International Renewable Energy Agency

Small Island Developing States at a Crossroads:

THE SOCIO-ECONOMICS OF TRANSITIONING TO RENEWABLES

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IKI INTERNATIONAL CLIMATE INITIATIVE

CONTENTS

FIGURES

BOXES

TABLES

ABBREVIATIONS

AIS	Atlantic, Indian Ocean and South China Sea
EVs	electric vehicles
GW	gigawatt
IRENA	International Renewable Energy Agency
MW	megawatt
NDCs	Nationally Determined Contributions
O&M	operations and maintenance
PV	photovoltaics
SIDS	Small Island Developing States

ABOUT IRENA'S *SMALL ISLAND STATES AT A CROSSROADS* SERIES

Small island developing states (SIDS) account for less than 1% of global greenhouse gas emissions, yet they are home to some of the world's most climate-vulnerable populations. Sea level rise and extreme weather extremes may render some of these territories uninhabitable by the end of the century unless urgent action is taken to mitigate global heating. This makes SIDS important climate action ambassadors.

Renewable energy offers vast opportunities for SIDS. Its deployment will be instrumental in building sustainable energy systems and opening socio-economic opportunities in these special geographic contexts. Those opportunities include energy security, climate resilience, economic development and energy access. Renewables translate directly into better quality of life and services, with an environmental footprint smaller than that of fossil fuels. They also fit well within the socio-cultural context of SIDS, whose populations' welfare is closely tied to the health of the land and the oceans that surround them. All of these benefits can unfold if the right technical, capacity and financial support is provided.

The *Small island developing states at a crossroads* series focuses on the present and potential socio-economic and environmental benefits, barriers and opportunities of the transition to renewables in SIDS. **Volume I: The socio-economics of transitioning to renewables** focuses on contexts that are largely electrified, relying heavily on imported fossil fuels, while **Volume II: Towards equitable energy access in the least-electrified countries** features contexts having significant unelectrified populations and the opportunity to leapfrog to renewables-based energy access.

KEY FINDINGS

Small island developing states (SIDS) comprise more than 30 countries with a large variety of income and development ranges; yet they share characteristics that affect their environment and socio-economic context: geographic remoteness, susceptibility to natural disasters and the effects of climate change, and high levels of dependence on imported fossil fuels. Many SIDS have achieved near-universal access to electricity (the focus of this report), although its quality, reliability and affordability differ markedly.

Renewable energy technologies (solar, wind, geothermal, and hydroelectric power, deployed at various scales) hold substantial promise for SIDS. Beyond emissions reductions and climate mitigation, they are clean, cost-effective sources of energy that make energy systems more resilient in the face of extreme weather events and other disruptions. Renewables like solar photovoltaics (PV) are scalable and highly adaptable to the specific geographies of SIDS, with both grid-based and decentralised applications. They also allow countries to lower their dependence on costly fuel imports. Even though SIDS cannot expect to become manufacturers of renewable energy equipment, the deployment of renewable energy has the potential to create jobs in construction and installation, operation and maintenance, and productive uses.

To implement their Nationally Determined Contributions (NDCs), a growing number of SIDS are adopting targets and policies to incorporate substantial amounts of renewable energy into their electricity supply mix. Applications include not only residential electricity supply, but also the use of renewables for energy generation in agriculture, fisheries, and maritime transport.

SIDS will require greater financial and human resources to implement renewable energy systematically in the coming decade. Governments, the private sector and development finance institutions should thus prioritise arrangements for sustainable finance, facilitate technology transfer, and take steps to build institutional capacity and develop local skills. Equipped with adequate resources, SIDS can achieve high shares of renewable energy in the energy mix, thereby promoting climate action while exploiting the socio-economic benefits of renewable energy.

1. INTRODUCTION

Small island developing states (SIDS) are on the front line of climate change. Despite accounting for less than 1% of global greenhouse gas emissions, they are exceptionally exposed to rising sea levels and extreme weather events, linking many SIDS' habitability by the end of the century to effective global climate action (IPCC, 2022). SIDS can be categorised by geographic regions and development levels. They are typically discussed as three distinct regions: the geographically disparate group of AIS countries (Atlantic, Indian Ocean and South China Sea) and the more contiguous Caribbean and Pacific SIDS. Table 1 lists the SIDS covered in this report.

Table 1 Selected SIDS covered in this brief,[1] by geographic group and income level, 2022

	ATLANTIC, INDIAN OCEAN AND SOUTH CHINA SEA	CARIBBEAN	PACIFIC
Low-income countries	Guinea-Bissau	—	—
Lower middle-income countries	Cabo Verde, Comoros (the), São Tomé and Principe	Haiti	Kiribati, Papua New Guinea, Samoa, Solomon Islands, Timor-Leste, Vanuatu
Upper-middle-income countries	Maldives, Mauritius	Belize, Cuba, Dominica, Dominican Republic, Grenada, Jamaica, Montserrat,[a] Saint Lucia, Saint Vincent and the Grenadines, Suriname	Marshall Islands, Niue,[a] Palau, Tonga, Tuvalu
High-income countries	—	Guyana	Nauru

Based on: (World Bank, 2024a).
[a] Not income-categorised by World Bank.

The overwhelming majority of SIDS, some 90%, are located in tropical areas where they are at high risk of extreme weather events, which often have a significant impact on economies and people's well-being (UNOPS, 2020). This vulnerability makes SIDS' voices crucial in international negotiations, notably the processes of the United Nations Framework Convention on Climate Change and the summit meetings of its Conference of Parties. Indeed, as frontline states they have been instrumental in pushing for ambitious climate action, emphasising the need to reduce carbon emissions and to marshal the financial and technical support needed for transitioning to a more sustainable energy system.

[1] *In this study, SIDS highlighted in the report were prioritised based on eligibility criteria from Official Development Assistance (ODA) lists. Preference was given to SIDS actively involved in initiatives like the Lighthouses Initiative and affiliated with the International Renewable Energy Agency (IRENA). To showcase practical examples and best practices, SIDS meeting these criteria were favoured. However, acknowledging data challenges, we extended analysis to include other SIDS. This inclusive approach ensures a comprehensive examination of energy landscapes in SIDS, enriching our findings for a nuanced understanding.*

But SIDS are not only a crucial voice for effective global climate action, they are also agents of change within their own regions, with the potential to demonstrate how renewable energy can help support a just transition in small developing countries. Many SIDS have increasingly ambitious targets for the deployment of modern renewable energy to replace fossil fuels, targets that are expressed in their NDCs (IRENA, 2023a, 2022a). The Solomon Islands, Vanuatu (in the Pacific) and Antigua and Barbuda (in the Caribbean) have made plans to generate 100% of their electricity from renewable resources by the year 2030 (IRENA, 2021a; Solomon Islands Government, 2022). Mauritius is targeting a 60% renewables share in its energy mix by the same year (Mauritius Ministry of Energy and Public Utilities, 2022).

While most SIDS rely overwhelmingly on imported fossil fuels,[2] they have immense potential for renewable energy which, in view of their small markets and ample renewable resources, puts them in a position to replace fossil fuels while increasing the supply of electricity. Besides solar energy, which is plentiful, some SIDS are exposed to windward coasts, making many of them suitable for wind power applications (Zahari *et al.*, 2018). Many SIDS from the AIS, Caribbean and Pacific regions also have good potential for geothermal energy (Tawake, 2017; UNOPS, 2020). Other solutions include biogas based on agricultural waste, and ocean-based technologies – such as ocean thermal energy conversion and wave and tidal energy (IRENA, 2023a). The solar, wind, and hydropower resource potential in the SIDS regions is briefly discussed in chapter 3.

Renewable energy technologies offer many benefits to SIDS, beyond emissions reductions and climate mitigation. First, they represent clean, cost-effective sources of energy that are readily adaptable to the specific geographies of SIDS. Second, they can be used both for grid-based and decentralised energy production, the latter being important for expanding access to electricity. Third, they can substantially lower dependence on fuel imports, a particularly important factor for many SIDS given their own narrow resource base. Fourth, they confer large environmental and health benefits, which are significant given the importance the natural environment plays for people and their welfare in SIDS. Fifth, they have the potential to create new jobs and to make energy systems more resilient in the face of the increased occurrence of extreme weather events. Finally, the wide range of technology options available enables various forms of renewable energy to be used in combination, enhancing energy security.

This brief is the first of a two-part series focused on the role, opportunities and challenges of increasing renewable energy deployment in SIDS. This brief focuses on grid-based electricity generated from renewable sources; the second examines decentralised applications. **Chapter 2** of this brief is an overview of the features of grid-based electricity systems in SIDS. **Chapter 3** explores the socio-economic benefits of renewable energy (particularly job creation) along the value chain. **Chapter 4** studies end-user benefits, while **Chapter 5** outlines policy priorities to help accelerate grid-linked renewable energy deployment. **Chapter 6** concludes with an outlook.

[2] *As of 2024 small number of SIDS produce fossil fuels: Belize, Cuba, Guyana, Jamaica, Papua New Guinea, and Suriname. Most produce small volumes of oil and/or natural gas, still requiring imports. Based on data from (EIA, 2024).*

2. FEATURES OF GRID-BASED ELECTRICITY SYSTEMS IN SIDS

SIDS present special challenges and opportunities for electricity access and infrastructure development related to countries' small size, remoteness, and vulnerability to environmental threats (UNOPS, 2020). Demand for electricity is rising in SIDS, pushed up by economic development, higher personal incomes, improved living standards, and growing electrification of end uses in line with SIDS' objectives for the decarbonisation of their economies under the Paris Agreement (UNDP, 2022a). Choosing renewable energy to help expand grid-based electricity supply fits well with these objectives and could have many benefits for SIDS beyond climate mitigation.

This section presents some of the main opportunities of grid-based renewable energy in SIDS: electricity access (§2.1), import dependence and affordability (§2.2), energy security (§2.3), environmental and welfare benefits (§2.4), and job creation (§2.5). The intermittent nature of some sources of renewable electricity can be addressed by energy storage, and by combining renewable sources in complementary way. The challenge of intermittency is faced by many countries, but the often unpredictable and extreme weather conditions common to SIDS heighten the importance of electricity system reliability.

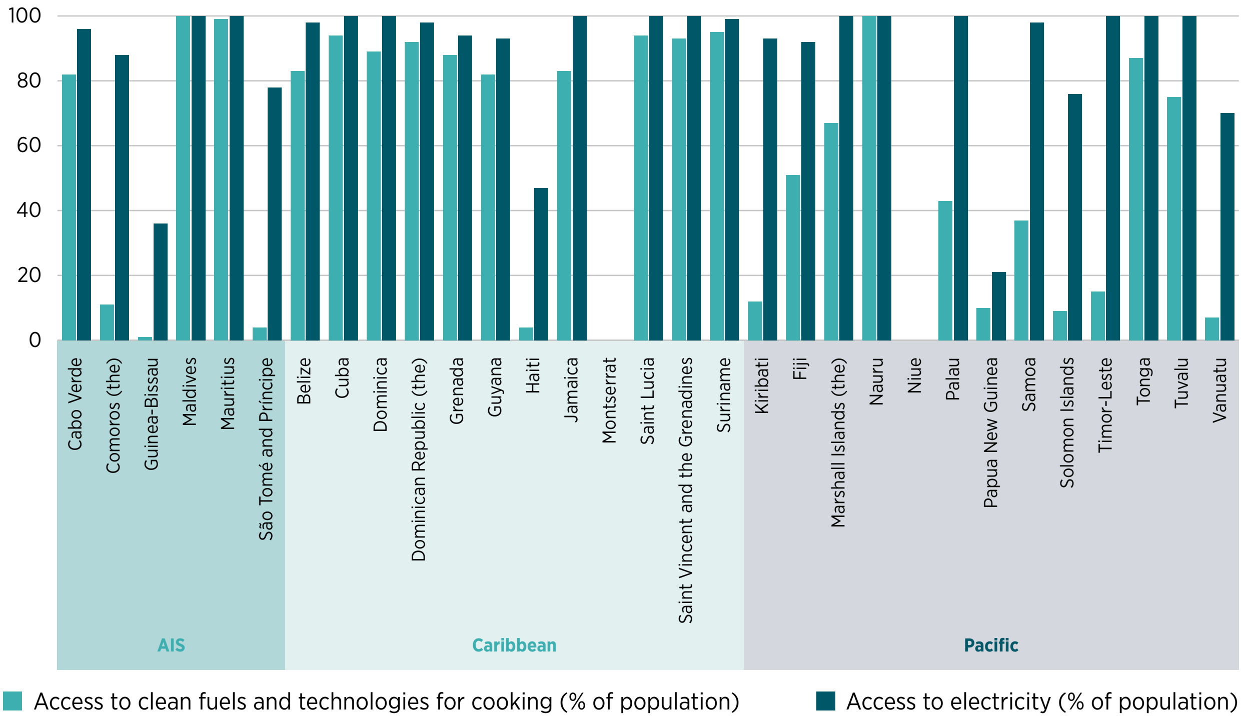
2.1 ELECTRICITY ACCESS

Although SIDS have achieved fairly high levels of electricity access compared with other developing countries, access is far from universal. About two-thirds of SIDS are archipelagos that together include hundreds of islands. Because of their remoteness and lack of economies of scale, it is often difficult to achieve universal access to electricity on these chains and clusters of islands. As a consequence, access is only partial in many SIDS, which must rely on diesel generators in many remote locations (UNOPS, 2020; World Bank, 2024b). Renewable energy holds great potential to help SIDS expand access, both by increasing electricity supply at competitive cost and through the installation of decentralised systems – for example, solar arrays coupled with a storage system (IRENA, 2023g).

