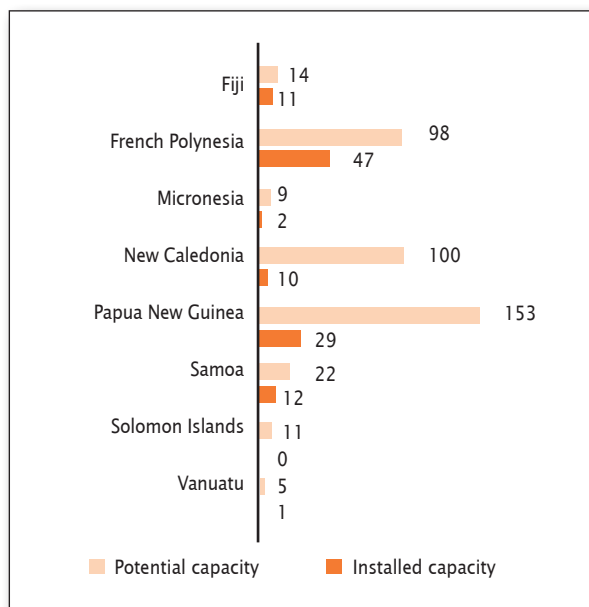


FIGURE 72

SHP capacities in the Pacific Island Countries and Territories (MW)



All of the countries, with the exception of Fiji, have proactively conducted feasibility studies in the last three years to further establish the prospective SHP sites. Furthermore, New Caledonia, in particular, is enforcing new governmental reforms that allow for the development of renewable energy projects. Specifically, the island has published new information on hydropower potential, which shows a significant increase of the potential capacity.

Sources: All data for this region are referenced in the respective chapters.

Conclusions

SHP is a mature and versatile technology, effective for increasing access to clean and sustainable electricity in the developing world, particularly in rural communities. SHP also helps developed nations achieve renewable energy advancement and targets in reducing greenhouse gas emission. Through developing SHP, many countries have already taken steps—or are beginning to take steps—to alleviate poverty and increase access to electricity, both of which are key elements in the Sustainable Development Goals and the Sustainable Energy for All (SE4ALL) programmes.

China and India are two examples that have taken advantage of the effectiveness of SHP in recent years, both having taken leading measures to improve electricity access through SHP development. Moreover, there has been a significant increase in other countries proceeding to follow their lead.

The purpose of this Report is to illustrate the development that SHP had, and continues to have, to the world. In regard to SHP potential, this Report demonstrates great improvements and impacts throughout all the major continents of the globe. This notion certainly takes an even more powerful influence when it comes to battling the greater global energy issues that plague many countries, such as dependency on fossil fuels. Nevertheless, the Report also demonstrates that there is still room for improvement. South America, for example, continues to possess large amounts of potential but—aside from Brazil—the region has so far not developed any significant portion of it.

The importance and advantages of SHP as a solution to rural electrification and inclusive sustainable industrial development also still remains underestimated. This is exposed particularly when SHP is compared to other small-scale renewable energies. For example, the Report cites that the focus many countries have on their wind and solar potential through fiscal incentives often becomes a barrier for SHP, as those same incentives are usually not extended to SHP. In some cases, such as in Algeria and Saudi Arabia, this fiscal focus is due to a simple lack of appropriate SHP resources. In other cases, the focus is due to a lack of studies to determine accurate potential figures, which then often leads authorities to pursue more readily achievable projects in the wind and solar sectors. Additionally, while the power obtained from SHP plants is significant, the initial costs of project implementation can be considerable in comparison to other technologies. This, too, discourages both government officials and private investors from taking interest in SHP. Lastly, SHP sometimes suffers from poor public perception concerning the environmental and social impacts normally associated with large-scale hydropower projects.

