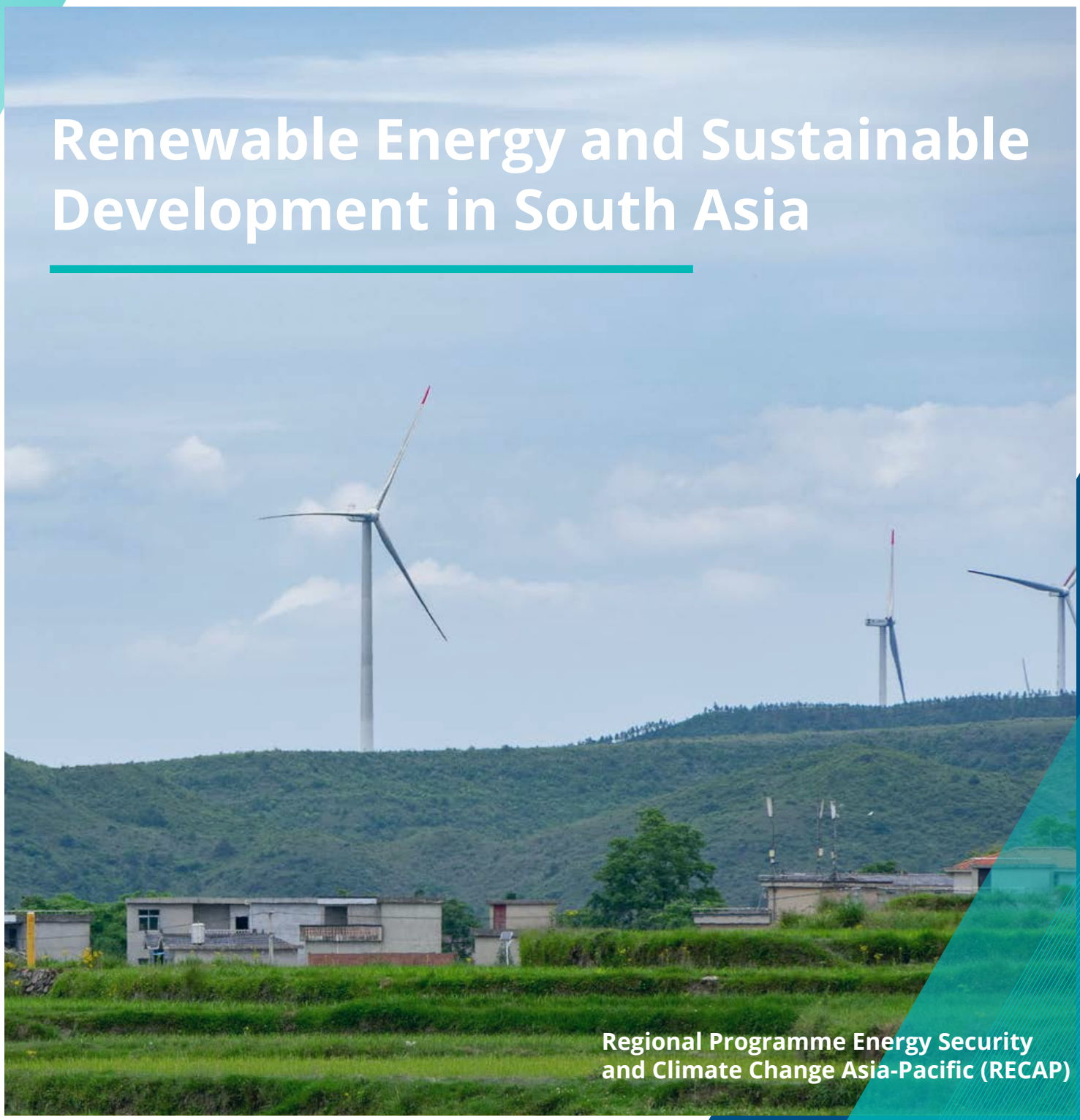
KONRAD ADENAUER STIFTUNG

Renewable Energy and Sustainable Development in South Asia



Regional Programme Energy Security and Climate Change Asia-Pacific (RECAP)

CONSORTIUM OF SOUTH ASIAN THINK TANKS

COSATT

BRIDGING POLICY RESEARCH IN SOUTH ASIA

Renewable Energy and Sustainable Development in South Asia

Foreword

Energy supply is a key factor for economic development in South Asia. With their energy production primarily based on imported fossil fuels, South Asian countries are vulnerable to volatile prices on international energy markets. In the wake of the COVID-19 economic recovery and global energy market disruptions following Russia's invasion of Ukraine, high energy prices have impacted various South Asian sectors — from power generation and industrial activities to transportation.

The region's heavy reliance on fossil fuels is also reflected by the energy sector being South Asia's largest greenhouse gas emitter. The decarbonisation of the region will play a vital role not only for its own sustainable growth but also to achieve global climate goals and net-zero emissions.

Renewable sources of energy are relevant for a transition to a decarbonised energy supply. For South Asia, an expansion of renewable energy also enhances energy security by reducing dependence on fossil fuel imports. Furthermore, decentralised renewable energy production allows some South Asian countries to provide electricity to the most remote parts of their populations for the first time.

It is therefore crucial to accelerate the expansion of renewables in the region. But a sudden transition to renewable energy has some challenges. Insufficient grid infrastructure requires a substantial infrastructure upgrade to enable the integration of renewables given their often intermittent nature. Grid capacity should also be able to support the development of regional, cross-border energy markets for renewable energy trade. Lack of financing and limited technical capacity are just two of the challenges further complicating the sustainable development of renewables in the region.

Generally, South Asia has significant potential for renewable energy — be it hydropower, solar pv or wind. The region's diversity, however, requires a closer look in order to identify opportunities and understand the specific challenges. KAS' Regional Programme Energy Security and Climate Change Asia Pacific (KAS RECAP) in cooperation with the Consortium of South Asian Think-Tanks (COSATT) initiated this publication with papers from Bangladesh, Bhutan, India, the Maldives, Nepal, Pakistan and Sri Lanka. Experts from the respective countries analyse the status quo and future opportunities for renewable energy development and expansion as well as greater regional cooperation. It also provides concrete recommendations on how policy and improved institutional arrangements can promote renewable energy, and thus sustainable development, in the region. We hope this publication will contribute to enhancing the understanding of renewable energy and sustainable development in South Asia and will prove useful to academics, researchers and practitioners alike.

Dr. Frederick Kliem
Director
Regional Programme Energy Security and Climate Change Asia-Pacific (RECAP)
Konrad-Adenauer-Stiftung e.V.

Dr. Nishchal N. Pandey
Convener
Consortium of South Asian Think-Tanks (COSATT)

Table of Contents

1

Bangladesh

Bangladesh

Author: Faiz Sobhan

Renewable energy is becoming an increasingly important aspect of Bangladesh's energy mix, given its potential to support sustainable development and reduce the country's reliance on fossil fuels.[1] Bangladesh, a densely populated country with limited natural resources, has historically struggled to meet its energy needs, leading to energy shortages and frequent power outages.[2] However, in recent years, the government has made significant efforts to promote the development of renewable energy, and the sector has shown promising growth.

Current State of Renewable Energy in Bangladesh

Bangladesh has significant potential for renewable energy, with abundant solar, wind, hydro, and biomass resources.[3] However, despite the government's efforts to promote renewable energy development, the sector still faces several challenges.

According to government figures, Bangladesh's renewable energy capacity is estimated to be about 911 MW, consisting of solar energy at 677 MW, hydro at 230 MW and other sources at 2.0 MW while total power generation exceeds 25,000 MW.[4]

Despite the growth of the renewable energy sector in recent years, Bangladesh still faces several challenges in promoting renewable energy, including a lack of adequate financing, insufficient grid infrastructure, and limited technical capacity.[5] Moreover, the intermittent nature of some renewable energy sources, such as solar and wind, presents challenges for grid integration.[6]

Government Policies Initiatives to Promote Renewable Energy

The government of Bangladesh has taken several initiatives to promote the development of renewable energy in the country. The government's Renewable Energy Policy of 2008 was the first comprehensive policy framework to promote renewable energy development in Bangladesh.[7] The policy aimed to increase the share of renewable energy in the country's energy mix to ten per cent by 2020.[8] However, the actual amount generated was 1.42 per cent by 2015 and 2.84 per cent by 2019.[9]

In 2019, the government launched the Bangladesh Power System Master Plan (PSMP) 2016–2041, which provides a comprehensive plan for the development of the power sector in Bangladesh.[10] The plan emphasizes the development of renewable energy sources, including solar, wind, and hydro, and aims to increase the share of renewable energy in the country's energy mix to ten per cent by 2021 and 20 per cent by 2030.[11] To support the development of renewable energy, the government has also implemented several financial incentives, including tax exemptions and reduced tariffs on renewable energy equipment and components.[12] The government has also established the Infrastructure Development Company Limited (IDCOL), a state-owned non-banking financial institution that provides financing for renewable energy projects.[13]

To achieve its target of generating ten per cent of the country's electricity from renewable energy sources by 2021, the government has implemented several initiatives, including the installation of grid-connected solar power plants and the promotion of off-grid renewable energy systems, particularly in rural areas, where access to electricity is limited.[14]

In 2012, the government established the Sustainable and Renewable Energy Development Authority (SREDA) to promote renewable energy and energy efficiency in the country. SREDA is responsible for

developing policies and regulations for renewable energy and promoting the development of renewable energy projects.[15]

The government has also taken steps to improve grid infrastructure and grid integration of renewable energy sources. In 2018, the government launched the Bangladesh-India Grid Interconnection project, which aims to connect the power grids of Bangladesh and India, enabling the import and export of electricity between the two countries.[16]

Another key initiative implemented by the government is the Bangladesh Climate Change Trust Fund (BCCTF), which was established in 2009 to finance climate change adaptation and mitigation projects, including renewable energy projects.[17] The BCCTF has supported the development of several renewable energy projects in Bangladesh, particularly in the solar and wind energy sectors.

Private Sector Engagement

Private sector engagement in Bangladesh's renewable energy sector has been crucial in driving progress and increasing access to clean energy sources.

At an international conference in 2022, Bangladesh's Power Minister, Nasrul Hamid stated that SREDA was providing logistic and technical assistance to expand renewable energy in the country. He added that the government planned to attract 50 billion US dollars in investments over the next twelve years, with twelve billion US dollars already invested in the past decade. The minister said that 44 per cent of power was being generated by the private sector, and five out of eight under-construction renewable power plants were owned by the private sector and the government had agreed to set up ten more power plants in the private sector.[18]

Furthermore, the government has taken steps to improve grid infrastructure and grid integration of renewable energy sources. One such example is the Bangladesh-India Electrical Grid Interconnection Project, which aims to establish a cross-border transmission link between Bangladesh and India to facilitate power transmission. The MOU was first signed in 2010 and after several delays the project was inaugurated on 5 October 2013.[19]

The Behrampur-Bheramara link's power transfer capacity rose to 1,000 MW on 10 September 2018, following the commissioning of a second 500 MW HVDC block at the Bheramara back-to-back station. To enhance connectivity and reliability, a second 400 kV double circuit line was constructed between Behrampur and Bheramara, with its first circuit energized on 14 June 2021. Additionally, a 63-km long, 400 kV double circuit line connecting Surjyamaninagar, India, and Comilla, Bangladesh, was put into operation on 17 March 2016, linking Bangladesh to India's North-Eastern region, specifically the Tripura state.[20]

The Bangladesh-India Electrical Grid Interconnection Project is expected to have significant economic and social benefits for both countries, including increased access to electricity and improved energy security. In addition to the economic and social benefits, the project is also expected to have significant environmental benefits, as it will facilitate the exchange of clean energy between the two countries.[21]

Despite these successes, private sector engagement in the renewable energy sector in Bangladesh faces several challenges. One major challenge is the lack of financing options for renewable energy projects, particularly for smaller-scale initiatives.[22] Additionally, there is a need for stronger policies and regulations to promote private sector investment in the renewable energy sector.

Challenges Faced by the Renewable Energy Sector in Bangladesh

Despite the government's efforts to promote renewable energy, the sector faces several challenges that hinder its growth and development. Although the government has established IDCOL to provide financing for renewable energy projects, the amount of funding available is limited, and access to finance remains a significant challenge for renewable energy developers.[23]

The high cost of renewable energy technologies, particularly solar energy systems, which make up the majority of renewable energy installations in Bangladesh, is a significant challenge for the financial viability of renewable energy projects, especially when coupled with low levels of

electricity tariffs.[24] The financial barriers to the development of renewable energy projects in Bangladesh are mainly due to high risks and a low rate of return on invested capital compared to fossil-energy projects.[25] However, renewable energy in Bangladesh has a compelling economic case due to its low cost and the need for the country to reduce import dependence.[26] Hybrid renewable energy systems (HRESs) have been analyzed in Bangladesh, particularly in areas with low population density, due to the high cost of extending the grid.[27]

Moreover, the development of renewable energy projects requires a range of technical skills, including engineering, project management, and maintenance. The lack of skilled personnel in these areas makes it difficult for renewable energy projects to be implemented effectively and efficiently.[28]

Finally, the intermittent nature of some renewable energy sources, such as solar and wind energy, poses a challenge to the integration of these sources into the grid as they cannot provide constant power supply. Moreover, energy storage technologies are not widely available or affordable in Bangladesh.[29]

Opportunities of the Renewable Energy Sector in Bangladesh

The renewable energy sector presents numerous opportunities for economic growth, job creation, and sustainable development, as it has significant renewable energy potential, particularly in solar, wind, and biomass.[30] Here are some of the opportunities that the renewable energy sector presents in Bangladesh:

- **Economic Growth:** The renewable energy sector can drive economic growth by creating jobs, attracting investment, and reducing dependence on expensive fossil fuel imports.

- **Rural Electrification:** The renewable energy sector has the potential to improve access to electricity in rural areas. In 2021, Bangladesh has launched the world's largest off-grid solar power program, which has enabled 20 million Bangladeshis to access electricity by harnessing solar power. The program was started in 2003 as a 50,000 household pilot and at its peak provided electricity to roughly 16 per cent of the rural population. This program was implemented through a public-private partnership and offers lessons for other countries looking to expand access to clean and affordable electricity.[31]

  The Bangladesh Solar Home Systems (SHS) Program is the world's largest national program for off-grid electrification. The program led to the acceptance of solar as an electricity generation technology and, starting in 2003, enabled 16 per cent of the un-electrified rural population to obtain electricity services far sooner than would have been possible with grid electricity.[32] The expansion of renewable energy systems can further increase access to electricity in rural areas, helping to drive economic development and improve the quality of life.

- **Climate Change Mitigation:** Renewable energy can help Bangladesh mitigate the impacts of climate change by reducing greenhouse gas emissions. According to a study by the World Bank, Bangladesh is one of the most vulnerable countries to climate change, with rising sea levels and increased frequency of natural disasters.[33] The adoption of renewable energy sources can help reduce the country's reliance on fossil fuels, which contribute to greenhouse gas emissions.

- **Energy Security:** The renewable energy sector can help Bangladesh achieve energy security by reducing dependence on imported fossil fuels. According to the Bangladesh Energy Regulatory Commission, the country's energy demand is expected to increase by 7–8 per cent per year until 2030.[34] The adoption of renewable energy sources can help meet this growing demand and reduce dependence on expensive and volatile fossil fuel imports.

- **Innovation:** The renewable energy sector presents opportunities for innovation and technological advancements in Bangladesh. The country has already made significant progress in developing renewable energy solutions, such as the Solar Home System program and the use of biogas plants in rural areas. Further investment in research and development can lead to the development of more efficient and cost-effective renewable energy systems.

Benefits of Renewable Energy

Renewable energy has numerous benefits including increased access to electricity, improved air quality, and reduced greenhouse gas emissions.

According to the World Health Organization, air pollution is a major public health issue in Bangladesh, causing 20 per cent of premature deaths per year.[35] The use of renewable energy sources can help reduce air pollution by replacing traditional sources of energy such as coal and diesel, which are major contributors to air pollution.

In addition to reducing air pollution, renewable energy can also help to reduce greenhouse gas emissions, which are a major contributor to climate change. Bangladesh is one of the most vulnerable countries to climate change, with rising sea levels, increased frequency of natural disasters, and other climate-related challenges. The development of renewable energy sources can help to mitigate these impacts by reducing greenhouse gas emissions and promoting sustainable development.

Bangladesh's most recent climate change plan which was announced in 2021, called the "Bangladesh Delta Plan 2100"[36], outlines the country's strategy for addressing the impacts of climate change and achieving sustainable development. In the document, the government suggested that the shift from reliance on fossil fuels to a low-carbon model that emphasizes renewable energy and energy efficiency could result in the creation of approximately 55,000 new jobs from 2016 to 2030.[37] This could help reduce unemployment rates in the country, particularly in rural areas.