As of 2021, 28% of SIDS' total population – 16 million people – had no access to electricity, and almost half of SIDS' total population – over 28 million people – had no access to clean cooking fuels (World Bank, 2024b) (Figure 1). Caribbean SIDS (with the exception of Haiti) are better off than the AIS grouping, with over 80% of their populations having access to electricity (IEA *et al.*, 2023; Surroop *et al.*, 2018; UNOPS, 2020; World Bank, 2024b). Lack of electricity access reinforces poverty, and affects women and girls particularly, who often bear the responsibility of collecting biomass fuels such as wood to meet household energy needs (UN Women, 2018).

In addition, the quality and stability of electricity access differ considerably across islands and among user groups (IRENA, 2017; ESMAP, 2023).

Figure 1 Energy access rates in SIDS, 2021



Source: (World Bank, 2024b).

2.2 IMPORT DEPENDENCE AND AFFORDABILITY

Electricity supply in SIDS typically relies on imported fossil fuels, particularly diesel, which is expensive and unaffordable for many, especially in rural areas. Three-quarters of SIDS' electricity mix is made up of fossil fuels (Atteridge and Savvidou, 2019; IRENA, 2023b, 2020; Mead, 2021). This not only makes them vulnerable to fluctuations in global oil prices, but, combined with transport costs to remote locations, makes fuel imports and cost of energy services in SIDS among the highest in the world (UNOPS, 2020). Imports absorb a significant percentage of public budgets and foreign currency reserves, increasing SIDS' dependence on overseas development assistance and exacerbating their indebtedness (Atteridge and Savvidou, 2019; UNOPS, 2020). Reducing fossil fuel dependence through a transition to an energy system centred on renewables can free up financial resources, allowing SIDS to address pressing climate adaptation and resilience needs.

Renewable energy technologies could help SIDS expand electricity generation while saving costs. Even back in the mid-2010s – when technology costs for renewable energy were still far higher than today – a study suggested that a switch to renewables could save SIDS 3.3% of their annual gross domestic product, and up to 30% in the less-developed countries (Blechinger *et al.*, 2016). This conclusion covers grid-based electricity generation as well as electricity generated from diesel generators, as shown in the case of Fiji, for example (Prasad *et al.*, 2017). A study of a 25.5 megawatt (MW) wind farm in Cabo Verde found that renewables allowed the country to cut annual oil imports by 12% (17 million litres costing more than EUR 10 million), while also providing more reliable electricity supply than before (Finnfund, 2015).

While renewable energy solutions are often more expensive up front, over time they offer savings compared to fossil fuels because they do not require a continuous fuel supply (IRENA, 2021c). In principle, these savings can be recycled within the domestic economy, rather than being spent on imports, offering economic benefits in other sectors of the economy. In addition, reducing import dependence makes countries less vulnerable to market price fluctuations, providing greater economic stability.

2.3 ENERGY SECURITY

Partly because it lowers costs and reduces vulnerability to cost swings of imported fuel supplies, renewable energy contributes to energy security. With few exceptions (such as Trinidad and Tobago, Suriname and Guyana, which produce and export oil and gas), most SIDS are almost entirely dependent on fossil fuel imports for their energy needs (IRENA, 2017b). The Caribbean region as a whole spends some 40% of its foreign exchange reserves on imported fuels (NGC, 2022). Not only are SIDS exposed to fluctuating world market prices and geopolitical factors, they are vulnerable to supply disruptions, affecting the stability of their electricity systems. The Dominican Republic, Haiti, Cuba and many Pacific islands, for instance, experience regular power outages due to fuel shortages, with significant negative impacts on daily life, health systems and economic activity (DDC, 2024; Reuters, 2023; UNICEF, 2021; World Bank, 2023a).

By contrast, renewable energy is a domestic energy source that does not require ongoing fuel imports once the generating equipment (*e.g.* solar panels) is installed. While the initial cost of installing renewable energy is higher than that of fossil fuel-based power plants, renewable energy is typically cost-effective in the medium- and long-term. For remote SIDS in particular, reductions in import dependence are critical arguments in favour of renewable energy (Atteridge and Savvidou, 2019; IRENA, 2023c). By tapping into local renewable sources, these islands can establish a stable and independent energy supply, vital for economic and energy security in the face of global market shifts.

In addition, renewable energy systems can be more resilient to extreme weather events, further bolstering energy security (IRENA, 2023a). Many SIDS experience frequent cyclones, hurricanes, floods and droughts, and some experience volcanic eruptions. These events affect power lines, power plants, but also seaports, preventing ship docking and impeding the import of needed fuels (Locke, 2017). For example, damage to power plants in the British Virgin Islands from Hurricane Irma led to a loss of generation capacity, plunging the country into darkness that lasted six months in certain communities (Malo, 2018; Ministry of Communications and Works, Government of the Virgin Islands, 2017). Noteworthy examples of grid impacts are Hurricane Maria in Dominica and Hurricane Dorian in the Bahamas.

Many solar panel systems can be designed to successfully resist shocks from hurricanes (Jordan *et al.*, 2021; NREL, 2022). In Antigua, climate adaptation measures were incorporated in the design, mounting and structuring of solar power racking systems and panels, allowing them to withstand the 275 km/hour winds brought about by Hurricane Irma (Newenergyadmin, 2017; Energetica India, 2017). Geothermal installations are also highly resilient against extreme weather events (Mustapa *et al.*, 2017).

2.4 ENVIRONMENTAL BENEFITS AND WELFARE

Renewable energy has many environmental benefits. Sustainable environmental management is key to the economic, social and cultural welfare of SIDS' populations, given that their cultural history, identity, and modern-day socio-economic development are closely linked to their natural environment. This includes SIDS' overwhelmingly nature-linked industries, including fisheries, agriculture and tourism. (UNEP, 2007, 2014; United Nations, 1992). Many SIDS populations self-identify as Indigenous Peoples, for whom the health of their environment is paramount to their own health and wellbeing (Techera, 2010; UNEP, n.d.; UNESCO, 2022; United Nations, 2023). This makes environmental policy critical to the welfare of people and the economy in SIDS, and renewable energy can fit well into this context.

While no energy system or infrastructure development is without environmental impacts, renewable energy can avoid many of the negative effects of fossil fuels, including scarring of the landscape from extractive activities, indoor and ambient air pollution from fuel burning, water pollution, and noise pollution, in addition to their carbon footprint. By reducing indoor air pollution, renewable energy can also be an important contributor to public health, particularly of women and children, who are disproportionally affected by indoor smoke (UNOPS, 2020). At the same time, it is also important to anticipate and mitigate possible negative environmental impacts from renewable energy deployment, in particular those related to high impact-activities such as building roads and dams, as well as mining activities (UNEP, 2014).

Renewable energy can viably be embedded in policies to ensure energy security while protecting the environment – a powerful political message in countries that are as highly dependent on their environment as they are vulnerable to climate change. The tourism sector illustrates that this message can also go hand in hand with business creation and economic security, such as in the Pacific Tourism Organisation's sustainable tourism framework (see Box 1) (Harrison, 2023). Renewable energy and sustainable "eco-tourism" can be important selling points for SIDS as tourist destinations. In agriculture and fisheries, too, clean electricity can be a useful tool to help the sector become more sustainable, safeguarding market access and incomes.

Box 1 Renewable energy and sustainable tourism initiatives in SIDS

A growing number of SIDS across geographic regions have sustainable tourism strategies, often including renewable energy. For instance, the Pacific Tourism Organisation, a 21-country industry group, has developed a sustainable tourism framework and destination standards containing guidelines on a range of topics, from reducing plastic to energy use and cultural preservation.

In **Fiji**, 15 small- and medium-sized entities are investing in sustainable tourism initiatives as part of the Duavata sustainable tourism collective. For instance, Nukubati Island Resort meets its own energy demand solely through clean energy supplied by 300 solar panels and 4 wind power generators (Nukubati, 2022; UNDP accelerator labs Fiji, 2022). The resort is partnering with nearby communities as well, strengthening local energy co-operation. Recently, the resort has begun to explore the use of green hydrogen for off-grid use (German-New Zealand Chamber of Commerce, 2023). Such practices align with the Fijian government's movement to promote sustainable tourism in the country by adopting the standards of the Global Sustainable Tourism Council (Tuuhia and Harrison, 2023). Fiji is also working on a national sustainable tourism framework to guide the country's tourism sector for the next 10 years. The framework will embed renewable energy in the tourism sector. For example, one of its indicators is "percentage of tourism accommodation businesses using renewable energy" (Ministry of Tourism and Civil Aviation, 2023, n.a.; Ministry of Trade, Co-operatives, Small and Medium Enterprises, n.d.).

In **Saint Kitts and Nevis**, multiple clean energy sources, including geothermal systems, are powering up the Sunset Reef Saint Kitts Resort and strengthening the local grid by funnelling surplus electricity generated from renewable sources to the grid. An integrated energy storage system is now used to support the local community in extreme weather situations. Moving away from fossil fuel generators has brought benefits like less pollution and reduced electricity bills to the resort and the surrounding areas (CS Global Partners, 2024; Surface Energy Solutions, n.a).

2.5 JOB CREATION

Globally, renewable energy employs 13.7 million people (IRENA and ILO, 2023). Given the small size of SIDS populations and economies, the number of jobs that can be expected to be created in these countries will be a small fraction of the global total, but nonetheless significant in the domestic context. In the course of meeting NDCs in wind and solar PV, renewable energy jobs in SIDS could more than double by 2030 (see Box 2). The potential is especially great in the areas of planning, designing, installation and maintenance of renewable energy deployment (see Section 3), in addition to jobs created by non-energy industries that benefit from more reliable and cleaner electricity supply.

Box 2 Renewable energy jobs in SIDS

As they progress towards their Nationally Determined Contributions, SIDS are poised for significant employment growth in wind and solar PV, which could lead to the addition of as much as 13 gigawatts (GW) of renewable energy capacity by 2030 (Rana and Abou Ali, 2022). Combined job numbers in solar PV and wind could expand from just over 6 000 in 2022 to over 16 000 by 2030. Job creation in solar PV is forecasted to grow much faster than for onshore wind. This growth is largely attributed to the targets set for the solar PV sector, which is expected to generate more than 90% of renewable energy employment by 2030.

The Caribbean region stands out for having the highest absolute number of jobs In both technologies. But both the AIS region and the Pacific are on track to see considerable growth, starting from a low base but making significant strides by 2030. **Mauritius**, the **Dominican Republic**, and **Papua New Guinea** are set to emerge as regional leaders in renewable energy employment, with projections indicating that Mauritius could have around 2 600 jobs in the AIS region; the Dominican Republic, approximately 5 500 jobs in the Caribbean; and Papua New Guinea, an estimated 2 550 jobs in the Pacific.

Table 2 Estimated growth in onshore wind and solar PV jobs in SIDS under Nationally Determined Contributions

	ONSHORE WIND		SOLAR PV		WIND AND SOLAR PV	
	2022	2030	2022	2030	2022	2030
Atlantic, Indian Ocean and South China Sea	24	192	466	3 619	490	3 811
Caribbean	718	994	4 534	7 983	5 252	8 977
Pacific	9	51	253	3 254	262	3 305
Total	**751**	**1 237**	**5 253**	**14 856**	**6 004**	**16 093**

Note: Renewable energy employment data (employment factors) based on local and international data were used to estimate the jobs in the AIS, Caribbean, and Pacific regions. AIS includes Cabo Verde, Comoros, Guinea-Bissau, Maldives, Mauritius, São Tomé, and Seychelles. Caribbean SIDS include Antigua and Barbuda, Barbados, Bahamas, Barbados, Belize, Cuba, Dominica, Dominican Republic, Grenada, Guyana, Haiti, Jamaica, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, and Trinidad and Tobago. Pacific SIDS include Cook Islands, Fiji, Kiribati, Marshall Islands, Federated States of Micronesia, Nauru, Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Timor-Leste, Tonga, Tuvalu, and Vanuatu.

Unlike larger and less remote countries, SIDS are not expected to become large manufacturers of value chain components. But there is potential for some local manufacturing or assembly of components, for instance in the case of hydroelectric projects, as discussed further on. A 2022 report found that "drawing upon the local technical expertise, strong business environment and low costs of production, Trinidad and Tobago could seek to become an attractive destination for solar PV manufacturing", satisfying the demand for panels in 15 Caribbean territories (NGC, 2022).