Despite the underestimation of SHP, the publishing of this

Report does record new progress and challenges since *WSHPDR 2013*. For example, due to newly available data, the potential of SHP in the Russian Federation (Russia) has been demonstrated to be much larger than previously reported (up to 30 MW). This indicates the status of SHP development in Russia has vast opportunities for growth, with only 0.10 per cent of its capacities developed. The change is drastic and demonstrates both an achievement and a challenge. The achievement is that the re-evaluation of the true SHP potential in Russia—thus in Eastern Europe and, more largely, in all of continental Europe—provides a more accurate portrait of the SHP landscape and future development opportunities. The challenge, however, is that Russia now needs to re-evaluate its legislation in order to create incentives for tapping into such a rich energy potential.

This section provides general conclusions from *WSHPDR 2016*. Despite an increase in SHP development, many of the conclusions and recommendations remain similar as in the previous report.

The need for data

One conclusion that remains unchanged from *WSHPDR 2013* is the need for accurate and shared data on SHP potential at a country level. A commonly cited barrier to SHP development in developing countries is the lack of accurate data to encourage private investment in the sector. For many of the countries reviewed in this Report, the available data are outdated, dependent on studies or reviews that are often decades old and not the true representation of current technological improvements or policy frameworks that greatly impact the accuracy or feasibility of technical and economic estimates. Detailed information on SHP potential informs potential investors about suitable areas and reduces the costs for feasibility studies. To truly realize the full potential of SHP around the globe, and to attract private investment to the sector, governments need to seriously consider the importance of new and detailed studies that incorporate the latest technological and economic developments. Additionally, international donor programmes and other development funds should consider the value of financing similar studies at the local level.

In developed countries a common barrier is that the majority of known SHP resources have already been developed. Nonetheless, many of the assessments are based on outdated studies and new comprehensive reviews utilizing computer models based on geographic information system (GIS) are likely to reveal additional potential. Many of the existing assessments do not include the potential for either the rehabilitation of old sites or the development of existing waterways and dams for SHP use. For example, across the world, there are many water reservoirs and dams constructed for irrigation or drinking water collection that do not yet

produce electricity, so SHP turbines could be installed and run concurrently with the larger system.

Europe already has a considerable amount of its SHP developed. Nevertheless, a study by the European Renewable Energy Sources Transforming Our Region (RESTOR) hydro project between 2012 and 2015 has identified some 50,000 historical sites, mills and hydropower stations that are currently inoperative but suitable for SHP redevelopment. In Latvia, for example, these sites are considered as some of the only undeveloped potential for SHP remaining in the country. However, sites such as these are often not included in assessments of national potential. Furthermore, regulatory barriers have prevented development of SHP in some cases. In Poland, for example, ownership of many of the identified sites remains unclear and a new government policy is required to establish access for independent power producers (IPPs) to develop them.

Most countries also lack assessments of how new and non-conventional SHP technology could significantly increase potential. In-conduit turbines that can be incorporated into waste or drinking water systems—such as those that have been successfully implemented in the USA—promise to significantly increase the total potential in developed countries. Additionally, new low or zero head turbine designs can provide SHP in previously unconsidered locations that are often closer to population centres. This lowers the overall cost and can be of great benefit to rural electrification programmes.

Lack of focus on small hydropower

Focus on other forms of renewable energy such as wind and solar power has, in some cases, hindered progress within the SHP sector. In countries such as Egypt and the Dominican Republic, policies and financial incentives aimed at other forms of renewable resources do not apply to SHP. In other cases, focus is overwhelmingly in favour of large hydropower. Paraguay, which has an extraordinary hydropower potential and relies heavily on large hydropower, has yet to develop SHP at all. SHP potential is also often associated with large hydropower potential and consequently given less attention when the latter has achieved high levels of development. A lack of governmental stimulus for SHP owes itself in part to the perceived lower financial gains as well as a lack of data on total SHP potential. While the development of renewable energy resources should not be discouraged, governments would benefit from new studies on total SHP potential as well as from introducing new legislation that fully understands the contribution that SHP can make in providing clean sustainable energy.