It is clearly evident that renewable energy has significant benefits for Bangladesh, including increased access to electricity, improved air quality, reduced greenhouse gas emissions, and job creation. The government and private sector have taken steps to harness the potential of renewable energy sources, but more needs to be done to ensure that renewable energy plays a more prominent role in the country's energy mix.

Future Outlook

The renewable energy sector in Bangladesh has significant potential for growth and development, but several challenges must be addressed to realize this potential.

One of the key areas for future growth is the development of offshore wind power. Bangladesh has a long coastline and a high potential for offshore wind power generation, which could provide a significant source of renewable energy for the country.[38]

Another area for future growth is the development of energy storage technologies, which could help to address the intermittency of renewable energy sources such as solar and wind power. Energy storage technologies, such as batteries and pumped hydro storage, are becoming increasingly affordable and could play a crucial role in the integration of renewable energy into the grid.[39]
In addition, there is a need for more targeted policies and incentives to promote the growth of the renewable energy sector.[40] For instance, the government could provide tax incentives, subsidies, and feed-in tariffs for renewable energy projects to make them more financially viable.[41]

Finally, there is a need for more investment in research and development to drive innovation in the renewable energy sector. Bangladesh could benefit from international partnerships and collaborations to support the development of new technologies and expertise.[42]

Overall, the future outlook for the renewable energy sector is positive, but concerted efforts are needed to address the challenges facing the sector and to promote its growth and development.

Conclusion and Recommendations

The renewable energy sector has shown remarkable growth in recent years, with increasing investment in solar and other renewable energy sources. The government's commitment to increasing the share of renewable energy in the national energy mix is a positive step in this direction. However, despite this progress, there is a need for more targeted policies and incentives to promote the growth of the sector, as well as more investment in research and development to drive innovation.

The development of offshore wind power and energy storage technologies could provide significant opportunities for the sector. Offshore wind power has been identified as having significant potential in Bangladesh, and the government should explore ways to facilitate its development.[43] Energy storage technologies, such as battery storage, can help to address the intermittent nature of renewable energy sources and support their integration into the grid.[44]

It is apparent that the renewable energy sector has a critical role to play in Bangladesh's sustainable development. The sector can contribute to reducing poverty, promoting economic growth, and improving energy security, while also protecting the environment and combating climate change. Bangladesh can build on the progress made to date and achieve a sustainable energy future.

Based on the challenges and opportunities facing the renewable energy sector in Bangladesh, the following recommendations can be made:

Increase policy support and incentives for renewable energy: The government should provide more policy support and incentives, such as tax credits, subsidies, and feed-in tariffs, to encourage investment in renewable energy sources.[45]

Promote energy efficiency measures: Promoting energy efficiency measures, such as the use of energy-efficient appliances, can help to reduce overall energy demand and support the growth of renewable energy.[46]

Increase investment in research and development: More investment is needed in research and development to drive innovation in the sector and support the development of new technologies.[47]

Develop offshore wind power: The development of offshore wind power has significant potential in Bangladesh, and the government should explore ways to facilitate its development.[48]

Develop energy storage technologies: The development of energy storage technologies, such as battery storage, can help to address the intermittent nature of renewable energy sources and support their integration into the grid.[49]

By implementing these recommendations, Bangladesh can overcome the challenges facing the renewable energy sector and realise its full potential for sustainable development.

Faiz Sobhan is Senior Research Director of Bangladesh Enterprise Institute.

2 Bhutan

Bhutan

Authors: Karma Yangzom Dorji, Phuntsho Choden

Bhutan has rigid environmental and ecosystem conservation laws. A lengthy history of low-carbon growth and energy security can be found in this nation. With regard to the impact of climate change on its water and hydropower resources, Bhutan is now exploring alternative renewable energy resources. Detailed analysis and pilot projects have been carried out and the country is presently prioritizing solar energy. This will help to reduce the import of electricity during the winter season and also generate supplementary energy in the grid which can contribute to national revenue. Friendly policies to allow regional energy integration will play a pivotal role in supplying the surplus energy to areas with high demand. This paper will give an overview of Bhutan's steps towards renewable energy and the country's potential regarding various renewable energy resources.

Figure 2.1: Solar and Wind Energy Pilot Sites in Rubesa, Wangdue Phodrang, Bhutan

Source: Department of Renewable Energy, MoEA[50]

Bhutan is rich in hydropower resources which are also an important source for the country's socio-economic development. The energy sector in Bhutan is dominated by large hydropower projects. Seven hydropower plants (2,326 MW) are under operation, four under construction (2,938 MW) and eight projects are planned (8,814 MW) in different potential basins.[51] They are mostly run-of-river type, flow dependent hydropower plants and only good monsoon seasons yield higher electricity generation and greater revenue, while poor monsoons have negative impact on electricity generation and the country's economy.

The vulnerability and adaptation assessment study carried out in 2020[52] reveals that there will be temporal and spatial variation in flow with high flows during monsoon and very low flows during the lean season. Hydropower generation is at risk because it relies on the climate sensitive water sector and any change in flow will have adverse impact on hydropower management. Furthermore, Bhutan has some of the firmest environmental and ecosystem conservation laws; the conservation of the environment is one of the four pillars of Bhutan's Development Philosophy.

To conserve the ecological integrity of the aquatic ecosystems and river corridors, through the Water Regulation, 2014, minimum environmental flows are to be determined during an Environmental Impact Assessment. Minimum Environmental flow (E-Flow) is the minimum amount of water flow required to sustain freshwater ecosystems and the human livelihoods that depend on them.

The First Step towards Exploring Solar and Wind Energy

A wind power pilot plant of 600 kW (2× 300 kilowatt) and a 180 kW pilot grid-tied ground-mounted solar power plant have been successfully installed in 2016 and 2021 respectively at Rubesa in Wangdue Phodrang by the Department of Renewable Energy (DRE), Ministry of Energy and Natural Resources. The department subsequently identified several more sites for possible development of utility-scale renewable energy sources in the country. The pilot wind farm has potential to provide energy to 300 households in Rubesa.[53] The department has carried out a detailed technical feasibility study on two solar park sites and two wind farm sites in Bhutan. They are currently implementing the 17.38 MW solar park at Sephu, Wangdue Phodrang with financial assistance from the Asian Development Bank (ADB). The Project Manager shared that the other projects will be implemented as funding sources become available. The department has also identified seven suitable project locations for pre-feasibility studies, essentially to check if the project locations are worth moving forward and also to identify the top three most eligible locations.

Bhutan has achieved 99.97 per cent electrification[54], there are only three areas which do not have access to electricity due to topographical challenges. One of the areas is Aja Nye in Mongar district, a popular pilgrimage destination for locals. Visitors and local communities have no option but to rely heavily on wood for cooking, lighting and heating. However, with the introduction of 80 kW of Solar Photovoltaics (PV) system, 34 households in Aja Nye will experience using electricity in an environmentally responsible manner with this initiative. Thus, the community can experience electrical appliances and familiarise themselves with their use for the first time. Lunana in Gasa district is another area without electricity and the department is taking numerous initiatives to explore ways to electrify these areas and achieve 100 per cent electrification in the country. DRE is taking several technical and financial feasibility measures considering that the project will be constructed at an altitude of over 4,000 meters.

Expedition towards Discovering Other Sources of Renewable Energy

Apart from major hydro, solar and wind ventures, Bhutan has the potential for other renewable energy resources like biomass and solid waste which have not been fully exploited yet. Across the country, approximately 13,500 cooking stoves and 6,087 biogas plants were installed (as of December 2019).[55] A biogas plant which has the capability to convert one ton of waste into energy has been installed at one of the educational institutions in Bhutan. The advantages of waste-to-energy methods are twofold, waste management is addressed on the one hand, and there is an extra energy source on the other.

On a minor scale, about thirty solar water heating systems have been installed successfully in institutional buildings with capacities ranging from 500 to 1,500 litres. Due to a lack of expertise and high costs, it has not been executed profusely. Apart from that, a solar car park capable of generating 11.7 KW of energy has been implemented. A “prosumers” concept project is being explored for the rural households, which means the household producing solar power becomes a consumer itself. The solar cells are installed on the rooftop and the generated power will be used for home lighting.

Environmental and Socio-Economic Benefits and Sustainability of Renewable Energy

Exploring and implementing environment friendly and climate resilient forms of renewable energy will be a bonus to an already environment friendly country like Bhutan. Bhutan has achieved almost 100 per cent electrification; however, some households even today depend on wood and kerosene for cooking and heating purposes due to difficult

topography. The advancement of technologies in heating, cooking and renewable energy implementation can enhance living conditions of the poor. It will also reduce deforestation, indoor emissions and bring significant health benefits. As they are most impacted by interior pollution and the tedium of obtaining fuel-wood, particularly women benefit from such efforts. Off-grid renewable energy is suitable for the inaccessible rural areas and a low cost, quickly deployable, and adaptable tool to accelerate the electrification process. This technology mix has been further diversified due to the expanding use of small wind and solar PV-based technologies.

Since 2005, the country has seen a sharp increase in its energy consumption. The majority of the energy demand, particularly that of the transportation and industrial sectors, is met by imported fossil fuels, which is a substantial financial burden for the kingdom. According to government data, import costs are higher than export incomes. The use of electric cars can increase the sustainability of the transportation industry. This may provide a quick and affordable route to electrifying Bhutan's transportation industry, creating possibilities for lowering imports of gasoline and diesel.[56]

The sustainability of renewable energy sources and their capacity to slow climate change is challenged by a number of factors. These problems include market failures, knowledge gaps, lack of access to raw materials for the deployment of future renewable energy sources, and — most importantly — the inefficient way we use energy.[57]

Environmental concerns are an important factor in sustainable development. The use of renewable energy sources and technologies is crucial for sustainable development because **i) it has a smaller negative impact on the environment**, **(ii) it is more flexible**, **(iii) it is not exhausted**, and **(iv) it allows for decentralization**.[58] It has been recognized that renewable energy industry faces significant challenges. Some of these are unavoidable in all renewable energy technologies, while others are the result of a distorted market and regulatory environment.

The implementation of renewable technology is hampered by the lack of thorough regulations and regulatory frameworks. To attract investors, the market for renewable energy needs clear regulation and enforceable laws.[59]

According to the Executive Engineer in DRE, the main factor that is obstructing the country in venturing into renewable energy is investment. Feasibility studies for solar and wind have been carried out but due to constraint in the economy, implementation has been on hold. Apart from funding sources, the other challenge is the country's mountainous topography, altitude and scattered settlements across the country.

Bhutan's commitment and policies to reduce high dependency on Hydropower Plants

The Third Communication report to UNFCCC stated that it would give priority to explore other sources of renewable energy for diversifying the energy sources.[60] The Twelfth Five-Year Plan, 2018–2023 sets forth policies and actions to achieve the ambitious national goal of a just, harmonious and sustainable society through increased decentralization.[61] In view of the low-carbon development and energy front, renewable energy sources will be promoted to meet national energy needs through the use of solar and wind energy and promote a low-emission transport system. To reduce the dependency on hydropower, the Alternative Renewable Energy Policy (AREP) aims to diversify the energy mix by harnessing other domestic sources of clean renewable energy to ensure energy security, economic development, and protection of the environment and promote renewable energy technologies, such as wind and solar power. This policy sets out a preliminary minimum target of 20 MW by 2025 through a mix of renewable energy technologies. To diversify and become energy secured, Bhutan has started exploring the development of other renewable energy technologies, focusing on utility scale of wind and solar power. As per the Renewable Energy Management Master Plan, Bhutan could produce twelve gigawatts (GW) of solar and 760 megawatts (MW) of wind energy in technical terms.[62] Bhutan's Nationally Determined Contributions plans to

include low GHG emission development for mitigating climate change, promote green and self-reliant economy towards carbon neutral and sustainable development and promote clean renewable energy generation.

Bhutan is well represented in the international and regional environmental arena as part of its commitment to environmental conservation and protection. In connection with renewable energy, it has signed the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 and endorsed it on 25 August 1995 during its 73rd session. The mandate to prepare and submit a periodic National Communication report containing a national inventory of anthropogenic emissions by sources and removals by sinks of greenhouse gases was delineated. The Royal Government of Bhutan made a pledge to remain carbon neutral during the 15th session of Conference of Parties (COP15) of the UNFCCC in Copenhagen. The Paris Agreement addresses fundamental areas necessary to combat climate change and aims to substantially reduce global greenhouse gas emission to limit the global temperature increase in this century to two degrees Celsius above pre-industrial level, while pursuing the means to limit the increase to 1.5 degrees.

Potential Regional Renewable Energy Cooperation

The key to addressing current energy security concerns is to increase the use of renewable energy. Considerable renewable energy sources, including hydro, wind, solar, and biomass, are available in South Asian countries. To achieve energy security, South Asian nations could collaborate in using these resources to create clean and dependable energy, reduce their dependence on fossil fuel, and promote economic growth.

It can lead to cost saving via numerous ways. Countries may obtain economies of scale and save expenses, which can help their economies, by combining assets and expertise. According to best practices in the area, reducing regulatory obstacles, which are a major cause of delays for renewable energy (RE) construction, can lower the developer's costs.

The regional collaboration in RE can increase energy security and lessen reliance on imports. If countries with comparable energy security issues — such as lack of fossil fuel to meet rising demand — coordinate their deployment of renewable energy sources in the area, along with the development of infrastructure, this can help diversify their energy mix and increase overall energy security and quality in the supply of electric power. Regional collaboration can support grid stability. With rising RE market share, it is more crucial than ever to ensure system compatibility and market design. Grid stability may be aided by regional collaboration, for instance, if regional balancing is extended beyond international boundaries.

Such collaboration can help attain regional goals. Any gap analysis must begin with an evaluation of whether the measures and policies in place are capable of achieving a regional goal. Therefore, by providing a forum for discussion and coordination, regional cooperation can aid in bridging this gap between national policy and the aspirational RE objectives.

Lastly, through promoting information sharing networks between member states of the South Asian Association for Regional Cooperation (SAARC), regional collaboration can make it easier to attain the aspirational regional RE objectives. Exchanging information and experiences with RE project creation, grid integration, and RE support programs might help less experienced countries to overcome challenges.

A region's technical aspirations on a global scale can also be advanced through regional collaboration. More states working together on RE-related technologies and innovations can encourage information dissemination and boost technical inventiveness. To guarantee that qualified personnel is available, collaboration on training may also be included.

Countries may face challenges in collaborating due to the presence of political conflict, economic inequality or competing national interests which are classified as political and economic barriers.

National technical disparities make it challenging to synchronize energy systems and infrastructure. Variations in regulatory frameworks for energy systems across countries or trade restrictions can be obstacles.

Conclusion

The renewable energy sector in Bhutan is dominated by hydropower. Other alternative energy sources like solar, wind and bioenergy are gradually picking up. A research in Bhutan states that the renewable energy sources including solar, wind and biogas are less complicated and more dependable.[63] The ADB also believes that Bhutan's success would encourage other nations to look into methods to develop their own renewable energy sources and encourage cross-border power trading for the benefit of all.[64] An energy system that is diverse and includes a variety of renewable energy sources perhaps will be more resistant to the effects of climate change and emit little to no greenhouse gases or pollutants into the air.

The low river flow and high energy demand in winter months oblige Bhutan to import energy from outside. The Royal Government of Bhutan is prioritising the establishment of various sizes of solar power plants and the relevant policies aim at fulfilling the national demand and making Bhutan energy sufficient throughout the year. Decentralized solutions might therefore assist Bhutan in supplying off-grid electricity and lessen the demand for hydro-generated electricity. These can complement large hydropower in forming a more diversified electricity generation portfolio, which is, in healthy mix, resilient to climate-related changes in seasonal weather patterns and weather extremes that can adversely affect power supply.[65] Since hydropower plants and wind farms are cost extensive, Bhutan is currently exploring solar energy and its potential on state owned land across the country.

A situational assessment of household energy needs in Bhutan carried out by UNESCAP Energy Division in 2021 recommends that together with financial assistance, awareness-raising for the advantages of clean home energy would encourage demand for upgraded stoves and change in behaviour of households.[66] Clean fuel and technologies are a novel product; thus, some families may have doubts about how effective and healthy they are. Customers therefore have a "Wait and See" mentality, particularly with relation to biogas.

In the shift to clean fuels and technologies for cooking and space heating, the growth of the private sector can be crucial. The private sector may participate more actively through programs that facilitate access to capital (e.g., through specific schemes providing guarantees or collateral for private entrepreneurs, introducing micro-financing schemes for women and rural technicians). Think tanks, international organizations, and CSOs also have significant influence in pushing for the necessary political will for energy cooperation in South Asia.