For SIDS, this also means that training and (re-)skilling of local labour is particularly critical to the success of renewable energy technologies. As end uses such as transport or fisheries are electrified, knowledge-transfer and training will be needed for local engineers and technicians to ensure that installed generating capacities can be properly maintained or repaired. Easy access to spare parts is also critical. The good news is that most of the skills required for renewable energy are easily transferred and can create new opportunities for residents of SIDS. In the context of more sustainable development of SIDS, opening up new engineering and non-engineering jobs – such as sustainable urban and rural planning, urban design, and reform of local agriculture and fishery industries – can offer skilled jobs to young citizens and to more women, thus increasing inclusion and preventing brain-drain.

3. SOCIO-ECONOMIC OPPORTUNITIES AND BARRIERS ALONG THE RENEWABLE ENERGY VALUE CHAIN

SIDS have a wealth of renewable energy resources at their disposal to be deployed at a scale large enough to generate high shares of grid-based electricity. In 2022, SIDS had around 7.6 GW of renewable energy installed, of which the countries included in this report (see Box 3) had 4.55 GW (IRENA, 2023b). The resource potential paired with the individual geography of each SID determines which technologies are most suited for large-scale deployment, with important limitations remaining for countries with remote islands that cannot be economically connected to a grid. Solutions for the latter problem are offered in the second brief in this series, but this section focuses on technologies suitable for use with grid-based electricity, including via local or island-based mini-grids. This section looks into four technologies, with a special focus on local job creation potential and skills needs: solar PV (§3.1), hydropower (§3.2), wind energy (§3.3) and geothermal (§3.4).

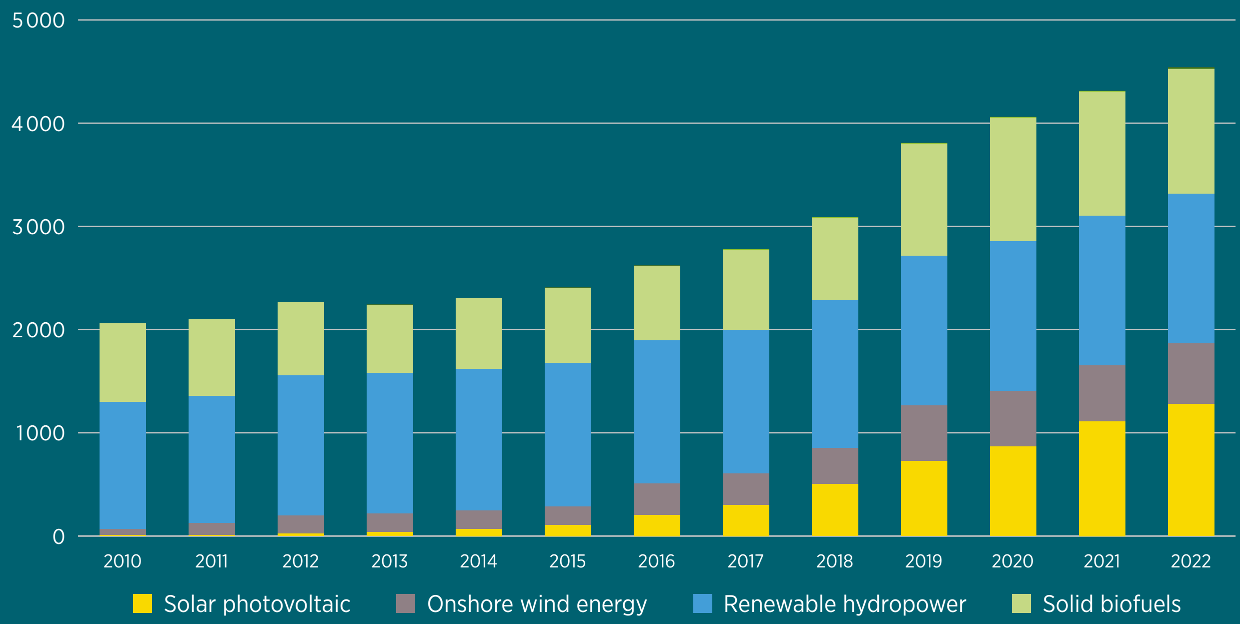
Box 3 Renewable energy deployment in Small Island Developing States

SIDS are forging ahead with the deployment of renewable energy. Combined installed generating capacity has more than doubled over the past decade from about 2 GW in 2010 to over 4.55 GW in 2022 (see Figure 2). IRENA data indicates that solar PV expanded most quickly, to almost 1.3 GW, accounting for 28% of SIDS' total installed grid-based renewable energy capacity in 2022. Hydropower grew more slowly during this period but remains the most important source of renewable energy in SIDS (with around 1.45 GW), accounting for 32% of the total in 2022. Wind power grew tenfold to almost 600 MW by 2022, from just over 60 MW in 2010. While the share of bioenergy has declined as a result of more solar and wind development, solid biomass increased from 760 MW in 2010 to over 1.2 GW by 2022, reflecting the fact that it is based on diverse, widely available resources in island economies.

Figure 3 contrasts the mix of renewables between 2010 and 2022, highlighting the emergence of solar PV as a major factor in the expansion of installed capacities. Having remained more static, hydropower's share declined considerably during this period, as did that of solid biofuels.

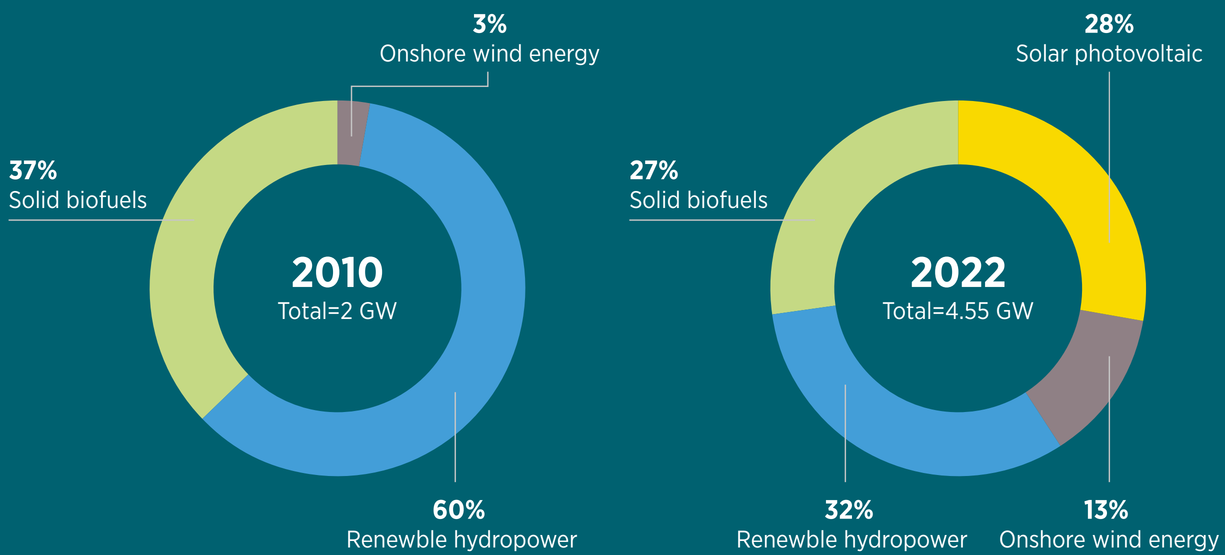
As of 2022, renewable energy accounted for around 24% of grid-based electricity generation capacity in SIDS, a share that has been growing over the past decade, though with large differences between countries (IRENA, 2022b). Hydropower is an important renewable energy source for some SIDS, but is not predominant overall. Whereas hydropower accounted for around 8% of the SIDS' total installed electricity generation capacity in 2022, solar PV accounted for 7% – and much more in some, including over 20% in **Kiribati, Niue, Samoa, Tonga** and **Tuvalu** (IRENA, 2022b). **Cabo Verde, Cuba, Fiji, Jamaica, Mauritius, Samoa, Tonga** and **Vanuatu** also have onshore wind power. Several SIDS, including **Cuba, Fiji** and **Mauritius** have solid biomass plants.

Figure 2 Installed renewable energy generation capacity (on-grid) in SIDS, 2010-2022 (MW)



Source: (IRENA, 2023b).
Note: Countries included are American Samoa, Belize, Cabo Verde, Comoros, Cuba, Dominica, Dominican Republic, Fiji, Grenada, Guinea-Bissau, Guyana, Haiti, Jamaica, Kiribati, Maldives, Marshall Islands, Mauritius, Federated States of Micronesia, Montserrat, Nauru, Niue, Palau, Papua New Guinea, Saint Lucia, Saint Vincent and Grenadines, Samoa, São Tomé and Principe, Solomon Islands, Suriname, Timor-Leste, Tonga, Tuvalu, Vanuatu.

Figure 3 Installed renewable energy generation capacity by technology (on-grid) in SIDS, 2010 and 2022 (% of total renewable energy installed)



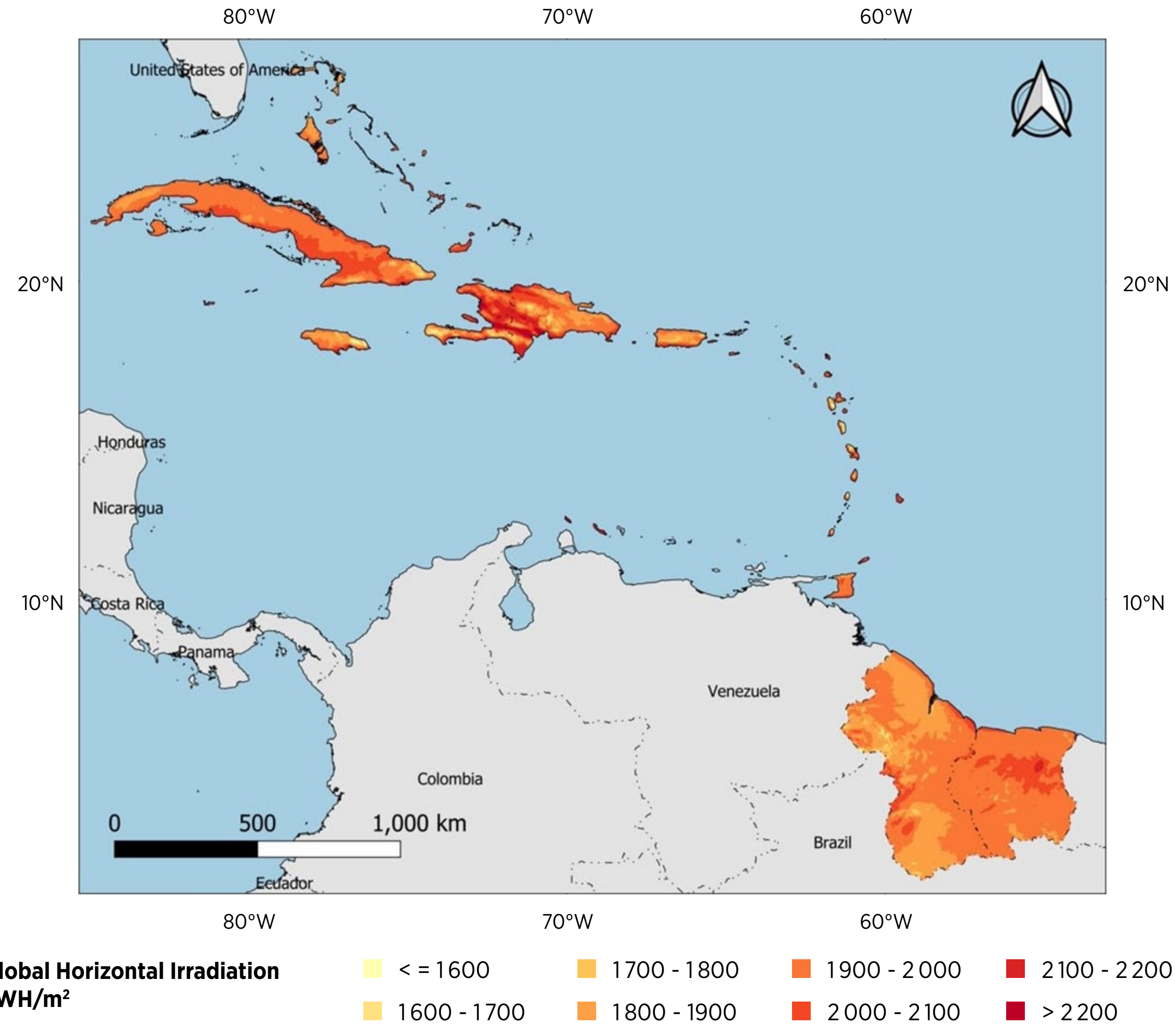
Source: (IRENA, 2023b).

3.1 SOLAR PV

Solar PV is the most utilised source of renewable energy generation in SIDS after hydropower, and, for many SIDS, it is the most important renewable technology of all (IRENA, 2022b). The modular nature of solar PV installations is a key advantage. Solar PV systems can be deployed at different scales, flexibly and incrementally, in stand-alone and mini-grid assemblies, and can thus be tailored to local needs and budgets. This is especially important in the SIDS context, where limited land space and financial resources often necessitate a more gradual approach to energy infrastructure development.

