UN-OHRLLS
Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States

IRENA
International Renewable Energy Agency

SCALING UP

RENEWABLES IN LANDLOCKED DEVELOPING COUNTRIES

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ABOUT IRENA

The International Renewable Energy Agency (IRENA) serves as the principal platform for international co-operation, a centre of excellence, a repository of policy, technology, resource and financial knowledge, and a driver of action on the ground to advance the transformation of the global energy system. A global intergovernmental organisation established in 2011, IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energy access, energy security, and low-carbon economic growth and prosperity.

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ABOUT UN-OHRLLS

The Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States (UN-OHRLLS) serves the 91 vulnerable member states that are LDCs, LLDCs and SIDS, and is responsible for advocating, supporting, mobilising, co-ordinating and reporting on the implementation of programmes of action and the achievement of the Sustainable Development Goals (SDGs). Since UN-OHRLLS was established, it has been working through a dedicated unit to advocate for LLDCs; to mobilise and co-ordinate the UN system and other stakeholders towards supporting LLDCs; to monitor implementation of the Programme of Action (PoA) for the LLDCs at the country, regional and global levels; to provide intergovernmental support to the LLDCs; and to build effective linkages between the PoA for LLDCs and those of the 2030 Agenda for Sustainable Development.

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FOREWORD

SCALING UP RENEWABLES IN LANDLOCKED DEVELOPING COUNTRIES (LLDCS)

The International Renewable Energy Agency (IRENA) and the UN Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States (UN-OHRLLS) are pleased to share this report on scaling up renewable energy in landlocked developing countries (LLDCs).

LLDCs constitute 32 of the world's most vulnerable nations and are home to 533 million people, accounting for 7% of the world's total population. LLDCs face multi-faceted development challenges emanating from their geographical locations, which limit their access to international markets and intensify their susceptibility to climate change and the impacts of external shocks such as the COVID-19 pandemic. These factors exacerbate the obstacles LLDCs face in achieving the Sustainable Development Goals (SDGs).

While notable progress has been made towards access to reliable, sustainable, modern and reasonably priced energy in recent years, 215 million people in LLDCs still live without reliable energy. Access to energy is an essential enabler for economic activities – such as agriculture, commerce and industry – that are vital for growth in LLDCs. Furthermore, scaling-up renewable energy in these countries is key to building resilience and addressing the impacts of climate change.

The Vienna Programme of Action (VPoA) for the period 2014-2024 highlights energy among its priorities, and investment and power infrastructure upgrades comprise the foundation for LLDCs to structurally remodel their economies, increase access to affordable clean energy, and boost their trade potential.

Therefore, the energy transition is a top priority for all LLDCs, which must leverage their existing domestic bioenergy, solar, hydropower, wind and geothermal resources. The drop in costs for renewable energy, coupled with rapid technological innovation, provide an excellent opportunity to deploy renewable energy in these countries.

This report provides an overview of emerging trends, challenges and drivers for the energy transition in LLDCs and outlines possible actions to advance renewable energy to support the delivery of the SDGs. The report highlights enabling framework options that policy makers in LLDCs can deploy to address barriers and support the increased use and integration of renewables.

The report also provides recommendations for mobilising investments for renewables in LLDCs. It stresses that successful implementation of renewable energy projects will depend on efficient application of public resources, and expansion of financing and risk mitigation instruments. The report also reflects on best practices, highlighting the importance of multi-stakeholder partnerships in LLDCs' energy transitions.

We are confident that this publication will serve as an important advocacy tool to champion efforts to scale-up renewable energy deployment in LLDCs and serve as a key resource for the preparatory process of the Third United Nations Conference on LLDCs, scheduled to be held in 2024.

Francesco La Camera
Director-General, IRENA

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ABBREVIATIONS

ADFD	Abu Dhabi Fund for Development
CASA-1000	Central Asia-South Asia power project
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
CIP	Climate Investment Platform
COP	Conference of the Parties
CSP	concentrated solar power
ETAF	Energy Transition Accelerator Financing
GDP	gross domestic product
GHG	greenhouse gas
GW	gigawatt
HDI	Human Development Index
IRENA	International Renewable Energy Agency
LDC	least developed country
LLDC	landlocked developing country
LTS	long-term strategies
MRV	monitoring, reporting and verification
MW	megawatt
NDC	Nationally Determined Contribution
OHRLLS	Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States
PV	photovoltaic
PoA	programme of action
PPP	public–private partnerships
RRA	Renewables Readiness Assessment
SDG	Sustainable Development Goal
SEforALL	Sustainable Energy for All
SIDS	small island developing states
SMEs	small and medium-sized enterprises
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
VPoA	Vienna Programme of Action
VRE	variable renewable energy

EXECUTIVE SUMMARY

This report outlines a number of possible actions for LLDCs to advance the adoption of renewable energy and harness related socio-economic and environmental benefits. The report concludes that the world is likely to fail to achieve the SDG 7 target of 100 percent access to electricity by 2030, despite notable progress in electrification being recorded over the last decade.

Globally, 733 million people in 2020 lacked access to electricity. While meaningful efforts continue to bring this number down, global advances are marked by unequal progress across different regions. Significant disparities exist amongst and within the LLDCs; currently, 11 out of 32 LLDCs are still lagging behind, with electricity access rates below 50%, while clean cooking access rates are much lower at 27%.

As new solutions to bridge the energy access gap emerge, innovations in distributed renewable energy systems in particular present a pragmatic and affordable alternative for even the most isolated of rural communities. It is therefore recommended that LLDCs consider both on- and off-grid solutions for power and clean cooking to reach universal energy access in a timely manner.

The global discourse on the means to ensure a climate-safe future has placed renewables at the center of recommended measures to definitively tackle the regressive effects of climate change. Nationally Determined Contributions (NDCs) are a key instrument to achieve net-zero emissions globally by 2050. Whilst all LLDCs have submitted their first NDCs, which include renewable energy as a mitigation measure, only 21 among 32 LLDCs had submitted their updated NDCs by the end of COP 26 in November 2021.

In order to successfully shift to a green energy sector, governments need to commit to the energy transition and align it with long-term strategies. LLDCs will therefore require substantiated renewable energy targets consistent with National Determined Contributions (NDCs) and Long-Term Strategies (LTS) to advance development and climate objectives.

Accelerating progress in the global energy transition – and therefore expanding renewable energy markets – will require continued mobilisation and effective deployment of significant investments. Renewable energy investments still fail to meet the requisite threshold to steer the world towards achieving sustainable development and climate goals and realising the many benefits of the energy transition.

IRENA estimates that USD 57 trillion in investment in the energy system will be required between 2021 and 2030 to limit global temperature increase to below 1.5 degrees. One common challenge among vulnerable economies centres around the lack of access to affordable finance. LLDCs will need to leverage public finance to attract and crowd-in private finance investments through strategic tools such as innovative financing instruments including public guarantees and risk mitigation facilities.

Spurred by innovation, renewable energy technologies have seen significant technological advances and competitive pricing in recent years. IRENA analysis indicates solar PV has witnessed the most significant cost decline over the period 2010-2020 at 85%, followed by concentrating solar power (CSP) at 68% and onshore wind at 56%.

Renewable power technologies now account for a significant proportion of new electricity generation capacity. IRENA analysis shows that in 2021 about 260 GW of renewable power was added globally. In LLDCs, the share of installed grid-connected renewable energy capacity in total final energy capacity reached 44% in 2021, a rise from 37% in 2001.

Inadequate information about the viability of renewable resource potential has contributed to the slow deployment of renewables in developing countries such as LLDCs, where such information is insufficient. It is therefore recommended that LLDCs conduct renewable energy resource assessments to inform the viability of renewable energy potential and renewable energy targets in policy commitments, as well as to facilitate project development and investments. In this regard, IRENA's tools for solar and wind assessment have been made available to countries through the Global Atlas Platform for Renewable Energy.

Holistic policy and regulatory frameworks have been instrumental in increasing renewable energy development, as they facilitate the evolution of renewables industry, spur market creation and expansion, and promote technology development, all providing impetus to renewables investment. These factors contribute to decreasing costs and increasing competitiveness.

LLDCs, in collaboration with international development partners, can play an important role in advancing the energy transition by developing policies that eliminate barriers and support the increased integration of renewables. A comprehensive policy package that tackles the twin goals of energy and climate in tandem with socio-economic objectives is therefore required.

LLDCs that are net importers of energy can benefit from electricity trade with neighboring countries where cross-border electricity interconnections are available, reliable and cost-efficient. Regional organisations are therefore encouraged to develop regional policies and implementation processes that facilitate cross-border renewable energy cooperation. In line with IRENA's clean energy corridors' initiative, regional utility entities (*i.e.* power pools) in collaboration with multilateral development finance institutions are called upon to enhance initiatives to spur investments in multi-country generation and transmission projects.

LLDCs are encouraged to utilise existing facilities such as the Climate Investment Platform, which assists in creating a pipeline of projects and supports matchmaking with potential investors; and the Energy Transition Accelerator Financing (ETAF) Platform, which is expected to provide capital to fast-track the pace and scope of renewable energy deployment in tandem with climate and development objectives. LLDCs are also encouraged to request technical assistance to utilise the Renewables Readiness Assessment tool provided by IRENA to identify recommendations to scale up renewable energy.

Meanwhile, the United Nations, IRENA and other relevant inter-governmental organisations and development partners must facilitate the scaling up of investments and technical support to promote renewable energy on a wider scale in LLDCs to overcome rural-urban and gender disparities and increase overall access to modern cooking fuels and electricity with a view to ensuring LLDCs' progress towards the goals of the VPoA and the SDGs.

In particular, LLDCs should be supported to help strengthen their capacities for planning, implementing and monitoring renewable energy policies, and for developing bankable projects in order for them to leverage climate funding for energy projects.

1.

INTRODUCTION AND BACKGROUND

Characterised by remoteness from global markets due to the absence of territorial access to the sea, landlocked developing countries (LLDCs)[1] grapple with a myriad of special challenges, including complex procedures for border transit exacerbated by poor infrastructure, inefficient logistics systems and weak institutions. As a result, LLDCs sustain considerably higher transactional costs for transport and associated trade as compared to coastal territories. Subsequently, the steep costs create a significant fiscal deficit, which has a negative effect on LLDC's budgets and disproportionately impacts progress towards economic development (UN-OHRLLS, 2020a). LLDCs' vulnerabilities with respect to international trade and transit have further been exacerbated by the COVID-19 pandemic, as many countries continue to resort to restrictions on free movement of goods and people.

LLDCs are reliant on a few commodities for their earnings and are characterised by weak growth rates; they therefore feature among the poorest of the developing countries. Of the 32 LLDCs, 17 are categorised as least developed countries (LDCs).

Box 1 LLDCs in a socio-economic development context

- The annual growth rate of LLDCs' real gross domestic product (GDP) declined from 4.3% in 2019 to 2.4% in 2020. Only eight LLDCs had a positive GDP growth rate in 2020.
- In 2020 the LLDC's average GDP per capita was USD 1 508 (constant 2010 USD), the lowest level since 2013. GDP per capita is still below USD 1 000 in 12 LLDCs. The average Human Development Index (HDI) value for LLDCs fell to 0.511 in 2019, the lowest level since 2013.
- The percentage of the population in LLDCs below the international poverty line of USD 1.90 per day declined from 27.3% in 2015 to 23.9% in 2019. Yet the pandemic pushed 119-125 million people into poverty globally, which is likely to have reversed poverty alleviation trends in LLDCs.
- At 14.2%, social protection coverage in LLDCs is significantly lower than the global average of 46.9%, measured as the percentage of the population guaranteed minimum benefits. Of the 35 countries around the world experiencing food crises, 18 are LLDCs.

Source: UN-OHRLLS (2020a).

[1] *The 32 LLDCs comprise: Afghanistan, Armenia, Azerbaijan, Bhutan, Bolivia, Botswana, Burkina Faso, Burundi, Central African Republic, Chad, Eswatini, Ethiopia, Kazakhstan, Kyrgyzstan, Lao People's Democratic Republic, Lesotho, Malawi, Mali, Mongolia, Nepal, Niger, North Macedonia, Paraguay, Republic of Moldova, Rwanda, South Sudan, Tajikistan, Turkmenistan, Uganda, Uzbekistan, Zambia and Zimbabwe.*

The Vienna Programme of Action (VPoA) for the LLDCs during the period 2014-2024, the successor framework of the Almaty Programme of Action, was adopted at the Second UN Conference for LLDCs held in 2014. The VPoA aims to eradicate poverty resulting from countries' landlocked status, remoteness and geographical constraints, through implementation of key interventions in the following prioritised sectors: international trade and trade facilitation, regional integration and co-operation, structural economic transformation, infrastructure, transit and mechanisms for execution, with the ultimate goal of transforming countries from being landlocked to land-linked.

Access to sustainable and modern energy serves as a catalyst and vital enabler for the progress of societies and is rightly highlighted as a top priority in the VPoA, with the desired goal of expanding energy services to rural and urban areas by improving the supply infrastructure associated with renewable energy technologies.

For the energy sector, the VPoA calls for LLDCs to embrace energy trade and joint investment in power generation and transmission projects with neighbouring countries. Secondly, the VPoA encourages LLDCs to implement enabling policies that will meaningfully enhance production and distribution of clean energy in order to facilitate universal access to energy and economic transformation (UN-OHRRLS, 2014).

To facilitate implementation, the VPoA encourages development partners to take action in the field of energy and support LLDCs to advance the sector by facilitating investment in clean technologies to ensure a sustainable economic transformation.

The adoption of the Political Declaration of the Midterm Review of the Implementation of the VPoA, in December 2019, renewed the pledges made by international partners to support LLDCs achieve the global Sustainable Development Goals (SDGs) (UN-General Assembly, 2019). The Midterm Review revealed that despite the numerous efforts made by LLDCs and partners, limited progress had been recorded in many areas of the VPoA. It was further noted that these efforts fell short for LLDCs to fully implement the VPoA and to achieve the SDGs in line with the Paris Agreement (UN-General Assembly, 2019). Some of the major challenges identified include limited capacity to develop projects, limited access to financial resources and lack of reliable and regular data to inform policy.