Karma Yangzom Dorji works as an Environmental and Social Expert in the RIR-WB project, PMU under Department of Local Governance and Disaster Management, Ministry of Home Affairs in Bhutan.

Phuntsho Choden is Water Engineer at Mawongpa Water Solutions Private Limited.

3

India

India

Author: Prof. D. Suba Chandran

The essay from India on "Renewable Energy and Sustainable Development in South Asia," looks at the following three questions. First, what measures has India taken to achieve renewable energy? Second, what progress has India made in accomplishing SDG-7? Lastly, what are the challenges that India faces at national, regional, and global levels?

India and the Renewable Energy

According to the latest report (2022–23) of the Ministry of New and Renewable Energy (MNRE), "India now stands committed to achieve about 50 per cent cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030."[67] As per the report, India has installed a total of 167.75 GW of renewable energy capacity by the end of 2022. Additionally, there are 78.75 GW capacity projects in various stages of implementation. Further, 32.60 GW capacity are under various stages of bidding.[68]

According to the latest report of the MNRE, the achievements of the government have been listed under the following heads:

- First, by the end of 2022, under the "Pradhan Mantri Kisan Urja Suraksha Evam Utthaan Mahabhiyan (PM-KUSUM) for decentralized solar", 88.45 MW capacity of solar power plants and 1.81 lakh stand-alone solar pumps have been installed. Moreover, 1,174 pumps have been converted to solar power.

- Second, the "Roof Top Solar (RTS) Programme (Phase-II)" fell short of its target of installing 4 GW of solar capacity in residential areas by the end of 2022; however, it succeeded in installing 1.66 GW of capacity during 2022.

- Third, under the "Grid-Connected Solar Photovoltaic (PV) Power Projects" India had awarded 8.2 GW of projects by the end of 2022. Out of this, 1.5 GW has been commissioned while the rest are still under implementation.

- Fourth, as of the end of 2022, India approved a total of 57 solar parks with a combined capacity of 39.28 GW under the "Development of Solar Parks and Ultra Mega Solar Power Projects". These parks are located in 13 states throughout the country.

- Fifth, under the Production Linked Incentive (PLI) scheme, the "National Programme on High Efficiency Solar PV Modules" aims to achieve manufacturing capacity of Giga Watt (GW) scale in High Efficiency Solar PV modules.

- Sixth, on implementing the "Green Energy Corridor" by the end of 2022 8,759 circuit kilometres (ckm) of intra-state transmission lines were constructed and 19,868 MVA intrastate substations charged. According to the report, seven states (Gujarat, Himachal Pradesh, Karnataka, Kerala, Rajasthan, Tamil Nadu and Uttar Pradesh) were in the process of issuing tenders to implement projects for evacuation of 20 GW renewable capacity.

- Seventh, under the "Human Resource Development Programme", the government had trained 4,363 Suryamitras during 2021–2022. By the end of 2022, the total of trained Suryamitras were more than 51,000.

- Eighth, under the "Renewable Energy Research and Technology Development (RE-RTD) Programme" India continued with 17 R&D projects. The emphasis of these projects were on cost reduction, reliability, and efficiency improvement of renewable energy systems and components.

- Ninth, on achieving "Wind Energy" the MNRE had recommended concessional custom duty benefit (CCDC) for several wind turbine components. Based on the above recommendation, the ministry of finance had extended the date until March 2025.

- Tenth, on "Bioenergy" the cumulative installed capacity of biomass power and cogeneration projects by the end of December 2022 was 10.2 GW.[69]

Besides the above, the government of India has decided to pursue the following new initiatives on rooftop solar, green hydrogen, energy storage etc.:

The MNRE in 2022 had launched the "National Portal for Rooftop Solar." The portal — solarrooftop.gov.in aims to enable residential consumers from any part of India to apply for rooftop solar. As on June 2023, more than 195,000 have registered under the portal.[70]

On "Green Hydrogen" the government in 2023 had approved the "National Green Hydrogen Mission". The objective of the mission is to develop by 2023 "at least five million metric tons of green hydrogen production capacity per annum with an associated renewable energy capacity addition of about 125 GW."[71]

With a special focus on women as stakeholders in renewable energy, the MNRE has issued "Women in RE: Call for Action". According to the MNRE, the "initiative acknowledges the role of women stakeholders in RE sector and thrives to drive attitudinal change by recognizing their contribution across the RE value chain. An Inter-Ministerial multi-stakeholder Committee to promote Women-centric policies, programs, and intervention in RE sector has been constituted for convergence across women-centric schemes. This will ensure engagement of self-help groups, producer groups and use of other community models for implementation of DRE schemes, capacity building and skill upgradation of women in RE."[72] According to the Secretary MNRE, "We see women as enablers of change, so the transition from non-conventional energy technologies to Decentralised Renewable Applications may start right from their households, their kitchen, their agricultural lands, their businesses and improving the quality of their lives."[73]

As a part of establishing 24×7 solar-powered village, India established its first one in Gujarat in 2022.[74] In October 2022, when the UN Secretary-General António Guterres visited India, he took time in his two-day tour to visit the first solar powered village — Modhera. The UN News covered the above and interviewed a local resident saying: "Earlier, when solar was not there, I had to pay huge amount for the electricity bill — close to 2,000 rupees. However, with the installation of the solar, my electricity bill is now zero. Everything from the refrigerator to washing machine now runs on solar in my house. I am not paying even one rupee electricity bill now."[75]

In 2022, the government launched the "National Bioenergy Programme". According to a study supported by the MNRE, "the current availability of biomass in India is estimated at about 750 million metric tonnes per year".[76] According to the report titled "Evaluation Study for the Assessment of Biomass Power and Bagasse Power Potential in India", the MNRE found the following: "India bestowed with favourable climatic conditions for agriculture; immense biomass is produced from agriculture. About 32 per cent of the total primary energy used in the country is still derived from biomass, and more than 70 per cent of the country's population depends upon it for its energy needs".[77]

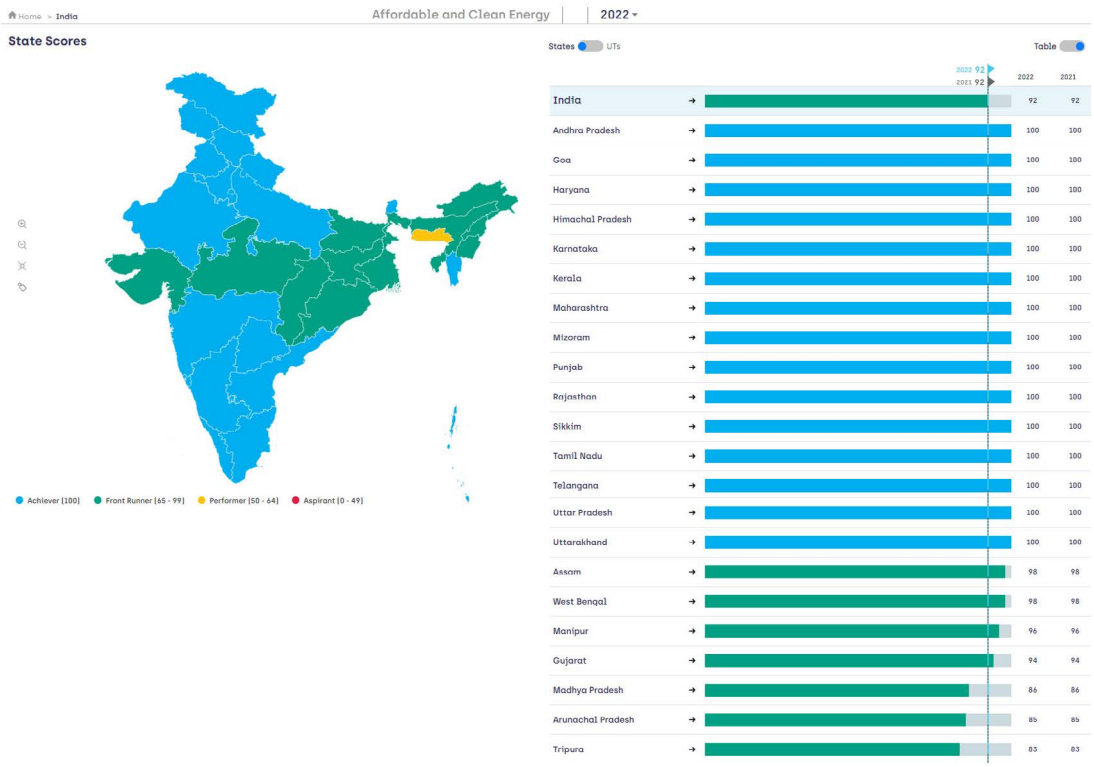
In 2022, the government reissued a draft policy for repowering of the wind power projects.[78] According to the draft policy, "the Ministry of New and Renewable Energy had issued 'Draft Policy for Repowering of the Wind Power Projects' on 5th August 2016 in order to create a facilitative framework for repowering. However, the majority of old Wind power projects with sub MW scale Wind turbines are yet to be repowered. Therefore, a revised policy has been drafted taking into account representations received from various stakeholders and subsequent deliberations."[79]

In 2022, the Ministry of New and Renewable Energy also issued a "Strategy Paper for Establishment of Offshore Wind Energy Projects". According to the strategy paper, "The policy provides for offshore wind power development up to a seaward distance of 200 nautical miles from the baseline, i.e., up to the country's Exclusive Economic Zone (EEZ)."[80]

Figure 3.1: Performace of States/UTs on SDG7

Source: NITI Aayog (2019)[81]

Figure 3.2: India's Performance on SDG 7 (Statewise)



Source: NITI Aayog (2022)[82]

India and the SDG 7

In India, the NITI Aayog published a SDG India Index, covering the performance and achievements on individual SDGs, at the national level.[83]

NITI Aayog in India acts as the nodal institution in coordinating the efforts at the national and state levels within. According to the NITI Aayog, "State and local governments also play a pivotal role in implementing development programmes by almost spending seventy per cent more than the central governments. State governments are, therefore, essential stakeholders if the SDGs are to be realised in India, as well as globally."[84] It has published reports periodically on India's performance in addressing the SDGs; the publications include a SDI Index at the national level, analysed through the States and Union Territories. According to the NITI Aayog, "the SDG Index is a powerful tool which offers excellent possibilities for the States/ UTs to identify priority areas which demand action, facilitate peer learning, highlight data gaps, and promote healthy competition."

An important aspect of NITI Aayog's approach towards the SDGs is the localization. According to the NITI Aayog, "The Indian model of SDG localisation is structured around four inter-related pillars operating sequentially and simultaneously at the national level, anchored by NITI Aayog in the centre and by respective state and UT governments at the sub-national level. The four foundational pillars in this model are:

Pillar 1: Creating institutional ownership.

Pillar 2: Establishing a robust review and monitoring system.

Pillar 3: Developing capacities for integrating SDGs in planning and monitoring.

Pillar 4: Promoting a "whole-of-society" approach."[85]

According to NITI Aayog, the Indian approach towards SDG 7 (Affordable and Clean Energy) is based on "equitable and universal access to affordable, reliable and clean energy" as a prerequisite for socio-economic development in India. For the government, the SDG 7 "has three key components: universal access to electricity and clean cooking fuel, increasing share of renewable energy in the country's energy mix and improving energy efficiency, endorsed in the National Energy Policy."[86]

What are the Challenges for India in Achieving the SDG7?

According to the above report, there are four major challenges: achieving low-carbon energy security; capacity constraints in terms of addressing the demands from the industrial, residential and infrastructural sectors; achieving grid parity; and regional inequalities, in terms of differences between different states and regions within the country.

India and Renewable Energy: National, Regional and Global Challenges

A report in 2020 by the World Economic Forum said: "As the world comes to terms with the enormity of the threat posed by climate change, India's emergence as home to one of the world's largest clean-energy expansion programmes is like a whiff of fresh air. On the back of a highly conducive policy environment, a steady influx of capital, falling prices and new technologies, India has seen an exponential growth in its renewable energy (RE) sector in the past five years."[87] Another report by the Institute for Energy Economics and Financial Analysis in October 2022, said: "India has been one of the champions globally in adopting renewable energy as part of its energy transition. Installed renewable energy capacity (including large hydro) rose from a few megawatts (MW) in 2010 to around 163 Giga watts (GW) as of August 2022. India's ambitious renewable energy targets and the associated policy and reform framework have been an important tailwind for the sector's development. Additionally, the transition has also resulted in shunning coal power capacity, with additions hitting rock bottom in FY2021/22. More than 606 GW of coal-fired power projects have been cancelled or shelved, and 15.6 GW retired in India during the 2010–2022 period."[88]

A report by the Asian Development Bank, acknowledging India's efforts towards energy transition also commented on its challenges. According to the report: "Attempting clean energy transition at the scale that India requires faces many challenges. These include access to affordable financing, lack of institutions that can deploy financing effectively in new low-carbon growth areas, and technology risks. Another key consideration, which has far-reaching impact, is ensuring a just transition."[89] So, the challenge is not just energy transition; but is also a just transition. The Just Transition Declaration agreed upon at the UN Climate Change Conference in Scotland (COP26) states "the transition towards net zero will affect, most acutely, those in workforces in sectors, cities and regions relying on carbon-intensive industries and production. [...] This should also display: a commitment to gender equality, racial equality and social cohesion; protection of the rights of Indigenous Peoples; disability inclusion; intergenerational equity and young people; the promotion of women and girls; marginalised persons' leadership and involvement in decision-making; and recognition of the value of their knowledge and leadership; and support for the collective climate action of diverse social groups. Social dialogue as well as rights at work are indispensable building blocks of sustainable development and must be at the centre of policies for strong, sustainable, and inclusive growth and development."[90] According to an ILO report, the declaration, "recognizes the need to ensure that no one is left behind in the transition to net zero economies — particularly those working in sectors, cities and regions reliant on carbon-intensive industries and production."[91]

What are the Challenges?

The first major challenge at the national level is meeting the targets. In the Glasgow Summit in 2021, Prime Minister Modi made an ambitious five-point target.[92] Referred to as "five nectar elements, Panchamrit," he presented the following targets:

i) India will reach its non-fossil energy capacity to 500 GW by 2030.

ii) India will meet 50 per cent of its energy requirements from renewable energy by 2030.

iii) India will reduce the total projected carbon emissions by one billion tonnes from now onwards till 2030.

iv) By 2030, India will reduce the carbon intensity of its economy by less than 45 per cent.

v) By the year 2070, India will achieve the target of Net Zero.

These panchamrits will be an unprecedented contribution of India to climate action.

It is an ambitious target; but achieving the same would not be easy. For example, by 2030 India wants to achieve 500 GW. Within the renewable basket, it had kept a 100 GW target through solar by the end of 2022, but could achieve only 63 GW. The challenges to meet the 2030 targets are comprehensive.[93]

The second challenge at the national level is financing. To achieve the national targets, India will have to invest heavily in the renewable energy sector, move away from fossil fuels, and invest in smart grids.

The third challenge is technology. There has been an adequate focus on the need for India to work on improving its technology in achieving its targets across the renewable energy spectrum — solar, wind, green hydrogen etc.

At the regional level, for India, there is a great potential to work with Nepal and Bhutan. According to an IEEFA report, Bhutan in 2022 had an installed power capacity of 2,335 MW, of which hydropower's share was around 99 per cent.[94] According to the same report, the installed generation capacity of Nepal in 2022 was more than 2,100 MW, and the country relies for more than 96 per cent of installed capacity on hydropower. The above data clearly provides an opportunity for India to work at a regional level. Along with Bangladesh, India is trying to forge a regional partnership of the four countries. Referred to as the BBIN, there has been extra push during the recent years to forge cooperation at various levels. According to the above report, the potential to cooperate on energy is high.[95] Referring to India's green energy corridor, it suggests: "India could use the Green Energy Corridor to increase hydropower imports from Nepal and Bhutan to attain the renewable energy target of 2030."[96]

Despite the opportunities, India has not been able to achieve much at the regional level in exploiting energy resources, especially hydropower. The primary challenge for India is the bilateral equations, especially with Nepal and Bangladesh, and the highly politicised environment that prevents any substantial movement in achieving the potential.

Prof. D. Suba Chandran is Professor & Dean at School of Conflict and Security Studies at the National Institute of Advanced Studies (NIAS) in Bangalore.


4
Maldives

Maldives

Author: Dr. Rasheeda M. Didi

The Maldives, a country that has access to universal electricity since 2008, relies heavily on imported diesel and isolated island-based grids which have driven up the prices. Even with government subsidies, electricity tariffs in the Maldives are the highest in South Asia.[97] Because of the insignificant size of the landmass, from an economic and practical point of view, the use of solar powers or wind energy is not viable as the Maldives consist of small islands. Therefore, the trend now is to use solar energy on the ocean.