The Caribbean SIDS have good solar potential characterised by an annual global horizontal irradiation of between 1342 kWh/m^2 (kilowatt hours per square metre) and 2268 kWh/m^2, with an average value of 1946 kWh/m^2 (Figure 4). The maximum development potential for solar PV is estimated at 71.8 GW, considering an installation density of 50 MW/km^2 (megawatts per square kilometre), maximum concentration capacities of 5000 MW and a land utilisation factor of 50% (IRENA, 2024a). The installed capacity was 2.137 GW in 2022 (IRENA, 2023d).

Figure 4 Average annual global horizontal irradiation in the Caribbean region



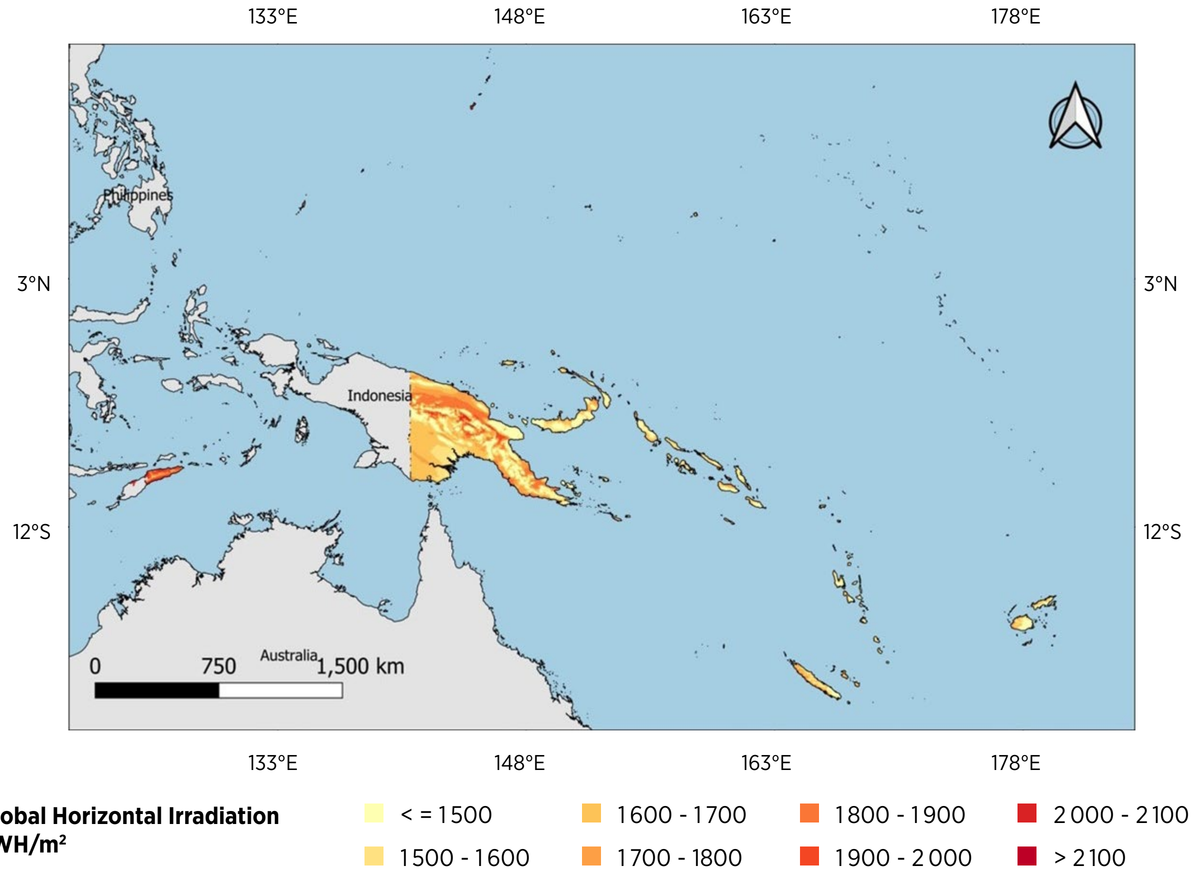
Source: Global Solar Atlas (ESMAP, 2019).

Note: kWh/m^2 = kilowatt hours per square metre. Maps are also available from the IRENA Global Atlas for Renewable Energy.

Disclaimer: This map, which uses UN boundaries, is provided for illustration purposes only. The boundaries shown do not imply endorsement or acceptance by IRENA.

The Pacific SIDS have moderate solar potential, with an annual global horizontal irradiation ranging from 907 kWh/m² to 2 430 kWh/m² and an average value of 1 639 kWh/m² (Figure 5). The maximum development potential for solar PV is estimated at about 17.5 GW, considering an installation density of 50 MW/km², maximum concentration capacities of 5 000 MW and a land utilisation factor of 50% (IRENA, 2024a). The installed capacity was 0.361 GW in 2022 (IRENA, 2023d).

Figure 5 Average annual global horizontal irradiation in the Pacific region



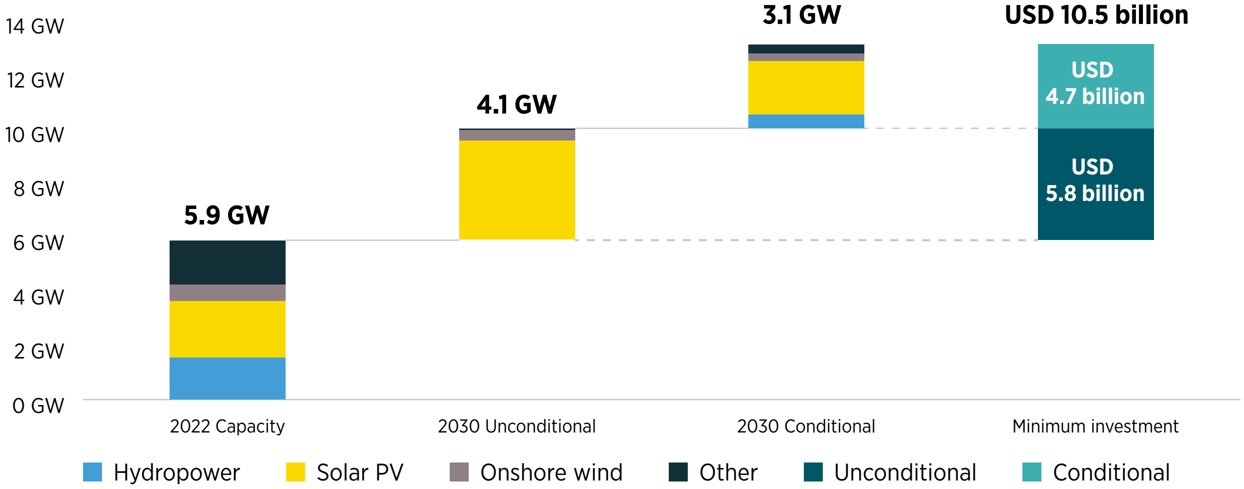
Source: Global Solar Atlas (ESMAP, 2019).
Note: kWh/m² = kilowatt hours per square metre.Maps are also available from the IRENA Global Atlas for Renewable Energy.
Disclaimer: This map, which uses UN boundaries, is provided for illustration purposes only. The boundaries shown do not imply endorsement or acceptance by IRENA.

The AIS countries have good solar potential. Annual global horizontal irradiation ranges from 1 298 kWh/m² to 2 285 kWh/m², with an average value of 2 008 kWh/m². The maximum development potential for solar PV is estimated to about 2.3 GW, considering an installation density of 50 MW/km², maximum concentration capacities of 5 000 MW, and a land utilisation factor of 50% (IRENA, 2024a). The installed capacity was 0.748 GW in 2022 (IRENA, 2023d). No map is provided given the scattered location of AIS countries.

The NDC submissions of SIDS indicate that solar will likely continue to be the major renewable electricity source in coming years, accounting for 88% of the 2030 unconditional targets and 63% of the conditional targets (see Figure 6).

The introduction of solar PV can help boost the green energy job market in SIDS. The industry entails a broad spectrum of employment opportunities, including roles for project managers, electricians, engineers, technicians, salespersons and distributors in various specialisations along the value chain (see Box 4). Some of these jobs come with high salaries and demand specific skill sets, but the majority are for electricians, technicians, and others with skills that are not exclusive to the energy sector. Workers already skilled in relevant trades can be transitioned into these new roles, although some on-the-job training or formal re-certification may be required. SIDS can also identify segments of the value chain where they can capture greater value for communities by leveraging their own capacities. This can be accomplished either by developing specific training capacities or by identifying and strengthening current capacities within local industries.

Figure 6 NDC targets in SIDS by conditionality and level of financing required



Source: (IRENA, 2023e).

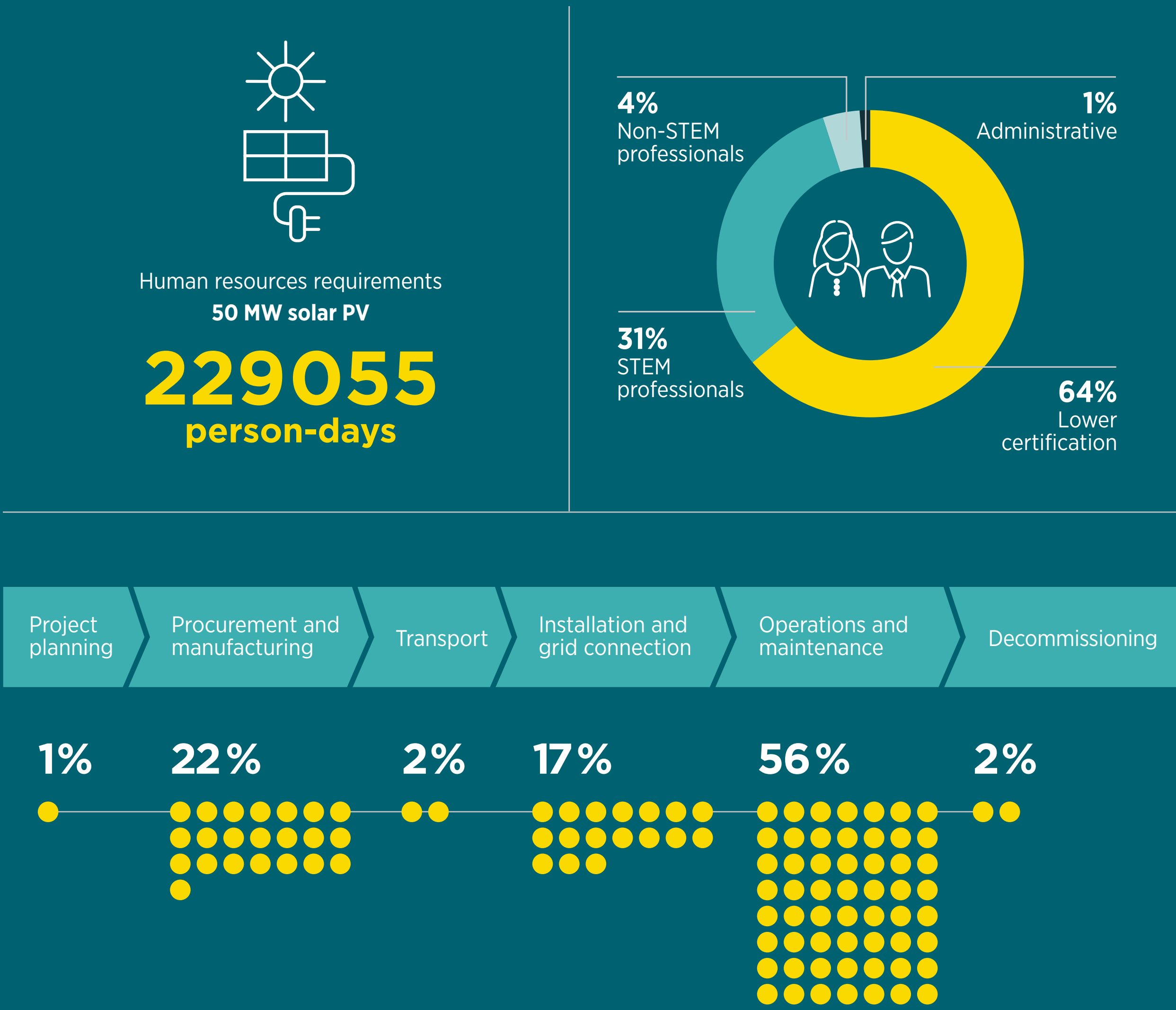
Box 4 The solar PV value chain

The solar PV value chain encompasses project planning, procurement, manufacturing, transportation, installation and integration into the power grid, operation and maintenance (O&M), and eventual dismantling and recycling. The chain's labour requirements are illustrated in Figure 7, using the example of a 50 MW solar PV plant.

On average, the development and operation of a typical 50 MW solar PV plant requires around 229 055 person-days through its lifetime, split among the different segments of the value chain (IRENA, 2017b). The workforce requirements shown in Figure 7 could be modified by a number of factors. Smaller projects are likely to be more labour intensive. (Ram *et al.*, 2022) and (Briggs *et al.*, 2022) suggest that the per unit labour requirements during the construction and installation and O&M of rooftop solar could be double those for utility scale projects. Labour requirements may decrease over time as productivity improves through learning and automation. Labour requirements may also vary by region and country, reflecting local labour productivity, wages and automation, among other factors.