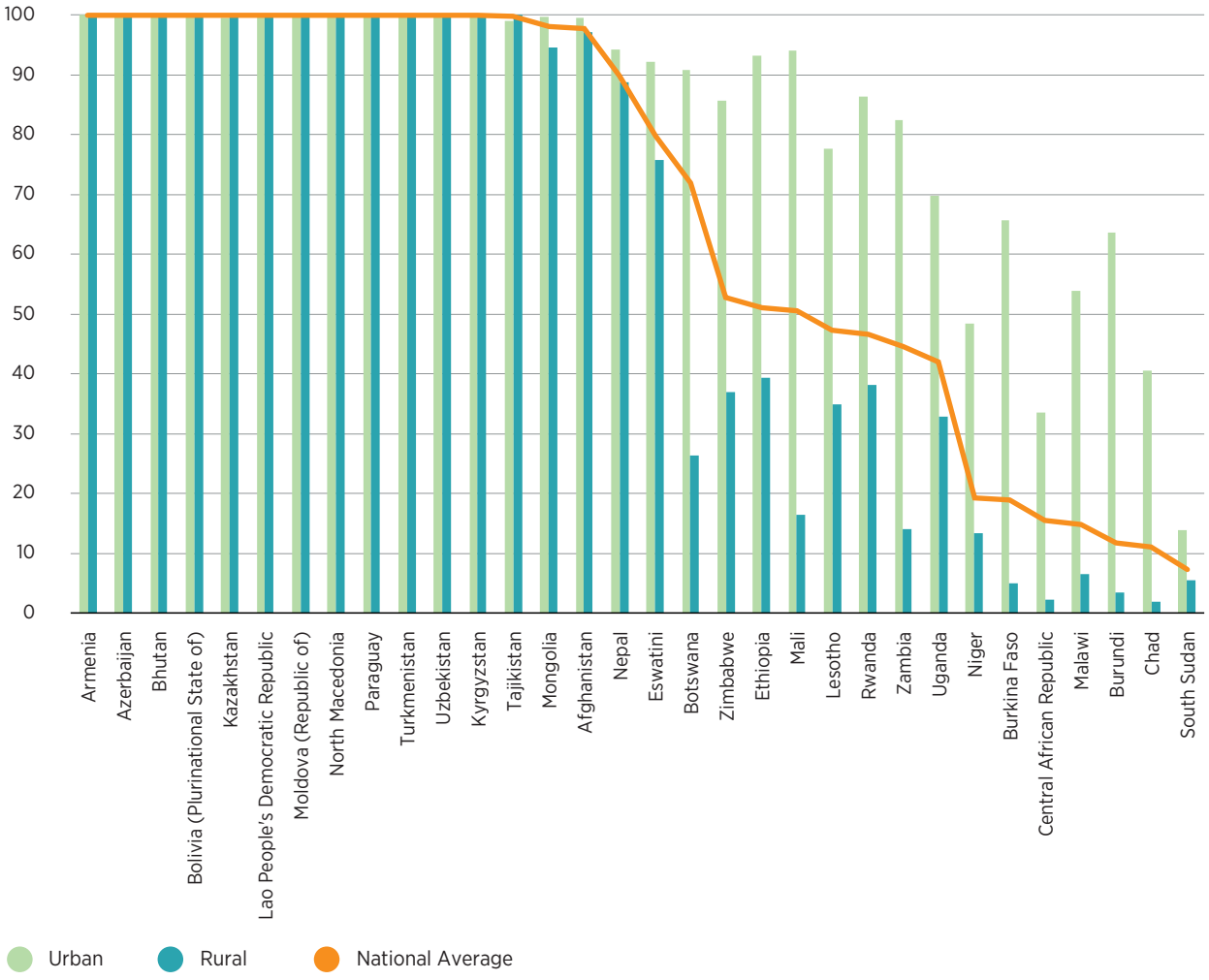
Against this background, the International Renewable Energy Agency (IRENA) established a memorandum of understanding with UN-OHRLLS in September 2019 to strengthen co-operation aimed at promoting renewable energy deployment in LDCs, LLDCs and SIDS, namely through the energy components of the respective PoA. The two organisations aim to deploy joint efforts towards supporting LDCs, LLDCs and SIDS accelerate the energy transition, achieve 100% access and leverage the benefits of renewable energy.

This joint UN-OHRLLS and IRENA report on scaling up renewable energy in LLDCs is one of the deliverables of the Roadmap for Accelerated Implementation of the VPoA (UN-OHRLLS, 2020b). The report is based on IRENA and UN-OHRLLS analytical reports, and provides an overview of deployment trends, drivers, barriers and opportunities for energy transition. It focuses in particular on the challenges facing LLDCs in attracting renewables investment towards achieving universal access and net zero targets. The report provides recommendations for LLDCs to accelerate deployment in line with Agenda 2030, the Paris Agreement and the VPoA. In addition, this report contributes to the substantive preparatory process on the thematic area of renewable energy for the Third United Nations Conference on LLDCs in 2024, which aims to formulate and adopt a renewed framework for international support.

1.1 LLDCs' progress on energy access and renewable energy deployment

While notable progress has been made towards improving access to electricity in recent years (declining globally from 1.2 billion people unserved in 2010 to 733 million in 2020), about 215 million people in LLDCs continue to lack access (IRENA, IEA, UNSD, World Bank, WHO, 2021) (IRENA *et al.*, 2021). While the average level of electricity access rates in LLDCs grew from 45% in 2010 to 60% in 2020 (World Bank, 2021), this is significantly lower than the global average of 83% in 2010 and 91% in 2020.

Figure 1 Electricity access rate by LLDC in 2020 (%)



Source: IRENA *et al.* (2021).

Figure 1 shows that 13 LLDCs were able to close their electricity access gap or were close to closing it as of 2020. At the same time, 11 LLDCs still have access rates below 50%, all of which are located in sub-Saharan Africa.

A significant imbalance remains between urban and rural populations in LLDCs, with 88% and 46% having access to electricity in 2020, respectively. Meanwhile, the global urban average was at 97% in 2020 and the rural average 83% – significantly higher in comparison to the average LLDC rate.

The share of LLDCs' overall population with access to clean cooking fuel increased from 25% in 2010 to 27% in 2020 (WHO, 2021). There is a significant access deficit in rural areas, which have a 14% access rate,

compared with 54% in urban areas in 2020. Women are disproportionally impacted by energy poverty in the LLDCs, more so due to domestic reliance on charcoal and wood, and the associated health implications (UNDP and UN-OHRLLS, 2021).

Challenges in electrifying the last mile – such as affordability constraints, the lack of adequate financing for end users and enterprises, and a dearth of infrastructure investment and sustainable business models, as well as operational inefficiencies – often mean that many off-grid rural customers and enterprises are bypassed by traditional electrification projects. At the same time, these customers and enterprises frequently represent a strong element of support for local economies, particularly in agriculture and agro-processing (Box 2). The agricultural sector, for instance, accounted for 16.2% of the GDP of LLDCs in 2019, whereas the global average was 4% (UN-OHRLLS, 2020a).

Box 2 Renewable energy to improve agri-food value chains in the Hindu Kush Himalayan region

Recognising the common thread between energy and agriculture, IRENA, the International Centre for Integrated Mountain Development and the SELCO Foundation have partnered to assess energy needs across three agri-food value chains in the Hindu Kush Himalayan region, which encompasses mountain communities in Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal and Pakistan. The analysed value chains are of economic importance across the region. The value chains included in the analysis are:

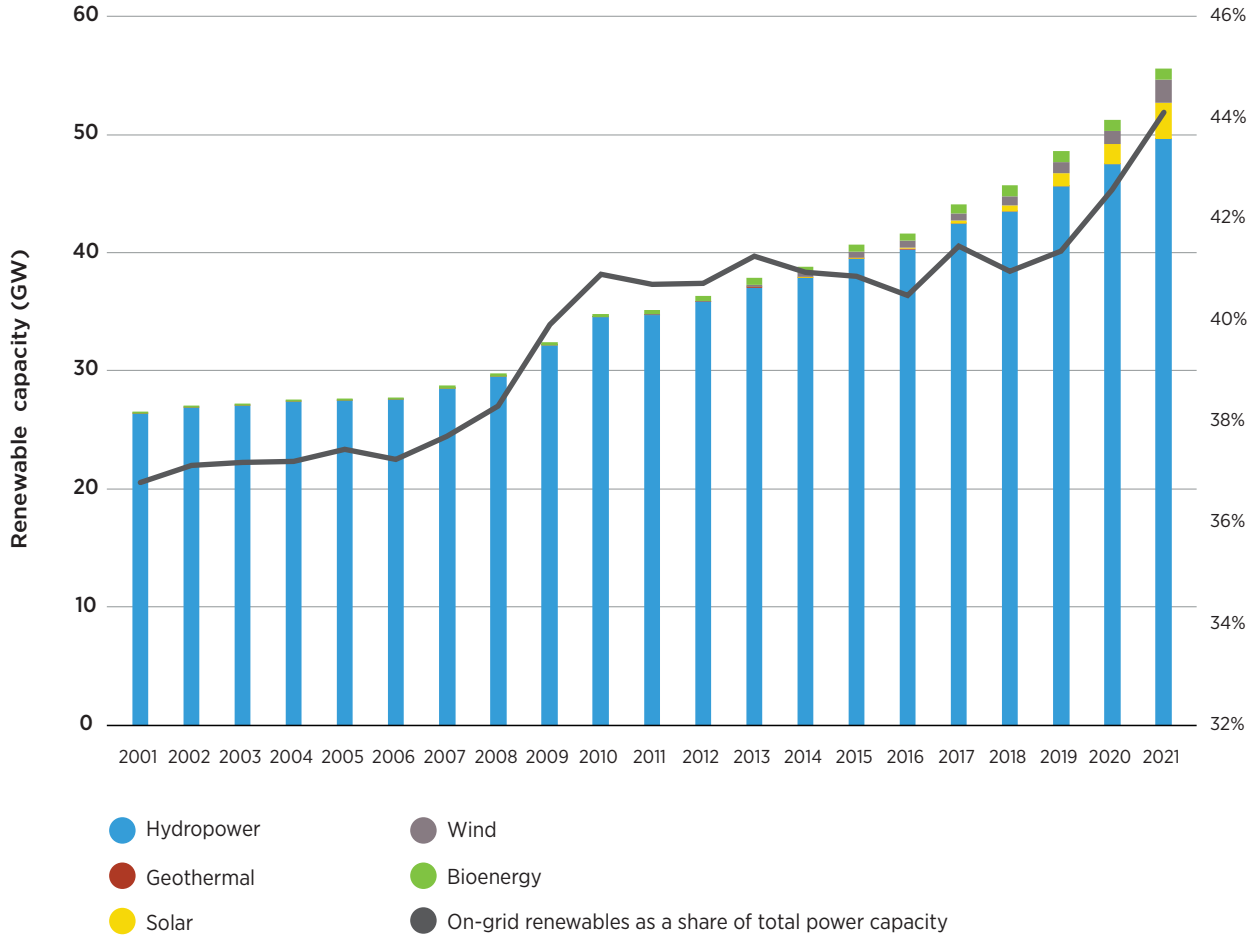
- Buckwheat, a very common crop in the region, grown primarily for human consumption. It is a short-season crop and does well in low-fertility or acidic soils. In Nepal, buckwheat is counted as the sixth staple food crop; in Bhutan, over 70% of marginal farmers depend on it.
- Yak is the main animal source of livelihood for high-altitude populations, particularly those where climate and terrain make farming difficult. Yaks provide milk, fibre, meat and associated by-products.
- Potatoes are widely grown across the region, mainly in hilly areas at relatively lower altitudes. Particularly in Nepal and Bhutan, they are grown as a short-duration crop offering high yields in cool climates. They are well suited to the production of seed tubers for sale at lower altitudes.
- Vegetables are commonly grown across the region both for subsistence and for selling. Leafy vegetables, particularly fermented and sun-dried (*gundruk*), are a highly popular food in Nepal.

Across each value chain, the analysis identifies decentralised renewable energy applications to improve energy access, reduce losses and drudgery, and raise incomes. A preliminary cost-benefit analysis has been undertaken to assess the viability of various solutions. Some of the most viable, according to the assessment, include renewables-based weeding, threshing and winnowing machines (buckwheat), cold storage (yak milk, potatoes and vegetables), pumped and drip irrigation systems (potatoes and vegetables), and butter churners and cream separators (yak milk).

Source: FAO and IRENA (2021).

Technological innovation and advancement in business models, combined with falling costs, have supported the global uptake of renewables, offering affordable energy access to even the most remote rural communities. The percentage of total installed electricity capacity in LLDCs comprising on-grid renewable electricity capacity reached 44% in 2021, a rise from 37% in 2000 (Figure 2). The high share of renewables is mostly due to hydropower installed in the countries with a large potential for this technology (*e.g.* Ethiopia, Zambia, Bhutan, Kazakhstan and Tajikistan).

Figure 2 Installed renewable capacity (GW) and installed on-grid renewable power capacity as a share of total installed power capacity (%) in LLDCs

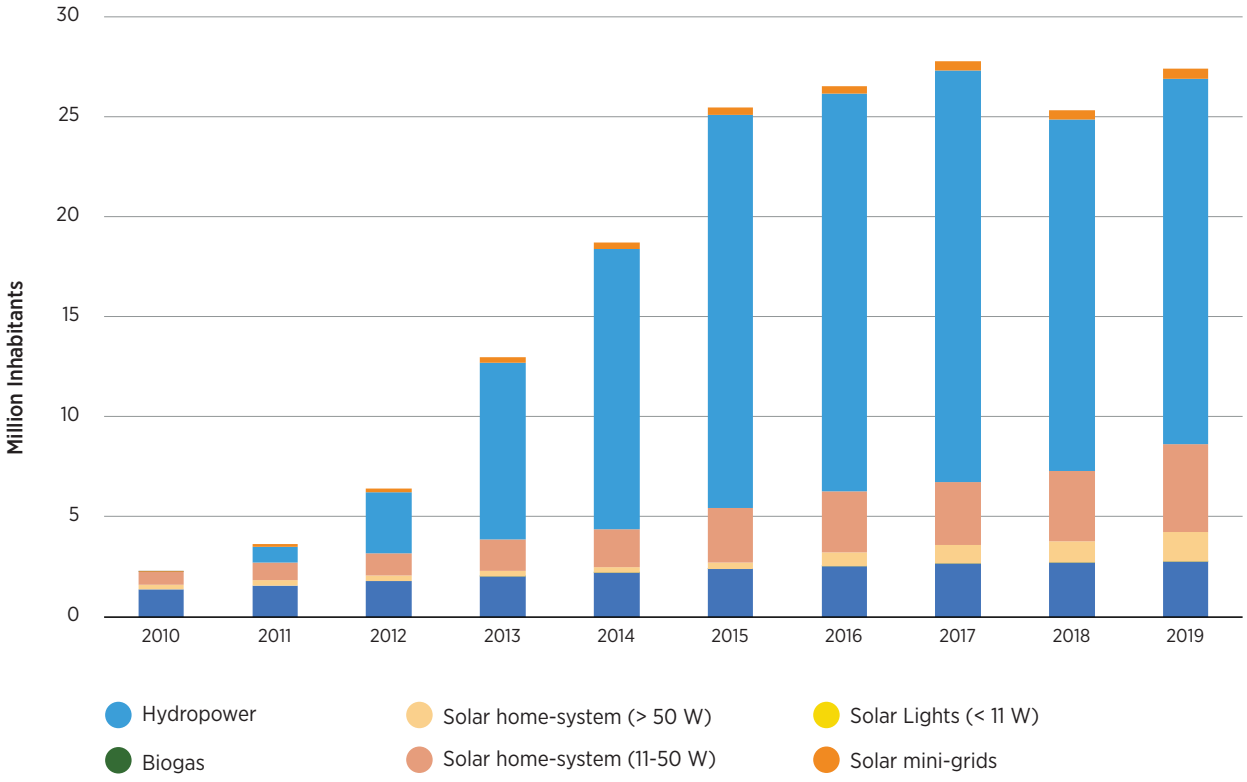


Source: IRENA (2022a).

Over the last five years, renewable energy capacity has grown at an annual rate of less than 10% in developing countries, and within this subset, LLDCs recorded a much lower growth rate of only 2.4%. With such annual growth rates and without further interventions, LLDCs are likely to take more than 40 years to achieve the renewables deployment rate being achieved globally in 2020.

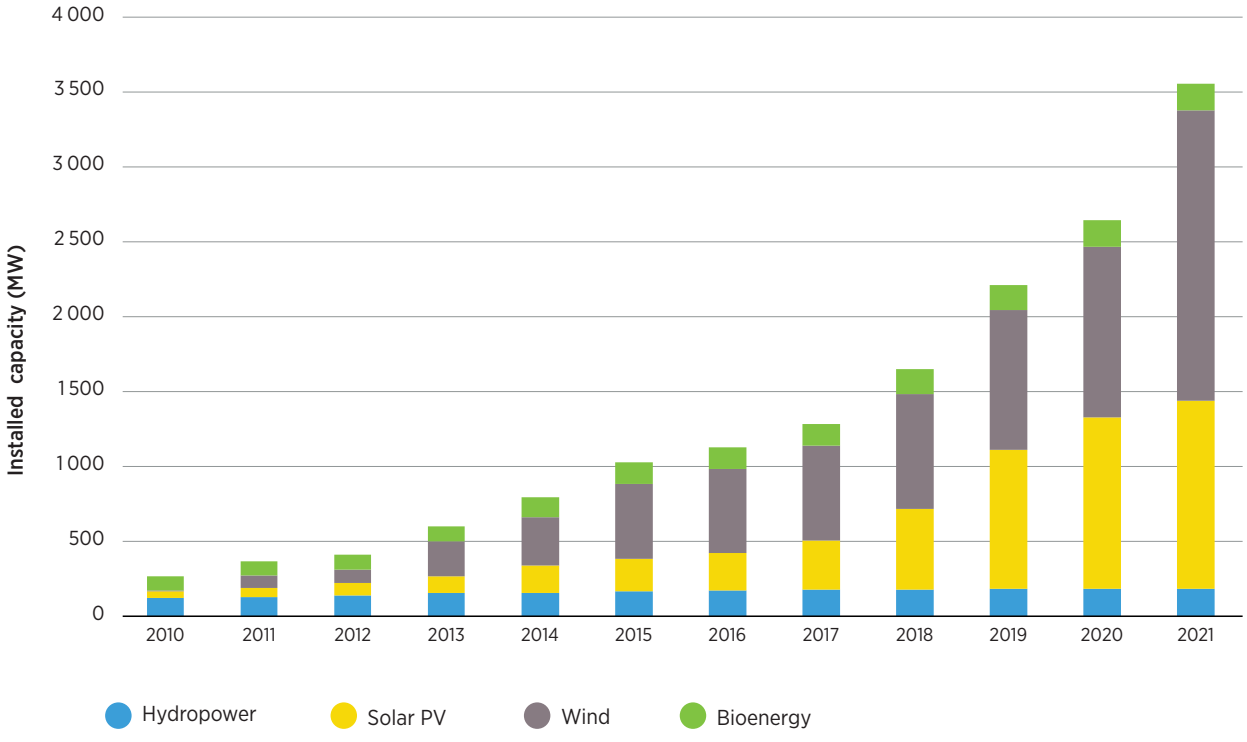
As regards distributed energy solutions, the number of people benefiting from off-grid renewable technologies in LLDCs reached 27 million in 2019 (Figure 3). The total capacity of off-grid renewables in LLDCs increased from 265 MW in 2010 to 3 554 MW in 2021, with the contribution of hydro growing from 120 MW to 181 MW, solar photovoltaic (PV) from 42 MW to 1 255 MW, wind from 5 MW to 1 939 MW and bioenergy 97 MW to 178 MW (Figure 4).