Figure 4.1: Maldives Opens World's First Fully Solar Powered Resort

Source: Maldives Insider (2014)[101]

The country's dependency on fossil fuel imports makes its economy particularly vulnerable to external shocks such as pandemics, natural disasters, overseas wars, and political conflicts, among others. A perfect example of this is the Coronavirus pandemic which caused the country's GDP to contract by at least thirteen per cent. This is 18.5 percentage points lower than the pre-COVID-19 baseline. Another such example is the high prices of crude oil caused by inflation and the Ukraine war, which "pushed the country's import bill to approximately 500 million US dollars in 2022, 80 per cent of which is due to diesel imports. This is equivalent to one-fifth of all imports and 10 percent of GDP."[98]

In the absence of rivers, lakes, and other types of large inland bodies of water, the Maldives depends heavily on imported fossil fuel for which it pays extremely high prices. Because of lack of rivers or flowing water, hydroelectricity is out of the question. Therefore, the Maldives needs renewable energy urgently. But the drawback is the limited land mass.

Hence, for renewable energy, rooftop space for solar installations often cannot meet the energy demands of an island. As the leading renewable energy company, SwimSol stated that the land is too scarce for ground-mounted solar panel installations. Therefore, offshore floating solar platforms are considered to be the most reliable as they allow almost limitless renewable energy expansion.[99]

To mitigate the energy challenges, the government's signing of the five-megawatt solar power purchase agreement (PPA) has not only national but international significance as well in that the action has been recognized as a showcase for sustainability in a post-COVID world, through renewable energy across Small Island Developing States (SIDS), a group to which Maldives belongs. Emphasising this significance, the World Bank stated that the "Maldives: the land of sun, sea and sand, will become a #SIDS nation that is leading the way in showcasing".[100] This has been very encouraging for the Maldives.

The Status of Renewable Energy

At the UN Climate Ambition Summit, in December 2020, the President of Maldives, Ibrahim Mohamed Solih, assured the forum that the Maldives is on track to reducing carbon emission by a quarter by 2030,[102] and, more importantly, that Maldives aim to reach net-zero or carbon-neutrality by 2030 as well.[103]

Aiming to achieve this goal, the government has accepted two World Bank-funded sustainable energy projects. One is the Accelerating Sustainable Private Investment in Renewable Energy (ASPIRE), and the other is the Accelerating Renewable Energy Infiltration and Sustainable Energy (ARISE). Through these two projects, the Maldives is expected to install more than 50 MW of solar capacity and 40 megawatts hours (mWh) of battery storage. This would allow for annual diesel consumption savings of approximately up to 30 million litres, reducing the country's import expenses by approximately 30 million US dollars annually and 750 million US dollars over the total project lifetime of 25 years.[104]

The preparatory work for the 5-mw solar project under the ASPIRE scheme began in 2014 and was inaugurated on 7 December 2022. This is a significant step towards achieving the sustainable development goals of the country. This project has a lot of interest from international investors and is helping to "establish Maldives as an investment destination for sustainable projects".[105] This is demonstrated by the increased number of foreign investors' bids.

For example, in 2014, the first 1.5 MW solar project under ASPIRE had only four investors' bids and resulted in a high power purchase price of 21 US cents per unit of electricity. A second project (5 MW) in 2020 saw an increase in investor bids to 25 and resulted in an already lower power purchase price of 10.5 US cents. Later, in 2022, the number of investors for the third (11 MW) solar project in the remote islands increased to 63. For this, a record low price of 9.8 US cents was received.[106]

Undoubtedly, it is envisioned that these projects will decrease the country's reliance on fossil fuels and the financial burden on the government immensely. The reason is that for the ARISE project alone, the 12.4 million US dollars provided by the World Bank would have leveraged over 140 million US dollars in financing.[107] The project includes guarantees from other stakeholders such as the Multilateral Investment Guarantee Agency (MIGA) and co-financing from Climate Investment Fund (CIF), the Asian Infrastructure Investment Bank (AIIB), Energy Sector Management Assistance Program (ESMAP), Sustainable risk Mitigation Initiative (SRMI) and the private sector.[108]

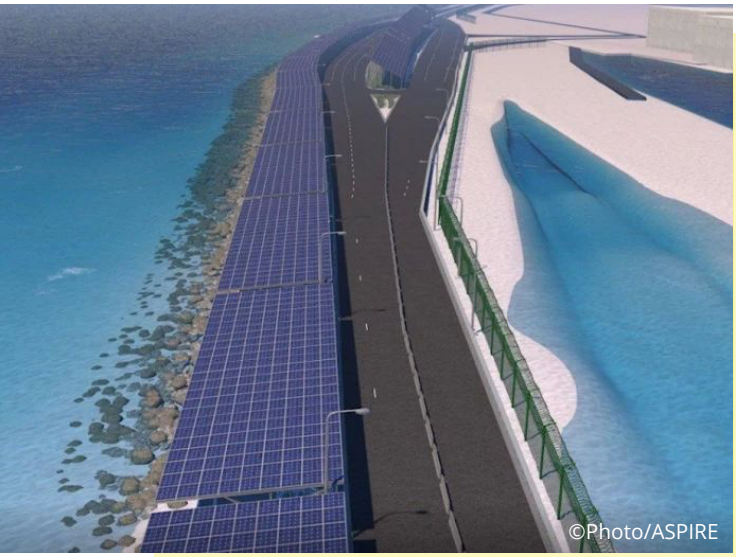
Maldives has an advantage since some international donors such as the World Bank consider it to be a safe country to invest in projects because of its reputation for resilience. For example, Faris Hadad-Zervos, the World Bank Country Director for Maldives, stated that "the Maldives story has always been one of resilience. Time and again, we have seen the Maldives face against its climate vulnerabilities and external shocks, only to re-emerge stronger. With COVID-19, it has been even more critical for the Maldives to attain energy independence".[109]

The Government's Efforts

The Ministry of Environment, Climate Change and Technology (MoECCT) is the main government entity under whose portfolio renewable energy falls. Within its authorized portfolio, currently, the Ministry implements three different renewable energy programs which include the Outer Islands for Sustainable Development (POISED) program, the Hakathari Program and the Hulhulé-Hulhumalé solar power project.

Out of these, the largest is the Hulhulé-Hulhumalé Link Road project which was launched in November 2020. This is a World Bank-funded, five-megawatt solar project that was envisioned to drive the country move closer towards its renewable energy targets. This falls under the umbrella of the Accelerating Sustainable Private Investments in

Figure 4.2: Hulhulé-Hulhumalé Solar Panels



Source: Mohamed (2022)[110]

Figure 4.3: POISED project

Source: Climatae Investment Funds (2020)[111]

Renewable Energy (ASPIRE) project, with the power purchase agreement (PPA) signed with Thailand-based company Ensys Co. Ltd.[112] With this project, solar grids would be deployed across the Hulhulé-Hulhumalé Link Road, which connects the airport island of Hulhulé and the suburb of Hulhumalé to the capital island of Malé through the Sino-Maldives Friendship Bridge.

The signing of this agreement for the 5-megawatts is a significant milestone regarding the price of energy for a solar power project. A similar project in 2017 received bids for 21 US cents a kilowatt hour (without battery), while under this project the cost of a kilowatt hour is down to 10.9 US cents which is one of the lowest prices for an island nation. According to World Bank, "even with the most efficient technology for diesel, power costs nearly 23 US cents and could go up to 33 US cents".[113]

This project is the largest initiative in the Maldives under the second phase of ASPIRE and is expected to decrease the reliance on fuel significantly and allow the government to save 1.3 million US dollars and generate 7.3 million units of electricity each year.[114]

The POISED project, with Asian Development Bank (ADB), entitled Preparing Outer Islands for Sustainable Energy Development, was launched on 2 August 2016. With funds of 115 million US dollars, completion had been targeted for June 2020 but has been delayed due to the COVID-19 pandemic. In this project the government works with ADB to transform the existing energy grids on the islands into a hybrid renewable energy system. This project is also installing energy management and control systems; energy storage; and improvements in distribution networks to significantly reduce the need for diesel to generate electricity.[115] This is important because it targets the outer islands most of which had been operating with private island-based grids until 2010 or so. Under this program, the government implemented a 43-mWh Battery Energy Storage Project in 20 outer islands for hybridization of DieselSolar-PV storage mini grids. Later, on 13 December 2022, the government invited interested parties to participate.

Apart from the various projects implemented by the Ministry of Environment, the State Electric Company (STELCO), the country's sole energy provider, offers two types of renewable energy — solar and wind. To achieve "very ambitious short-term goals"[116], in

2020 the company launched a new solar centre to provide photovoltaic solutions across the country, while deploying solar generation in its network. To ensure conformity with the government's planned renewable energy targets, STELCO has initiated and completed the installation of 66.96 kWp of solar panels on Gaafaru Island's (Kaafu Atoll) powerhouse rooftops. The plan is to install rooftop solar on all the powerhouses that are operated and managed by STELCO. Additionally, earlier in February 2022, it had installed 33.48 kWp solar on Maafushi Island's (Kaafu Atoll) powerhouse rooftop.[117]

This is very important as Maafushi Island is one the most popular destinations for budget tourists who want to stay in an inhabited (by Maldivians) island and experience the culture. As opposed to the resorts, in an inhabited island the beneficiaries are the rural indigenous inhabitants of the island and ordinary Maldivians who are the owners of the guesthouse operations.

In December 2020, STELCO introduced its "Green Life Solar Pod," considered to be capable of producing renewable energy through world-class solar panels. This was crafted after analysing the world's best over-water solar panel systems for both rivers and oceans. According to the Managing Director of STELCO, the Green Life Solar Pod energy initiative was part of the company's efforts to promote clean energy alternatives, and that it was especially suited to the environment of the Maldives. The project experimented at Vaavu Atoll was a critical experience in creating these pods as effective systems with 25-year warranty.[118]

Furthermore, STELCO has launched a highly unique rooftop project named Avikatha, in which the company will be renting the roof of houses to install solar panels to allow households to generate revenue. Those who are renting buildings but are interested in installing the solar panels under this scheme, must have permission from the homeowner. Additionally, the building needs to have a rooftop that spans 100 square feet and is exposed to sunlight, with the capacity to sustain 150 kg in weight.[119]

To deal with renewable energy, the Maldives has attracted much enthusiasm from investors with more than 60 international bidders expressing interest to invest when the government opened the invitation for qualification for solar PV systems in selected islands in 2020.

Local Companies Practicing Renewable Energy

The leading private companies that deal with renewable energy are SwimSol, Renewable Energy – Maldives, Avi Tech, the State Electricity Company (STELCO), and EcoGreen. Out of these, most projects have been implemented by SwimSol, which started its work in 2014. According to the company, in cooperation with Vienna University of Technology and the Fraunhofer Institute in Germany, it launched the world's first floating solar power plant for the sea after more than four years of research.[120]

Today, SwimSol, a global leader in offshore (marine) photovoltaic, is the leading solar energy company in the Maldives. It is also an expert in island micro-grids and heavy-duty tropical solar PV systems.[121] It has implemented a project in SolarSea and RoofSolar with a capacity of 678 kWp in the LUX Resort in South Ari Atoll. The type used in this project is offshore floating PV Solar Sea (191 kWp) and Roof Solar (487 kWp) combined.[122]

Because of the limited land space for solar panels, the solar PV system at LUX Resort utilizes all the available roof space and is expanded to the sea with floating offshore Solar Sea platforms to reach the needed solar power production capacity. This is a highly innovative project for the Maldives. The system works in hybrid mode with the diesel powerhouse of the island and reduces the diesel consumption of combustion generators.

The other leading local company is Renewable Energy - Maldives (REM), a company founded in 2007 with the aspiration to reduce Maldives' over-reliance on fossil fuel for its energy needs. Accordingly, REM introduced innovative solutions to reduce fossil fuel in the country and, up to date, has installed more than four MW solar systems consisting of 3,964 kilowatts in 43 islands, covering 11 of the 26 atolls in the Maldives.[123]

These include the installation of a solar-powered electrical vehicle charging station at Vadhoo Tourist Resort. In collaboration with Norsk Solar, designing and installation of a floating and roof top solar system is underway in Un'goofaaru Island, in Raa Atoll. In the future, REM hopes to introduce wind, solar and wave energy to the Maldives. REM explains the reason for this hope by stating that they carry "products to harness wind and solar power and can be used to generate in environments unthinkable before", such as from high-rise buildings to commercial rooftops to retail buildings and wind farms. This will be a cost-effective way for people "to harness the power of clean and renewable resources".[124]

Though not as well-known as the above-mentioned two, Avi Tech Pvt. Ltd. founded in 2015, is another company that attempts to solve the fuel problem because it feels that it is "imperative to meet the nation's energy demand via clean, renewable, and sustainable sources such as solar energy."[125]

While it specializes in solar energy, it seeks future solutions for Maldives' fossil-reliance with other types of renewable energy by means of electrical engineering-related services. Its main specialties are solar PV systems, sub-station automation, uninterpretable power supply systems (UPS) and other renewable energy-related services.[126]

So far, it has installed solar panels at Emir of Qatar School in Gan Island, Laamu Atoll. This project was funded by UNDP and the Maldivian Red Crescent.[127] The purpose of the project was to reduce carbon emissions and use environment-friendly energy to meet the electrical needs of the school.

Another venue is the Addu High School in Addu City where, at the request of the school in 2015, Avi Tech installed solar panels. The project was funded using a grant won by the school for Zayed Future Energy Awards. Avi Tech was awarded the bid for installation after evaluation of bids submitted to the school.[128]

A fourth company practicing renewable energy is Eco Green whose commercial Solar Project, at Javahiru Maage, is a 30 kWp solar project commissioned in 2015. This solar system was installed in a house and the system is fully functional, generating and exporting energy.[129]

Eco Green Maldives also has a vessel solar project termed 'Dhoani Solar Project', named after the small boats, that travel within the country. The first one of these projects was installed at Haisham Dhoani, which has been functioning without any problems since early 2019. The system powers the lighting and small needs of the vessel. The company expects to expand this system.

Using larger batteries is a new innovation for this company. It was using 150-watt panels before, now it is using 400-watt panels with which the duration of usage is longer. This is particularly beneficial for the yellow-fin tuna fishing boats which spend more time at sea because their fishing trips require travelling longer distances which means having to spend some days on the sea, unlike the skip jack tuna-fishing boats which spend only a day or a few hours per day on the sea, depending on the catch.

At the earlier stages, Eco Green used solar battery for very basic purposes like phone charging for a crew of three to four working on a fishing boat. But now it has advanced and started using a 300-watt wind turbine in Haisham boat. However, currently this is not in use as the system is rusty because of sea salt.[130]

Conclusion

Maldives relies heavily on imported diesel and isolated island-based grids which have driven up prices. Even with government subsidies, electricity tariffs are the highest in South Asia. To mitigate these challenges, the World Bank recommends facilitating more private sector investments in renewable energy, especially in solar photovoltaic technology. Therefore, investing in renewables can help the country lower its cost of electricity, fuel imports and subsidy expenditure. It is crucial for achieving the government's goal of raising the share of renewable energy by 20 per cent by 2023 and increase it up to 70 per cent by 2030.[131]

The government started some solar energy programs with international financial institutions such as the World Bank and the Asian Development Bank, among others. There is enthusiasm on the part of the government to progress using renewable energy and investors believe Maldives to be an appropriate place for them to invest. But the challenge will be to entice the public towards accepting solar energy.

According to Ali Sajid, Eco Green's Director, the biggest challenge both in the urban and in the rural areas is peoples' mistrust and unwillingness to do something different. In this case it is experimenting with renewable energy which is an unknown entity. The people hesitate to invest in something that is new and perceived as strange as they are unsure of the results.

Dr. Rasheeda M. Didi is an independent lecturer/researcher.