A significant portion of the required labour (56%) is concentrated in the O&M phase, which tends to be more readily localised. This phase is spread across an expected lifetime of 25 to 30 years. Typically, the O&M of a large solar PV plant requires engineers (electrical, telecommunications, industrial), technical persons, operators, cleaners and safety experts, as well as smaller contributions by administrators, managers, lawyers and experts in policy and regulations.

Figure 7 Labour requirements for a typical 50 MW solar PV plant



Source: IRENA, 2017c.
Note: STEM = Science, technology, engineering and mathematics.

Manufacturing and procurement accounts for 22% of the workforce requirement, mostly in the production of cells and modules, followed by inverters and solar structures. But manufacturing is concentrated in a small number of countries, with limited job opportunities for SIDS.

Installation and grid connection accounts for 17% of total labour requirements. About 90% of the required person-days involve construction workers and technical personnel, and most of these roles can be filled domestically, although small SIDS may face constraints. Civil engineers and supervisors account for about 6% of total installation and grid connection work. Training is essential in localising many of these jobs. Transport and decommissioning are comparatively minor segments, accounting for 2% each, and project planning requires just 1% of total labour inputs (IRENA, 2017b).

Source: (IRENA, 2017b).

Solar PV is already mature and economies of scale are in place, so competing with current leaders in manufacturing is not possible for SIDS. However, there are other segments that provide plenty of opportunities. A 2022 study indicates what can be accomplished, assuming a locally appropriate mix of policies (Bunker, *et al.*, 2020). The study concluded that in a Caribbean Island economy with a population of 100 000 and a labour force of 50 000, reaching a 70% solar PV deployment rate could put 750 people to work for five years. Some 300 jobs could be generated over the same period with a wind generation capacity of 30 megawatt peak (MWp).

IRENA's conservative employment factor-based estimates suggest that the solar PV sector in SIDS directly employed close to 5 200 people in 2023, with the Caribbean region accounting for 86% of these jobs and AIS and Pacific accounting for 9% and 5%, respectively. The largest share of jobs in the Caribbean can be attributed to solar PV project deployment in the Dominican Republic. As the SIDS progress toward their NDC targets, the workforce in the region can increase in magnitude and become more geographically diverse (IRENA, 2023b). Solar PV employment can increase to 14 900 jobs by 2030, with the Caribbean, AIS and Pacific accounting for 54%, 24% and 22% jobs, respectively.

The aggregate population of the world's SIDS is 65 million. If the findings of (Bunker, *et al.*, 2020) are applied, the labour requirements for solar PV would be on the order of 487 500 jobs. This is a small number on the global scale, but significant for these small economies. However, it should be noted that individual nations' population size, economic and demographic structures, labour-market participation rates and skills profiles can vary substantially. The specifics of renewable energy use (including the technologies used and the scale of deployment chosen) may also diverge substantially and thus translate into rather different employment potentials and profiles. Policy making, in terms of both design and implementation, further differentiates likely outcomes in individual countries. A regional approach – one that creates regional industry clusters and skilling initiatives, for example – will have a different impact than a strictly national strategy.

A 2019 study of the Pacific Islands suggested that the maintenance of several renewable energy projects (primarily solar PV) continued to be dependent on international experts, which raises costs, limits sustainability and scalability, and reduces local economic benefits (ILO, 2019). To avoid such problems, strategies will need to include university, technical and vocational training programmes, partnerships with universities and research institutions, and government efforts to bring renewable energy companies together with education providers to assess needed skills and build training capacities accordingly. Neighbouring SIDS may wish to consider initiatives to create regional training clusters to share the costs and benefits of creating a well-trained workforce.

SIDS and their international partners are attempting to include local communities in projects to raise solar energy capacity, especially in the form of engaging local women in efforts to build the capacity of the renewable energy workforce. The **Republic of Marshall Islands** has set an ambitious target to reach 100% renewable energy in the electricity sector by 2050 (Government of the Republic of the Marshall Islands, 2018). While the project "IslandEco" directly contributes to the goal by deploying renewable energy in the rural parts of republic, it has also set a goal to raise to 20% the share of women in the pool of trained electricians. Young local women were trained to assemble and maintain the solar-powered lights and refrigerators, also engaging in the installation and commission of solar energy in rural areas (WECF, 2015a, 2015b).

Similar approaches have been observed in renewable energy projects funded through international sources. The Outer Islands Renewable Energy Project in **Tonga** is being implemented with contributions from the government of Australia and the Asian Development Fund. Recently the project deployed a hybrid solar system which generates up to 150 kilowatts of solar power during peak hours in Niuatoputapu community (Asian Development Bank, 2023). The project focuses not only on the deployment of energy generation facilities, but also on capacity building for women. Gender-specific plans have been established, including ensuring that at least 50% of participants in all training sessions are women. Additionally, the project aims to support business incubators led by women, resulting in more Tongan women gaining access to energy-related jobs (Asian Development Bank, 2018; UN Women, 2022).

The ASPIRE and ARISE projects operated in the **Maldives** with funding from the World Bank are deploying 53.5 MW of solar capacity combined with a battery storage facility. Together with the deployment of solar energy facilities, the projects include activities to involve women in the country's energy transition. In collaboration with the South Asia Gender and Energy (SAGE) program and the Women in Power Sector Professional Network (WePOWER), over 170 women are expected to be employed in technical roles across the two projects (World Bank, 2023b).

3.2 HYDROPOWER

Hydropower has long been a component of the energy mix of many SIDS. That remains so today, with hydropower accounting for 8% of SIDS' total electricity generation capacity (and 32% of grid-based generation capacity from renewable sources). SIDS in which hydropower plays a particularly important role include the **Dominican Republic, Fiji, Haiti, Papua New Guinea** and **Suriname**. While large hydropower plants can have 10 MW capacity or more, many hydropower installations in SIDS are of medium (1-10 MW) or small scale (>100 kW) (IRENA, 2023f). Large plants can generate enough power for substantial populations while medium, small and mini hydro (hydro mini-grids) can power small communities with the added potential to supply electricity to the national grid. Larger hydropower systems provide a reliable source of electricity for a broad range of applications but require greater investment (IRENA, 2023f, 2023g).

Caribbean SIDS have 547 MW of hydropower capacity installed today, but they have a potential estimated at 48.2 GW. Pacific SIDS have 545 MW of capacity and a theoretical potential of 256.6 GW. AIS countries have just 64 MW installed, but potential for 655 MW (IRENA, 2023h; Hoes, 2014).

Hydropower can be part of SIDS' efforts to transition away from fossil fuel dependence for electricity generation, if done sustainably. Hydropower has a main advantage over wind and solar energy in being dispatchable, but it is also prone, particularly in SIDS, to seasonality and variability of rainfall that can lead to inconsistent flow and therefore unreliable power generation. Seasonality may increase with climate change and more frequent extreme weather events (Ocko and Hamburg, 2019; Wasti *et al.*, 2022; Yalew *et al.*, 2020). This being said, while hydropower is susceptible to climate risks, it can also be a source of resilience when projects are adequately planned, for instance through proactive reservoir management (IRENA, 2023g). Additional growth in hydropower is likely to be limited for many smaller island states owing to the absence of large watersheds.

Unlike the components of other renewable technologies – solar and wind energy in particular – many hydropower components can be manufactured locally in some SIDS contexts, including sluice gates, penstock pipes, manifolds and water turbines. Providing such inputs can offer opportunities for local metal works and other types of shops. While generators may need to be imported in some cases, there are also opportunities for local manufacturing of control panels and electronic load controllers (IRENA, 2023f). Hydropower projects offer other opportunities for job creation within local communities, particularly in sectors such as civil works, including concrete pouring, digging, and rebar installation, where much of the capital investment is allocated (IRENA, 2023f).

Investment in the hydropower value chain presents both opportunities and challenges for SIDS (see Box 5). Barriers to localisation may include high upfront costs and technological expertise and knowledge gaps, requiring investment in capacity building and training, supportive policy and regulatory frameworks, and innovative financing mechanisms (*e.g.* blended finance, green bonds and public-private partnerships). SIDS' unique environmental sensitivities underline the need for careful environmental impact assessments of hydropower projects.

Box 5 The hydropower value chain

Of all renewable energy technologies, hydropower requires the most on-site civil works construction. Local capacity is required to survey the site; to design and build the intake, de-silting and water conveyance structures; to install the penstock pipe, and to build the powerhouse. In the case of larger systems, dams and other large infrastructure require additional labour.

In the small-scale hydropower value chain, operations and maintenance (O&M) generates the largest labour requirements as O&M is needed over the lifespan of the system. Of total person-days required for pico, micro and mini hydro facilities, O&M accounts for 94%, 87% and 78%, respectively. Small and large hydro systems require more person-days because the civil works are larger and take longer to complete, and because other value-chain phases are extended.

Within the global hydropower sector (which is dominated by large hydro), O&M also accounts for most of employment, representing two-thirds of direct jobs. This is followed by 30% in construction and installation; and about 6% in component manufacturing. The majority of the required labour involves low- to medium-level technical skills which tend to be readily available locally. If not available, the necessary skills can be developed through vocational training and certification programmes.

Source: (IRENA, 2023f; IRENA and ILO, 2023).

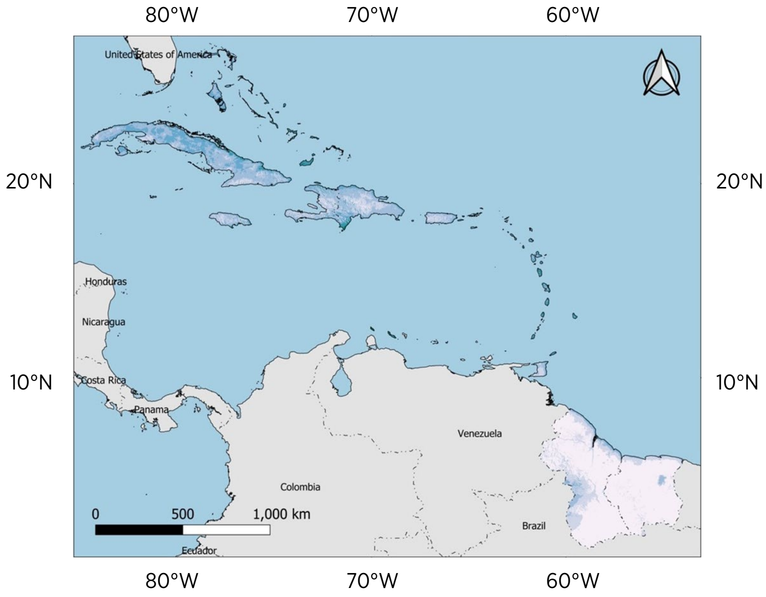
Given the geographical characteristics of SIDS, the deployment of small-scale hydropower plants in suitable areas can pose lower risks of conflict than larger-scale hydropower plants (Blaine *et al.*, 2022). The **Dominican Republic**, with its ample mountainous areas and abundant water resources in narrow valleys, is well-suited for the development of small hydropower projects. These conditions have facilitated the development of small, community-based hydropower projects with the support of a local NGO, Guakía Ambiente, and the Global Environment Facility's Small Grants Programme (UNIDO and ICSHP, 2022).

In addition to improved energy access and reduced energy prices, the Guakía Ambiente projects have led to greater engagement of women in political and educational fields. Furthermore, they have fostered the growth of local businesses in the tourism industry, as access to electricity has enabled the establishment of eco-tourist facilities (Liu *et al.*, 2019). The prosperity brought about by hydropower in Dominican communities has inspired neighbouring **Haiti** to explore small-scale hydropower, indicating the potential for co-operation in the renewable energy sector among SIDS (Small Grants Programme, 2017).

3.3 WIND ENERGY

Wind power contributes about 580 MW of generating capacity in SIDS (IRENA, 2022b). The Caribbean SIDS have a moderate wind potential, with the wind speed at 100 metres ranging from 1.9 metres per second (m/s) to 12.6 m/s, the average being 4.5 m/s (see Figure 8). The maximum development potential for onshore wind is estimated at about 5.7 GW, assuming an installation density of 5 MW/km^2, maximum concentration capacities of 5 000 MW, and a land utilisation factor of 50% (IRENA, 2024a). Installed capacity was 0.777 GW in 2022 (IRENA, 2023d).