Figure 3 Number of people benefiting from off-grid renewable technologies in LLDCs



Source: IRENA (2022a).

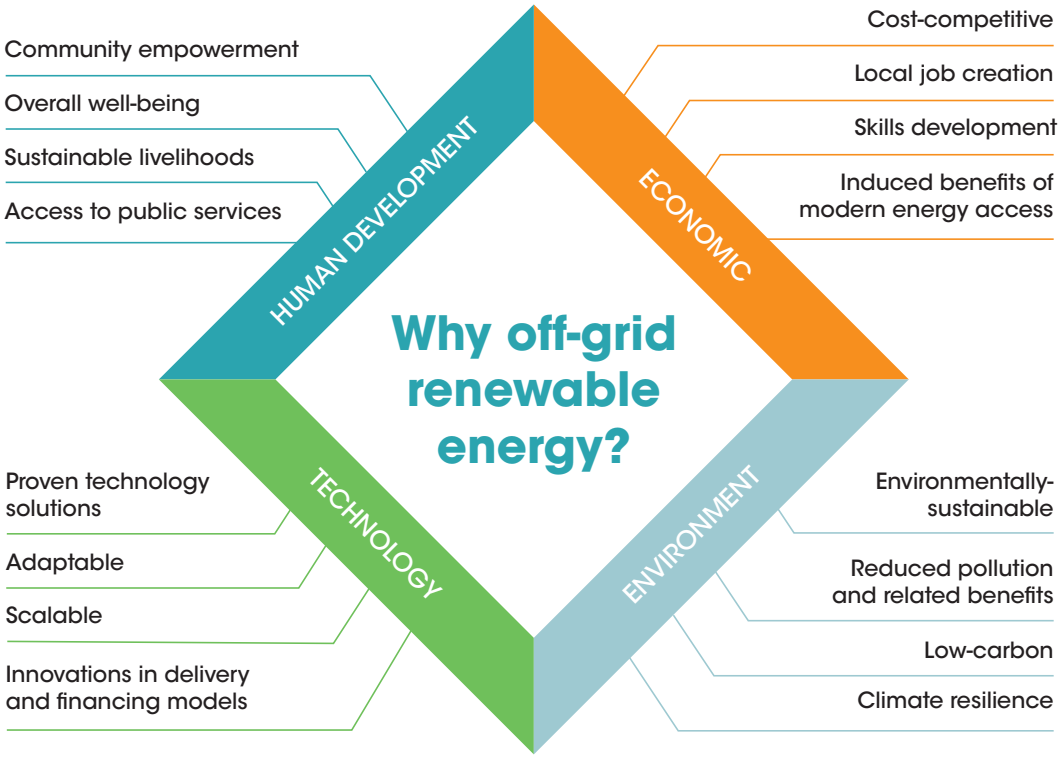
Figure 4 Installed capacity of off-grid renewable technologies in LLDCs



Source: IRENA (2022a).

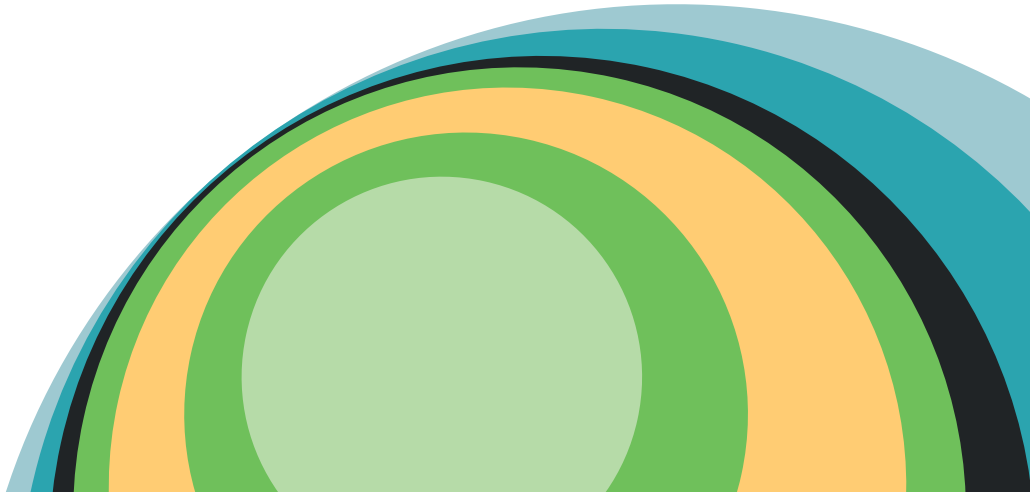
Several factors such as adaptability and scalability have precipitated electrification via off-grid solutions (Figure 5). Off-grid renewable technologies provide a viable electrification solution that requires low initial investment, is rapidly deployable, is environmentally sound, can be suited to match local needs and has the potential to empower rural communities, with a focus on youth and women, while enabling agricultural activities.

Figure 5 Case for off-grid renewable energy solutions



Source: IRENA (2019c).

The COVID-19 pandemic further reiterated the need for continuous electricity supply to power critical facilities such as healthcare facilities, water reticulation, information technology and cold chain infrastructure. Access to affordable, reliable and sufficient electricity is essential to guarantee efficient health services to communities. In this regard, renewable energy solutions present an opportunity to extend the reliable and cost-effective electrification of healthcare facilities and unlock substantial benefits (Box 3).



Box 3 Electrification of primary healthcare facilities in Burkina Faso

IRENA has undertaken sector assessments for the electrification of primary rural healthcare facilities in selected countries among its Membership. The agency has partnered with the SELCO Foundation and the government of Burkina Faso in a first pilot of this line of work, which is to be expanded to other Members. The objective is to support these countries' efforts in the electrification of healthcare facilities by carrying out a gap analysis and by providing tailored recommendations. This work will also comply with IRENA's engagement with the African Union to stem the COVID-19 pandemic.

The assessment will lead to the production of a report based on primary and secondary data, and will provide:

- Recommended energy solutions, based on local needs and optimised for energy efficiency, building design, medical appliance usage and specific energy needs of rural health facilities vis-à-vis the management of COVID-19.
- Capital and operations and maintenance (O&M) cost estimates for existing unelectrified or inadequately electrified rural health facilities.
- Recommendations pertaining to the overall ecosystem, including policy measures, institutional oversight, capacity development and delivery models.

Once the assessment report is completed, IRENA along with the government and other partners will support extensive outreach to share the findings and results, and in particular target entities that can potentially provide funding to the government for implementation.

Source: IRENA (forthcoming).

1.2 LLDCs and nationally determined contributions

In the period from 2014 to 2019, carbon dioxide (CO_2) emissions recorded an annual increase of 1.3% globally (IRENA, 2022a). While emissions in 2020 contracted by 7% relative to 2019, a rebound looks very likely. LLDCs are not amongst the large emitters: the total greenhouse gas (GHG) emissions of the 32 LLDCs add up to only 1.9% of global emissions (718 million tonnes of CO_2e) (EDGAR, 2020). Nonetheless, LLDCs are exposed to significant climate change risks and are already experiencing visible climate impacts such as change in precipitation patterns, intensified desertification, loss of biodiversity and melting of permafrost (IRENA, 2016).

Recognising the climate vulnerability of LLDCs, the Almaty Declaration (2012) stressed the importance of international support to address climate change impacts and access to clean technologies. In the political declaration adopted at the 2019 VPoA's midterm review, the UN General Assembly urged the international community to assist LLDCs develop and implement nationally determined contributions (NDCs) and national long-term climate change strategies in line with the goals of the Paris Agreement.

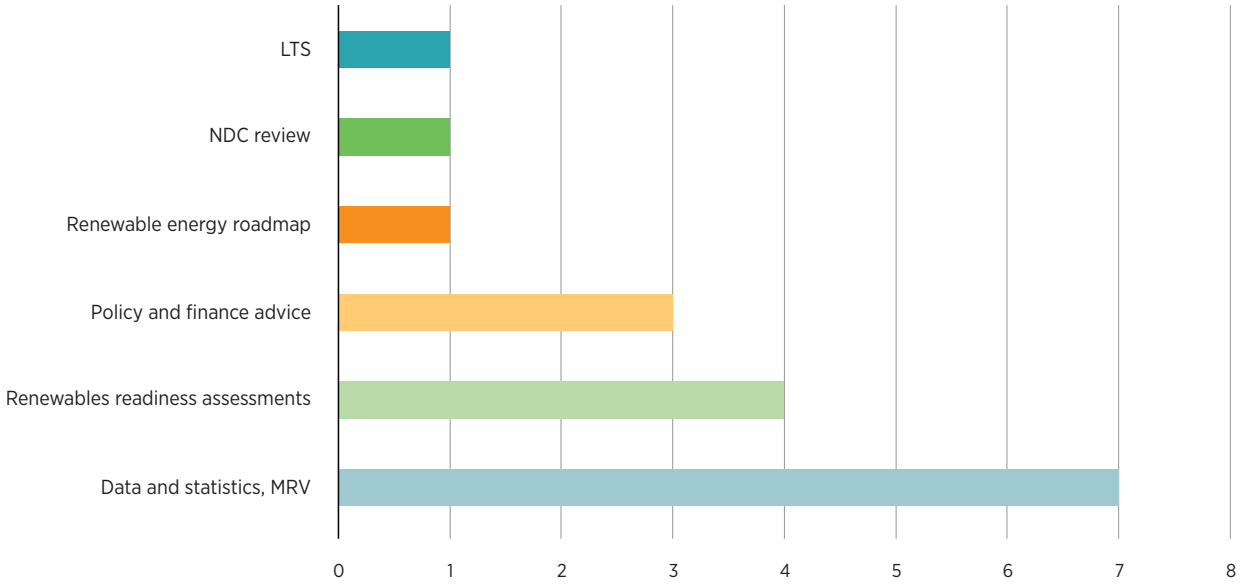
As part of the global impetus to address the climate change crisis, NDCs are a key instrument to achieve the medium- to long-term mid-century climate goal of net zero emissions, as Parties set the GHG emission reduction targets and sectoral plans reflecting different national circumstances and priorities in their NDCs. UNFCCC analysis in 2021 shows that total GHG emissions are estimated to be 0.7% lower than in 1990 by 2030 if all the conditional and unconditional measures in the NDCs are implemented. While current NDC pledges are not sufficient to realise the Paris Agreement goal, the year 2021 marked an important turning point towards a 1.5°C climate pathway as many countries had already submitted their updated NDCs before COP26 in Glasgow.

According to IRENA analysis (2022a), in order to limit global average temperature rise to below 1.5°C above pre-industrial levels, fossil fuel consumption should fall by 75% by 2050. Since the energy sector accounts for almost 80% of anthropogenic GHG emissions, the role of renewable energy as a clean and cost-effective mitigation option is critical. Coupled with energy efficiency measures, renewable energy can deliver over 90% of mitigation measures on a 1.5°C pathway. IRENA estimates that approximately an additional 10 TW of renewable power generation capacity would be deployed globally by 2030 if renewable energy targets in NDCs were achieved.

LLDCs can raise their ambitions to cut GHG emissions by putting progressive renewable energy targets in their NDCs in line with the Paris Agreement. Whilst all LLDCs have submitted their NDCs, which include renewable energy as a mitigation measure, only 21 countries among 32 LLDCs had submitted their updated NDCs by the end of COP26 in November 2021. This still leaves room for enhancing planned NDC updates. IRENA research found that while at least 18 have enhanced their ambition with respect to their GHG emission targets, only four had detailed specific renewable energy targets (IRENA, 2021a). Many LLDCs are facing challenges in NDC enhancement and implementation, especially access to finance, technology transfer and capacity enhancement. International support can serve an important role in advancing these countries' ambitions in their NDCs and implementing those targets.

IRENA's NDC engagement reaches across the world and includes 20 LLDCs with a total of 31 NDC support activities (Figure 6). This work has identified that improving GHG emission data and statistics, including for monitoring, reporting and verification (MRV), is the most frequently requested NDC support activity for LLDCs since Parties are required to update and submit them under Article 13 of the Paris Agreement. Developing cost-effective mitigation options in climate action plans and decarbonising end-use sectors using renewable energy are other key areas where many LLDCs request support. LLDCs also have specific needs for long-term energy planning, renewable readiness assessment (Box 4) and renewable energy policy advice. These activities support LLDCs not only in enhancing their NDC targets, but also in accelerating the deployment of renewable energy economy-wide by developing renewable energy project pipelines.

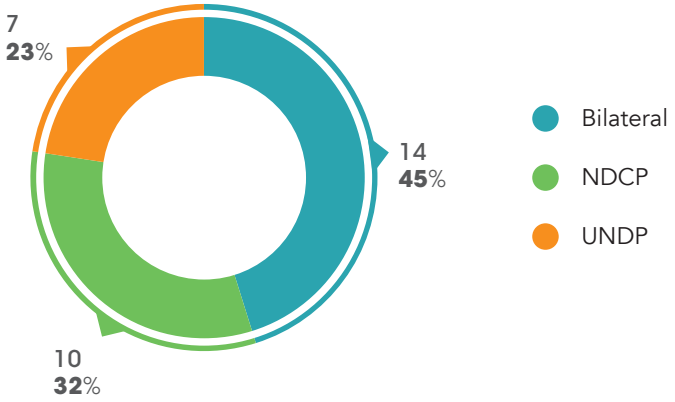
Figure 6 Distribution of IRENA climate action work packages (number of NDC support activities)



Note: LTS = long-term strategy.
Source: IRENA (unpublished).

International partnership is crucial in supporting LLDCs. IRENA's support for LLDCs is being made through bilateral engagement with governments and states in 14 activities, with the NDC Partnership in 10 activities and United Nations Development Programme (UNDP) in 7 activities (Figure 7).

Figure 7 Source of IRENA support requests for LLDCs



Source: IRENA (unpublished).

Box 4 NDC support for Bhutan

IRENA has supported Bhutan on NDC enhancement through the findings of the Renewable Readiness Assessment (RRA) that they completed in 2019. Capitalising on the NDC revision process, Bhutan's RRA outlines an energy sector roadmap that complements the country's work to accelerate widespread exploitation of various renewable energy resources (IRENA, 2019b). Further, the RRA sets out strategies for the country to secure its energy supply through a diversified and sustainable energy mix.

The RRA findings demonstrate that renewable energy technologies, including wind, solar, bioenergy and hydropower, present opportunities for meeting the country's growing energy demand. Standalone renewable systems would help enhance access while yielding socio-economic benefits, including improved indoor air quality and livelihoods.