5
Nepal

Nepal

Author: Kosh Raj Koirala

Despite being endowed with abundant sources of renewable energy, Nepal continues to heavily rely on traditional fuels to fulfil its domestic energy needs. Although there has been a decrease in the use of traditional fuels from 85 per cent to 69 per cent [132] in less than a decade, the dominance of biomass and fossil fuels remains prevalent. Consequently, Nepal has a low electricity consumption rate of merely 177 kWh per annum in 2018, in stark contrast to the global average of 3132.15 kWh.[133] According to a 2019 report from the National Statistics Office, Nepali citizens have nearly doubled their consumption of gasoline over the five-year period from 2014 to 2019, leading to an alarming 90 per cent surge in fuel consumption. The country's petroleum demand has been growing at a rate of ten per cent per year due to the significant increase in the number of vehicles, contributing to an expanding trade deficit and detrimental environmental repercussions.[134]

The evolving landscape of technology, progressive government policies promoting the adoption of renewable energy sources, and increased availability of financing in recent years have brought about a promising outlook for the global transition towards renewable energy. However, Nepal's progress in this Himalayan nation has not kept pace with the global level, despite setting an ambitious target of achieving negative carbon emission by 2050 whilst reaching net-zero before or by 2045.[135] Over the past three decades, Nepal has experienced a substantial increase in overall energy demand, reaching approximately 145 per cent. Yet, the country's industrialization and development goals have not been fully realized. As a result, biomass still constituted around 85 per cent of Nepal's energy consumption in 2020, primarily utilized by the residential sector, which accounts for about 83 per cent of the total energy consumption. Additionally, the transportation sector accounts for seven per cent of the total consumption, while industries consume approximately five per cent of the total energy. Furthermore, studies indicate that hydroelectric power contributes only around four per cent of Nepal's energy consumption to date.[136]

Nepal significantly trails behind developed countries in terms of per capita electricity consumption compared to its developed counterparts. As of mid-April 2022, Nepal's per capita electricity consumption was a mere 325 kWh, although the government has set an ambitious target to increase it to 700 units by 2024.[137] Nevertheless, there has been a noticeable shift towards the utilization of electricity for daily household activities.[138] The rising adoption of electric ovens for cooking has led to a substantial reduction in the import of liquefied petroleum gas (LPG) in Nepal. Import data from the state-owned fuel monopoly, Nepal Oil Corporation (NOC), reveals a decrease of 19.2 million kg (equivalent to 1,352,112 cylinders) in LPG imports during the first eight months of the fiscal year 2022/23 compared to the previous year's total consumption. This transition has resulted in cost savings of 1.91 billion Indian Rupee from LPG imports during the specified period under review. It is anticipated that the increasing use of electric stoves in Nepal's urban areas will gradually replace the significant quantities of LPG currently consumed.[139]

Policy and Institutional Arrangements to Promote Renewable Energy

Nepal has made significant strides in implementing a diverse range of policies and institutional arrangements to foster the growth and development of the country's renewable energy sector. In 2013, Nepal introduced the National Energy Strategy,[140] which takes a comprehensive and long-term approach, aiming to enhance energy supplies while promoting cleaner and more efficient energy utilization. The strategy also emphasizes the integration of clean energy with environmental and economic considerations. Its overarching objective is to achieve five specific national goals: increasing the availability of renewable energy sources, enhancing energy security, promoting energy efficiency, reducing dependency on imported fuels, ensuring secure and affordable energy for all consumers, and safeguarding the environment. A key focus of the strategy is improving the living conditions of rural populations by providing them with affordable and environmentally-friendly energy solutions, while addressing social justice concerns. The policy principles encompass crucial aspects that prioritize rural electrification and alternative energy for accelerated progress.

Additionally, the strategy proposes allocating revenue generated from hydropower royalties and taxes on fossil fuels to support rural electrification and alternative energy initiatives. Furthermore, there is a concerted effort to strengthen the existing policy framework on rural energy, taking a sector-wide approach with the active involvement of diverse stakeholders. Ministries and institutions associated with rural development play an integral role in advocating for the adoption of clean, reliable, and appropriate energy sources. These measures aim to alleviate rural poverty and safeguard the environment, reflecting a comprehensive approach to sustainable development in Nepal's energy sector.

Nepal's commitment to the development of renewable energy is evident through initiatives such as the Energy and Water Resources Decade (2018–2028) and the effective implementation of the Roadmap for Energy Development. These efforts have led to significant progress in power generation, positioning Nepal to explore opportunities for exporting surplus energy to neighbouring countries, including India and Bangladesh. By mid-April 2023, Nepal had achieved an impressive total installed hydropower capacity of approximately 2700 MW. The roadmap places a strong emphasis on electricity generation and utilization, with the goal of stimulating production, consumption, and national income through energy sales. Notably, around 95 per cent of Nepal's population already has direct access to electricity. Building on this achievement, the government has set an ambitious target of achieving universal energy access, covering 100 per cent of the population, by the fiscal year 2022/23.

In terms of institutional arrangements, the government established the Alternative Energy Promotion Centre (AEPC) in 1996, initially under the Ministry of Science and Technology. It currently operates under the Ministry of Energy, Water Resources, and Irrigation. The AEPC's core mandate is to mainstream renewable energy as a vital resource in Nepal. It envisions achieving these goals by enhancing access, knowledge, and adaptability, ultimately contributing to the improved living conditions of the population. The AEPC has been working to promote alternative energy sources beyond hydropower to serve communities that are not connected to the national electricity grid. Over the years, the AEPC has made notable contributions in the renewable energy sector. It has successfully installed nearly a million solar home systems, developed micro and small hydropower projects with a combined capacity of 37.7 MW, and established 439,547 domestic biogas systems, along with a few solar mid-grid systems. These initiatives have significantly expanded access to clean and sustainable energy sources in Nepal, benefiting a wide range of communities.[141]

Current Status of Renewable Energy Generation

i) Hydropower

With its extensive network of over 6,000 rivers and rivulets, Nepal has the potential to become an example of energy security in South Asia. The untapped hydropower resources in the country hold great promise for future energy supply, offering an affordable and renewable source of electricity with minimal environmental impact. Leveraging this potential can have a profound impact on reducing the carbon footprints of neighbouring giants, including India and Bangladesh — the two most populous countries in the region. According to the latest statistics released by the Nepal Electricity Authority (NEA), Nepal currently has an installed plant capacity of approximately 2,577.48 MW for electricity productions. Out of this total capacity, 2,492.95 MW is connected to the national grid, while the remaining 84.53 MW is dedicated to off-grid supply.

In fact, Nepal has been making significant progress in terms of power generation from hydropower. The country added over 500 MW electricity from mid-April 2022 to mid-April, 2023 alone.[142] This substantial increase has enabled Nepal to achieve self-sufficiency in electricity production, generating 11,064 GWh in 2022 — a three-fold surge from 4,258 GWh in 2013. Of the total installed capacity of around 2,600 MW, NEA-operated companies and their subsidiaries are responsible for producing 1,139.44 MW, while the private sector has contributed with power plants possessing a capacity of 1,392.92 MW. Furthermore, small hydropower projects and alternative energy sources have generated 4.53 MW and 80 MW respectively, primarily for off-grid supply. According to NEA records, 32 privately-run power projects supplied a combined total of 552.119 MW of electricity between mid-April 2022 and mid-March 2023, harnessing the power of both hydropower and solar plants. The largest private sector investment project during this period was the 86-MW Solu-Dudhkoshi project. Out of the total supplied amount of 552.119 MW, 28 hydropower plants supplied 523.319 MW to the NEA.[143]

Additionally, at least nine projects are currently in the testing phase, with a collective production capacity of 157.470 MW. This includes three solar plants with a combined capacity of 18.8 MW, and six hydropower plants with a total capacity of 138.67 MW. The country is projected to have an additional 800 MW of electricity production in the current fiscal year, bringing the total production capacity to over 3,000 MW. Notable hydropower projects expected to come into operation by the end of the fiscal year (i.e. mid-July, 2023) include the 111 MW Rasuwagadhi, 57.3 MW Sanjen and Upper Sanjen, 102 MW Madhya Bhotekoshi, and 54 MW Super Dordi.[144]

Moreover, NEA and privately-promoted projects with a combined capacity of 3,300 MW are currently under construction, and an additional 240 projects have conducted feasibility studies to produce 11,716 MW of electricity, eagerly awaiting the execution of power purchase agreements. Additionally, major hydropower projects such as Arun IV (490.2 MW), West Seti (750 MW), Arun III (900 MW), and Lower Arun (769 MW) are either under construction or in the process of starting actual construction works. These projects are expected to begin distribution between 2030 and 2035.

ii) Solar energy

Solar energy is the leading and most sustainable energy resource after water resources in Nepal. The government has set an ambitious target of installing 10,000 MW of solar energy by 2035.[145] As of fiscal year 2021–22, approximately 50 megawatts of solar energy have been connected to the national grid, according to the Ministry of Energy. Solar power projects have become increasingly attractive to investors among various alternative energy sources in Nepal. Initially utilized for household electrification, solar power is now being developed for commercial use as well. The Nepal Electricity Authority (NEA), the state-owned power utility, has recognized the importance of an energy mix for ensuring sustainable energy security, which includes incorporating solar power. The NEA has already launched a 25-MW solar project in Nuwakot, which is currently operating at approximately 50 per cent capacity.[146] Additionally,

four other solar projects are currently generating power with a combined capacity of 20 megawatts. The Kathmandu Upatyaka Khanepani Management Board, the state-owned drinking water supply office, is also operating a solar power plant with a capacity of 0.68 megawatts in the Kathmandu Valley. These initiatives demonstrate Nepal's commitment to integrating solar power into its energy mix.

Furthermore, there are notable solar power projects in operation, such as the Bishnupriya Solar Farm producing one megawatt of power, the Ridi Hydropower solar power project generating 8.5 MW in Rupandehi, and the Mithila Solar PV Power Project generating 10 MW in Dhanusha. The NEA has plans to construct solar power projects with an installed capacity of approximately 6 MW in Pratappur Rural Municipality-7 Suryapura, Nawalparasi (BardaghatSusta West) on the barren land owned by the Gandak Hydropower Project. In 2022, a total of 28.8 MW of power was supplied to the NEA by four solar plants. Similarly, a solar power project with an installed capacity of around 9 MW is being built on the land owned by the Middle Marsyangdi Hydro Project in Lamjung, along with the Jhuprakhola Micro-hydro Project in Surkhet. Additionally, the Duhabi Solar (8 MW), Baki Block Solar-1 (10 MW), and Bhrikuti PV Solar (8 MW) projects are expected to commence production by the end of the current fiscal year. The fact that the Department of Electricity Development has received survey applications for 33 solar projects with a combined capacity of 408 MW shows that Nepal is poised to make significant achievement in harnessing solar energy in the coming years.

iii) Wind Energy

In recent years, wind energy technology has emerged as a cost-effective and proven renewable energy solution. Nepal, recognizing its potential, has embarked on exploring wind energy, with numerous projects in the pipeline. The Solar and Wind Energy Resource Assessment (SWERA) project conducted a comprehensive evaluation of Nepal's wind resource potential, revealing a highly promising outlook for wind energy development. The assessment indicates a capacity of approximately 3,000 MW for wind power generation in Nepal.[147] To kickstart wind energy initiatives, several small wind solar hybrid system pilot projects have been initiated across the country. Additionally, with support from the Asian Development Bank, two wind turbines with a capacity of 5 kW each, along with a 2 kW solar hybrid system, have been successfully installed in Nawalparasi, Dhaubadi Rural Municipality.

The Alternative Energy Promotion Center (AEPC) has played a proactive role in promoting wind energy in Nepal. They have collected detailed wind speed data from ten different locations nationwide, facilitating the development of wind energy projects. According to the Nepal's Energy Sector Synopsis Report-2022,[148] the estimated wind power potential in Nepal is around 3,000 MW. However, the current harnessing capacity remains modest at 113.6 kW, with ongoing construction projects totalling 5 MW. As of 2022, the installed capacity of solar wind hybrid mini-grid systems in Nepal has reached 1,500 kW.

Challenges

While Nepal has made significant progress in harnessing renewable energy, the sector still faces numerous challenges. It is estimated that Nepal has the potential to generate over 83,000 MW of hydropower, with 42,000 MW considered economically feasible. However, the current hydropower generation only contributes to a little over three per cent of the country's total energy generation. Nepal submitted an updated Nationally Determined Contribution (NDC) plan[149] to the UN Framework Convention on Climate Change (UNFCCC) in December 2020, pledging to increase its reliance on clean energy sources and meet its energy demands. The plan aims to generate 5,000 megawatts of electricity from hydropower using Nepal's own financial and technical resources by 2030, with a conditional target of generating 15,000 megawatts, including five to ten per cent from solar, wind, and bioenergy sources.

However, several challenges pose concerns for the reliable supply of hydroelectricity in the future, including the impacts of climate change. Nepal

is vulnerable to natural disasters such as floods, earthquakes, and landslides, which can disrupt energy infrastructure, increase costs, and lead to human and property losses. Additionally, the variability in hydropower generation poses a major challenge, with excess electricity during the wet season and insufficient generation during the dry season, resulting in significant electricity imports from India.

Furthermore, the development of export-oriented hydropower projects requires substantial additional investments of 0.5-1.0 billion US dollars annually, which may strain Nepal's limited capital resources. Prospective investors in the hydropower sector have expressed concerns, but the government is demonstrating a willingness to introduce progressive policies, create a favourable investment climate, and forge international collaborations. These efforts aim to transform the energy landscape and make significant strides toward achieving a sustainable and low-carbon future. Addressing these challenges will be crucial for energy security and the long-term success of its renewable energy sector. By adopting innovative solutions, implementing climate resilience measures, attracting investment, and fostering international partnerships, Nepal can overcome obstacles and unlock its vast renewable energy potential.

Powering South Asian Countries with Renewable Energy

The 2017 Electricity Demand Forecast Report by the Water and Energy Commission Secretariat under the Ministry of Energy, projected that electricity demand would reach 5,800 MW by 2025 and 9,000 MW by 2030.[150] However, the actual demand has not aligned with these projections. Currently, during peak hours on working days, the electricity demand stands at approximately 1,800 MW. This decreases to around 1,100 MW during base hours (daytime) and further drops to 700 MW during off-hours (11 pm–5 am).[151] The disparity between projected and actual demand presents a unique situation for Nepal. With the government's goal of generating 15,000 megawatts of electricity by 2030, there is an opportunity to not only meet the domestic demand but also export surplus electricity to neighbouring countries such as India and Bangladesh. This is expected to contribute to building a sustainable energy future in the region and create economic benefits for Nepal through electricity export.

In fact, Nepal has already made remarkable strides in electricity exports, making a significant earning through the energy trade. Between June and December 2022, Nepal earned 11 billion Indian Rupees through the sale of electricity to India via the Indian Energy Exchange (IEX).[152] This achievement solidifies Nepal's position as the first neighbouring country to participate in the exchange, marking a significant milestone in cross-border electricity trade. Under the IEX, Nepal successfully exported 39 MW of electricity to India. In a positive development, the Indian government has granted permission to export up to 408 MW of electricity generated from eight projects starting in November 2022.[153] This expanded export capacity presents new opportunities to meet the rising electricity demand in India while generating revenue through electricity sales. Nepal's collaboration with India is further strengthened by ongoing discussions to establish a long-term intergovernmental agreement for the sale of surplus power.

Beyond India, Nepal is actively exploring avenues to export electricity to Bangladesh, which has expressed keen interest in procuring power from Nepal. The two countries have already shown interest in forging a strong partnership in the energy sector, with notable developments in electricity trading. Bangladesh has granted approval for the purchase of 50 MW of electricity from Nepal,[154] and discussions are underway for an additional procurement of 500 MW from the Upper Karnali Hydropower Project. This extension is contingent upon the approval of the Indian government, showcasing the collaborative efforts of all involved parties. Recognizing the potential for further collaboration, Bangladesh is also considering investments in Nepal's Sunkoshi-3 (683 MW)[155] and Khimti-Shivalaya (1,547 MW) hydropower projects.[156]

To facilitate seamless electricity trading, Nepal is strategically planning the construction of dedicated transmission lines connecting India. These transmission lines will enhance the efficiency and reliability of power exchanges between Nepal, India and Bangladesh, paving the way for increased energy cooperation in the region. In a significant development, India has proposed the export of 50 MW of electricity from Nepal's hydropower projects to Bangladesh, subject to specific conditions. This proposal underscores the regional collaborative approach to meet the energy needs of Bangladesh while utilizing Nepal's abundant hydropower resources. If all plans proceed as intended, bilateral energy trading between Nepal and Bangladesh is expected to commence during the rainy season of 2023. These developments highlight the country's potential to become a key player in the regional electricity trade.

Conclusion

Nepal has made remarkable strides in transitioning to renewable energy sources, ushering in a new era of sustainability and energy independence. The excessive dependence on fossil fuel including the price and resource volatility that it entails has forced Nepal to reassess traditional sources of energy. Over the years, Nepal has undertaken significant initiatives to tap into abundant renewable resources at its disposal, focusing on hydropower, solar power, and wind energy. The development of numerous hydropower projects, both large and small-scale, has played a pivotal role in meeting the country's growing energy demands while reducing reliance on fossil fuels. Furthermore, the widespread adoption of solar energy has been a game-changer, particularly in rural areas where access to electricity was once limited. Additionally, wind power potential has been harnessed through the establishment of wind farms in suitable locations, contributing further to the country's renewable energy mix. As it is focused heavily on harnessing its renewable energy potential through various proactive measures and eventually transforming itself as a carbon neutral country, Nepal is poised to drive neighbouring countries, mainly India and Bangladesh, in the path of sustainable energy future in the coming years.