Financing small hydropower

Attracting finance for SHP is key to the sector's development. Approaches adopted by developers vary around the world, including community finance, public

funding, equity investment, and grants and loans from local financing institutions. In developing countries, most notably in Africa, most of the existing SHP development has so far been realized through grants or soft loans from foreign development institutions or other countries. The key concern with this approach is the unsustainability of the model. Efforts have increased to create environments that are financially attractive for private investment.

However, creating an attractive environment for investment is often hampered by a number of competing issues that need to be addressed before suitable incentives can be established. This includes, most notably, investment in a robust electricity sector with a suitable grid coverage and infrastructure.

Although the medium- and long-term benefits outweigh the high levels of initial investment, SHP is still often perceived as high risk by investors. This can be further exacerbated by uncertain and unclear legislation and guarantees for producers. Clear and uncomplicated legislation and regulatory processes alongside adequately designed financial incentives are thus required.

Appropriate policies and regulations

The lack of clear policies as well as regulatory and institutional frameworks regarding renewable energy and SHP are important barriers to development. While many countries have renewable energy targets, including targets specifically for SHP, they nonetheless require appropriate and well-defined pathways to achieve these targets.

There are a number of policies that have the potential to improve development opportunities, including: obligations to conclude long-term power purchase agreements (PPAs) with renewable energy producers, FITs, net-metering policies for small-scale projects and priority access for renewable energy.

In addition, the goals of renewable energy development plans need to be aligned with those from other sectors such as water and environment. In Montenegro, for example, an attractive environment for investment is hindered by a conflict between various national documents and regulations.

Feed-in tariffs

FITs are a common tool used to provide a credible guarantee for the purchase of electricity from renewable energy sources, thus increasing the confidence of banking institutions and facilitating longer-term loans at more affordable interest rates. The Renewable Energy Policy Network for the 21st Century (REN21) notes that FITs account for a greater share of renewable energy development than either tax incentives or renewable portfolio standard (RPS) policies. As of 2012, it was estimated to be responsible for 64 per cent and 87 per cent of the world's wind and photovoltaic installed capacities. Although analysis of the precise impact of

FITs on SHP development was not among the aims of this Report, a general pattern can be observed with many of the countries without FITs witnessing comparatively low levels of SHP development. Although FITs are not the only method for encouraging development, as the European Commission has concluded, “well-adapted Feed-in tariff regimes are generally the most efficient and effective support schemes for promoting renewable electricity”. Thus, in agreement with the European Commission, this Report advises that countries with low levels of SHP development should seriously consider the option of introducing these incentives or similar financial guarantees.

Nonetheless, FIT policies need to be tailored to the specific needs of the country and poorly structured FITs can have a more negative-than-positive effect on SHP development. Tariffs in Ghana, for example, have been criticized for being inadequate. A few of the critiques in Ghana are as follows: having too short of a guarantee period (10 years); having no green power priority rule; and vague conditions in regards to who bears the cost of grid connection and grid enhancement. FITs are not strictly based on the cost of generation, given the currently low levels of consumer tariffs, it is also unclear how the programme will be financed, potentially deterring more risk-averse investors. In general, FIT schemes in Africa are working poorly due to unfavourable institutional design, insufficient design, and insufficient level of FIT rates or obstacles in the process of implementation.

Deficiencies, however, can be explained by conflicting policy targets, most notably the need for affordable power prices. FITs are expensive and thus it is paramount that energy policies be clear on how the costs are absorbed. For example, until 2012, there were two different financial support options in Spain—an FIT and a market premium with a cap and a floor—on the sum of market price and premium. However, on 27 January 2012, the Spanish Council of Ministers approved a Royal Decree-Law ‘temporarily’ suspending the FIT pre-allocation procedures and removing economic incentives for new power generation capacity involving cogeneration and renewable energy sources (RES-E) due to a tariff deficit of roughly EUR 26 billion (US\$28.7 billion). The deficit was largely driven by the incentives to renewable energy sources.