Contrary to the first NDC, which did not have any specific renewable energy targets, substantial progress has been made on this topic. Bhutan has included various types of renewable energy, with specific targets in its second NDC consisting of solar, mini-hydro, wind, waste-to-energy and green hydrogen technologies.

Source: IRENA (2019b).

2.

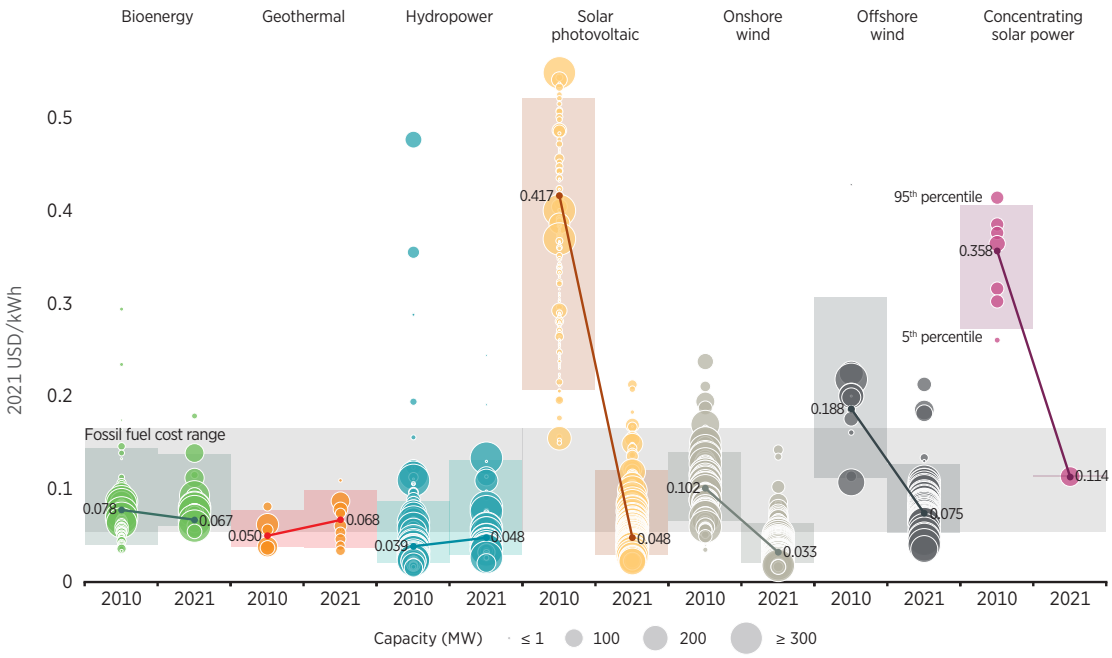
THE RATIONALE FOR RENEWABLES IN LLDCS

The global transition towards sustainable energy systems is inexorable. LLDCs – many of them rich in renewable resources – can take full advantage of decreasing renewable energy costs and make progress in realising a clean energy transition and close the access gap, while creating new jobs and advancing socio-economic and industrialisation objectives. This chapter provides an overview of the factors that make renewables a viable option, including renewable energy costs, innovation trends, cross-border electricity trade, global impetus to achieve universal access, and associated socio-economic impacts.

2.1 Renewable energy costs

Despite the impact and disruption caused by COVID-19 pandemic, renewables recorded notable resilience to become more competitive than new fossil-based electricity. Driven by enabling policies, rapidly evolving technologies, effective supply chains and economies of scale, solar PV and wind became the most cost-effective sources of electricity.

Figure 8 Global levelised cost of energy of utility-scale renewable power generation technologies, 2010-2020



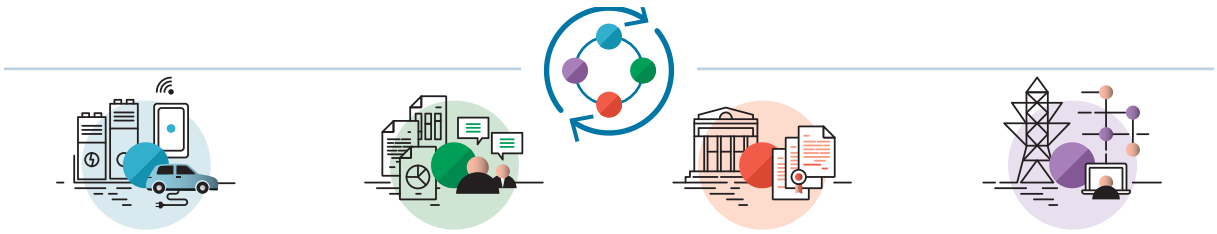
Source: IRENA Renewable Cost Database.

IRENA analysis (Figure 8) indicates solar PV to have recorded the most significant cost decline over the decade 2010-2020 at 85%, with concentrated solar power (CSP) at 68%, onshore wind at 56% and offshore wind at 48% (IRENA, 2021b). Vulnerable economies such as LLDCs with growing electricity demand should leverage competitive renewable power generation costs and shift investment from fossil fuel power generation towards renewables to benefit from the much-needed socio-economic development.

2.2 Renewable energy innovation trends

Countries experiencing growing renewable generation capacity must jointly match this innovation with increased system flexibility and resilience to integrate very high shares of renewables. Innovative solutions go beyond innovation in technology, involving innovations in business models, new regulations and market design as well as new ways to operate the system. IRENA has outlined 30 key innovations that can empower the integration of higher shares of variable renewable energy (VRE), such as solar PV and wind (Figure 9).

Figure 9 The landscape of innovation options for LLDCs



ENABLING TECHNOLOGIES	BUSINESS MODELS	MARKET DESIGN	SYSTEM OPERATION
1 Utility-scale batteries 2 Behind-the-meter batteries	12 Aggregators 13 Peer-to-peer electricity trading 14 Energy-as-a-service	17 Increasing time granularity in electricity markets 18 Increasing space granularity in electricity markets 19 Innovative ancillary services 20 Re-designing capacity markets 21 Regional markets	25 Future role of distribution system operators 26 Co-operation between transmission and distribution system operators
3 Electric-vehicle smart charging 4 Renewable power-to-heat 5 Renewable power-to-hydrogen	15 Community-ownership models 16 Pay-as-you-go models	22 Time-of-use tariffs 23 Market integration of distributed energy resources 24 Net billing schemes	27 Advanced forecasting of variable renewable power generation 28 Innovative operation of pumped hydropower storage
6 Internet of things 7 Artificial intelligence and big data 8 Blockchain			29 Virtual power lines 30 Dynamic line rating
9 Renewable mini-grids 10 Supergrids			
11 Flexibility in conventional power plants			

Source: IRENA (2019a).

To develop appropriate solutions for a renewable powered system, it is effective to match and leverage synergies among innovations in multiple components of the power system (IRENA, 2019a). IRENA has created an eight-step innovation guideline for the integration of innovation into power systems (Box 5).

Box 5 IRENA eight-step innovation guideline

1. Develop far-sighted policy frameworks that anticipate future power system needs.
2. Adopt a systemic approach, drawing together innovations in technology, market design, business models and operation.
3. Foster learning by doing through ongoing trial and demonstration.
4. Account for changing roles and responsibilities in the operation of the power system.
5. Make market design innovation a priority, as it fosters flexibility at relatively low cost.
6. Create synergies between renewable power supply and electric mobility, heating and cooling.
7. Turn smart innovations into smart solutions using digital technologies.
8. Adopt an open and co-operative approach to innovation.

Source: IRENA (2020a).

2.3 Cross-border electricity trade in renewable energy

Half of the LLDCs are net importers of energy. Renewable energy can be an important tool for promoting trade facilitation and making supply chains more efficient. For LLDCs, reliable renewable energy can reduce delays caused by power outages at border crossings and customs clearance, as well as other transit processes. Greater efficiency in their operation would reduce the cost of transactions and expand opportunities for LLDCs to participate in international markets.

One of the opportunities for landlocked countries is that they can benefit from cross-border trade in electricity with neighbouring countries, where electricity interconnections are in place. Trading electricity across borders increases system flexibility and resilience and allows more rapid and widespread renewable capacity expansion (Box 6).

Box 6 Collaborative Framework on enhancing dialogue on high shares of renewables in energy systems

Responding to a request received from its membership, IRENA has established a series of Collaborative Frameworks on key topics. These expand the agency's efforts to facilitate bespoke collaboration that allows countries to explore synergies and common solutions to address challenges impeding the rapid deployment of renewables. As part of this initiative, IRENA started the Collaborative Framework on enhancing dialogue on high shares of renewables in energy systems, to facilitate the exchange of knowledge among participating countries, and to guide countries that are on a similar path.

Preparatory meetings were held in July and October 2020, aimed at setting a clear scope and objectives for the framework along with an implementation approach. This Collaborative Framework will frame the discussion around six areas: 1) system planning; 2) system operation; 3) cross-border interconnections; 4) energy markets and regulations; 5) cross-sectorial strategies; and 6) system innovation. Canada and Uruguay were elected as co-facilitators of this framework.

The pilot phase of this Collaborative Framework started in 2021 centred on the following three focus areas in the form of workstreams: 1) power system interconnections to promote multi-lateral trade of renewable electricity; 2) efficient operation of energy systems with a high penetration of VRE; and 3) robust power system planning and long-term energy scenarios.

Source: IRENA (unpublished).

2.4 Renewable energy for universal energy access

Access to electricity is more likely to be achieved if centralised connections are deployed together with standalone systems. This calls for a paradigm shift from implementation mainly centred on providing on-grid electricity to households. It is also important to ensure access to levels of electricity that are higher than those generally required by households in accordance with the multi-tier framework, which measures access based on attributes such as affordability, safety and reliability. Electricity supply of Tier 3 and above is necessary to support productive uses that are vital for socio-economic development and job creation. Assessments of energy needs for productive user groups should therefore be undertaken (IRENA *et al.*, 2021). Moreover, stronger emphasis should be placed on promoting modern fuels and technologies for cooking and heating.

There is considerable potential for the rollout of decentralised renewable energy solutions, such as mini-grids and standalone systems (*e.g.* solar home systems, solar lights), to meet both energy consumption and production needs and to support productive uses of equipment. Corresponding, measures should be put in place to facilitate capacity building, financing and linking energy to livelihoods.

2.5 Renewable energy and resource potential

In most LLDCs, current generation capacity does not reflect the existing renewable resource potential and progress towards exploiting renewables has been delayed. Several studies – undertaken to better understand the issues affecting renewable energy deployment and subsequent project success – identify inadequate resource assessment as one of the critical factors contributing to slow deployment of renewables in developing countries such as LLDCs, where such information is insufficient.

By conducting resource assessments, LLDCs could deepen understanding of the viability of renewable energy sources, facilitate project development planning, boost local capacity, and inform renewable energy targets and commitments in their NDCs. Data and information on renewable energy techno-economic potential underline the overarching framework for renewable energy project development, and influence decision-making by public authorities and policy makers responsible for planning their countries' energy future.

To address this gap, IRENA's geospatial site assessment services (Box 7) support countries in evaluating their resource potential and identifying cost-effective power generation zones that are appropriate for deploying utility-scale wind, solar PV power and CSP projects.

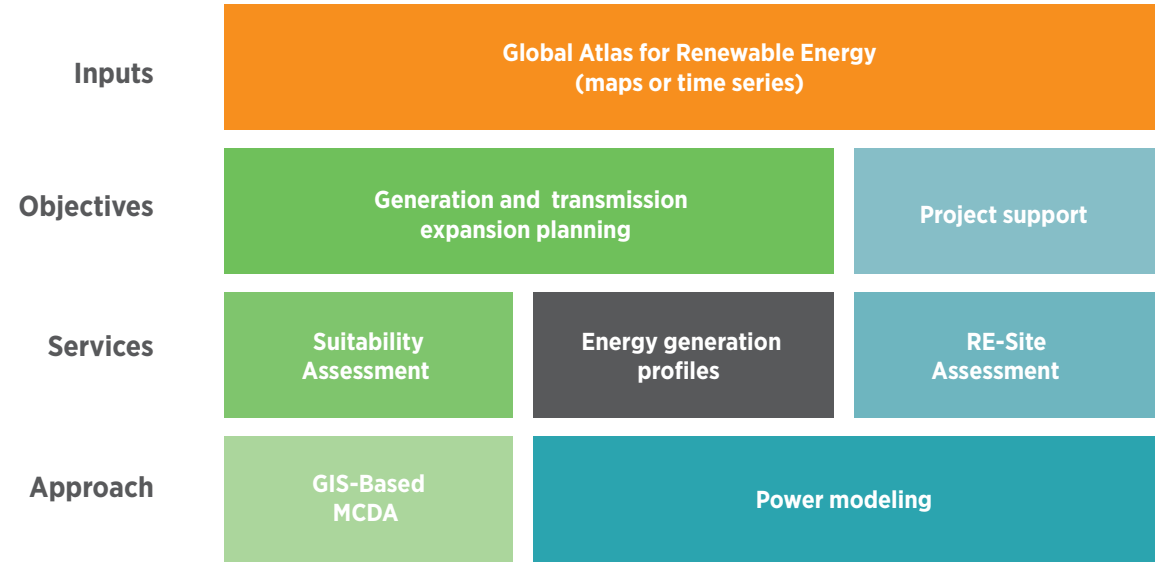
Box 7 IRENA geospatial site assessment services

The Global Atlas for Renewable Energy (Global Atlas) is an initiative co-ordinated by IRENA, aimed at closing the gap between nations that have access to the necessary datasets, expertise and financial support to evaluate their national renewable energy potentials, and those countries lacking such elements. The initiative provides a collaborative internet-based geographic information system (GIS) for wind and solar resources that can direct and enhance co-operation on global scenarios and strategies. Featuring data from a consortium of more than 50 international research institutions, the Global Atlas is the world's largest collection of the most recent and most accurate public maps of renewable energy resources. Results take the form of map pixels representing suitable areas that can be sensibly aggregated to estimate the resource potential. The Global Atlas provides access to the datasets and methods to allow a first screening for areas of opportunity where further assessments can be of particular relevance. It enables the user to overlay information listed in a catalogue of more than 2 000 maps and datasets, and to identify areas of interest for further prospection. The potential spectrum of end users for the Global Atlas ranges from policy makers and public authorities to investors and developers, academics and the interested public.

Box 7 IRENA geospatial site assessment services (continued)

IRENA's renewable energy site assessment service aims to evaluate the technical and financial viability of sites for solar PV and wind project development. The methodology uses high-resolution site-specific time series resource data, site characteristics and technological parameters to calculate the annual energy production at different exceedance probabilities for each site. It further simulates the levelised costs and tariffs at which the sites would become viable for further investment based on *in-situ* measurements and subsequent development. This information is of critical value to local authorities, which can screen these sites by comparing the pro-forma tariffs or levelised costs against a benchmark, ensuring resources are invested only in worthwhile locations.

Figure 10 IRENA geospatial site assessment services



Note: MCDA = multi-criteria decision analysis.