Figure 8 Annual average wind speed at 100 metre height in the Caribbean region



Wind speed at 100 m m/s

< = 4 | 4 - 5 | 5 - 6 | 6 - 7 | 7 - 8 | 8 - 9 | > 9

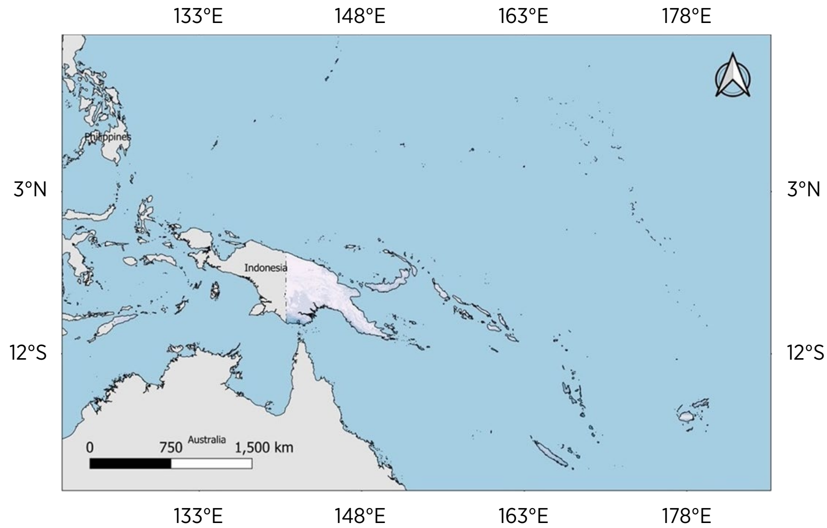
Source: Global Wind Atlas (DTU, 2015).

Note: m/s = metres per second. Maps are also available from the IRENA Global Atlas for Renewable Energy.

Disclaimer: This map, which uses UN boundaries, is provided for illustration purposes only. The boundaries shown do not imply endorsement or acceptance by IRENA.

The Pacific SIDS have a moderate wind potential, with the wind speed at 100 metres ranging from 1.15 m/s to 13.5 m/s, the average being 4.2 m/s (see Figure 9). The maximum development potential for onshore wind is estimated at about 2.5 GW, assuming an installation density of 5 MW/km^2, maximum concentration capacities of 5 000 MW, and a land utilisation factor of 50% (IRENA, 2024a). Installed capacity was 0.054 GW in 2022 (IRENA, 2023d).

Figure 9 Annual average wind speed at 100 metre height in the Pacific region



Wind speed at 100 m m/s

< = 4 | 4 - 5 | 5 - 6 | 6 - 7 | 7 - 8 | 8 - 9 | > 9

Source: Global Wind Atlas (DTU, 2015).

Note: m/s = metres per second. Maps are also available on the IRENA Global Atlas for Renewable Energy.

Disclaimer: This map, which uses UN boundaries, is provided for illustration purposes only. The boundaries shown do not imply endorsement or acceptance by IRENA.

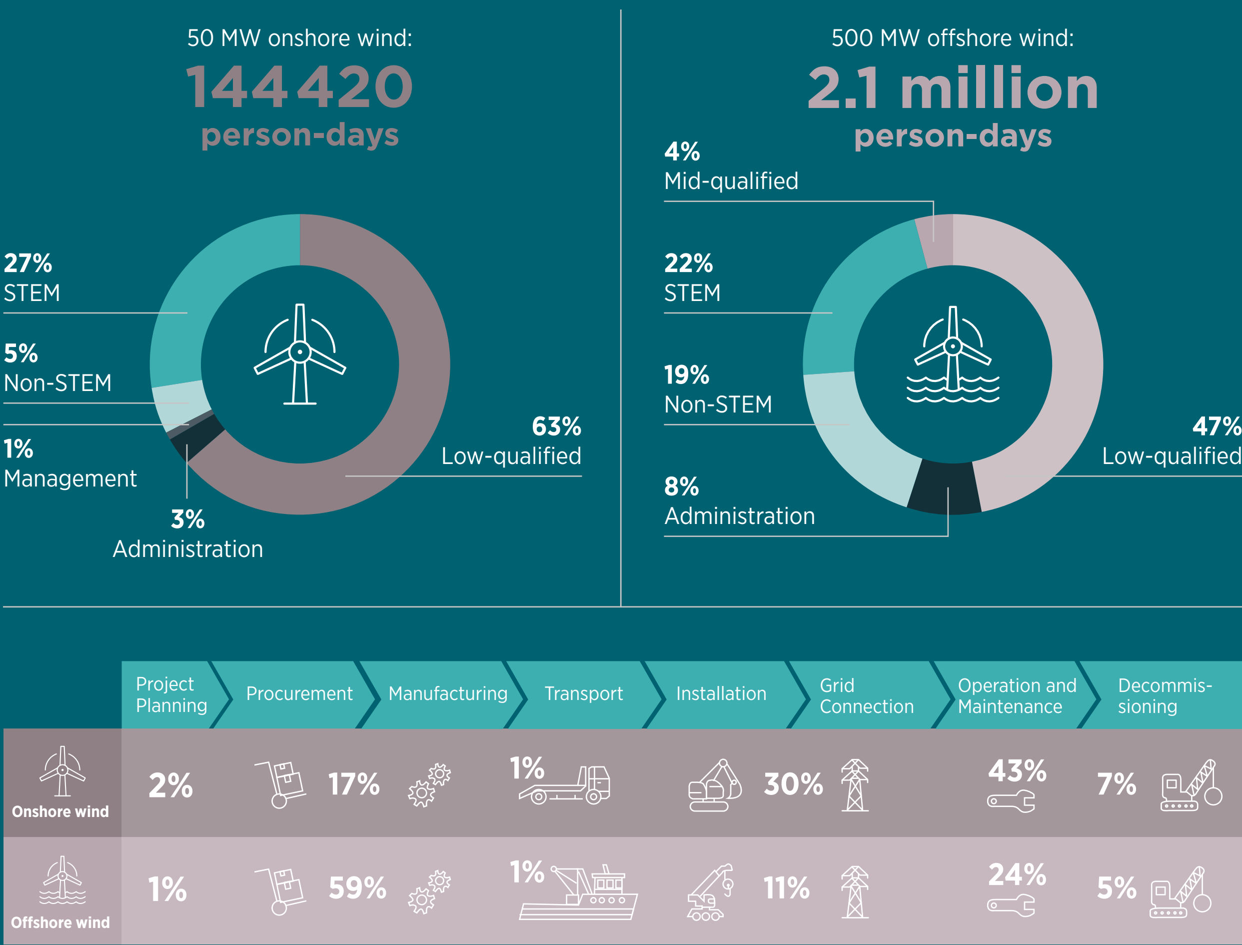
The AIS region has a moderate wind potential, with the wind speed at 100 metres ranging from 2.2 m/s to 13.3m/s, the average being 4.7 m/s. The maximum development potential for onshore wind is estimated at about 0.72 GW, assuming an installation density of 5 MW/km^2, maximum concentration capacities of 5 000 MW, and a land utilisation factor of 50% (IRENA, 2024a). Installed capacity was 0.046 GW in 2022 (IRENA, 2023d).

The onshore and offshore wind energy value chains offer ample employment opportunities as discussed in Box 6.

Box 6 The wind energy value chain

IRENA's analysis provides insights on the labour requirements and employment opportunities in the value chains of onshore and offshore wind energy technologies. A 50 MW onshore wind farm typically requires approximately 144 000 person-days to develop. These person-days are for direct jobs and do not include indirect or induced jobs. Operations and maintenance (O&M) is the most labour-intensive segment, accounting for 43% of total jobs. This is followed by construction and installation (30%), and manufacturing (17%, a segment from which SIDS economies are unlikely to benefit given their lack of relevant industries).

Figure 10 Labour requirements in onshore and offshore wind supply chains



Based on: (IRENA, 2018, 2017c).
Note: STEM = Science, technology, engineering and mathematics.

At present, offshore wind is limited to very few countries worldwide; no such installations exist or are being planned in any of the SIDS. But if such projects are developed in future years, the labour requirements would be significantly higher than for onshore deployments, with a 500 MW farm demanding around 2.1 million person-days. The majority of this labour is concentrated in the manufacturing and procurement sectors, with supply chains that are not located in SIDS.

The wind energy sector supports a network of businesses that provide goods and services to wind farms, such as transportation companies, caterers, and security firms. The development of the wind energy sector has led to increased demand for training programs and educational opportunities in related fields. The presence of wind farms can attract tourists interested in renewable energy and sustainability, leading to job creation in the tourism industry.

Construction and installation of a wind farm typically requires 12 to 20 months. This activity usually relies strongly on domestic labour, creating opportunities for employment, especially of low- to medium-skilled workers. However, in the SIDS context, a part of these jobs could be sourced from other countries owing to the absence of a large local workforce. Site preparation has the greatest labour requirement, followed by equipment assembly, cabling, and grid connection and commissioning.

O&M covers the expected lifetime of about 25 years. Modern wind farms are automated, and their operation is normally monitored remotely by operators who reset the systems after line or grid outages. Job opportunities are therefore limited. Operators, engineers and construction workers are typically the most important roles in the O&M phase.

Source: Based on (IRENA, 2021b, 2018, 2017c).

Some 300 jobs could be generated over five years assuming a 70% renewable energy penetration target achieved with about 30 MWp of wind generation capacity in a Caribbean Island economy with a population of 100 000 and a labour force of 50 000 people (Bunker, *et al.*, 2020). A back-of-the-envelope calculation similar to that mentioned in the solar PV section above implies that given an aggregate SIDS population of 65 million people, the overall labour requirement may total some 195 000 potential jobs. While this may give a rough indication of potential, detailed job creation estimates must consider specific SIDS contexts, with due attention to factors like the size of the economy, the existing industrial base and available skills, among others.

Shirley and Kammen (2012) offer project-level data from wind energy farms in **Jamaica**, **Barbados, Grenada** and other Caribbean islands. Though clearly dated by now, they give an indication of per-megawatt job creation potential in different segments of the value chain. Construction and installation may require anywhere from 1.5 to 10 jobs/MW, depending on project size, difficulty, workforce availability and other factors. Jobs in operation and maintenance could range from 0.2 to 1 job per MW.

A more recent study of the Cabeólica wind farm in **Cabo Verde** suggests that it has allowed businesses to operate longer hours, translating into an estimated gain of 390 jobs (not full-time equivalent) and EUR 3.8 million of added economic output (Finnfund, 2018). The construction of the wind farm created temporary jobs for construction workers, engineers, and other specialists. Permanent operations and maintenance jobs are more limited in number, estimated at 10 direct and 52 indirect jobs (Finnfund, 2015).

The Pacific ocean archipelago **Vanuatu** has an ambitious climate policy, having committed to 100% renewable energy in electricity generation by 2030. The country is already today carbon-negative, and has also been one strong supporter of a loss and damage facility that helps developing countries with climate damage (Government of Vanuatu, 2022; Jackson, 2022). As part of its commitment to climate action and sustainable energy, Vanuatu has invested significantly in renewable energy already. The country is home to a 3.4 MW wind farm located in Kawéné ("Devil's Point") (UNELCO, 2020a). The wind park includes an automatic system that helps stabilise supply, and thus prevent curtailment problems. In addition, the system was specifically designed to withstand tropical weather conditions, with Vanuatu being frequently hit by cyclones (European Investment Bank, 2010). Special attention was paid during the project design phase to minimise impacts environmentally protected zones or areas of cultural significance, in addition to a noise impact study to ensure no undue noise pollution to nearby communities (EIB,2010). Vanuatu also has several grid-connected solar PV farms, the first of which was commissioned as far back as 2011. Kawéné solar PV farm was built on the same site as the wind farm (UNELCO, 2020b).

3.4 OTHER RENEWABLE ENERGY SOURCES: GEOTHERMAL AND BIOENERGY

Other renewable energy technologies available to SIDS could provide secure electricity access.

Geothermal energy has potential in several SIDS. A particular benefit of geothermal energy is its comparably small land footprint, making it suitable both for large grid connections and also for smaller islands (see Box 7). A key obstacle to deploying geothermal energy is access to finance for exploration and drilling.

Similar to other extractive industries, geothermal energy has environmental impacts that must be considered. These include potential negative impacts on Indigenous Peoples and local communities related to local landscapes, land rights and places of spiritual significance, among others (Blaine, 2021; Dhar *et al.*, 2020; Veit, 2021). In order to be truly sustainable, geothermal projects must contribute to community welfare; planning, implementation and decommissioning must rest on a solid basis of community support (Agrawal *et al.*, 2023).

Box 7 The geothermal value chain

The geothermal value chain involves several phases: exploration and resource assessment, feasibility studies, design and drilling, power plant construction, operations and maintenance (O&M), power generation and distribution, environmental monitoring and compliance, and ongoing research and development. In the exploration and resource assessment phase, roles include conducting geological surveys, geophysical exploration and exploratory drilling by geologists, geophysicists and drilling engineers.

Subsequently, reservoir and geothermal engineers conduct feasibility studies and create designs, while drilling crews construct wells. In the plant construction phase, engineers design the plant, after which construction managers and workers build both the plant and transmission lines and related facilities. The technicians install turbines, generators and heat exchangers.

In the O&M phase, operators control and manage the plant; specialists monitor performance; and technicians perform maintenance and conduct routine inspections. Engineers and grid operators oversee power generation and manage distribution to the grid. Environmental scientists conduct environmental impact assessments, and other expert consultants ensure regulatory compliance and safety standards. Finally, researchers may conduct ongoing research to improve efficiency and technologies.

In SIDS, there is substantial room for job creation in the construction and O&M segments of the geothermal value chain. Industries and educational institutions can co-operate to offer geothermal curricula and local, specialised training programs; developers can be incentivised to offer on-the-job training. Both forms of co-operation can benefit local job creation, including for women.