In many developed countries where FITs have been adopted, the cost is, at least in part, passed on to the customer. In developing countries, however, the cost for electricity is already too high. In these cases, FITs may not be an economically viable or politically attractive option for policymakers. Therefore, developing countries instead have opted to establish PPAs between producer and supplier. However, this too poses many challenges, as it often leads to protracted discussions, higher costs and risks that deter banks from issuing loans. South Africa is an example of a FIT scheme that became ineffective due to the negotiations between producers and the grid.

In addition, many developing countries lack suitable grid-capacity to implement FITs without limitation. Thus for the developing countries in this Report that have established FITs or are planning to, caps are often used to limit the total share of renewable sources as well as minimum sizes to avoid smaller plants that may have higher generation costs per kWh. By limiting the share of FITs, caps can also limit the impact on prices for the customer.

In general, the establishment of FITs must be part of—and aligned to—a wider development strategy. Governments might also consider how international donors and climate finance instruments can contribute to the overall costs.

While FITs have become somewhat of an international norm, it should be noted that several countries are actively seeking alternatives to replace existing tariff policies. For example, Brazil and Peru have employed energy auction models and seem to prefer it to FITs. However, though auctions can be an efficient avenue for fostering private investment, the model does tend to favour the sale of low-cost energy, leaving SHP at a disadvantaged position in comparison to other renewable sources. Nevertheless, there are ways to avoid these disadvantages, mainly with reformulations in the energy auction rules. If countries that employ the auction model commit to reforms, auctions can actually prove to be a more efficient model for SHP development. This is especially the case for developing countries with already high electricity costs. Brazil is an example of one successfully making these reforms. In 2015 the country established larger cap costs, making energy sources such as wind and SHP more equally competitive. As a result, SHP plants in Brazil are seen to be recovering in the regulated market and will continue to do so as time passes.

Renewable Energy Portfolios (REPs)

While FITs can be the most prominent economic instrument to promote renewable energy technology if the right circumstances are present, other tools may be appropriate. Renewable energy portfolios (REPs) are a useful and common policy tool for the promotion of renewable energy in general. REPs require electricity suppliers to source a specific share of the electricity they purchase from renewable energy sources. As such, they differ from FITs by allowing for more price competition between different renewable energy sources. REPs are usually established alongside certification programmes that oblige suppliers to purchase renewable energy certificates from generators. This can provide a useful financial incentive to IPPs. However, since certification programmes are operated on a market basis, it can lead to situations where certificates become significantly devalued as a result of oversaturation of the renewable energy marketplace. This ultimately can deter future development and investment. Such has been the case in countries such as Norway, Sweden and Poland, with the value of Polish certificates falling to just 40 per cent

of their long-term stable price. As a result, commercial entities strengthened their requirements, increased loan rates for new offerings, asked for additional loan collateral, stopped renewable energy financing and examined financing applications of all projects. This also increases the risk of a reduction of existing plants due to decreased income for renewable energy producers.

Considering the different financial incentives for SHP development and their relative benefits and risks, it is important to establish not only a more robust analysis of the effectiveness of these policies but also a platform for policymakers in different countries to share experiences. This will help identify the most suitable financial mechanisms for developing SHP in different socio-economic and political environments. Knowledge exchanges involving ministries, utilities, regulators, financiers, project developers and community representatives have been a successful tool in this context.

Technology and skills

A lack of appropriate technical skills and indigenous technology is seen as a significant barrier in many countries that has hindered both planned and existing SHP projects. In countries with insufficient indigenous technology, access to foreign imports can be aided through the establishment of concessionary duties and reduced import taxes.

Capacity building is one of the key measures for advancing the skills needed for the maintenance of SHP. With week-long trainings, experts can teach the local population how to manage an SHP system and even repair it should there be technical problems in the future. Kenya was recently a recipient of a successful SHP capacity-building training session provided by ICSHP and COMESA. The two organizations coordinated a five-day training in Nairobi to spread and share advanced Chinese SHP technology and experience within the COMESA countries. The coordinators visited the Wanjii Hydropower Station of the KEN-GEN in Muranga County and set it as an example of successful international cooperation for green energy in a developing country.