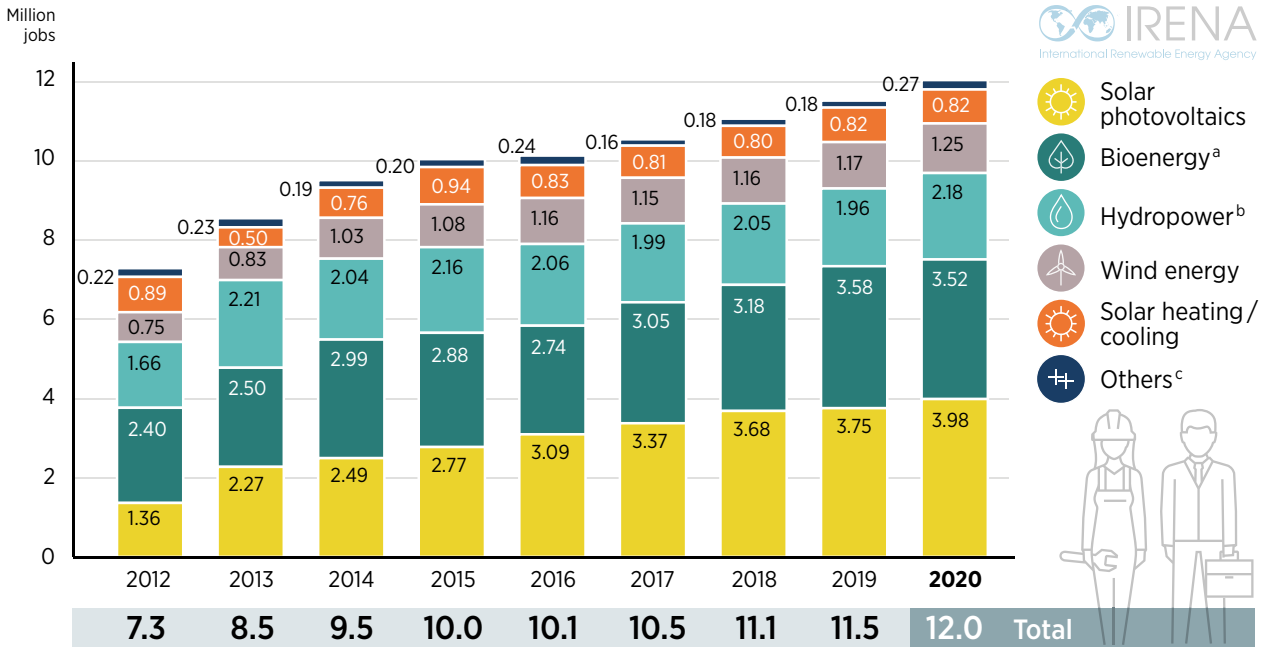
2.6 Socio-economic impacts of renewable energy

The deployment of renewables yields a range of socio-economic benefits, including the creation of numerous diverse jobs. IRENA (2020b) estimates an employment intensity of investment of more than 25 jobs per USD million. Moreover, IRENA's analysis now indicates that each million dollars invested in renewable energy technologies generates almost three times more jobs than fossil fuels.

In 2020, employment in renewable energy worldwide reached an estimated 12 million, with women accounting for about 32% of these jobs (IRENA and ILO, 2021). Globally, solar PV employment contributed one-third of the workforce to reach 4 million jobs in 2020, while employment in the bioenergy, hydropower and wind sectors was estimated at 3.5 million, 2.2 million and 1.25 million respectively (as illustrated in Figure 11).

For LLDCs, where overall modern energy services are inadequate, renewable energy plays an increasingly important role in improving energy access. Distributed renewable energy solutions – solar for homes and businesses, green mini-grids and standalone machinery for productive use (such as solar-powered irrigation pumps, food processing and healthcare) – are generating significant economic opportunities, including employment (IRENA and ILO, 2021).

Figure 11 Global renewable energy employment by technology, 2012-2020



a Includes liquid biofuels, solid biomass and biogas.
b Direct jobs only.
c "Others" includes geothermal energy, concentrated solar power, heat pumps (ground based), municipal and industrial waste, and ocean energy.

Source: IRENA jobs database.

Source: IRENA and ILO (2021).

Analysis by GOGLA, the association for the off-grid solar energy industry, roughly estimates there to be 342 000 full-time equivalent jobs in direct off-grid solar employment in areas of sub-Saharan Africa where the majority of LLDCs are located. Additional analysis shows 56% of these jobs to be in rural areas and 27% filled by women (IRENA *et al.*, 2021; WHO, 2021). Nonetheless, despite the positive socio-economic footprint, deployment of renewables is still relatively limited in most developing countries, including LLDCs. Box 8 presents examples of the socio-economic benefits of renewable energy projects financed by the IRENA/Abu Dhabi Fund for Development Project Facility in selected LLDCs.

For LLDCs to realise the domestic socio-economic benefits and leverage the job opportunities that emanate from renewable energy deployment, a range of targeted measures – including industrial policies, programmes for educational and skills development, and enabling labour market interventions – would be needed to develop local supply chains. IRENA's Leveraging Local Capacity series further studies the nature of jobs created along the supply chain for various renewable energy technologies, including the materials and equipment needed, and suggests ways to enhance local industries (IRENA, 2017). Governments in partnership with labour stakeholders could co-ordinate initiatives, such as support for SMEs, to ensure broader societal transformation through renewables. Providing financing to SMEs and entrepreneurs working in renewable energy should also be considered. Finally, developing linkages between research institutes worldwide focused on renewable energy and domestic stakeholders should also be prioritised.

Box 8 Renewable energy socio-economic impacts in LLDCs

Investing in renewable energy in LLDCs greatly improves the population's socio-economic conditions and contributes to community resilience and delivery of national development and climate action targets. IRENA partnered with the Abu Dhabi Fund for Development (ADFD) to implement the IRENA/ADFD Project Facility, where IRENA recommended projects to ADFD for selection and support with concessional financing. Through this facility, five LLDCs (namely Burkina Faso, Chad, Mali, Nepal and Niger) have access to concessional finance from ADFD, amounting to USD 59.5 million and translating into six renewable energy projects of 68.75 MW capacity. The benefits include:

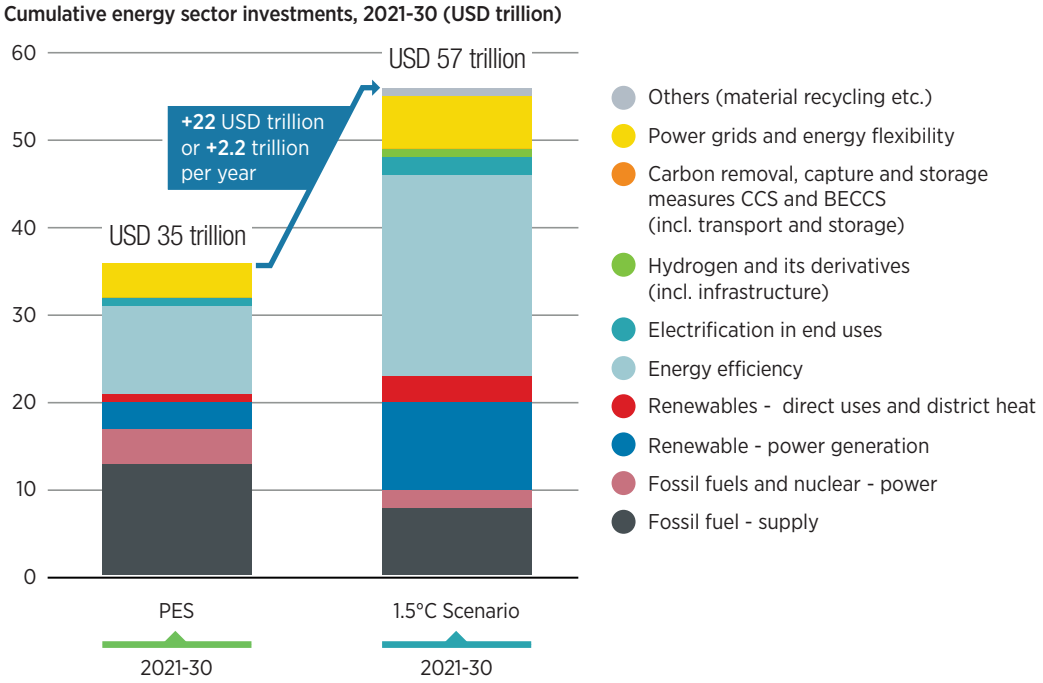
- **Rural electrification and access:** Through the implementation of these projects, nearly one million people will gain electricity access in the five African LLDCs featured in the facility. These projects involve the installation of mini-grids, and standalone solar PV systems in areas that are either running diesel generators or have no access at all.
- **Job creation:** As a result of rural electrification, close to 90 000 direct and indirect jobs are estimated to be created within the five countries featured. Another benefit of rural access in LLDCs is the promotion of gender equity and empowerment. For example, in Mali 40 000 women are set to benefit from the project through income-generating activities.
- Renewable energy enables improved access to **basic services** including electrification of health centres and schools, provision of water for domestic use and agriculture, and power for food processing and preservation. Within the five projects, close to 2 700 schools, small and medium-sized enterprises (SMEs) and health centres will benefit from the electrification initiatives, and over a million litres of fresh water will be supplied annually.
- Renewable energy creates **cost savings** by offering a substitute for imported fossil fuel. This is especially beneficial to LLDCs without access to ports, as fuel costs are higher than in countries with seaports. Through the implementation of these projects, the five countries are expected to save over 9 million litres of fuel annually, equating to USD 19 million in savings.
- **Climate benefits:** Through these projects, the five countries should avoid the annual emission of over 215 000 tCO_2e, which could be traded for additional funding for operations, maintenance and future roll-out of renewables or other socio-economic projects.

Source: IRENA (unpublished).

2.7 Renewable energy finance and investment trends

A transformation of the global energy system compatible with internationally agreed climate and development objectives requires a significant scale-up in energy investment. Globally, up to USD 57 trillion needs to be invested in the energy sector between now and 2030 (IRENA, 2022b), in order to cap global temperature rise to 1.5°C and limit CO_2 emissions to net zero (Figure 12) (IRENA, 2021c). Further, the analysis estimates that up to USD 0.7 trillion of annual fossil fuels investment should be redirected towards energy transition technologies. This would require substantial effort in project facilitation and the mobilisation of financing from public, private, banking and non-banking financial institutions.

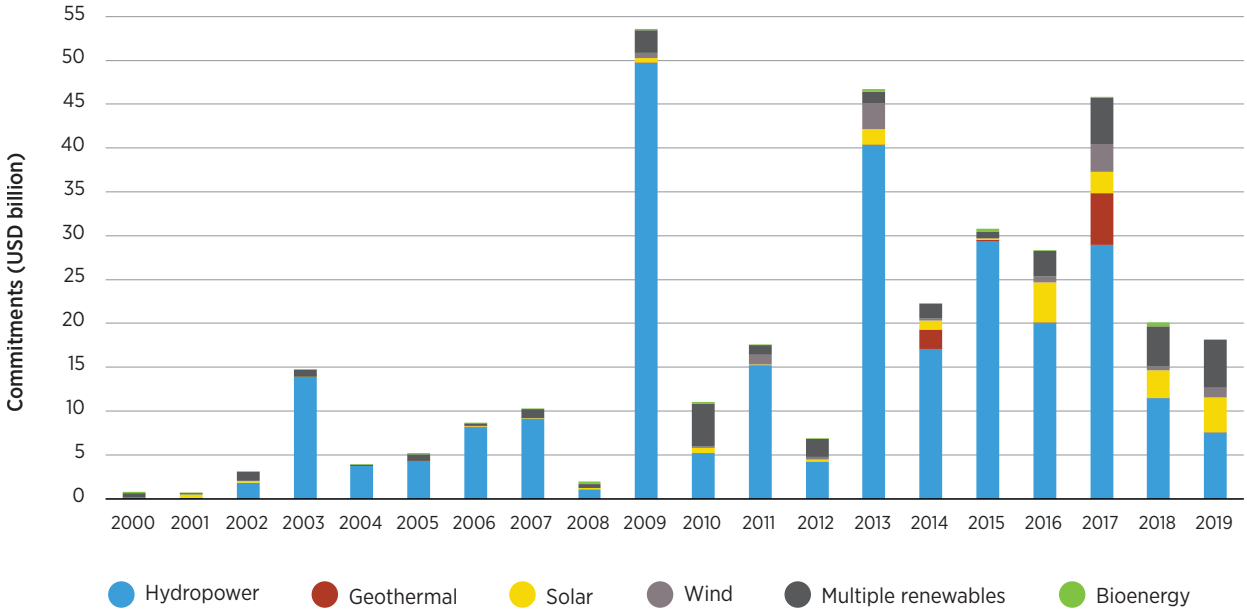
Figure 12 Global new investment priorities: Renewables, efficiency and electrification



Notes: BECCS = bioenergy with carbon capture and storage; CCS = carbon capture and storage; PES = Planned Energy Scenario.
Source: IRENA (2022b).

Figure 13 shows international public finance flows to LLDCs by renewable energy technology, representing annual commitments from 2000 to 2019 in support of renewable energy-related research and development and production. The 2019 commitment of USD 16 billion presents a decrease of 20% in comparison to 2018. Globally, financial flows in support of clean energy to all developing countries dropped for two consecutive years, whereby a total of approximately USD 11 billion was recorded in 2019. This means that only 15% of these commitments reached LLDCs in 2019.

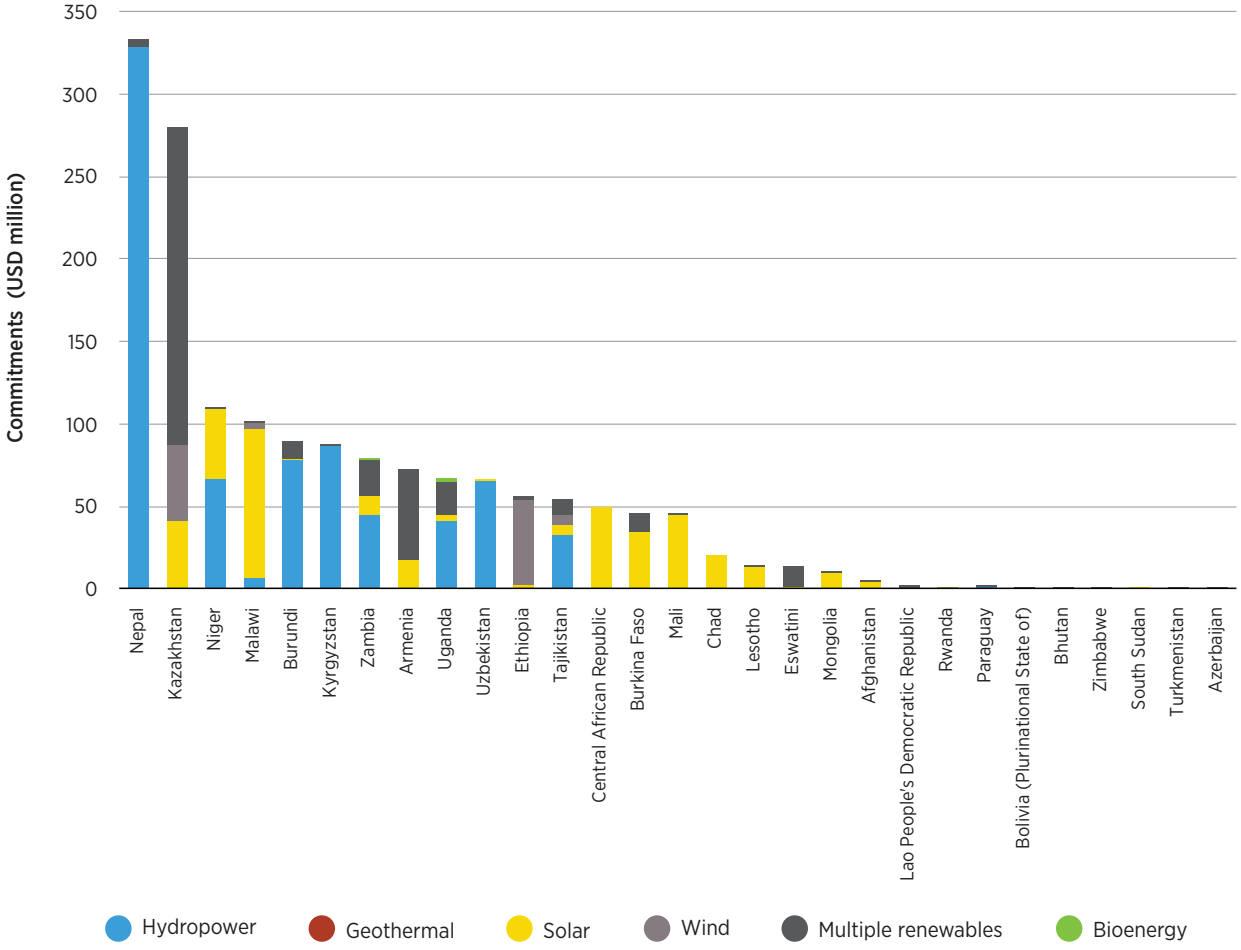
Figure 13 International public finance flows to LLDCs by technology, 2000-2019



Source: IRENA (2022a).

Figure 14 shows international public financial flows by LLDC in 2019. As seen in the graph, finance is barely reaching the countries that most need it, with some countries such as Botswana missing out on any sort of minimum commitment.