Since geothermal projects involve mining operations and land access in what could be culturally significant areas, their sponsors should seek a “social license” to operate, including through community engagement, transparent information, comprehensive consultation and benefit sharing. Benefit sharing can involve localised Infrastructure and service enhancement; job training, skills development, and employment; and arrangements to share ownership and revenue.

Source: (ESMAP, 2023b; IRENA, 2017d; IRENA and IGA, 2023).

The Renewable Energy Sector Development Project backed by the World Bank aims to contribute to **Saint Lucia’s** energy transition by developing geothermal energy (Richter, 2021). The project is including women throughout the implementation stages by tracking women’s engagement in management and the workforce (Barthelmy, 2019). Moreover, part of the project’s budget is allocated to scholarships for women who are pursuing engineering degrees. As of 2023, 17 scholarships have been awarded and 15 more scholarships are to be granted (Times Caribbean Online, 2023). A similar approach is taken in the **Dominica** Geothermal Risk Mitigation II Project, which aims to provide education to permit the local workforce to compete for technical jobs. A component for women offers technical positions in the energy field to prospective participants who complete their training (World Bank, 2024c).

Bioenergy can offer an added source of electricity suitable for mini-grids, particularly when based on agricultural waste and residue. IRENA’s recent study of Caribbean SIDS identifies crops that can be grown in some SIDS and provide valuable material for biofuel production, such as sugar cane (molasses, bagasse, straw and vinasse), cassava (peels, leaves, stems and cassava wastewater), coconuts (shell and husk), oil palm fruit (fibre, shell, empty fruit bunch and palm oil mill effluent), coffee (husk and spent coffee grounds) and cocoa (husk) (IRENA, 2024b).

Like hydropower and geothermal energy, bioenergy in SIDS is not without complications, however. While bioenergy can be a valuable renewable energy source, it is important to acknowledge the potential competition with food production, especially in smaller SIDS. There is also a risk of biomass use driving further deforestation in SIDS already facing space constraints. Biomass solutions will thus require careful land-use planning, with the inclusion of communities. Biomass that relies on existing resources, such as agricultural and municipal waste, could avoid some of these problems.

As part of the Improving the Performance and Reliability of Renewable Energy Power System in **Samoa** (IMPRESS) project funded by the Global Environment Facility, the Afolau Biomass Gasification Plant started to operate in 2020 (United Nations in Cook Islands, Niue, Samoa and Tokelau, 2020). The plant, fuelled by weeds and coconut by-products like husks and shells, not only promotes circular economy by converting waste to energy (Secretariat of the Pacific Regional Environment Programme, 2021), as Samoa is a major exporter of coconut-based products, but also is improving local livelihoods. Re-education of the local workforce has boosted local economic activities.

Another example of the IMPRESS project is a biogas system that has been deployed in Sa’asa’ai in Samoa. This biogas system operates on the waste from the livestock facilities, food scraps, and agricultural waste such as coconut logs, husks and coconut shells, thereby improving local waste management while also reducing the use of liquefied propane gas, creating job opportunities and stimulating the local economy (The Ministry of Natural Resources and Environment, 2021; United Nations in Cook Islands, Niue, Samoa and Tokelau, 2020). The biogas system has also enhanced energy access, providing women in the area with affordable gas for cooking and lighting (IRENA, 2023).

4. BENEFITS FOR END USERS

Renewable energy can provide additional benefits for SIDS by electrifying end-use sectors. In this section, the potential for renewables-based electrification is discussed with respect to three main sectors: residential and commercial (§4.1), agriculture and fisheries (§4.2), and transport (§4.3). The potential in each case depends heavily on the geographic, climatic and economic circumstances of each country. In other words, not all solutions will be appropriate for all SIDS.

4.1 RESIDENTIAL AND COMMERCIAL USERS

Renewable energy has many benefits to offer residential and commercial users in SIDS. For island states with limited or low-quality access to electricity that make extensive use of diesel generators, renewables-based energy systems offer a more stable supply without many of the negative consequences associated with conventional fuel-based systems (indoor and ambient air pollution, noise, and fire hazards stemming from fossil-fuel-based generator systems) and improved household safety. While renewables-based energy systems require substantial initial investments, they lead to savings in the medium and long term owing to the absence of fuel costs. For SIDS with incomplete access to clean cooking, electrification of cooking can improve household health.

The commercial sector also stands to benefit. Besides generating local jobs (see Chapter 3), renewable energy can also serve commercial enterprises, such as the tourism sectors. Tourism contributes to the economy of many SIDS and usually has different energy and water consumption patterns than other commercial and residential users, including higher demand for space cooling and water heating. Sustainability strategies that include environmental responsibility, recycling and clean energy can be important selling points for the tourism sector in SIDS, while reductions in air and noise pollution from replacement of fossil-fuel-generated electricity can be a major added attraction for tourists. The use of clean energy to power hotels and local transport can fit in well with the promotion of nature tourism on island states.

4.2 AGRICULTURE AND FISHERIES

SIDS are highly vulnerable to the impacts of climate change on agriculture and fisheries (Ahmed *et al.,* 2021). Vulnerability to prolonged droughts or floods in the rainy season may rise, even as SIDS are already exceptionally dependent on food imports (Ahmed *et al.,* 2021; Parker, Parchment and Gordon-Strachan, 2023; UN Water, 2023).

Renewables-backed agricultural technologies can make it easier to adapt to such climate-change-induced susceptibilities (Ahmed *et al.,* 2021). Solar-powered irrigation systems, for instance, can offer an off-grid renewable technology solution to irrigating land, increasing yields for small farmers (Falchetta *et al.,* 2023). Applications for high-yield crops have been demonstrated in **Cabo Verde** and **Guinea-Bissau**, as have socio-economic benefits such as lower electricity bills, which in turn help farmers afford more water for irrigation, while also lowering consumer prices for produce (Ahmed *et al.,* 2021; Xingfei, n.a.).

Renewables-based technologies also can be integrated into the value chain of fisheries. Many of the more than 200 million people residing in Pacific SIDS rely on fisheries and aquaculture for food and livelihoods

(UN-OHRLLS, 2020), making the sustainability of these industries very important. For example, a 40 kW grid-connected solar PV system in Dhiffushi, **Maldives**, has greatly benefitted the local fishing industry, as an ice-making machine is now integrated into the grid, replacing the former battery system. The solar-generated ice supply is used to store fish, reducing waste due to more and better cooling at lower cost. The fishing industry and consumers are the beneficiaries. Fisheries in Cabo Verde have also demonstrated the case for small-scale solar PV systems. On the island of Brava, a small solar PV system generates some 1 000 kWh monthly, generating electricity for both households and a small ice-making factory managed by the fishermen's association, lowering electricity costs for fishermen and reducing waste (Xingfei, n.a.).

Solar PV systems can also reduce other fuel uses indirectly, for instance because fishermen no longer need to use fuel to obtain ice from nearby islands. Moreover, ice can also be an additional source of income, as surplus generation can be sold to households, as has been the case for the Dhiffushi Island Council (GSEP, n.a.). In 2020, the Maldives government initiated a tender for solar-powered and grid-tied ice plants as a part of a project funded by the Asian Development Bank. The POISED project (Preparing Outer Islands for Sustainable Energy Development) expanded this model to four other islands, benefitting local communities through lower fuel and electricity costs, lower environmental pollution, improved air quality and less noise (Bellini, 2020; POISED Project Ministry of Environment, Climate Change and Technology for the Asian Development Bank, 2022). The project is being supported by USD 55 million in grants from the ADB: USD 38 million from the Asian Development Fund, USD 12 million from the Strategic Climate Fund, and USD 5 million from the Japan Fund for the Joint Crediting Mechanism, in addition to a USD 50 million loan from the European Investment Bank.

Solar-based electricity systems in the agriculture and fisheries sector can also empower women. Women represent 52% of the agricultural labour force in SIDS, and thus stand to benefit from renewable energy proportionally (FAO, 2020). In Guinea-Bissau, solar-irrigation systems for rice cultivation have also been shown to free up women's time for further education, as automation powered by solar energy reduces the time women spend pumping water from wells (ASAD, n.d.; eurofins foundation, n.a.). A similarly positive experience occurred in the **Solomon Islands**, where local women's associations have started creating microbusinesses that rent out the freezer space for locally caught fish, creating revenue streams for them and their families. The women's community has raised more than USD 3 000 (Agrilinks, 2019; WorldFish, 2023).

4.3 TRANSPORTATION

SIDS can also benefit from the electrification of their transport systems, reducing reliance on imported, polluting fuel. Most transport in SIDS, whether on land or at sea, is fossil-fuel-based. Approximately two-thirds of SIDS in all geographic regions are archipelagos or semi-archipelagos characterised by multiple islands, compact road networks, and short driving distances. These unique features offer a potentially conducive environment for the adoption of electric and hybrid vehicles (Shah, Awojobi, and Soomauroo, 2022; UNCTAD, 2021).

Electrifying public transport fleets could enhance local energy security and cut dependence on imported fossil fuels and their associated costs, while simultaneously improving air quality and reducing noise pollution (Shah, Awojobi, and Soomauroo, 2022; Soomauroo, Blechinger, and Creutzig, 2023). Electrified vehicle fleets also fit well with the tourism strategies of SIDS, by providing clean, low-carbon and low-noise transport options.

While the widespread adoption of electric vehicles (EVs) in SIDS has many challenges – including the high upfront cost of new vehicles and limited charging infrastructure on island states, some countries, including **Vanuatu, Fiji, Nauru** and **Tonga**, have included EVs and the decarbonisation of the transport sector in their NDCs. Fiji, Nauru, Vanuatu, Tonga and **Tuvalu** have undertaken feasibility studies and are piloting an increase in EVs. Fiji has 20 EVs and seven charging stations, and Nauru had plans to bring in two EVs in December 2023 through a UNDP-funded project, while Tuvalu has a pilot e-bike programme (The Commonwealth, 2024).

Barbados shows that EVs, including for private transport, can be a feasible option for SIDS. The country has rapidly increased their use in recent years and, in 2021, had the largest per capita EV fleet in the Caribbean (Masson and Perez, 2021). Not only has the government offered a tax break, removing duties on electric vehicles and instituting a flat 10% in added taxes, it has also invested substantially in charging stations, which now outnumber gasoline stations (Buckholtz, 2023). A single charge is sufficient for traveling more than 350 km, allowing an EV to cover a substantial portion of the island's territory, which covers less than 450 km^2 (Buckholtz, 2023). The power provider allows users to charge their cars using public chargers by scanning a barcode on their phone, thus streamlining point-of-sale payment. Barbados offers additional incentives for government agencies to switch to EVs through a loan facility that provides low-interest financing.

In addition, many SIDS make extensive use of marine transport – based on boats of various sizes –for inter-island transport, including private boats and "water taxis". Maritime transport has a large local environmental impact, in addition to its climate impact: spills and leaks from diesel-operated boats pollute waters and coastlines, and toxic emissions from burning fuel can contribute to conditions such as asthma and cardiovascular disease in people living near ports (Smith, 2023). This also applies to fishing boats. Transitioning catch boats and small water vehicles from fossil fuels to electric engines with batteries or solar PV and battery systems can thus unlock economic, environmental and social benefits and, for commercial fishing boats, add value to the final product through reduced fuel costs (FAO, 2023; UNCTAD, 2014).

The **Republic of Marshall Islands** has begun studying technological options to rid the island-state of its reliance on diesel fuel for marine transport. The country has partnered with the Republic of Korea to develop alternative boat models, including wingships (vessels that are part-boat, part-plane), and to take advantage of ocean thermal energy, using the temperature difference between warm water and cold water to generate electricity. Surplus energy can go into creating hydrogen-based electro-fuels to be used to power boats (Smith, 2023).

Larger, containerised port infrastructure for cargo ships, too, can benefit from upgrading to renewables-based electricity for some or all of their operations, based on grid- and off-grid technologies (UNOPS, 2020). The potential of electrifying parts of SIDS' marine transport fleets is also present. The potential includes both the vehicle fuel itself, as well as onboard needs such as lighting, freshwater pumps, air conditioning, hot plates, and refrigerators.

As part of a new pilot project focused on reducing emissions and demonstrating the use of renewable energy in Pacific maritime transport, **Samoa** and **Vanuatu** started a pilot project in 2019 to equip vessels with solar systems to power lights, fresh-water pumps, air-conditioning, hot plates and refrigerators. Boats equipped with solar systems have been found to save up to 32% per year on operating costs. The pilot project is part of the Maritime Technology Cooperation Centre in the Pacific under a global project funded by the European Union and implemented by the International Maritime Organization (Pacific Community, 2019).

5. POLICY PRIORITIES

While renewable energy technologies hold many benefits for SIDS in addition to their emissions mitigation potential, their deployment also involves challenges. A core element in realising renewable energy's potential and securing socio-economic benefits is local training and (re-)skilling. But efforts to put in place a trained workforce (§5.1) need to be complemented by other measures that make the exploitation of renewable resources consonant with environmental imperatives and thus sustainable for communities (§5.2). Securing sufficient financing is another concern (§5.3). This section looks at these topics to provide a checklist for policy makers and businesses interested in deploying more renewable energy in SIDS.