Despite the successes that several international organizations have had in promoting SHP, more cooperation is needed from experienced countries, especially in regards to providing technical assistance in the planning, development and implementation of SHP projects. In particular, the need for suitable experts to assist in feasibility studies is needed.

Infrastructure and grid access

A common issue for all countries is that, 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. This is especially true

for developing countries with limited grid capacity and coverage. Establishing robust and extensive grid networks that can accommodate the introduction of new small-scale renewable energy developments is a priority when seeking to attract private investment capital. Establishing micro-grids with SHP providing base-load power offers a short- to medium-term—or even permanent—solution for electrifying remote and inaccessible communities. Additionally, for many developing countries, distribution losses are high, requiring investments to match those in generation and transmission.

Environmental regulations

Environmental regulations have led to complications in developing the SHP potential in some countries as well as increased costs of installations. SHP technology has advanced to lower the impact on the environment and provide suitable protection for surrounding eco-systems, most notably migratory fish. 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. In Norway and Sweden, for example, feasible SHP potential has been almost completely developed due to the implementation of a new regulation that has rendered development of potential sites illegal or economically unviable. Similarly, in Austria, there have been requests from the government regarding environmental concerns. One example involves fish conservation, specifically fish bypassing an SHP system and reserved flow. In this case, the government consensus took a while to reach and many have criticized the consensus itself as being unstable and unreliable for both fish conservation and SHP development.

Although ensuring a low environmental impact should be fundamental to SHP development, governments should consider SHP developers as important stakeholders when devising and implementing regulations. At the same time the industry must continue to lower the impact of SHP and seek lower-cost technology in order to ensure that environmentally sound sites remain viable.

Bureaucratic barriers

A number of countries highlight cumbersome and lengthy administrative processes as one of the biggest barriers to development. Complicated permit requirements that cross numerous departments are costly, delay project implementation and discourage investors. For example, in the Netherlands, the main limitation for SHP results from the low hydrological potential in a flat country, but the biggest restriction is receiving a permit from the local water communities (*Waterschappen*). The permit can simply be for the purpose of determining whether there is potential of an SHP site, and not construction. But even this is extremely difficult. The country does have quite a few places where development of an SHP plant could be possible, and yet the development of SHP is nearly halted due to the lobby of recreational and professional fishermen.

Faster development can be encouraged by streamlining the licensing process with several experts suggesting the implementation of a one-stop shop—a single responsible agency with standardized contracts. In addition, legislation covering land acquisition of suitable sites for development needs to be clear and transparent. This would both lower costs and speed up development.

Knowledge sharing

Knowledge sharing between experienced countries and those with undeveloped SHP resources is crucial. While ICSHP and UNIDO operate such programmes, these need to be expanded and improved through additional funding.

In Nigeria, a collaborative workshop between the Energy Commission, UNIDO and other stakeholders, devoted specifically to SHP for rural development, has helped to formulate future strategies for the sector's development. This resulted in a memorandum of understanding signed between the Commission, UNIDO and ICSHP for further cooperation in harnessing the identified SHP potential.

As can be noted with Nigeria and ICSHP, networking, practices of knowledge sharing and information dissemination through forums and conferences are a basic requirement for SHP development.

Public perception

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 development of the sector, as well as the implementation of policies designed to encourage that development, i.e. FITs, needs the backing of all its stakeholders in order to be successful. SHP should be promoted as a source of clean energy, an excellent replacement for wood-fuel for lighting, and ideal for electrification in suitable remote locations.

The impact of climate change

Climate change threatens the reliability of SHP, with experts from several countries citing erratic and unpredictable weather as a key barrier to development. One of the main advantages of SHP is the predictability of supply as opposed to other sources of renewable energy, such as solar or wind. Erratic water supplies can also lead to competition between small hydroplants and other sectors, most notably drinking water, leading to plants running less efficiently. Future assessments of SHP sites may need to start including assessments of how changing weather patterns may impact site efficiency and plan accordingly. In addition, better water management systems can help alleviate conflict between the different users of water resources. However, far from reducing the need for SHP, the impacts of climate change only highlight the desperate need for countries to adopt this and other forms of renewable energy as quickly as possible.