Figure 14 International public financial flows by LLDC



Source: IRENA (2020a).

Many LLDCs, such as Chad and Malawi, are among the countries with the greatest deficit between finance need and provision. LLDCs particularly are dependent on international public finance as they are most often underserved by the private sector owing to factors such as weak markets. Distributed renewable energy technologies offer an attractive, cost-effective solution to the challenge of reaching universal access to modern energy, particularly for rural areas. Therefore, additional efforts should be made to provide affordable financing approaches for these projects, including risk mitigation instruments to attract private-sector finance.

3.

THE WAY FORWARD

This chapter presents an overview of the policy framework to support the integration of renewable energy. It further discusses the challenges facing renewable energy development and makes recommendations to drive investment and funding, including showcasing best practices on renewable energy deployment in LLDCs.

3.1 Policy framework for enhanced renewable energy deployment in LLDCs

Despite the remarkable global progress in advancing renewables, their full potential is yet to be realised in LLDCs. Globally, several key barriers (Box 9) still hamper their deployment and to this extent policy makers in LLDCs can facilitate the energy transition by endorsing policies that address them.

Box 9 Barriers to increased deployment of renewables

Awareness and capacity barriers relate to a lack of sufficient information and knowledge about renewables and their performance, as well as a lack of skilled personnel and training programmes. LLDCs often struggle with limitations in capacity and training and, therefore, they lack a qualified and skilled workforce and a robust local value chain.

Financial barriers pertain to the lack of adequate funding opportunities and financing products for renewables. This can be a question of availability and cost of financing, difficulty in accessing suitable financial instruments (debt with a long tenor, for example, or structured finance vehicles, including aggregation and securitisation of assets), lack of institutional knowledge (in project finance, for example), or lack of access to and affordability of effective risk mitigation instruments (such as guarantees, currency hedging instruments or liquidity reserve facilities).

Infrastructure barriers pertain to the availability of the necessary infrastructure to incorporate renewable energy into the energy system, which can include problems linked to system flexibility and the ability of the power grid to manage renewable energy.

Institutional and administrative barriers include: a lack of institutions and authorities dedicated to renewables; the absence of clearly defined responsibilities; complicated licensing procedures; difficulty with land acquisition and permission; inadequate planning guidelines; and complex, slow, lengthy or opaque permitting processes.

Market barriers include inconsistent pricing structures that lead to disadvantages for renewables, irregular pricing of renewable energy products, information asymmetries, distortions in market power, fossil fuel and nuclear subsidies, and a failure to incorporate social and environmental externalities into costs.

Box 9 Barriers to increased deployment of renewables (continued)

Public acceptance and environmental barriers are constraints that could lead to a renewable energy project being found unsuitable for a specific location.

Regulatory and policy barriers include bad policy design, discontinuity of policies, perverse or split incentives, unfavourable or inconsistent policies, unclear agreements (such as power purchase agreements, feed-in tariffs or self-consumption) and a lack of transparency.

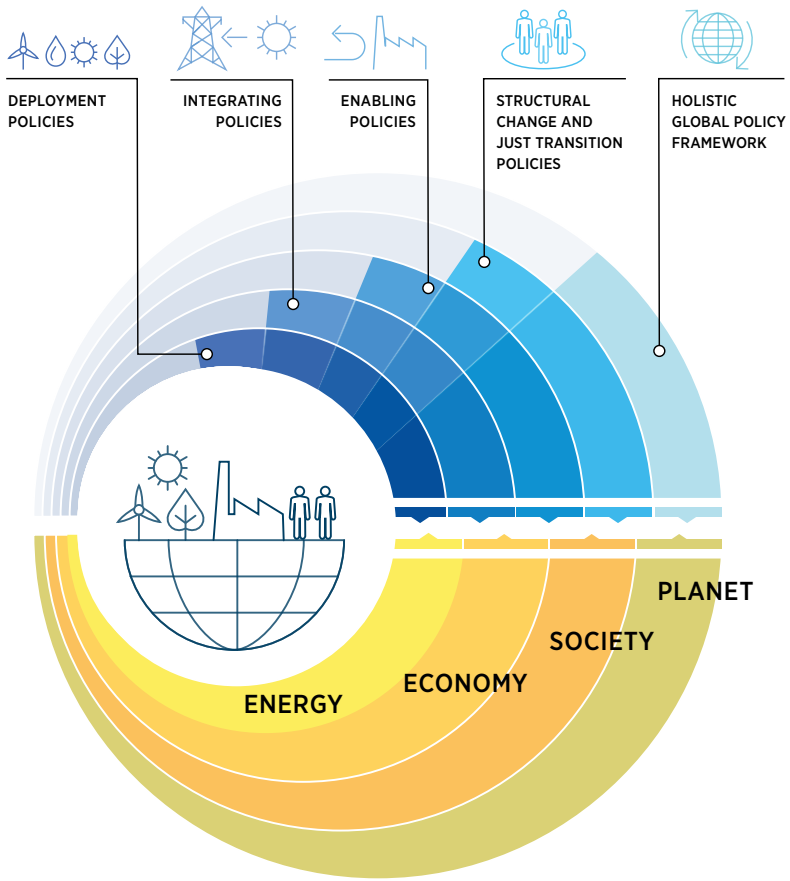
Limited data to support the development, effective implementation, monitoring and evaluation of supportive policies.

Sources: IRENA, IEA and REN21, (2018); UN-OHRLLS, UNIDO and Government of Austria (2017).

As renewable technologies drive the energy transition and require an accelerated rate of deployment to reduce emissions in the energy sector, policy makers are confronted with new challenges due to the intermittency of renewable energy resources.

A comprehensive policy framework (Figure 15) is required that addresses policies related to deployment, integration, enabling environment, structural change and just transition, as well as global and south–south co-operation.

Figure 15 Illustration of comprehensive and inclusive policy framework



Source: IRENA (forthcoming).

Deployment policies and related measures are required to support market creation; these typically include fiscal and financial incentives (*e.g.* tax incentives, import duty exemptions and grants), regulatory and pricing policies and tradable certificates.

Integrating policies ensure flexible deployment of resources and sustained system reliability. They include policies to promote infrastructure development, such as district heating and cooling, and transmission and distribution infrastructure.

Enabling policies that cut across sectors and end uses and provide enabling conditions for accelerated deployment of renewables. These include policies that provide strong market signals through specific targets embedded within long-term plans in order to facilitate access to financing.

Structural policies for a just and inclusive transition ensure that socio-economic benefits are equitably distributed and any challenges and misalignments arising from the transition are effectively managed. These include, for instance, policies related to labour markets (*e.g.* green industry promotion).

3.2 Mobilising investment and funding for renewables in LLDCs

While trends in capacity additions depict positive progress in the renewable energy sector, cumulative investment is yet to match the global requirements for the sustainable development climate objective of limiting global temperature rise to below 1.5°C. Long-term uptake of renewables will be determined by clear policy frameworks coupled with the improvement and expansion of existing financing and risk mitigation instruments. In order to drive investment and funding for renewable energy development in LLDCs, the following recommendations should be adopted. Important government actions include:

Raise renewable energy targets and increase national climate ambitions to demonstrate strong commitment to investors and attract capital. IRENA analysis indicates that setting ambitious renewable energy targets consistent with climate pledges as part of NDCs and LTS offers a strong business case for renewable energy investment.

Attract foreign private investment in renewable energy. Considering the large investment gaps in LLDCs with respect to meeting renewable energy targets, leveraging foreign direct investment through greenfield projects is crucial. Greenfield projects refer to foreign companies establishing new facilities or expanding their existing facilities. Since greenfield investments are driven by the profit motive and lead to the long-term presence of foreign multinational enterprises, they are one of the main sustainable solutions to addressing investment gaps, as opposed to relying on public finance or donor funds, which can be contingent on the fiscal policies of domestic and foreign governments.

It has been reported that LLDCs attracted 22 greenfield FDI projects for renewable energy with a cumulative investment of USD 3.6 billion between January 2020 and mid-2021 (FDI Markets Database, 2021). Projects ranged from USD 18 million (Zimbabwe) to USD 216 million (Armenia). Some projects extend across LLDCs as part of foreign investors' plans to establish a regional network of renewable energy facilities. For example, Schneider Electric (France) is investing USD 165 million in each of Mali and Burkina Faso as part of its plan to establish a solar energy network in sub-Saharan Africa.

Leverage public finance to crowd in private finance through investment and risk mitigation instruments such as guarantees and blended finance. LLDCs' share of public resources available to invest in renewable energy investments is limited and often constrained to addressing existing socio-economic challenges, which have been exacerbated by the current pandemic. Thus, it is important to effectively leverage public resources in mobilising private capital to accelerate implementation of net zero and renewable energy projects.

Mobilise new sources of capital from corporate actors and institutional investors through market, policy and regulatory solutions. Measures, such as the creation of bankable project pipelines and green bonds will enable countries to access and channel private capital pools towards renewable energy development.

Apply new financing approaches and instruments for off-grid distributed energy systems. Mechanisms such as results-based financing, high-risk innovation capital and long-term concessional debt (Box 10) all serve to improve the affordability of off-grid renewable energy products and services for the underserved majority of households, who live in rural areas. Familiarise local private and finance institutions with the renewable energy market potential in LLDCs to attract more interest from them in project finance.

Box 10 Energy Transition Accelerator Financing and Climate Investment Platform

The Energy Transition Accelerator Financing (ETAF) platform is an inclusive, multi-stakeholder climate finance solution managed by IRENA to advance the energy transition across the agency's 166-strong membership. With anchor funding of USD 400 million from the United Arab Emirates via the ADFD, the platform serves as the first global climate finance partnership from the Middle East. ETAF aims to mobilise approximately USD 1 billion of capital by 2030 from various funding partners, investors, the private sector and donors. ETAF supports the implementation of ambitious NDCs to meet the Paris Agreement targets and the realisation of the SDGs, while serving important national objectives.

At the international level, the **Climate Investment Platform (CIP)** was announced in September 2019 by IRENA, the UNDP and Sustainable Energy for All (SEforALL) in co-operation with the Green Climate Fund. It aims to mobilise energy-transition investment on a scale commensurate with climate goals. Working with all interested partners, the CIP aims to mobilise investment in alignment with climate objectives, with an initial focus on regional and national energy transitions. To promote targeted action on the ground, IRENA is co-ordinating the development of sub-regional operational frameworks for CIP implementation. Regular sub-regional investment forums, co-ordinated by IRENA, are intended to support decision makers in creating enabling conditions, assist developers in preparing bankable projects, and improve access to finance.

3.3 Best practices in renewable energy deployment in LLDCs

The following are best practice examples of scaling up renewable energy deployment to suit LLDCs' context:

- **Adapt renewable energy solutions to local contexts to address suitability and cost-effectiveness for the end users.** In Chad, for example, solar PV mini-grids with battery storage systems are being proposed in six cities to replace diesel generation. In the case of Burkina Faso and Mali, the option is to use mini-grids in rural trading centres and towns selected for their inaccessibility to the grid. In Niger, a combination of solar PV mini-grids and standalone solar PV equipment is to be installed in rural trading localities with high population density.

- **Provide concessional on-lending** to downstream local developers. In Nepal this is enabling developers to leverage concessional funding to access additional local credit for implementation. This model could be replicated in economies where governments would like to leverage affordable international development funding for local investors to co-finance and deploy renewable energy solutions on the ground.

- **Work through public–private partnerships (PPPs).** In Mali and Burkina Faso, for example, PPPs have proven to provide a good framework for the success of energy projects. In the case of Burkina Faso, the government decided to partner with a local developer and successfully secured funding from ADFD and other financing partners for a solar PV project. Through the PPP approach, the risk profile of the projects can be reduced by bringing together the benefits of government backing with the technical and financial resources of a private developer. The model also encourages the participation of funders who may never have taken part in either a purely public or purely private sector-led project.

- **Bundle demand:** Individually, the off-grid communities in Burkina Faso, Mali and Niger have low electricity demand. However, by developing projects and programmes that cover several communities, governments and partners are able to roll out decentralised electricity services that benefit from economies of scale during project development, procurement and implementation. These approaches are also enabling governments and partners to support faster roll-out compared to iterative individual community project development.

- **Use local contractors:** Working with local contractors on energy projects injects some of the funding into the economy and brings about additional co-benefits over and above electricity access. For example, local employment is boosted and local capacity is developed, which becomes useful in future project implementation and provision of operational and maintenance services for existing installations.

4.

CONCLUSION

In order to help LLDCs implement these actions, it is important that the UN system and other relevant international partners provide the facilitation for the scaling up of investment in renewable energy, backed by policy, analytical and technical support to place renewable energy at the centre of LLDCs' post-COVID green recovery plans.

With a view to ensuring LLDCs progress towards achieving the VPoA and the SDGs, international partners should also provide meaningful support to LLDCs to help strengthen capacities for planning, implementing and monitoring renewable energy policies, as well as developing bankable projects with access to climate funding for energy projects.

LLDCs are encouraged to utilise existing facilities such as the Climate Investment Platform, which assists in creating a pipeline of projects and supports matchmaking with potential investors, and the Energy Transition Accelerator Financing (ETAF) platform, which could provide capital to accelerate the scale up of renewable energy deployment. LLDCs are also encouraged to request technical assistance to utilise the IRENA Renewables Readiness Assessment tool to identify recommendations to scale up renewable energy.

Regional organisations are encouraged to develop regional policies and implementation processes that facilitate cross-border renewable energy co-operation in collaboration with multilateral development banks – particularly in the context of power pools – to scale-up regional generation and transmission initiatives.

In summary, this report's recommendations are that LLDCs, with the support of their partners, should:

a. Prioritise renewable energy and the energy transition as an essential element of post-COVID-19 recovery measures connected with medium- and long-term actions to reinforce sustainable development.

b. Create a strong business case for renewable energy investment by updating NDCs under the Paris Agreement with quantified substantiated renewable energy targets consistent with LTS to advance climate and development objectives.

c. Devise comprehensive national energy plans that encompass renewable energy technologies, and which are based on substantiated renewable targets to support achievement of a resilient and affordable carbon-neutral energy system providing universal access to electricity.

d. Conduct renewable energy resource assessments to inform the viability of renewable energy potential, inform renewable energy targets in policy commitments, and facilitate project development and investment.

e. Create an enabling framework by enacting strong policies that address barriers to and support the increased deployment of renewables for energy services. National policies should include both on- and off grid solutions that cover clean cooking.

f. Leverage the current low cost of renewable power generation and shift investment from costly fossil fuel power generation towards much needed socio-economic development.

g. Attract and crowd in private finance investment by leveraging public finance using strategic tools such as risk mitigating instruments.

h. Exploit existing opportunities for cross-border bilateral renewable electricity trade with neighbouring countries and through regional electricity markets (*e.g.* regional power pools) to help address demand deficits in national power systems.

i. Design market interventions to optimise job opportunities that emerge from renewable energy deployment by creating partnerships with stakeholders for initiatives such as support for SMEs.

j. Foster systemic innovation and roll out solutions through the eight-step innovation plan, which calls for far-sighted policies coupled with building synergies between renewable power supply and applications such as electric mobility.