Kosh Raj Koirala is a journalist of Republica National Daily in Kathmandu.

6 Pakistan

Pakistan

Author: Prof. Dr. Shaheen Akhtar

Pakistan's power sector has grown over the years, but it is still striving for the affordable, reliable and environmentally sustainable energy. Pakistan's energy problems have aggravated manifold by the Russia-Ukraine conflict and the global supply crisis. The fuel import bill surged to 23 billion US dollars in FY2021-22, a 105 per cent increase from the previous financial year.[157] The country has tremendous potential to generate solar and wind power. The Alternative and Renewable Energy Policy 2019 (ARE 2019) is set to increase the share of renewable energy capacity to 20 per cent by 2025 and 30 per cent by 2030. This study looks at Pakistan's potential and growth in renewable energy, institutional and policy framework, reasons for slow growth and challenges faced by this sector. It also explores the possibility of regional cooperation in renewable energy and makes some practical recommendations to enhance green energy development and cooperation. The research relies on mix method, document analysis and interviews with key informants in the field.

Pakistan's Energy Landscape

Pakistan is producing a very limited percentage of oil to meet the overall demand of the country. This necessitates import of crude oil and other oil products in large quantities to meet significant share of the total demand. Higher oil prices in the global market and massive depreciation of the Pakistani rupee is making oil more expensive, triggering external sector pressure and widening trade deficit of the country.[158] Pakistan's dependence on liquefied natural gas (LNG) has also increased in recent years due to depleting indigenous natural gas deposits. In the FY 2021, around 373 million MMBTU of LNG gas worth around 3.4 billion US dollars was imported.[159] Coal is also used for electricity generation. Thar region in Sindh has the largest coal reserves which have been actively developed in recent years. Currently, the overall electricity generation from coal has reached 5,280 MW. Thar coal is contributing 1,320 MW, while imported coal contribution in electricity generation is 3,960 MW which is around 75 per cent of the total electricity generation from coal in the country. [160] Pakistan is very rich in hydropower with a potential around 60,000 MW. The country is not utilizing full potential due to high investment cost for the installation of hydro plants, development of electricity transmission network and resettlement of the affected population. Currently, the Hydro power installed capacity is 10,251 MW which is around 25 per cent of the total installed capacity.[161] The contribution of nuclear energy is increasing gradually. The gross capacity of nuclear power plants has increased by 39 per cent and stood at 3,530 MW (July-March FY2022).[162]

According to National Electric Power Regulatory Authority's (NEPRA) 2021 report, Pakistan's total installed power generation capacity was 39,772 MW, of which 63 per cent of energy came from thermal (fossil fuels), 25 per cent from hydro, 5.4 per cent from renewable (wind, solar and biomass) and 6.5 per cent from nuclear.[163] The total electricity generation capacity increased to 41,557 MW (July-April 2022). Although fossil fuels continue to dominate the energy mix, there is an increase in the percentage share of renewable energy which is a positive sign for the economy as well as for the environment. The share of wind has increased from 3.31 per cent to 4.8 per cent while the percentage share of solar has increased from 1.07 per cent in July-April FY2021 to 1.4 per cent during July-April FY 2022.[164]

Pakistan has witnessed a 69 per cent increase in generation capacity over the last ten years, which has helped bridge the energy demand-supply shortfall from over 6.6 GW in FY2012 to 0.43 GW in FY2021.[165] The government is looking for both short as well as long-term alternatives solutions to respond effectively to the substantial energy requirements. The revised Renewable Energy (RE) Policy 2019 aims to develop 60 per cent of energy from renewable sources including hydro by 2030 that would substantially reduce Pakistan's dependence on imported fuel products.

Table 6.1: Fuel-wise Installed Capacity Breakup July–April FY2022

	Installed (MW)	Share (%)
Hydel*	10,251	24.7
RLNG**	9,884	23.8
RFO	5,958	14.3
COAL	5,332	12.8
Gas	3,536	8.5
Nuclear***	3,647	8.8
Wind****	1,985	4.8
Solar	600	1.4
Bagasse	364	0.9
Total	**41,557**	**100.0%**

*Karot Hydel Power 2 Units of 360 MW Capacity are running on Commissioning test and are included in Installed Capacity.

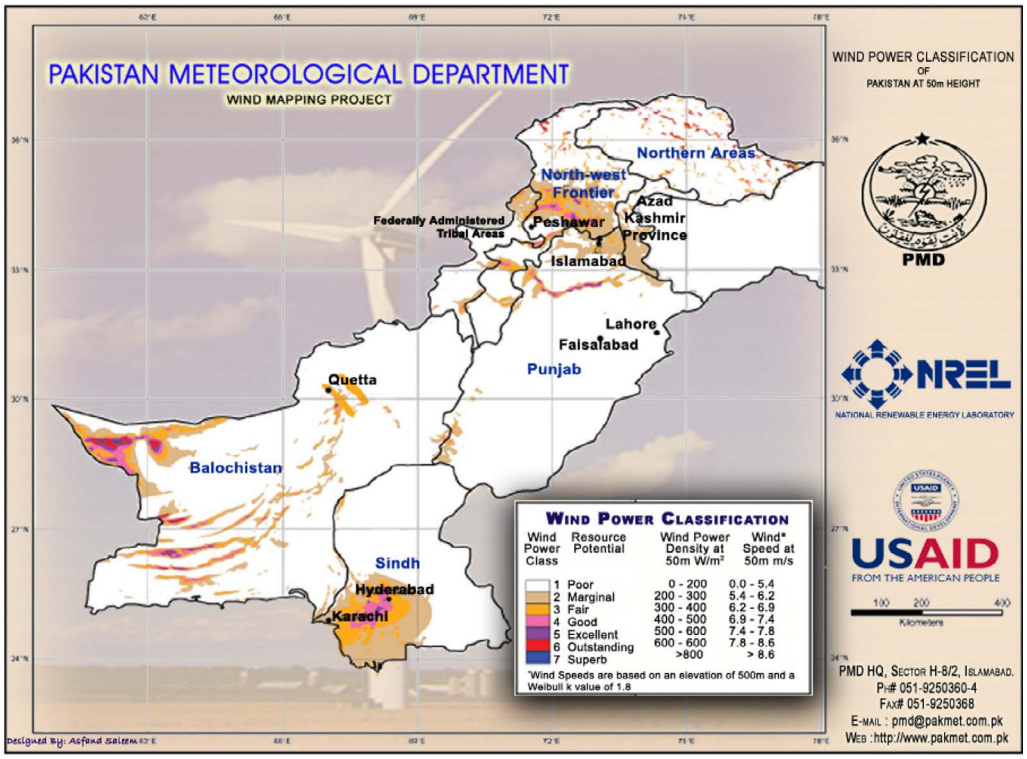
**All KE power plants are operated on Indigenous gas and RLNG as the same is supplied by SSGC on co-mingled basis.

***Supply from KANUPP was discontinued from August 2021

****Two Wind Power Plants 100 MW Capacity are running on Commissioning test and are included in Installed Capacity.

Source: Power Division, Ministry of Energy (n.d.)[166]

Figure 6.1: Wind Map of Pakistan



Source: Aized (2019)[167]

Economics of Renewable Energy

Renewable energy, especially wind and solar, are becoming cheapest forms of new power generation across the globe and its share in global energy mix is projected to rise from 28 per cent by 2030 to 66 per cent by 2050.[168] Fuel prices volatility has encouraged investments in renewables. They have started replacing the conventional fuels for power generation to meet the future demand growth throughout the world. The cheaper and widely accessible renewable energy has the potential to substantially decrease the reliability of power sector on expensive imported fuels. The Indicative Generation Capacity Expansion Plan (IGCEP) 2021-30, observed that the CAPEX has degraded by 3.6 per cent and 1 per cent for solar and wind respectively every year up till 2030 in line with various international projections including Lazard, IRENA, etc. Future prices up till the year 2030, pertaining to REs i.e. Wind, Solar and BESS are given below:

Table 6.2: Climate Risk Index of ASEAN Nations

Year	Solar PV (3.6%) ($/kW)	Wind (1%) ($/kW)	BESS (~6%) ($/kW)
2021	505	908	386
2022	487	899	363
2030	363	830	221

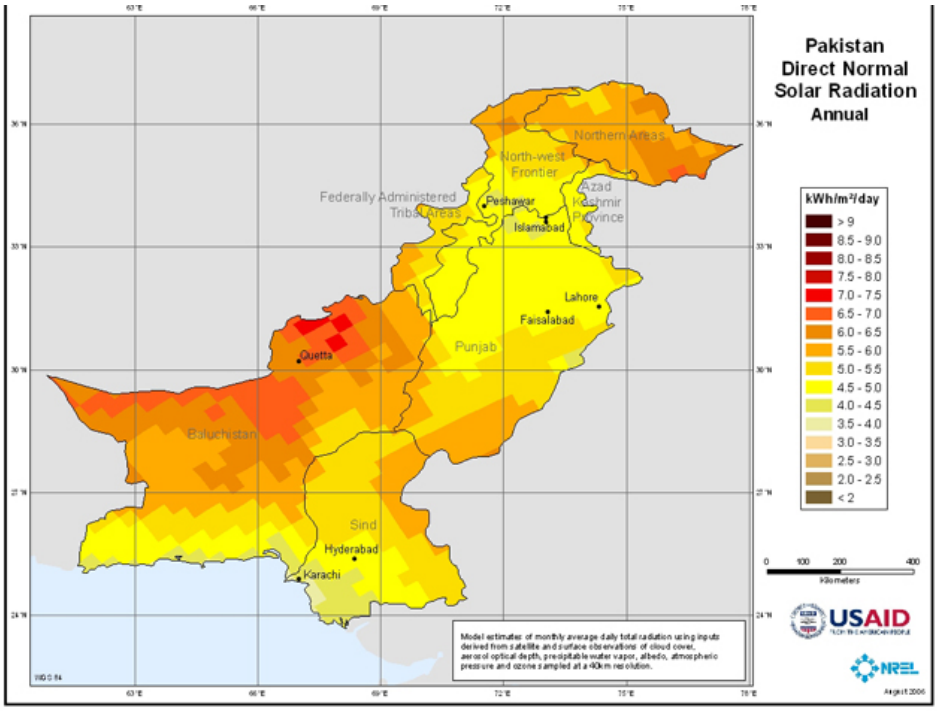
Source: IGCEP (2021–30)[169]

Renewable Energy Potential

Pakistan has huge potential to generate wind and solar power. The wind map developed by National Renewable Energy Laboratory (NREL), USA in collaboration with USAID, has indicated a potential of 346,000 MW in Pakistan. The Gharo-Keti Bandar wind corridor spreading 60 KM along the coastline of Sindh and more than 170 km deep towards the land alone has a potential of approximately 60,000 MW.[170] The wind corridor is the most attractive to investors due to good resource potential, its close proximity to major load centres and the National Grid. With the attractive tariff for wind power generation by NEPRA and incentives by government this sector is expected to grow even further. Several wind power plants have already been commissioned and some are in the pipeline. The contribution of wind in the total installed capacity is 4.8 per cent and currently stood at 1,985 MW.[171] It is anticipated that by the end of year 2030 additional 4,195 MW wind power based electricity will be added to the national grid.[172]

The country also has immense solar power potential. Pakistan lies in the area of one of the highest solar insulation in the world and has immense solar resources, suitable for both photovoltaic (PV) and thermal solar power applications. The North Eastern part of Sindh, Quetta valley and Central Punjab receive maximum solar radiation, where sun shines b/w 7 and 8 h daily or approximately more than 2,300–2,700 h per annum. Solar energy potential is 2.9 million MW with feasible of 50,000 MW. However, the installed solar capacity is 600 MW, around 1.4 per cent of the total installed capacity.[173] Balochistan has excellent solar and wind resources in the west of the province. Going by economic logic, the development of large wind-solar farms and construction of a high-voltage DC line over 1,000 km can bring power to the rest of the country.[174] With the new upfront tariff provided by NEPRA and government incentives this sector is expected to grow and by the end of 2030, additional 3,259 MW electricity will be supplied to the national grid from PV solar power plants.

Figure 6.2: Solar Radiation in Pakistan



Source: HelioSCSP (2019)[175]

Table 6.3: Pakistan's Renewable Energy Targets & Status

Policy	Current Scenario	Target	Target Year
ARE Policy	5% share of renewables (including bagasse)	30% capacity share of renewables (including bagasse)	2030
IGCEP 2021–2030	4% capacity share of solar and wind 3% generation share of solar and wind	21% capacity share of solar and wind 10% generation share of solar and wind	2030
SDG 7 — Affordable and Clean Energy	75.4% population with access to electricity 49.1% population with access to clean fuels for cooking (WBG, 2020)	100% population with access to electricity 100% population with access to clean fuels for cooking	2030
National Electric Vehicle Policy, 2020–2025	2,000 passenger electric vehicles on roads by mid-2021	30% of new sales of cars and trucks to be electric vehicles 50% of new sales of 2-3-wheeler electric vehicles	2030
Nationally Determined Contributions	24% share of renewables (including hydro)	60% capacity share of renewables (including hydro)	2030

Source: SDPI (2022)[176]

Renewable Energy Institutional and Policy Framework

Several public and private sector institutions are responsible for the adoption of renewable energy technologies. The key stakeholders include Ministry of Energy (Power Division), National Electric Power Regulatory Authority (NEPRA), Private Power and Infrastructure Board (PPIB), Alternate Energy Development Board (AEDB), National Transmission and Despatch Company (NTDC), Central Power Purchasing Agency (CPPA) and National Energy Efficiency and Conservation Authority (NEECA). Pakistan Council of Renewable Energy Technologies (PCRET)[177] and AEDB were set up respectively in 2001 and 2003 to play a major role in promoting the development of infrastructure for ARE power generation. AEDB took a number of steps to promote ARE technologies and attract private sector investments in green energy.

The first Alternate Renewable Energy Policy 2006 (ARE 2006), set the initial target of generating 100 MW through wind energy, upgrading it to 700 MW by 2010 and 9,700 MW by the year 2030. Approval was granted for setting-up up to 41 wind power projects exceeding 3,000 MW. Twenty two parties were allocated sites for setting up projects totaling 1100 MW. The revised Alternate Renewable Energy Policy 2019 (ARE 2019), set specific target of 20 per cent renewable energy generation by 2025 and 30 per cent by 2030.[178] The policy stressed on alternative renewable technologies including solar power and onshore and offshore wind energy. It offered incentives to renewable power projects, especially attracting private capital.[179] Under ARE 2019, AEDB works as a 'one window facilitator' to approve RE projects. The NEPRA set up in 1997 works as a regulator in a liberalised market. It is also vested with powers to determine tariff for renewable energy projects generating energy for public procurement.

There are several government policies and initiatives which focus on clean and affordable energy. National Climate Change Policy 2021 provides policy measures for power generation and efficiency across both the electricity and wider energy sector. The policy promotes futuristic building designs with solar panels. The National Action Plan 2019 was aligned with Sustainable Development Goal 7 ('Sustainable Energy for All'), which is an all-encompassing approach linking energy access to other goals. The three key goals of the plan are: a) achieve universal access to energy by 2030; b) double the share of renewable energy; and c) double the rate of energy efficiency in the country.[180,181] According to the updated 2021 Nationally Determined Contribution (NDCs), solar and wind power generation will only begin to accelerate after 2030 due to current system constraints related to the grid, operational procedures, and storage facilities. National Energy Policy 2021 includes principles of competitive bidding, environmentally responsible expanded generation through renewable energy. Pakistan Vision 2025 recognised the need for sufficient, reliable, clean and cost effective availability of energy.[182]

Growth of Renewable Energy

Pakistan's energy mix witnessed an offtake of renewables over the past decade. Energy generated from solar and wind jumped from almost zero in 2011 to 4,320 GWh of electricity units in 2021.[183] In 2007, USAID in collaboration with Pakistan Meteorological Department (PMD) and AEDB, developed solar and wind atlases of Pakistan. After completion of World Bank funded Renewable Energy Mapping Project, high resolution (5 Km × 5 Km) wind and solar atlases will not only help in long term planning and development of renewable energy projects but also help in attracting further investment in the country.[184]

A World Bank study in 2020 urged Pakistan to urgently expand solar and wind "to at least 30 per cent of electricity generation capacity by 2030, equivalent to around 24,000 MW," which commensurate with target set by ARE 2019.[185] This will result in fuel savings equal to five billion US dollars over 20 years, increase energy security, and reduce greenhouse gas emissions. This will require Pakistan to install around 24,000 MW of solar and wind by 2030, up from just over 1,500 MW today. This represents around 150-200 MW per month.