Recommendations

The following recommendations are aimed at the national, regional and international levels. They are provided as general recommendations and should not be considered as comprehensive.

National level

Resource assessment

1. Developing countries should undertake a detailed analysis of potential SHP resources in order to lower the cost for development and encourage private investment. Development funds, grant-making institutions and international NGOs should consider the possibility of supporting the costs of these studies.
2. Developed countries should similarly undertake detailed assessments of SHP potential while specifically considering new technological improvements, the conversion of existing waterways or conduits for generation, and the rehabilitation of old sites, which in some cases are applicable in developing countries as well.
3. In general, more hydrological data need to be collected over a longer period of time. In order to achieve this goal, technical equipment such as a network of prospective stations is required.
4. Existing feasibility studies of potential sites need to be reassessed due to the constant effect that hydrological and environmental changes have had on watersheds. Without this reassessment, many SHP developers are left with outdated studies that may not reflect the present conditions of selected SHP sites. New economic conditions, regulatory environments and technological improvements should also be considered.
5. Potential multi-purpose sites need to be identified to incorporate SHP into existing reservoirs and dams that were initially constructed as an irrigation system or for drinking water. These sites are often overlooked but can aid greatly in providing access to electricity and clean energy, both key elements of the SDGs.

6. Potential non-conventional sites based on technical innovation should be identified in order to determine whether existing infrastructure such as water channels with very low heads could serve as SHP sites.
16. Governments should also implement regulations on the use of waterways to avoid conflict between agriculture, fishery, electricity generators and biodiversity.

Policies and regulations

7. Suitably designed policies and financial incentives already established for other sources of renewable energy should be extended to cover SHP, with a particular emphasis on green technology and energy generation.
8. Countries should assess the impact of implementing different policy tools and financial incentives to encourage SHP development. These assessments should also give due consideration to the overall design of the policy and how costs are to be absorbed.
9. Special consideration should be given to FITs and governments should consider how international donors and climate finance instruments can contribute to the overall costs.
10. Governments should develop clear laws and regulations surrounding the rehabilitation of sites, most specifically laws on land ownership.
11. Government agencies should also streamline the development process by creating a one-stop shop for standardized permits and contracts.
12. Clear targets for SHP development should be implemented as a part of a broader target for renewable energy. This should include appropriate and well-defined pathways that will guarantee the achievement of these targets, which will assist countries to make their commitments for renewable energy targets. SHP can significantly increase the share of green energy generation.
13. In domestic policy, adhering to a unified, international definition of SHP would aid in policy harmonization and remove ambiguity in bilateral or transnational interactions in the SHP development process.
14. Renewable energy and SHP goals need to be aligned with competing goals from other sectors, most notably the water and environmental sectors.
15. There needs to be an improvement in collaboration among agencies responsible for water resources, environment and electricity. With this collaboration, there should also be a focus to avoid overlapped mandates and conflicting legislation while reducing the duration needed for approval/authorization processes.
17. Developing suitable water management systems will also aid in reducing resource conflict between the competing needs of the population.
18. Government agencies should also focus on introducing new environmental regulations that give consideration to SHP developers as significant stakeholders.
19. An improvement on timely land allocation by ensuring land records are clear and up-to-date will also aid in avoiding conflict over land rights/ownership and concessions/permits.

Financing

20. Investors often face financial risk when developing SHP projects. Therefore, there should be an overall strategy that reduces the investor's risk by developing new financial policies and streamlining existing regulation.
21. High initial costs also need to be overcome with easier/improved access in order for project developers to be able to successfully provide finance. One measure that can mitigate this is creating awareness of SHP among local banking institutions or microfinance institutions in order to improve the risk assessment and provide conducive loan conditions.