ANNEX: SELECTED LLDCS' ENERGY STATISTICS

Table 1 Access to electricity (% of population)

	2003	2008	2013	2014	2015	2016	2017	2018	2019
Afghanistan	..	42.4	68.9	89.5	71.5	97.7	97.7	98.7	97.7
Armenia	99.2	99.4	99.9	100.0	100.0	100.0	100.0	100.0	100.0
Azerbaijan	99.0	99.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Bhutan	41.1	67.4	87.3	91.4	95.5	99.6	97.7	100.0	100.0
Bolivia	72.3	84.7	89.5	90.0	91.5	91.8	91.8	95.6	96.3
Botswana	33.4	43.1	53.7	55.9	58.1	60.4	62.6	64.9	70.2
Burkina Faso	11.4	12.5	15.6	19.2	16.3	16.9	17.5	14.4	18.4
Burundi	4.0	4.8	6.9	7.0	8.6	9.6	9.3	11.0	11.1
Central African Republic	7.2	9.7	18.6	21.2	24.1	27.1	29.8	32.4	14.3
Chad	4.0	5.8	8.0	8.6	7.7	10.4	10.9	11.8	8.4
Eswatini	28.7	42.8	58.7	65.0	65.8	69.6	73.5	76.5	77.2
Ethiopia	27.3	31.5	36.0	27.2	29.0	42.9	44.3	45.0	48.3
Kazakhstan	99.3	99.4	99.9	100.0	100.0	100.0	100.0	100.0	100.0
Kyrgyz Republic	99.7	99.4	99.5	99.8	99.8	99.9	100.0	100.0	99.9
Lao PDR	48.0	66.0	79.5	83.0	89.7	90.8	93.6	97.9	100
Lesotho	5.6	15.9	26.6	27.8	31.8	35.3	33.7	47.0	44.6
Malawi	6.2	7.9	9.0	11.9	10.8	11.0	12.7	18.0	11.2
Mali	15.0	24.1	33.7	35.7	37.6	41.2	43.1	50.9	48
Mongolia	76.3	79.1	81.2	85.9	88.0	91.1	93.8	98.1	99.1
Nepal	39.0	57.6	78.2	84.9	85.2	90.7	92.4	93.9	89.9
Niger	9.5	11.7	15.1	15.7	16.6	17.5	18.2	17.6	18.8
North Macedonia	..	99.2	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Paraguay	92.6	96.7	99.0	99.0	99.3	98.4	99.3	100.0	100.0
Republic of Moldova	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Rwanda	7.9	6.0	15.2	19.8	22.8	29.4	34.1	34.7	37.8
South Sudan	..	..	11.8	15.0	18.4	21.9	25.1	28.2	6.7
Tajikistan	100.0	98.5	98.7	98.8	98.0	99.2	99.3	99.3	99.6
Turkmenistan	99.7	99.7	100.0	100.0	100.0	100.0	100.0	100.0	99.9
Uganda	10.5	14.9	13.9	20.4	18.5	26.7	31.8	42.7	41.3
Uzbekistan	99.8	99.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Zambia	18.5	24.4	28.0	27.9	31.1	35.3	40.3	39.8	43
Zimbabwe	35.0	36.4	38.3	32.3	33.7	39.9	40.5	41.0	41.1
Average, LLDCs	38.8	43.5	48.8	49.5	49.1	55.5	56.3	58.7	58.0
Average, World	79.8	82.2	85.1	85.6	86.7	88.0	88.8	89.6	90.1

Source: United Nations SDG indicators database.

Table 2 Proportion of population with primary reliance on clean fuels and technology (%)

	2003	2008	2013	2014	2015	2016	2017	2018	2019
Afghanistan	13	18	25	27	29	31	34	37	36
Armenia	88	>95	>95	>95	>95	>95	>95	>95	>95
Azerbaijan	80	91	>95	>95	>95	>95	>95	>95	>95
Bhutan	39	58	71	73	74	75	77	77	79
Bolivia (Plurinational State of)	65	73	81	81	82	83	83	84	86
Botswana	50	55	56	55	55	54	54	53	53
Burkina Faso	<5	5	7	8	8	9	9	10	10
Burundi	<5	<5	<5	<5	<5	<5	<5	<5	<5
Central African Republic	<5	<5	<5	<5	<5	<5	<5	<5	<5
Chad	<5	<5	<5	<5	<5	<5	<5	<5	<5
Eswatini	28	36	44	46	48	50	52	54	55
Ethiopia	<5	<5	<5	<5	<5	<5	<5	5	7
Kazakhstan	87	92	95	>95	>95	>95	>95	>95	>95
Kyrgyzstan	58	68	75	76	76	76	76	77	77
Lao People's Democratic Republic	<5	<5	<5	5	5	6	7	7	8
Lesotho	21	29	35	35	36	37	38	39	39
Malawi	<5	<5	<5	<5	<5	<5	<5	<5	<5
Mali	<5	<5	<5	<5	<5	<5	<5	<5	<5
Mongolia	24	31	40	42	44	46	48	50	52
Nepal	10	18	25	26	27	28	29	29	31
Niger	<5	<5	<5	<5	<5	<5	<5	<5	<5
North Macedonia	61	65	65	66	66	65	65	65	76
Paraguay	48	54	63	64	65	66	67	68	68
Republic of Moldova	75	88	94	94	95	>95	>95	>95	>95
Rwanda	<5	<5	<5	<5	<5	<5	<5	<5	<5
South Sudan	<5	<5	<5	<5	<5	<5	<5	<5	<5
Tajikistan	50	65	74	76	77	78	80	81	82
Turkmenistan	>95	>95	>95	>95	>95	>95	>95	>95	>95
Uganda	<5	<5	<5	<5	<5	<5	<5	<5	<5
Uzbekistan	84	86	86	86	86	85	85	85	85
Zambia	15	16	15	15	15	14	14	13	16
Zimbabwe	33	31	30	29	29	29	29	29	13
Average, LLDCs	24	25	26	26	26	27	27	27	27
Average, World	51	55	59	59	60	61	62	63	66

Source: United Nations SDG indicators database.

Table 3 Total renewable energy (production)

GWH	2011	2012	2013	2014	2015	2016	2017	2018	2019
Afghanistan	683	765	885	1 000	1 034	1 061	1 087	965	1 193
Armenia	2 494	2 315	2 177	1 997	2 209	2 354	2 274	2 340	2 398
Azerbaijan	2 676	1 821	1 626	1 479	1 828	2 192	1 976	2 052	1 910
Bhutan	7 067	6 824	7 550	7 165	7 747	7 954	7 730	6 960	8 875
Bolivia	2 461	2 467	2 649	2 412	2 660	1 937	2 423	2 967	3 727
Botswana	0	1	2	3	3	5	5	6	6
Burkina Faso	91	106	116	102	107	156	158	191	209
Burundi	247	259	260	251	247	285	273	254	254
Centr. Afr. Rep.	142	142	142	142	142	136	136	136	136
Chad	0	0	0	0	0	9	9	9	9
Eswatini	458	459	424	461	429	338	307	375	411
Ethiopia	6 330	7 604	8 733	7 396	9 563	10 509	12 580	13 259	14 553
Kazakhstan	7 905	7 611	7 758	8 419	9 562	12 080	11 760	11 269	11 758
Kyrgyzstan	14 309	14 179	13 097	13 298	11 093	11 498	14 204	14 318	13 859
Lao PDR	12 992	12 769	15 523	15 760	16 008	17 611	19 521	21 235	18 972
Lesotho	468	494	474	505	518	521	517	518	503
Malawi	1 933	1 929	1 924	2 034	2 032	2 020	1 915	1 457	1 458
Mali	1 127	1 237	1 467	1 524	1 556	1 674	1 733	1 733	1 733
Moldova	356	272	316	336	287	249	317	332	378
Mongolia	63	63	123	203	223	253	269	480	664
Nepal	3 482	3 652	3 624	3 737	3 710	3 951	4 609	4 927	5 710
Niger	5	7	8	10	11	13	15	33	33
Paraguay	57 626	60 233	60 506	55 415	55 889	63 940	59 824	59 344	49 582
North Macedonia	1 434	1 044	1 593	1 292	2 029	2 067	1 296	1 966	1 344
Rwanda	224	272	244	300	348	359	345	380	445
South Sudan		0	0	0	0	1	1	1	1
Tajikistan	16 200	16 900	17 071	16 312	16 900	16 803	17 312	18 573	19 348
Turkmenistan	3	3	3	3	3	3	3	3	3
Uganda	1 661	2 615	3 443	3 495	3 393	3 541	3 690	3 941	4 393
Uzbekistan	8 100	8 100	8 102	8 102	8 102	8 105	8 106	5 904	6 468
Zambia	11 938	12 419	13 349	14 115	13 110	11 102	12 551	13 775	12 427
Zimbabwe	5 277	5 595	5 186	5 620	5 204	2 944	4 077	5 730	5 731
World	4 401 683	4 753 448	5 035 767	5 319 299	5 516 427	5 893 848	6 222 600	6 602 443	6 963 450

Source: IRENA (2021d).

Table 4 Total renewable energy (capacity)

GW	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Afghanistan	245	289	294	299	303	349	355	355	364	364
Armenia	1152	1253	1292	1301	1289	1316	1332	1357	1389	1434
Azerbaijan	999	1024	1125	1120	1154	1184	1194	1277	1291	1291
Bhutan	1488	1488	1488	1488	1615	1615	1615	1615	2335	2335
Bolivia	590	591	592	628	638	669	796	923	1057	1057
Botswana	0	2	2	2	2	3	3	4	6	6
Burkina Faso	38	38	38	39	41	43	80	95	98	98
Burundi	56	56	57	58	58	59	57	57	57	57
Centr. Afr. Rep.	19	19	19	19	19	19	19	19	19	19
Chad	2	2	2	2	2	3	3	3	3	3
Eswatini	186	186	186	169	169	169	169	169	169	169
Ethiopia	2080	2081	2224	2230	2619	2649	4366	4451	4451	4713
Kazakhstan	2278	2582	2608	2805	2893	2951	3015	3369	4214	4997
Kyrgyzstan	3072	3072	3572	3671	3677	3677	3689	3673	3673	3677
Lao PDR	2556	2965	3010	3296	4398	4857	5067	5317	6144	7437
Lesotho	73	75	75	75	75	75	75	75	75	75
Malawi	301	302	305	371	375	376	383	402	409	410
Mali	295	301	363	371	372	373	375	375	375	425
Moldova	64	64	65	66	69	71	81	106	110	110
Mongolia	34	35	85	85	85	97	180	251	276	277
Nepal	713	718	755	771	827	848	993	1113	1233	1363
Niger	3	4	5	6	7	8	9	27	27	27
Paraguay	8810	8810	8849	8849	8849	8849	8849	8849	8832	8832
North Macedonia	558	599	624	682	716	720	731	740	751	827
Rwanda	56	58	62	77	109	118	127	131	141	141
South Sudan	-	0	0	0	0	0	0	1	1	1
Tajikistan	4809	4811	4814	5035	5033	5039	5039	5153	5273	5273
Turkmenistan	1	1	1	1	1	1	1	1	1	1
Uganda	465	616	746	766	782	784	827	907	1177	1184
Uzbekistan	1788	1822	1823	1872	1882	1883	1861	1919	1912	2009
Zambia	1935	1942	2302	2302	2311	2431	2441	2442	2538	2541
Zimbabwe	854	854	860	861	878	882	887	1192	1192	1198
World	1331177	1443762	1566889	1699085	1852768	2014645	2186145	2359753	2542035	2802004

Source: IRENA (2021d).

Table 5 Renewable energy share of electricity production

% OF GWH	2011	2012	2013	2014	2015	2016	2017	2018	2019
Afghanistan	74.4	79.8	81.0	85.5	87.6	87.7	86.9	83.8	86.8
Armenia	33.6	28.8	28.2	25.8	28.3	32.2	29.3	30.0	31.4
Azerbaijan	13.2	7.9	7.0	6.0	7.4	8.8	8.1	8.1	7.3
Bhutan	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Bolivia	33.7	31.9	32.6	27.8	29.2	20.6	25.0	29.8	36.4
Botswana	0.1	0.3	0.2	0.1	0.1	0.2	0.2	0.2	0.2
Burkina Faso	16.9	16.7	15.6	11.6	10.5	15.8	14.2	17.9	26.2
Burundi	95.0	98.9	91.8	88.9	89.6	92.2	88.4	82.7	76.2
Centr. Afr. Rep.	99.8	99.8	99.8	99.8	99.8	96.3	96.3	96.3	96.3
Chad	0.0	0.0	0.1	0.1	0.1	2.7	2.7	2.8	2.8
Eswatini	99.8	99.8	99.8	99.8	99.8	99.7	99.7	99.7	99.8
Ethiopia	99.4	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0
Kazakhstan	9.1	8.2	7.5	8.8	10.4	12.8	11.4	10.5	11.0
Kyrgyzstan	93.4	93.5	93.5	91.4	85.2	87.6	91.9	91.0	91.7
Lao PDR	100.0	100.0	100.0	100.0	100.0	98.9	97.7	97.2	96.8
Lesotho	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.9	99.9
Malawi	99.4	99.4	99.4	99.5	99.8	99.8	97.1	77.3	77.3
Mali	61.5	67.0	73.3	68.6	65.1	63.7	60.4	60.4	60.4
Moldova	6.2	4.7	11.3	9.4	6.8	5.9	10.0	9.5	10.0
Mongolia	1.4	1.3	2.4	3.8	4.0	4.4	4.4	7.2	9.6
Nepal	99.9	99.7	99.6	99.9	100.0	100.0	100.0	100.0	100.0
Niger	1.5	1.4	1.6	1.8	1.9	2.1	2.4	5.9	5.9
Paraguay	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
North Macedonia	21.2	16.7	26.1	24.0	35.9	36.7	23.1	35.1	22.9
Rwanda	53.4	56.3	47.9	53.0	60.6	50.4	49.9	36.1	54.1
South Sudan	-	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.2
Tajikistan	99.5	99.3	99.5	98.1	98.0	96.3	94.4	93.2	92.8
Turkmenistan	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Uganda	63.4	90.5	99.9	97.4	97.5	98.2	93.8	95.2	97.7
Uzbekistan	16.1	16.4	16.0	16.0	16.0	13.9	13.5	10.1	11.2
Zambia	99.9	99.9	99.9	97.2	97.0	94.3	86.3	84.7	82.8
Zimbabwe	58.1	61.0	56.3	56.2	54.9	42.0	52.5	60.7	60.7
World	19.9	20.9	21.5	22.3	22.8	23.7	24.3	24.9	26.0

Source: IRENA (2021d).

Table 6 Renewable energy consumption (% of total final energy consumption)

	2003	2008	2013	2014	2015	2016	2017	2018
Afghanistan	42.3	21.3	17.1	20.4	20.0	24.3	24.7	21.4
Armenia	9.8	6.4	6.8	7.7	11.6	13.3	12.5	11.1
Azerbaijan	2.9	3.1	2.5	2.1	2.3	1.9	1.9	2.0
Bhutan	91.9	91.8	86.5	86.6	86.5	84.7	83.4	81.1
Bolivia	26.6	21.1	17.6	16.7	17.6	15.7	13.4	7.6
Botswana	34.2	27.0	28.8	28.3	28.4	28.3	28.6	28.2
Burkina Faso	79.1	82.9	75.4	75.2	72.7	72.3	70.0	67.0
Burundi	95.8	95.2	91.1	91.4	91.2	90.0	88.2	85.5
Central African Republic	85.5	80.6	77.1	76.8	76.4	76.1	75.8	80.9
Chad	83.9	81.9	85.4	85.5	85.4	85.3	85.4	85.3
Eswatini	63.9	65.5	65.6	68.4	66.4	60.0	60.6	66.1
Ethiopia	94.2	94.0	92.4	91.2	91.5	90.4	89.8	89.9
Kazakhstan	2.3	1.2	1.2	1.3	1.5	1.8	1.6	1.9
Kyrgyzstan	30.5	22.0	24.8	26.6	23.3	21.9	24.5	23.2
Lao PDR	78.8	69.3	58.6	58.3	53.9	49.6	45.9	41.9
Lesotho	55.9	55.0	44.7	42.8	44.1	42.2	38.7	38.4
Malawi	82.8	80.4	79.7	82.7	80.8	78.7	75.9	73.2
Mali	86.4	76.1	60.4	60.7	58.4	59.1	58.6	76.6
Mongolia	6.1	4.7	3.0	3.4	3.6	3.3	3.6	3.4
Nepal	89.4	90.5	86.1	84.1	85.0	79.2	76.6	75.0
Niger	87.0	86.1	78.7	78.1	78.9	79.7	79.5	78.0
North Macedonia	17.3	15.6	21.2	21.2	24.0	21.4	19.1	20.9
Paraguay	67.1	66.6	62.5	62.5	61.0	62.5	60.1	59.2
Republic of Moldova	5.9	4.9	23.8	24.3	24.7	25.3	26.1	25.7
Rwanda	87.3	90.6	88.5	88.2	86.7	86.0	86.7	85.7
South Sudan	0.0	0.0	29.7	30.4	26.2	27.8	27.9	33.2
Tajikistan	64.6	54.6	55.1	45.9	48.1	41.2	41.7	39.5
Turkmenistan	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Uganda	94.2	92.3	90.8	90.2	89.0	88.6	88.5	90.3
Uzbekistan	1.5	0.8	1.3	1.3	1.8	2.1	2.4	1.5
Zambia	89.4	92.4	89.0	88.6	88.0	88.2	84.5	85.1
Zimbabwe	77.8	82.1	79.4	81.0	81.6	82.8	83.3	81.4
Average, LLDCs	43.5	39.8	41.9	42.8	43.5	44.1	44.0	43.8
Average, World	16.7	16.1	16.9	17.0	17.0	17.2	17.3	17.1

Source: United Nations SDG indicators database.