5.1 SKILLS TRAINING AND JOB CREATION

Energy system transitions require technology training and skills for local engineers and technicians – for installation, maintenance and repairs. The latter in particular can be a challenge for small islands and remote locations (as much as access to spare parts!). Skills will also be needed in the areas of sustainable management and planning, including in the government sector, and for civil servants.

The business sector, too, could benefit from dedicated support to train their employees, including in critical sectors such as agriculture and fisheries, where electrification could be carried out across a wide value chain – provided investment and skills are available. The electrification of transport will require separate skills development and training, especially where SIDS are considering support for private EV use, which will require skills in repair and maintenance that differ from those required for internal combustion vehicles.

Training is thus essential to enable SIDS to fill skill shortages across various renewable energy technologies, and thus to take advantage of the job-creation potential of renewable energy development. Key steps include identifying skills deficiencies; designing specialised training programmes to address those deficiencies; retraining individuals from declining industries; collaborating with educational institutions to develop technology-related curricula; and incentivising developers to provide on-the-job training. Governments and the private sector can also help raise awareness about educational opportunities through initiatives such as competitions, mentorship programmes, internships and apprenticeships.

The potential benefit of a regional approach to technology education and training is great. A regional approach would foster collaboration and resource sharing in technology education, promoting international knowledge exchange by sending individuals to established technological markets for training.

A number of training initiatives have already been launched, some dating back to IRENA's 2014 collaboration with the Sustainable Energy Industry Association of the Pacific Islands and the Pacific Power Association. That collaboration supported a course on "Grid Connected Solar: Design and Installation" in **Samoa, Kiribati, Tonga, Fiji** and the **Republic of Marshall Islands**. The training focused on installation, commissioning and fault finding of grid-connected PV systems (IRENA, 2014).

More recently, the Global Green Growth Institute partnered with the Korea International Corporation Agency to provide training for 3 000 people in **Fiji, Vanuatu, Papua New Guinea** and the **Solomon Islands** in various areas of sustainability, including "Solar Operations and Maintenance Basics" and "Solar in the Community". The project specifically aimed to include 40% women and 20% vulnerable groups (GGGI, 2023). The project's main objective was to improve decision making by resource owners and local government officials on integration of the green economy and renewable energy into local level planning and to strengthen implementation of renewable energy infrastructure for rural electrification.

Training a capable workforce is paramount in maximising local industry development, as exemplified by the 2022 collaboration between the UNDP and the Sustainable Energy Research Institute at Papua New Guinea's University of Technology. The aim of the training was to provide a common platform to build institutional capacity in solar energy and to demonstrate the renewable energy technologies available in Papua New Guinea. Sixteen technical officers from PNG Power Limited were trained in rooftop solar PV (UNDP, 2022b).

A significant gender disparity remains in the energy sector, including in renewable energy. Women make up around 32% of the global renewable energy workforce, although this rate is higher for solar PV – which at 40% is almost double the percentage of women working in oil and gas industries (IRENA, 2019; IRENA and ILO, 2023). SIDS, with their relatively small populations, have much to gain by making the sector accessible to talent regardless of gender, and thus by ensuring that finance and training opportunities are available to all.

Gender diversity and social inclusion across all technologies in SIDS can be enhanced by setting clear objectives to increase female representation, particularly in technical roles; by facilitating mentorship and leadership programmes to empower women and marginalised groups in various technological sectors; and by establishing comprehensive data collection and monitoring systems to track progress in gender and social diversity, job creation, and skill development for all technologies.

In **Guyana**, the Women's Empowerment in Energy Programme offers training courses to enable women to become solar panel technicians (News Room Guyana, 2022). Similarly, in Toledo, **Belize**, women trained as solar engineers at Barefoot College International in India are now equipping their community with solar systems and lanterns, benefiting nearly 400 villagers. These programmes not only promote sustainable energy but also empower women in the sector (UNDP, n.d.).

5.2 ADDRESSING LAND CONSTRAINTS AND ENVIRONMENTAL CONCERNS

Land constraints are a major limitation to large-scale renewable energy deployment in SIDS. In many cases, land for larger-scale renewable energy projects must be assessed for other uses, notably agriculture. Local priorities may shield certain undeveloped areas from development because of the high value of these areas for recreational, cultural or spiritual reasons. SIDS are particularly vulnerable to environmental impacts of energy systems, given their small size and the high value nature has for people and economies, including SIDS' many Indigenous Peoples. While renewable energy has many advantages over fossil fuels, they still affect the environment, and thus people. This is important not only from an overall justice perspective (REN21, 2023), but also because making sure renewable energy works for ecosystems and people is critical to securing popular support for renewable energy.

Large, utility-size projects have commensurately great implications for the environment. Hydropower, for instance, can have significant impacts that grow with the size of dams, including changes to water quality and temperature; pollution through waste and hazardous materials from the construction phase; noise, dust, reduced air quality, erosion and sediment; and, in many cases, damage to the natural architecture of riverbeds and the surrounding environment (Agrawal *et al.,* 2023; Colchester, 2000; World Commission on Dams, 2001). Solar and wind plants can have a large land footprint and may face community opposition. They, as well as areas designated for geothermal energy production, may overlap with national parks, indigenous lands, tourist sites or areas of landscape value (IRENA and IGA, 2023). These impacts on people and the environment are not benign, even less so in SIDS, where land is scarce.

Poorly sited projects can aggravate deforestation and add to conflicts over competing land uses (UNOPS, 2020). For this reason, implementing renewable energy projects in SIDS needs to be tied closely to community work, including consultation, information, monitoring, benefit sharing, and, where necessary, new regulations adopted in concert with communities. Environmental and social impact assessments are critically important for transparently assessing the impacts of new energy projects – including employment potential, new market opportunities, energy savings and carbon dioxide reductions, as well as the overall environmental and social footprint (IRENA, 2022a).

New Zealand features a large, indigenous-driven geothermal project that may serve as an example of how renewable energy projects may be consistent with the needs of Indigenous Peoples in SIDS. He Ahi is a 45-hectare industrial zone site owned by Te Pae o Waimihia, a forest hapū cluster trust representing six indigenous Ngāti Tūwharetoa hapū (clans): Ngāti Rauhoto, Ngāti Te Urunga, Ngāti Hineure, Ngāti Hinerau, Ngāti Tutetawha and Ngāti Tutemohuta. The aim of the park is to develop an industrial estate that will promote the use of clean energy and support businesses that seek positive environmental and commercial outcomes. Te Pae o Waimihia aims to develop industrial and business lots for companies seeking a serviced site and a leased facility. Each site is planned to be specifically designed and built to meet the requirements of the tenant. The local commercial partner, Contact Energy, will provide geothermal energy to businesses that require geothermal heat. The sites will also promote other forms of clean energy and best practices for energy efficiency, waste management and low environmental impact (Canning, 2024; IRENA and IGA, 2023).

5.3 SECURING FUNDING FOR THE ENERGY TRANSITION

Accelerating the grid-based transition of energy systems in SIDS requires access to significantly more finance than has typically been available. Given that they are developing countries, SIDS' own financial resources are limited. In addition, the comparatively small scale of power grids in most SIDS (reflecting low volumes of electricity demand from small populations) makes it difficult to attract investment capital for the high upfront expenditure of renewable infrastructure development. At the end-user level, the higher upfront cost of new technologies, such as electric stoves and other appliances, means that additional financial support will be needed if SIDS are to be successful in electrifying end uses and switching from fossil fuels to renewables-powered grid electricity.

Installing renewable energy systems and electrifying end uses requires substantial initial investment. International co-operation can make renewable energy more affordable for SIDS by facilitating access to concessional loans and grants. The growing number of climate-related funds, including for climate adaption and mitigation, such as the Global Environment Fund, the Adaptation Fund, the Global Climate Fund and other specialised mechanisms, are of increasing importance for SIDS (Piemonte and Cattaneo, 2022). A report from the Organisation for Economic Co-operation and Development finds that disbursements to SIDS from these funds more than quadrupled between 2013 and 2020 to USD 239 million (OECD, 2022). Support for AIS and Caribbean SIDS has largely stagnated, but growth came in green climate commitments to Pacific SIDS, specifically a USD 78 million disbursement in 2019 for the Tina River hydropower project in the Solomon Islands. Funding for other renewable energy projects, including solar PV, has been much smaller to date. SIDS' access to such funds could be improved.

Promoting renewable energy, electrification and energy efficiency requires careful planning and regulatory reform, including in SIDS. Building capacity in government institutions and in the financial sector, and forging robust partnerships within government (between public and private stakeholders and with international organisations) will be an important ingredient of effective policy making for the energy transition in SIDS (OECD, 2023).

For end users, the initial investment cost of new electric equipment can often be prohibitive. The purchase cost of air conditioners (especially energy-efficient models) and electric cookers can surpass some households' means, while the upfront cost of equipment such as solar panels or battery-powered vehicles can be significantly higher than traditional fossil fuel-powered alternatives, typically requiring access to credit. Financing programmes, subsidies and incentives, including government-sponsored loans, will thus play an important role in making clean energy technologies and electrification affordable for consumers and other end users. For banks, special financing products will be required, including innovative financing models such as "pay-as-you-go" and "cooling as a service" to increase accessibility.

6. OUTLOOK

The challenges posed by climate change are monumental in scope, far surpassing the capacity of any single country to address, let alone small island nations with comparatively limited means and much greater exposure to climate impacts. Mitigating rising sea levels and averting the catastrophic impacts of climate-induced weather events requires global co-operation and concerted efforts. Nonetheless, renewable energy solutions offer a pathway to SIDS, not only by making a contribution to the global fight against climate change, but also by improving their socio-economic conditions.

By embracing solutions such as solar, wind and ocean energy, SIDS can diversify their energy mix, reduce reliance on fossil fuels, reduce costs and enhance energy security. By harnessing their abundant natural resources, SIDS can thus also make electricity more affordable for households and businesses. Renewable energy also holds substantial promise to reduce air, maritime and noise pollution across economic sectors, from residential electricity to agriculture, fisheries and maritime transport. An important end result is to cut the deleterious environmental and health impacts of burning fossil fuels.

The transition to a renewables-based energy mix not only mitigates carbon emissions and counters local air pollution but also creates new opportunities for economic growth and development. SIDS that are already renowned global climate champions within organisations like the Alliance of Small Island States can extend their leadership by embracing a renewable energy-based development model, setting a precedent for others worldwide. Collaborative frameworks such as the SIDS Lighthouses Initiative co-ordinated by IRENA (see Box 8) are crucial to translating discussions into action, supporting SIDS' energy transitions, and strengthening their climate resilience and sustainable development.

Box 8 About IRENA's SIDS Lighthouses Initiative

The SIDS Lighthouses Initiative is a collaborative framework for action to support SIDS in their efforts to transition from fossil fuels to renewables, in the process strengthening climate resilience and sustainable development. Co-ordinated by IRENA, the initiative brings together 40 SIDS and 44 partners from public, private, intergovernmental and non-governmental sectors, promoting dialogue, collaboration and knowledge exchange.

Through the initiative, IRENA facilitates multi-stakeholder events, capacity building efforts, technical analyses (*e.g.* to facilitate grid integration of renewables), and site appraisals to assess financial viability. Key tools include renewable readiness assessments, Quickscans, renewable energy roadmaps and grid integration studies.

The SIDS Lighthouses Initiative has generated numerous publications, including regional and country-level profiles tracking progress on the deployment of renewable energy technologies in SIDS.

In July 2022, IRENA received the inaugural United Nations SIDS Partnerships Award in the environmental category in recognition of its promotion of sustainable development through the SIDS Lighthouses Initiative.

Integrating renewable energy solutions can lead to the establishment of clean energy firms and industries, which in turn stimulate local economies. The implantation of renewable energy infrastructure, such as solar farms and wind turbines, requires both skilled and unskilled labour for installation, operation and maintenance, thereby creating jobs. Although SIDS are less likely to develop industries that manufacture renewable energy equipment, given the dominance of countries with large-scale supply chains, it may become possible in the future to develop some limited component manufacturing or small-scale assembly operations. But this may be more feasible if carried out jointly with neighbouring countries, bundling resources and fostering capacities in regional clusters.

The socio-economic impacts of integrating renewable energy solutions extend beyond providing energy. Access to reliable and affordable electricity stimulates economic activity, supports education and health care, and enhances the overall quality of life for island communities. Furthermore, renewable energy projects can attract foreign investment and promote technological innovation. Collaborative partnerships with international organisations and private investors can facilitate the transfer of knowledge, expertise, and funding for the development of sustainable energy infrastructure. Collaboration among SIDS could support the deployment of renewables (and other economic activity) by pooling experience and resources, including in areas such as education, training and regulation.

In conclusion, while SIDS will not single-handedly alter the trajectory of climate change, the pursuit of renewable energy solutions allows them to be international role models, contributing significantly to mitigating climate impacts while fostering positive socio-economic outcomes. Through strategic investments in renewable energy infrastructure and supportive policies, these states can build resilience, promote sustainable development and create a brighter future for generations to come.

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