Equipment and technology

22. Local manufacturing capacity is often lacking in many countries. Therefore, building or improving industries that serve as components to SHP, such as the concrete supply industry and metal manufacturers, will aid in the overall production of SHP plants.
23. National import taxes can also hinder SHP equipment provision. A solution to this can be a simple introduction of lower tax rates for the import of SHP equipment. This will also overcome the deficit of SHP technology should the country not yet have an existing SHP sector.

Infrastructure

24. SHP developers often face obstacles when they deal with the national grid. Therefore, developing robust grids with suitable capacity and coverage to accommodate additional connections will make connecting SHP plants much easier in the future. Similarly, there should be regulations that lower the cost of connecting to the grid for developers.

25. In order to avoid high distribution losses and raise overall efficiency of SHP projects, there should be an investment match in distribution systems to those in generation.
26. In some cases where isolated off-grid systems are not preferred, SHP plants in remote areas are often not economically feasible because mini-grids or connections to the central grid need to be built. By improving the electricity network planning, the need for investment into grid infrastructure will also be identified. This will help to better inform the economic feasibility of potential sites.
3. International and regional agencies should also provide reports of the impact climate change has had on SHP efficiency throughout all the regions.
4. A development of regional networks and learning exchange programmes for policymakers will help identify the most suitable financial mechanisms. These mechanisms will be suitable for developing SHP in different socio-economic and political environments. This network can include a list of professional and mechanical workshops that will help satisfy local and regional equipment demand.

Skills and expertise

27. Local populations often lack the technical expertise for SHP projects. By increasing local capacities in conducting feasibility studies, construction, and operation and maintenance of SHP plants, the whole SHP sector can become more self-sufficient and long-lasting for countries.

Rural electrification

28. SHP is a great solution to increasing rural electrification, which brings access to clean and reliable energy to those populations and helps to reduce poverty, both of which are fundamental goals of the SDGs. However, there needs to be an improvement on the reporting of the impact of SHP on rural electrification by keeping track of on-grid and off-grid installed and potential SHP capacity.
29. The productive use of electricity from SHP plants in rural settings should also be better developed and thoroughly reported in order to share lessons learnt and improve inclusive sustainable industrial development.
30. A development and promotion of new business models for sustainable SHP development for rural electrification should also be mainstreamed both nationally and internationally.

International and regional level

1. Promoting SHP from international and regional institutions will be essential in mainstreaming SHP as a positive renewable energy. Therefore, international and regional agencies should focus on providing a detailed analysis on the effectiveness of FITs and other financial incentives on SHP development.
2. Global actors in the development of SHP should identify and promote the adoption of a universal definition of SHP, acceptable by international organizations and national stakeholders alike.
5. International and regional agencies should also raise general awareness of the benefits of SHP to reduce negative impressions that impact public and investor perceptions.
6. International and regional agencies should promote new SHP designs that take into account new environmental regulations that can render potential sites unviable.
7. International development funds, grant-making institutions and NGOs should consider how supporting the implementation of financial incentives or national and regional resource assessments can serve rural electrification and/or renewable energy development efforts.
8. Promotion of sustainable models for community financing and ownership of SHP projects can also take place at the regional and international levels.
9. A regional and international network of focal points (e.g. Ministry of Water Resources and/or Ministry of Energy) should be developed in order to connect relevant stakeholders within the region.
10. International and regional agencies can also alleviate the lack of SHP expertise by using existing international technical training resources to train experts in each region.
11. By developing South-South cooperation and triangular cooperation among developing countries, developed countries and international organizations, international and regional agencies will be able to facilitate the transition of individual pilot SHP projects towards the successful implementation of full-scale SHP programmes. The cooperation should also allow for technology transfer, capacity building and financing, with International Financial Institutions (IFIs) assisting to kick-start programmes and helping to overcome funding barriers for countries in need.
12. Lastly, coordination, collaboration and knowledge sharing among regional and international organizations that include small-scale hydropower in their scope of work should continue and be expanded.