Table 7 Primary energy trade

	IMPORTS (TJ)		EXPORTS (TJ)		ENERGY SELF-SUFFICIENCY (%)		NET TRADE (USD MILLION)	
	2013	2018	2013	2018	2013	2018	2013	2018
Afghanistan	87 943	84 294	1 475	30 708	41	63	-1 453	-880
Armenia	99 475	102 866	6 657	5 903	34	28	-850	-597
Azerbaijan	5 545	77 685	1 907 801	1 805 968	440	387	22 087	17 154
Bhutan	6 828	10 871	20 401	16 492	123	107	n.a.	n.a.
Bolivia	41 109	61 093	630 910	497 601	281	206	5 382	1 839
Botswana	53 029	44 139	1 581	7 487	47	64	-2 268	-752
Burkina Faso	43 585	67 798	464	354	76	68	-910	-1 141
Burundi	6163	9 888	9	0	91	85	-167	-149
Central African Republic	5 564	3 925	1	0	82	86	-1	-22
Chad	177	120	190 415	261 854	337	405	n.a.	n.a.
Eswatini	21 792	17 732	5 797	3 358	70	67	-322	-255
Ethiopia	129 290	203 140	3 460	5 292	92	89	-1 809	-1 494
Kazakhstan	640 914	455 981	4 202 033	4 675 732	203	238	59 149	40 187
Kyrgyzstan	107 878	116 871	10 453	24 158	44	50	-1 115	-762
Lao's	38 256	45 777	48 239	97 978	110	123	-558	562
Lesotho	27 325	29 819	8	10	53	36	-236	n.a.
Malawi	13 334	19 572	329	545	84	78	-411	-303
Mali	36 651	52 082	1 685	2 423	62	78	n.a.	n.a.
Republic of Moldova	77 849	94 334	1 859	1 153	28	28	-717	-671
Mongolia	56 293	66 734	382 519	929 372	161	257	19	1 896
Nepal	78 116	152 147	14	126	85	75	-1 212	n.a.
Niger	3 674	7 300	16 230	14 695	116	111	328	126
North Macedonia	62 954	69 176	8 454	6 355	53	44	-969	-801
Paraguay	68 301	120 737	174 702	155 221	147	114	535	268
Rwanda	12 081	15 399	1	16	88	86	-334	-434
South Sudan	21 278	18 235	208 977	267 590	96	96	n.a.	n.a.
Tajikistan	30 270	46 934	4 167	11 686	83	83	n.a.	n.a.
Uganda	53 826	78 185	386	840	92	92	-1 187	-1 152
Uzbekistan	47 381	86 776	516 223	517 742	126	119	n.a.	1 787
Zambia	44 452	55 594	7 045	4 957	91	90	-883	-1 247
Zimbabwe	67 154	66 759	13 597	6 297	88	90	-1 556	-1 786

Source: IRENA Country Profiles, https://irena.org/Statistics/Statistical-Profiles.

Table 8 Hydropower production

GWH	2011	2012	2013	2014	2015	2016	2017	2018	2019
Afghanistan	682	736	855	968	1 001	1 025	1 049	928	1 143
Armenia	2 489	2 311	2 173	1 993	2 206	2 351	2 269	2 318	2 371
Azerbaijan	2 676	1 821	1 491	1 300	1 638	1 959	1 746	1 768	1 565
Bhutan	7 066	6 823	7 550	7 164	7 747	7 953	7 728	6 959	8 875
Bolivia	2 346	2 352	2 533	2 233	2 442	1 720	2 234	2 612	3 251
Botswana	-	-	-	-	-	-	-	-	-
Burkina Faso	82	97	106	90	93	139	128	91	105
Burundi	240	251	249	241	236	272	259	240	240
Centr. Afr. Rep.	141	141	141	141	141	136	136	136	136
Chad	-	-	-	-	-	-	-	-	-
Eswatini	325	291	251	290	252	154	123	189	225
Ethiopia	6 265	7 392	8 343	6 823	9 019	9 674	11 753	12 681	13 655
Kazakhstan	7 900	7 600	7 731	8 263	9 269	11 621	11 210	10 395	9 994
Kyrgyzstan	14 309	14 179	13 097	13 298	11 093	11 498	14 204	14 318	13 859
Lao PDR	12 992	12 769	15 517	15 749	16 000	17 601	19 489	21 170	18 899
Lesotho	468	494	474	504	517	521	516	518	502
Malawi	1 885	1 873	1 861	1 967	1 956	1 944	1 823	1 356	1 358
Mali	1 111	1 211	1 442	1 498	1 529	1 645	1 702	1 702	1 702
Moldova	356	272	313	320	269	230	285	276	301
Mongolia	55	54	61	68	61	87	86	81	87
Nepal	3 471	3 639	3 608	3 720	3 690	3 931	4 531	4 852	5 637
Niger	-	-	-	-	-	-	-	-	-
Paraguay	57 624	60 232	60 378	55 276	55 743	63 770	59 684	59 211	49 445
North Macedonia	1 433	1 041	1 584	1 207	1 865	1 897	1 110	1 791	1 164
Rwanda	222	270	241	291	325	328	305	333	397
South Sudan	-	-	-	-	-	-	-	-	-
Tajikistan	16 200	16 900	17 071	16 312	16 900	16 803	17 312	18 573	19 348
Turkmenistan	3	3	3	3	3	3	3	3	3
Uganda	1 513	2 430	3 224	3 259	3 115	3 249	3 402	3 584	4 000
Uzbekistan	8 100	8 100	8 100	8 100	8 100	8 100	8 100	5 897	6 452
Zambia	11 875	12 352	13 283	14 044	13 037	11 027	12 473	13 696	12 335
Zimbabwe	5 212	5 399	5 004	5 439	4 998	2 624	3 976	5 455	5 455
World	3 586 416	3 772 390	3 873 672	3 992 501	3 988 946	4 160 138	4 184 129	4 280 510	4 321 616

Source: IRENA (2021d).

Table 9 Wind energy production

GWH	2011	2012	2013	2014	2015	2016	2017	2018	2019
Afghanistan	-	0	0	0	0	0	0	0	0
Armenia	6	4	4	4	4	2	2	2	3
Azerbaijan	-	-	1	2	5	23	22	83	105
Bhutan	-	-	-	-	-	1	1	1	-
Bolivia	0	0	0	8	11	35	60	59	70
Botswana	-	-	-	-	-	-	-	-	-
Burkina Faso	-	-	-	-	-	-	-	-	-
Burundi	-	-	-	-	-	-	-	-	-
Centr. Afr. Rep.	-	-	-	-	-	-	-	-	-
Chad	-	-	-	-	-	9	9	9	9
Eswatini	-	-	-	-	-	-	-	-	-
Ethiopia	29	192	356	526	499	786	782	533	848
Kazakhstan	-	3	5	13	132	275	340	461	717
Kyrgyzstan	-	-	-	-	-	-	-	-	-
Lao PDR	-	-	-	-	-	-	-	-	-
Lesotho	-	-	-	-	-	-	-	-	-
Malawi	-	-	-	-	-	-	-	-	-
Mali	-	-	-	-	-	-	-	-	-
Moldova	-	-	1	1	2	3	7	23	43
Mongolia	1	1	54	126	154	159	155	340	460
Nepal	-	-	0	0	0	0	0	0	0
Niger	-	-	-	-	-	-	-	-	-
Paraguay	-	-	-	-	-	-	-	-	-
North Macedonia	-	-	-	71	121	109	110	97	102
Rwanda	-	-	-	-	-	-	-	-	-
South Sudan	-	-	-	-	-	-	-	-	-
Tajikistan	-	-	-	-	-	-	-	-	-
Turkmenistan	-	-	-	-	-	-	-	-	-
Uganda	-	-	-	-	-	-	-	-	-
Uzbekistan	-	-	-	-	-	-	-	-	16
Zambia	-	-	-	-	-	-	-	-	-
Zimbabwe	-	-	-	-	-	-	-	-	-
World	433 737	525 532	636 173	712 055	828 046	952 829	1 131 549	1 258 095	1 412 384

Source: IRENA (2021d).

Table 10 Solar energy production

GWH	2011	2012	2013	2014	2015	2016	2017	2018	2019
Afghanistan	0	28	30	32	33	35	38	37	50
Armenia	-	-	-	-	-	1	3	19	24
Azerbaijan	0	0	1	3	5	35	37	39	44
Bhutan	0	0	0	0	0	0	0	0	0
Bolivia	1	2	2	4	5	6	7	127	189
Botswana	0	1	2	3	3	5	5	6	6
Burkina Faso	9	9	10	11	13	16	29	98	103
Burundi	1	2	4	4	5	6	8	8	8
Centr. Afr. Rep.	0	0	0	0	0	0	0	0	0
Chad	0	0	0	0	0	0	0	0	0
Eswatini	1	1	1	1	1	1	1	1	1
Ethiopia	1	2	6	16	18	21	22	20	20
Kazakhstan	5	8	22	97	118	136	160	383	1 003
Kyrgyzstan	-	-	-	-	-	-	-	-	-
Lao PDR	0	0	1	4	4	5	5	19	27
Lesotho	-	-	0	1	1	1	1	1	1
Malawi	4	6	11	16	25	25	39	47	47
Mali	16	26	26	26	28	29	31	31	31
Moldova	-	-	-	1	2	2	2	3	3
Mongolia	8	8	8	8	8	8	27	59	117
Nepal	11	13	15	17	19	19	78	75	73
Niger	5	7	8	10	11	13	15	33	33
Paraguay	0	0	0	0	0	0	0	0	0
North Macedonia	1	3	9	14	23	24	24	23	23
Rwanda	0	1	1	7	21	30	37	44	45
South Sudan	-	0	0	0	0	1	1	1	1
Tajikistan	-	-	-	-	-	-	-	-	-
Turkmenistan	-	-	-	-	-	-	-	-	-
Uganda	24	25	27	29	32	39	62	71	117
Uzbekistan	-	-	2	2	2	5	6	7	0
Zambia	-	-	0	0	0	0	0	1	14
Zimbabwe	0	2	3	5	8	9	11	19	19
World	65 631	101 770	137 621	192 762	252 349	326 136	438 178	564 710	693 063

Source: IRENA (2021d).

Table 11 Bioenergy production

GWH	2011	2012	2013	2014	2015	2016	2017	2018	2019
Afghanistan	-	-	-	-	-	-	-	-	-
Armenia	-	-	-	-	-	-	-	-	-
Azerbaijan	-	-	134	174	182	175	170	162	196
Bhutan	-	-	-	-	-	-	-	-	-
Bolivia	113	113	113	167	202	176	122	169	217
Botswana	-	-	-	-	-	-	-	-	-
Burkina Faso	-	-	0	0	0	0	1	1	1
Burundi	6	6	7	6	6	7	7	6	6
Centr. Afr. Rep.	-	-	-	-	-	-	-	-	-
Chad	-	-	-	-	-	-	-	-	-
Eswatini	132	167	171	170	176	183	183	185	185
Ethiopia	17	10	28	31	28	28	23	26	30
Kazakhstan	-	-	1	46	42	48	51	30	44
Kyrgyzstan	-	-	-	-	-	-	-	-	-
Lao PDR	-	-	5	7	4	4	26	46	46
Lesotho	-	-	-	-	-	-	-	-	-
Malawi	45	50	52	51	51	52	53	54	54
Mali	-	-	-	-	-	-	-	-	-
Moldova	-	-	2	13	15	14	23	30	31
Mongolia	-	-	-	-	-	-	-	-	-
Nepal	-	-	-	-	-	-	-	-	-
Niger	-	-	-	-	-	-	-	-	-
Paraguay	2	2	128	139	146	170	141	133	136
North Macedonia	-	-	-	-	20	36	52	54	55
Rwanda	2	2	2	2	2	2	2	2	2
South Sudan	-	-	-	-	-	-	-	-	-
Tajikistan	-	-	-	-	-	-	-	-	-
Turkmenistan	-	-	-	-	-	-	-	-	-
Uganda	125	160	192	206	246	253	227	286	276
Uzbekistan	-	-	-	-	-	-	-	-	-
Zambia	63	67	66	71	73	76	78	78	78
Zimbabwe	65	194	179	176	199	311	90	257	257
World	335 893	371 002	404 156	436 166	459 106	485 112	503 100	526 557	557 853

Source: IRENA (2021d).

Table 12 Geothermal energy production

GWH	2011	2012	2013	2014	2015	2016	2017	2018	2019
Afghanistan	-	-	-	-	-	-	-	-	-
Armenia	-	-	-	-	-	-	-	-	-
Azerbaijan	-	-	-	-	-	-	-	-	-
Bhutan	-	-	-	-	-	-	-	-	-
Bolivia	-	-	-	-	-	-	-	-	-
Botswana	-	-	-	-	-	-	-	-	-
Burkina Faso	-	-	-	-	-	-	-	-	-
Burundi	-	-	-	-	-	-	-	-	-
Centr. Afr. Rep.	-	-	-	-	-	-	-	-	-
Chad	-	-	-	-	-	-	-	-	-
Eswatini	-	-	-	-	-	-	-	-	-
Ethiopia	18	8	-	-	-	-	-	-	-
Kazakhstan	-	-	-	-	-	-	-	-	-
Kyrgyzstan	-	-	-	-	-	-	-	-	-
Lao PDR	-	-	-	-	-	-	-	-	-
Lesotho	-	-	-	-	-	-	-	-	-
Malawi	-	-	-	-	-	-	-	-	-
Mali	-	-	-	-	-	-	-	-	-
Moldova	-	-	-	-	-	-	-	-	-
Mongolia	-	-	-	-	-	-	-	-	-
Nepal	-	-	-	-	-	-	-	-	-
Niger	-	-	-	-	-	-	-	-	-
Paraguay	-	-	-	-	-	-	-	-	-
North Macedonia	-	-	-	-	-	-	-	-	-
Rwanda	-	-	-	-	-	-	-	-	-
South Sudan	-	-	-	-	-	-	-	-	-
Tajikistan	-	-	-	-	-	-	-	-	-
Turkmenistan	-	-	-	-	-	-	-	-	-
Uganda	-	-	-	-	-	-	-	-	-
Uzbekistan	-	-	-	-	-	-	-	-	-
Zambia	-	-	-	-	-	-	-	-	-
Zimbabwe	-	-	-	-	-	-	-	-	-
World	69 856	70 842	72 361	77 294	81 205	83 271	86 018	89 521	92 047

Source: IRENA (2021d).

Table 13 Public flows to renewables (USD million 2018)

	USD MILLION
Afghanistan	72.5
Armenia	28.2
Azerbaijan	n.a.
Bhutan	0.1
Bolivia	83.5
Botswana	0.0
Burkina Faso	35.9
Burundi	10.0
Central African Republic	3.8
Chad	n.a.
Eswatini	n.a.
Ethiopia	34.7
Kazakhstan	334.0
Kyrgyzstan	0.1
Lao PDR	401.8
Lesotho	69.9
Malawi	16.8
Mali	21.6
Republic of Moldova	n.a.
Mongolia	91.4
Nepal	15.6
Niger	29.2
North Macedonia	n.a.
Paraguay	133
Rwanda	16.1
South Sudan	0.3
Tajikistan	n.a.
Uganda	236.3
Uzbekistan	1.0
Zambia	66.3
Zimbabwe	0.0

Note: n.a. = not available.
Source: IRENA Country Profiles, https://irena.org/Statistics/Statistical-Profiles.

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