The Indicative Generation Capacity Expansion Plan (IGCEP) 2021-30[186] showed that in base case scenario to meet a demand of 34,377 MW by the year 2030, a generation capacity of 53,315 MW is required. Major increase in the capacity is observed in the hydropower, solar and wind plants. According to IGCEP 2022-31 in the base case, the demand and installed capacity of the whole country is 41,338 MW and 69,372 MW, respectively by the year 2031. In the installed capacity, the optimized share from variable renewable energy (VRE) resources includes 8,350 MWp of Solar PV (utility solar & feeder based/ DG) and 4,928 MW of Wind. Apart from VREs, 3,544 MW and 990 MW of hydro and local coal is optimized by the tool, respectively.[187] New solar and wind plants are optimized by PLEXOS being cheaper source of energy.[188] The IGCEP 2021-30, approved by the Regulator, provides the following capacity additions from wind and solar energy by 2030:

Table 6.4: Cumulative Capacity Addition from Wind and Solar by 2030

Year	Capacity addition through Wind Energy (MW)	Capacity addition through Solar Energy (MW)	Cumulative Capacity Addition (MW)
2024	1,000	1,000	2,000
2025	1,000	1,000	2,000
2026	1,000	1,000	2,000
2027	62	1,000	1,062
2028	-	1,000	1,000
2029	-	1,000	1,000
2030	-	1,000	1,000
Cumulative Capacity Addition			**10,062**

Source: Power Division, Ministry of Energy (n.d.)[189]

Pakistan's first 50 MW Wind Power Project Jhampir started functioning in December, 2012 and its capacity was increased to 256 MW in 2014. The first 100 MW solar power project- Quaid-e-Azam solar power park in Bahawalpur, Punjab, at a cost of 131.15 million US dollars was connected to the national grid in May 2015. It is part of 1,000 MW Solar Park for generation of electricity from the solar energy. Pakistan is building solar power plants in Punjab, Sindh and Balochistan and Azad Jammu & Kashmir (AJK). Thirty six wind power projects of 1,835 MW, seven solar projects of 530 MW and eight sugar-mill based bagasse co-generation projects of 259.1 MW capacity were operational as of 30 June, 2022.[190] AEDB is already working on development of a 600 MWp solar PV project at Muzaffargarh, Punjab. According to Alternative Energy Development Board (AEDB) CEO Shah Jahan Mirza, "Pakistan has an ambitious goal of adding 14,000 MW of wind and solar energy to the grid in the next ten years."[191]

Solar Energy prices are becoming competitive with fossil fuels and have already reached grid parity, opening market opportunities for Solar PV in Pakistan. In December, 2022 the Prime Minister announced to shift federal government buildings to solar system and extend it later across the country. Pakistan Army has also decided to shift Cantonments from fossil fuel to solar power.[192] Pakistan Solar Association (PSA) projected country's import demand for photovoltaic products this year to be around 1.8 billion US dollars. According to a KTrade Securities analyst, "Pakistan's Solar Energy Market is expected to record a CAGR of 2.5 per cent during the period from 2022 to 2027, with Net Metering-Based Solar Installations and Power Generation growing by 102 per cent and 108 per cent respectively".[193] As of June 2021, the cumulative investment (foreign and domestic) in renewables amounted to 4.79 billion US dollars, of which 786 million US dollars was in solar, 3,752 million US dollars in wind and 258 million US dollars in bagasse.[194] There is a growing trend of off grids solarisation and solar net metering.

International Collaboration

USAID, International Renewably Energy Agency (IRENA), United Nations Industrial Development Organization (UBIDO), Asian Development Bank (ADB), World Bank, Germany, China and IFC are collaborating with Pakistan to develop renewable energy in the country. While World Bank has assisted in developing wind and solar atlases, the USAID has facilitated a study to identify human resource and capacity building requirements of AEDB and arranged financing of 44 million US dollars to construct grid for evacuation of wind power in Jhampir, Sindh.[195] IRENA is conducting a study on Renewable Readiness Assessment (RRA) of Pakistan that will identify strengths and weaknesses of RE market with possible solutions. ADB has assisted in a Project Preparatory Technical Assistance (PPTA) in 2005 that identified eight RE projects in public sector that were commercially viable.[196] Germany has provided technical assistance in RE and Energy Efficiency to build capacities of the public and private sector in RE. World Bank, ADB and KfW Bankengruppe are funding private sector wind energy projects.

Pakistan and China are also developing closer collaboration on renewable energy (solar PV). China is leading globally in renewable energy technology, while Pakistan needs to shift from thermal to renewable for power generation. Out of the 144 million US dollars foreign investment in PV plants in Pakistan, 125 million US dollars is from China, accounting for nearly 87 per cent of the total.[197] According to Liu Yiyang, Deputy Secretary-General and Press Spokesperson of China Photovoltaic Industry Association (CPIA), Pakistan imported about 1.2 billion US dollars in photovoltaic modules in the 2021, and in 2022, China's photovoltaic module exports to Pakistan reached approximately 870 million US dollars, with a total installed capacity of 3.2GW, a year-on-year increase of 54 per cent and 37 per cent, respectively.[198] Turkiye is going to invest in solar projects of 10,000 MW across Pakistan.[199]

Regional Cooperation in Renewable Energy

There is very limited electricity trade in the South Asian region, i.e., India with Bhutan and Nepal. The Iran-Pakistan-India (IPI) and Turkmenistan-Afghanistan-Pakistan-India (TAPI) gas pipeline projects could have built energy corridors in the region, but remain unrealised mainly due to political and economic reasons. The Central Asia-South Asia 1000 (CASA-1000) project was driven by surplus hydropower production in Kyrgyzstan and Tajikistan, (during the summer season). The power was to be supplied through ±500 kV HVDC Transmission Line emanating from Kyrgyzstan and passing through Sangtuda, Tajikistan, Afghanistan and terminating at Nowshera, Pakistan. This project may interconnect Kyrgyzstan, Afghanistan and Pakistan to form a Central Asia-South Asia Market,[200] but has made little progress so far.

Challenges and Constraints

Pakistan is at the energy transition crossroads. Like many other countries, Pakistan has taken policy initiatives to move to renewables, but growth in green energy has been quite slow. Pakistan's first ARE Policy 2006 could only add 1,235.20 MW capacity through wind power projects and 430 MW through solar projects into the system.[201] A SDPI report on renewables identified four major challenges to its growth in the country. These are: policy and regulatory uncertainty, financing challenges, project development delays and market and infrastructure barriers.[202] The key informants interviewed for this research revealed that policy and regulatory uncertainty and inconsistency and lack of understanding about renewables at the policy makers' level remains the foremost obstacle in the way of investment in renewable energy in the country. Some of the major constraints and challenges are discussed below.

- **Policy and Coordination Gaps:** Significant barriers noted for the policy's failure included regulatory insufficiency, high upfront cost, lack of proper subsidies and lack of institutional coordination[203] amongst federal and provincial authorities. In addition there is a lack of policy coordination between NEPRA and AEDB on the tariff determination for renewables. Muzaffar Ali, Chairman of the Energy Department observed that there is no long term policy on renewables which discourages investment in renewable energy.[204] Further, their understanding about the renewable energy industry is quite limited.

- **Political Constraints:** Lack of political will and reluctance of government investment is badly affecting the hopes of generating electricity through renewables. The mind-set of policy makers and dominant power planners in public sector energy institutions are heavily tilted in favour of base load plants relying on coal, thermal and hydel power generation, said Akram Ali, a high official in WAPDA.[205] Partly, it stems from lack of understanding of policy makers about variable power generation.

- **Lack of Conducive Investment Environment:** In the area of commercial and industrial development of renewable projects, lack of subsidised financing, Feed- in-Tariffs (FITs) and wheeling charges is hindering investment in renewables. According to Ghazala Reza, an energy expert, factors hindering solar power development include complications in finding space for solar farms, procedural delays in construction approvals and unattractive tariffs for selling power to national grid.

- **Technical Constraints:** The biggest challenge facing renewable energy technologies is to excel in state of the art technologies where more renewable options can generate energy at cost that is competitive with conventional sources. Further, NPCC and NTDC lack network capacity to deal with rapid growth in renewables.[206] Weak grid is unable to handle variability in renewables, especially wind and solar. In addition, over- installed capacity of thermal and hydel power is obstructing growth of renewables.[207]

- **Variability in Power Production:** While solar and wind projects may be more affordable, they operate depending on the strength of the sunlight and winds. In addition, energy output

is affected by natural conditions. For instance, in 2015, the 100MW Quaid-e-Azam solar project is only able to produce 18.5 per cent power against the 100 MW installed capacity[208] due to the dust and smog.

- **Economic Constraints:** While the cost of constructing wind and solar power plants is going down, rising shipping prices have increased the cost of producing and transporting solar photovoltaics modules, wind turbines and biofuels. Asim Riaz, a high official in the ministry of energy observed that Pakistan's uncertain political and economic conditions, especially depreciation of Pakistan rupee against the US dollar, leading to rise in price has affected the growth of renewables at residential, commercial and industrial and large scale level, though in varied manners.[209]

Recommendations:

Pakistan's slow growth in renewables can be fast tracked if a multidimensional approach is adopted to enhance understanding about the renewables amongst the policy makers and energy planners; develop human resource and build capacity of intuitions along with financial resource generation and addressing of the technical barriers.

- **Changing the mind-set and creating understanding about renewables:** There is no policy to support awareness campaigns of renewable energy technologies in policy makers, grid operators or general public.

- **Bridging Policy gaps:** There is need for bridging regulatory gaps and to simplify the licensing procedure and make regulations for implementation.

- **Building human resource in variable renewables:** There should be mandatory requirement of training of renewable energy plant operators from local communities and university/ college students. In addition, the capacity development of local stakeholders, especially R&D institutions, equipment manufacturers is essential. This requires policy to support R&D institutions, local equipment manufacturers, related educational institutions and ESCOs.[210]

- **Creating conducive investment environment:** The costs of energy transition in Pakistan will require 101 billion US dollars by 2030, and an additional 65 billion US dollars by 2040 for completion of renewable energy projects, additional hydropower, transmission, and phasing out coal by replacing it with hydropower.[211] This requires resource generation from multiple sources. Efforts must be made to take steps to fast track funding from Development Finance Institution i.e. International Banks- WB, ADB, Islamic Development Bank and Japan, China, France and Canada for renewable energy development in Pakistan. In addition, Green Climate Fund (GFC) is also available for countries that can procure it competitively, based on robust project feasibilities, technical assessments, and scientific studies. Pakistan needs to develop sellable projects and enhance its capacity to get share from the global fund.

- **Public-private partnership in hydro, wind and solar power should be reinvigorated:** This will help in raising financial resources for these projects. There is also a need to combine solar and wind generation parks to supplement each other.

- **Localization of renewable energy supply chain in Pakistan:** The supply chain disruptions, and increases in import bill having impact on the national economy, necessitate development of local supply chain in renewables.

- **Energy Transition Partnerships at the regional and global level:** Not much effort is underway in developing energy transition partnerships in South Asia. There is ample scope to develop collaboration in renewable technologies at the regional level and learn from each other's experiences.

Prof. Dr. Shaheen Akhtar is Head of the Department of International Relations at the National Defence University in Islamabad.

7

Sri Lanka

Sri Lanka

Author: Thilinakumari Kandanamulla

Energy Cooperation and Cross Border Energy Trade (CBET) are two key elements that could be utilized by Sri Lanka to achieve energy sustainability while realizing the targets set for mitigating the adverse impacts of climate change and for high economic gains. South Asian Region possesses a rich renewable energy potential whilst India has taken a lead in regional energy cooperation and CBET. In such a backdrop, it would be interesting for Sri Lanka to reap the benefits of CBET through renewable energy cooperation. This article aims to present Sri Lanka's national perspectives on the challenges and opportunities for regional energy cooperation, realizing the potential of regional cooperation in renewable energy trade in South Asia while presenting the wind, solar and biomass potential of the country along with the related advantages, issues and the way forward.

Energy landscape of Sri Lanka

The energy generation mix of Sri Lanka is comprised of major hydro (7%), thermal (coal) (34%), thermal (oil) (18%) and renewable energy (11%). The electricity demand which was initially fulfilled through hydro generation has been reversed with time making thermal generation prominent in the energy profile of the island.[212]

Electricity demand continues to grow at an annual rate of around five per cent and the Long-Term Generation Expansion Plan (LTGEP) of the Ceylon Electricity Board (CEB) indicates that capacity additions of some 8,341 MW will be needed by 2037 to fulfill such a requirement.[213] The "Sri Lanka Energy Sector Development Plan for a Knowledge-based Economy (2015 to 2025)" states that in order to meet energy requirements, the country needs to import 02 MMT of crude oil, 04 MMT of refined petroleum products, and 2.25 MMT of coal annually. This costs the government approximately five billion US dollars in foreign exchange, which is nearly 25 per cent of the import expenditure and nearly 50 per cent of total export income, resulting in a huge burden on the balance of trade and exchange rates".[214]

The Sri Lankan energy sector still faces multiple challenges in developing its capacities, in order to achieve its climate target of 100 per cent Renewable Energy (RE) for electricity generation by 2050 and to effectively engage in regional energy cooperation and CBET with a prominence to renewable energy.

Solar, Wind, Biomass Status and Potential

Solar, wind, biomass and hydro are the proven renewable energy resources being commercially developed at present in Sri Lanka.[215] The custodian institute of the renewable energy resources and the focal national entity for implementing renewable energy development programmes in the country is the Sri Lanka Sustainable Energy Authority (SLSEA).

An all-island Wind Energy Resource Atlas of Sri Lanka developed by National Renewable Energy Laboratory (NREL) of USA in 2003, indicates nearly 5,000 km^2 of windy areas with good-to-excellent wind resource potential in Sri Lanka. About 4,100 km^2 of the total windy area is on land and about 700 km^2 is in lagoons. The windy land represents about six per cent of the total land area (65,600 km^2) of Sri Lanka. This windy land could support almost 24,000 MW of potential installed capacity.[216]

Sri Lanka receives significant amount of solar radiation across all geographical regions and is blessed with year-round availability of sunlight being located close to the equator. Solar power is generated in two main ways, such as Photovoltaics (PV) or as Concentrated Solar Power (CSP). In 2016,

the Sri Lankan Government launched an enhanced version of the Rooftop Solar PV Programme under the theme "Sooryabala Sangramaya" which converts to "Battle for Solar Power" under which the excess energy exported to the grid can either be carried forward (as originally done in the net-metering scheme) or encashed.[217] Large scale solar power plants are also being set up with private sector investment. According to Wijesena and Amarasinghe (2018) their capacity had been over 24 MW in 2018.[218]

Biomass is a primary source of energy which is widely utilized as a source for heat generation for cooking in the rural sector of Sri Lanka as a traditional practice and to a lesser extent in cities (e.g. firewood). It is also called as bioenergy. Liquid biofuels produced from bagasse and other plants; bio-refineries; biogas produced through anaerobic digestion of residues; wood pellet heating systems etc. are some of the modern bioenergy technologies with a potential to be developed as alternative sources of energy. In general, biomass has a high potential to be utilized in the industrial sector of Sri Lanka, especially in the thermal energy supply.[219]

Sri Lanka in the Backdrop of regional Energy Cooperation and Trade in South Asia

Regional energy cooperation is strongly influenced by prevailing political, economic, social, and cultural factors. Conditions for convenient exchange of energy and possibilities for diversification of energy supply are generated by interconnection among the countries in renewable and non-renewable sectors.[220] Creation of regional electricity markets via the integration of existent national markets leading to Cross Border Energy Trade (CBET) is a current global trend which is yet to be harnessed fully by South Asia. It is envisaged that Cross Border Transmission Interconnection (CBTI) capacity of the region could be increased by ten folds through successful integration of energy markets.[221]

Enhanced regional energy cooperation is critical to boost energy security and sustainability and overall climate-resilience in South Asia. Such a connectivity would reduce energy costs, improve reliability, and reduce carbon emissions at a lower-cost, while increasing the share of and synergies among clean energy resources, particularly hydro, wind and solar.[222]

A potential renewable energy cooperation and CBET could be assessed based on options identified through several national, regional and global processes out of which the climate focus is more significant. Nationally Determined Contributions (NDCs) of the country related to the Paris Agreement on climate change provide an opportunity to create a common ground for collaboration, since climate change is a common concern for all. Scaling up of climate action in the region, accessing climate finance and technology for regional interventions and addressing existing gaps and needs in the energy sector at national and regional levels would be some of the key measures to achieve renewable energy cooperation and CBET while scaling up the climate action in the region.[223]

Growing demand and severe power shortages had led to the emergence of various scattered bilateral arrangements for CBET in South Asia. Initially, there was a lack of a common platform for integration. However, the SAARC Framework Agreement for Energy Cooperation (Electricity) which was signed in 2014 has created such a platform,[224] recognizing the importance of electricity trade, demand management, private public partnerships, etc. among other priority areas.[225] Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC) is another multilateral initiative launched in 2018 and is emerging as an attractive platform with a similar focus.[226]

Sri Lanka is one of the highly vulnerable countries to adverse impacts of climate change. Thus, decarbonizing the power sector is crucial to mitigate such impact. The country also has a considerable renewable energy potential and opportunities for clean energy transition to achieve sustainability and energy security. Large scale renewable energy based CBET offers cost saving and clean energy transition which eventually leads to enhanced energy affordability and sustainability.