Note: The following countries are not included in this Report –

Eastern Africa: Comoros, Eritrea, Mayotte, Seychelles and Somalia

Middle Africa: Chad

Northern Africa: Libya and Western Sahara

Western Africa: Cabo Verde, Guinea-Bissau, Mauritania, Niger and Saint Helena

Caribbean: Antigua and Barbuda, Bahamas, Barbados and Trinidad and Tobago

Northern America: Bermuda, Saint Pierre and Miquelon

South America: The Falkland Islands (Malvinas), Suriname and Venezuela

Southern Asia: Maldives

South-Eastern Asia: Brunei and Singapore

Western Asia: Bahrain, Cyprus, Israel, Kuwait, Omar, Qatar, State of Palestine, United Arab Emirates and Yemen

Southern Europe: Andorra, Gibraltar, Holy See, Malta and San Marino

Western Europe: Liechtenstein and Monaco

Technical Notes and Abbreviations

The findings of the *World Small Hydropower Development Report 2016* were arrived at by totalling data from a wide range of sources. Methodologies vary greatly from source to source, with an inevitable compromise of data integrity to varying degrees. One obvious issue is the lack of a universally agreed definition for small hydropower. While some countries define their small hydropower plants with a capacity of up to 1 MW, others include plants with capacities up to 30 MW or 50 MW. Nonetheless, a widely accepted definition of small hydropower is of plants up to 10 MW and, where possible, data have been provided according to this definition and care has been taken to indicate differing definitions within individual country reports.

An additional issue arises from the varying accuracy and specificity of estimated potential figures. For many countries, accurate assessments of potential capacity are difficult to establish. While care has been taken to provide the most accurate data, it should be noted that the information presented has been derived from various sources that are often unclear as to whether the estimate is theoretical, technical or economically feasible. Furthermore, not all countries have been able to identify their small hydropower potential and, in some cases, planned small hydropower projects have been reported instead. In other cases, data on potential were completely unavailable and already developed capacity was used to indicate the minimal available potential. Thus some countries would have been misrepresented to appear as having fully developed small hydropower resources. Where this occurs, care has been taken to make it clearer. However, it should be highlighted that despite the limitation on data, it is likely there is some level of small hydropower potential remaining in these countries.

When comparing data with the *World Small Hydropower Development Report 2013*, increases and decreases in installed capacity and estimated potential are, on occasion, due to the use of different or more accurate studies, and as such do not always reflect actual changes in small hydropower development. In other cases, plant improvements have led to higher capacities that moved individual plants above the 10 MW threshold and are therefore no longer included in the small hydropower figures. In general, however, differences between the Reports should be considered reflective of a growing degree of accuracy as much as they are an indication of additional small hydropower capacity or potential.

This Report covers 160 countries. Countries that were not included were those that had no known installed small hydropower capacity, potential or for which the data were inaccessible to the point that precludes a full country report. Countries adhered to the geographical regions and composition defined by the United Nations Statistics Division. Melanesia, Micronesia and Polynesia do not contain many countries or territories that use small hydropower and were therefore combined under the regional heading of 'Pacific Island Countries and Territories (PICT)'. This report was compiled for both 'countries' and 'territories'. Overseas territories have been included in the continent where they are geographically located following the online M49 list of the United Nations Statistics Division. Countries that are not part of the United Nations were not considered in this Report. In some cases, the terms 'country' and 'territory' may be used interchangeably. This does not imply an opinion on the legal status of any country or territory.

List of abbreviations

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

Technical abbreviations

| | | | |
|-----|------------------|-------------------|------------------------|
| Hz | Hertz | MW | Megawatt |
| kW | Kilowatt | Rpm | Rate per minute |
| kWh | Kilowatt hour | m ³ /s | Cubic metre per second |
| GWh | Gigawatt hour | kWp | Kilowatt peak |
| l/s | litre/second | CO ₂ | Carbon dioxide |
| MVA | Mega Volt Ampere | | |

Contributing Organizations



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