Also, the commercial forms of CBET help fostering private sector engagement and investment, which is much needed by Sri Lanka to achieve economic prosperity.

Sri Lanka's energy cooperation with the South Asian region is characterized by its close connectivity with neighboring India. Currently there is no physical interconnection between the two countries (or any grid connections of Sri Lanka with any other country in the South Asian Region) due to various geographic, political, and economic factors.[227] However, the growth of renewable energy potentials in both Sri Lanka and India and the geographical proximity of Sri Lanka to India create a vast opportunity for interconnection of the grids between them.

A memorandum of understanding (MoU) had been first signed in June 2010 among the Government of India, Government of Sri Lanka, the Power Grid Corporation of India Ltd. and the CEB to conduct a feasibility study for inter-connection of India-Sri Lanka electricity grids.[228] Though the scoping studies had been conducted, the aim of this MoU is yet to be realized.

Recently, India and Sri Lanka have signed an agreement for developing a 100 MW solar power plant in Trincomalee, Sampur as part of the efforts to strengthen bilateral economic partnership, including through cooperation in the renewable energy sector.[229] This is a joint venture between National Thermal Power Corporation (NTPC) Limited of India and the CEB.

Sri Lanka is also planning to set up 500 MW worth of renewable energy plants (wind and solar) in Mannar and Pooneryn by the end of 2024, funded by India's Adani Green Energy Limited, with an investment of 442 million US dollars, of which the initial work on the investment plans has been completed.[230]

Meanwhile, the country commercial guide for Sri Lanka by the US Department of Commerce has identified some renewable energy sources such as wind and solar plants, mini hydroelectricity plants, home solar systems and wind energy as sectors which contain a high potential for investment in Sri Lanka.[231]

Several factors, such as the surplus power projected to be present in many regions of India, evaluation of available options for new sources of energy supply by the planners of power systems in Sri Lanka in order to address the rising demand and the significant growth in Renewable Energy investments in the region due to falling technology costs and conducive national energy policies, have generated a conducive environment to stimulate CBET between India and Sri Lanka with win-win benefits.[232]

The two countries are separated by a narrow strait known as Palk Strait in the Indian ocean which is 53 to 82 km wide and connects the Bay of Bengal to Palk Bay. Indian and Sri Lankan power system planners, as well as the broader research community have for many years considered to connect the two countries with a high-voltage direct current transmission link. Benefits from cross-border trade such as the retained capital and operating costs along with increased reliability for both countries are supposed to outweigh the cost of such an integration project. Studies have identified the potential of such a transmission line to allow Sri Lanka to import power during peak periods and to export excess baseload power to India during off-peak hours.[233] Accordingly, CBET enabled by a 500 MW high voltage direct current transmission link between India and Sri Lanka in the year 2025 could present an opportunity to reduce the cost of providing electricity, reduce Renewable Energy curtailment in southern India and improve system reliability through coordinated use of energy resources. Accordingly, annual production cost by Sri Lanka is estimated to be decreased by 35 per cent. It would be less expensive to import power from Sri Lanka to India for 14 per cent of the annual energy production of the year, primarily in December, when high hydro and coal generation in Sri Lanka creates export opportunities to India. Improvement of the energy reliability in Sri Lanka through coordinated use of energy resources could be mentioned as follows; "Inter-annual

variability in hydropower resources creates a security of supply risk for Sri Lanka's power system. Cross-border trade reduces this risk by increasing the availability of reserves from generation sources in India. However, the DC tie also creates potential operational and national security risks, including that the DC tie serves twelve per cent of Sri Lanka's annual load. While the DC tie can help address contingencies in Sri Lanka, this service is dependent on a coordinated response between the countries".[234]

Sri Lanka's close relationship with India on renewable energy cooperation could be viewed in the point of Energy Diplomacy as well. Griffiths (2019) describes Energy Diplomacy as "government-related foreign activities that aim to ensure a country's energy security while also promoting business opportunities related to the energy sector".[235] It is further stated that "bilateral diplomacy can be particularly effective when encompassing the pursuit of common interests between countries as well as addressing differences and commonalities related to culture, politics and economy". In that respect, joint ventures as well as investments and grants by India to build the CBET capacities of Sri Lanka could be identified as acts of bilateral energy diplomacy and soft power by India on CBET and renewable energy cooperation with Sri Lanka.

Over the years, Sri Lanka has explored avenues for implementing CBET. Among such examples are the proposed India Sri Lanka grid connection lines (as mentioned above in detail), and exploration of avenues for regional cooperation on renewable energy based CBET such as the focus on oceanic thermal energy conversion projects.[236]

Scaling up technical capacities, technology, as well as access to finance are highlighted by energy sector experts and related stakeholders as key components of focus for CBET in Sri Lanka. Points highlighted in stakeholder discussions are "difficulties related to direct credit in financial systems for conducting projects at regional level; potential difficulties that need to be addressed with regard to grid expansion; the need for expanding the storage capacity of renewable energy in Sri Lanka; the need for awareness and better understanding of CBET including technical capacity and skills; and potential legal and institutional frameworks that need to be set up or enhanced."[237]

Assessing the energy needs of the country while prioritizing domestic energy security and sovereignty is considered a key important element in evaluating and understanding Sri Lanka's renewable energy generation capacity in the context of CBET. This could contribute to achieving energy sustainability locally and to effectively contribute to an emerging regional energy market. Determining of pros and cons of CBET, implications of its application to the domestic energy sector and safeguards to be implemented for energy security (such as relevant policy and regulatory frameworks) would also be very important factors which need attention.

Way Forward

Sri Lanka has not had grid integration with any other country so far. Thus, seeking the potential of striking a balance between optimizing the domestic renewable energy resources for economic gains and protecting the national energy security and sovereignty while harnessing potentials of CBET for win-win benefits would be an interesting focus for future considerations in energy sector planning in Sri Lanka. To attract private sector participation in the renewable and energy efficiency business, a more comprehensive policy and action-based framework is essential. Clearing regulatory uncertainties and implementing effective policies, improving grid capacity to allow more renewable energy, and making land acquisition easier are concrete measures to boost private investors' confidence in renewable energy markets in Sri Lanka. In addition to deploying mature renewable technologies through the private sector, incentivizing new technologies that are still in the early phases of adoption is also important.[238] With collaborative and coordinated efforts among the public and private sectors, Sri Lanka has a potential to tap into renewable energy development with a key focus on energy mix and to delve into the possibility of CBET to acquire a high socioeconomic and environmental impact in the long run.

Thilinakumari Kandanamulla is a Scientific Officer at the National Science Foundation, Sri Lanka (contributed in personal capacity).

References

1 Al Jazeera 2021: Bangladesh aims to increase renewable energy use to 40 percent by 2041, Al Jazeera, 22 Mar 2021, in: https://www.aljazeera.com/news/2021/3/22/bangladesh-aims-to-increase-renewable-energy-use-to-40-by-2041/ [1 June 2023].

2 The World Bank 2021: Bangladesh: Overview, The World Bank, 6 Apr, 2023, in: https://www.worldbank.org/en/country/bangladesh/overview#1 [1 June 2023].

3 International Renewable Energy Agency IRENA 2022: Energy profile: Bangladesh, in: https://www.irena.org/-/media/Files/IRENA/Agency/Statistics/Statistical_Profiles/Asia/Bangladesh_Asia_RE_SP.pdf [14 July 2023].

4 The Financial Express 2022: Revising existing renewable energy policy, The Financial Express, 7 Dec 2022, in: https://thefinancialexpress.com.bd/views/columns/revising-existing-renewable-energy-policy-1670344095/ [1 June 2023].

5 IRENA, 2022, N.3.

6 Ibid.

7 Government of Bangladesh 2008: National Renewable Energy Policy of Bangladesh, in: https://policy.thinkbluedata.com/sites/default/files/REP_English.pdf [14 July 2023].

8 Ibid.

9 Yousuf, Abu 2022: Renewable Energy Resources in Bangladesh: Prospects, Challenges and Policy Implications, International Journal of Renewable Energy Research, Vol.12, No.2, June 2022, p.1079.

10 Bangladesh Power Development Board 2021: Power System Master Plan (2016-2041), in: https://powerdivision.portal.gov.bd/sites/default/files/files/powerdivision.portal.gov.bd/page/4f81bf4d_1180_4c53_b27c_8fa0eb11e2c1/(E)_FR_PSMP2016_Summary_revised.pdf [14 July 2023].

11 Ibid.

12 Hossain, Monzur 2018: Green Finance in Bangladesh: Policies, Institutions, and Challenges, Asian Development Bank ADBI Working Paper Series, No. 892, November 2018. p. 16, in: https://www.adb.org/publications/green-finance-bangladesh-policies-institutions-challenges/ [1 June 2023].

13 Infrastructure Development Company Limited 2022, in: https://www.idcol.org/ [1 June 2023].

14 Bangladesh Power Development Board 2022: Renewable Energy, in: https://www.reb.gov.bd/renewable-energy/ [1 June 2023].

15 Government of Bangladesh 2012: Bangladesh Sustainable Renewable Energy Development Authority Act, in: http://www.pd.gov.bd/userfiles/SREDA%20Act_LawVetting.pdf [1 June 2023].

16 Bangladesh Power Development Board 2021: Annual Report Bangladesh Power Development Board, in: http://bd.bpdb.gov.bd/bpdb/resourcefile/annualreports/annualreport_1605772936_AnnualReport2019-20.pdf [14 July 2023].

17 Government of Bangladesh 2009: Bangladesh Climate Change Trust Fund, in: https://journal.bcsadminacademy.gov.bd/index.php/bjam/article/download/35/36/130 [1 June 2023].

18 The Business Standard 2022: Govt. encourages investment in power, energy sector: Nasrul, The Business Standard, 17 May 2022, in: https://www.tbsnews.net/bangladesh/govt-encourages-investment-power-energy-sector-nasrul-421594/ [1 June 2023].

19 Power and Technology 2013: India, Bangladesh inaugurate cross-border electrical grid interconnection project, Power and Technology, 6 Oct 2013, in: https://www.power-technology.com/uncategorized/newsindia-bangladesh-inaugurate-cross-border-electrical-grid-interconnection-project/ [1 June 2023].

20 Rehman, Saif/Shukla, Rahul/Gautum, Aman et al. 2021: Success Story of India-Bangladesh Power System Operation, 2021 9th IEEE International Conference on Power Systems (ICPS), Kharagpur, India, 2021, pp. 1-6, doi: 10.1109/ICPS52420.2021.9670352

21 Ibid.

22 Asian Development Bank 2022: Green Finance in Bangladesh: Policies, Institutions, and Challenges, in: https://www.adb.org/publications/green-finance-bangladesh-policies-institutions-challenges [14 July 2023].

23 Infrastructure Development Company Limited 2022, N.13

24 International Energy Agency 2021: Renewable Energy Market Update: Challenges and Opportunities Beyond 2021, in: https://www.iea.org/reports/renewable-energy-market-update/challenges-and-opportunities-beyond-2021/ [1 June 2023].

25 Peimani, Hooman 2018: Financial Barriers to Development of Renewable and Green Energy Projects in Asia, ADBI Working Paper Series, no. 862, Asian Development Bank Institute, Tokyo, Japan, Aug 2018, in: https://www.adb.org/publications/financial-barriers-development-renewable-green-energy-projects-asia [1 June 2023].

26 Alam, Shafiqul 2021: Building Renewable Energy in Bangladesh, National Bureau of Asian Research, 16 Jun 2021, in: https://www.nbr.org/publication/building-renewable-energy-in-bangladesh/ [1 June 2023].

27 Zebra, Emília Inês Come/van der Windt, Henny J./Nhumaio, Geraldo et al. 2021: A review of hybrid renewable energy systems in mini-grids for off-grid electrification in developing countries, Renewable and Sustainable Energy Reviews, vol. 144, July 2021, 111036, in: https://doi.org/gnkd86 [1 June 2023].

28 Yousuf, 2022, N.9.

29 Siddique, Abdul Hasib/Tasnim, Sumaiya/Shahriyar, Fahim et al. 2021: Renewable Energy Sector in Bangladesh: The Current Scenario, Challenges and the Role of IoT in Building a Smart Distribution Grid, Energies 2021, 14(16), 5083, in: https://doi.org/kcvq [1 June 2023].

30 Uddin, M.N. 2019: Renewable energy in Bangladesh: Status and prospects. Energy Procedia, 160, pp. 655-661, in:

https://doi.org/kcvr [1 June 2023].
31 World Bank 2021: Bangladesh Solar Home Systems Provide Clean Energy for 20 Million People, World Bank, 7 April 2021, in: https://www.worldbank.org/en/news/press-release/2021/04/07/bangladesh-solar-home-systems-provide-clean-energy-for-20-million-people/ [1 June 2023].
32 Ibid.
33 World Bank Group 2014: Turn down the heat: Confronting the new climate normal, Open Knowledge Repository, 23 Nov 2014, in: https://openknowledge.worldbank.org/handle/10986/20595/ [1 June 2023].
34 Bangladesh Energy Regulatory Commission 2018: Bangladesh Energy Outlook 2041, in: https://www.berc.org.bd/wp-content/uploads/2020/11/BEOutlook2041_web.pdf/ [1 June 2023].
35 The Business Standard 2023: Air Pollution Behind 20% of Premature Deaths in Bangladesh: World Bank, The Business Standard, 28 March 2023, in: https://www.tbsnews.net/bangladesh/environment/air-pollution-behind-20-premature-deaths-bangladesh-experts-606754 [1 June 2023].
36 Government of Bangladesh 2021: Bangladesh Delta Plan 2100, in: https://bdp2100kp.gov.bd [1 June 2023].
37 The Japan Times 2023: Bangladesh's energy plan faces gas dilemma as fuel crisis bites, 9 April 2023, in: https://www.japantimes.co.jp/news/2023/04/09/business/bangladesh-energy-plan-dilemma/ [1 June 2023].
38 Babu, Md. Tasruzzaman/Nei, Hisanori/Kowser, Md. Arefin 2022: Prospects and Necessity of Wind Energy in Bangladesh for the Forthcoming Future, Journal of The Institution of Engineers (India) Series C, vol. 103, no. 2, 11 June 2022, pp. 231-242, in: https://doi.org/kcvs [1 June 2023].
39 Roy, Riya/Jubayer, Abdullah Al/Sakib, Kazi Sadman et al. 2022: Electricity Access, Decarbonization, and Integration of Renewables, Policy Options While Increasing Share of Renewable Energy: Technology Choices for Peaking Power in the Context of Bangladesh, Chapter 03, pp.67-86, 2 November 2022, in: https://doi.org/kcvt [1 June 2023].
40 Karim, Mohammad E./Karim, Ridoan/Islam, Md. Toriqul et al. 2019: Renewable Energy for Sustainable Growth and Development: An Evaluation of Law and Policy of Bangladesh, Sustainability 11, no. 20 (2019): 5774, https://www.mdpi.com/2071-1050/11/20/5774 [14 July 2023].
41 Hossain, I. 2021. The solar energy revolution in Bangladesh. Renewable Energy, 174, pp.1146-1151.
42 Islam, M.M./Uddin, M.J./Ferdous, N. 2021: Challenges and prospects of solar energy development in Bangladesh., Renewable Energy Focus, 37, pp.39-44.
43 Chowdhury, N.H./Hasan, M.M./Ahmed, K./Rahman, S. 2021: An assessment of energy storage systems for renewable energy integration in Bangladesh, Energy Reports, 7, pp.2074-2088.
44 Ibid.
45 Azhgaliyeva, Dina 2019: Feed-in Tariffs and Loans for Boosting Private Investment in Renewable Energy, Asia Pathways - Asian Development Blog, 23 Oct 2019, in: https://www.asiapathways-adbi.org/2019/10/feed-in-tariffs-and-loans-for-boosting-private-investment-in-renewable-energy [20 July 2023].
46 Bangladesh Energy Regulatory Commission, 2018, N.34.
47 Uddin, M.J. et al. 2021: Renewable energy development in Bangladesh: An analysis of policies, prospects and challenges. Energy Policy, 149, pp.112010.
48 Babu, Tasruzzaman/Nei, Hisanori/Kowser, Arefin 2022: Prospects and Necessity of Wind Energy in Bangladesh for the Forthcoming Future. Journal of The Institution of Engineers (India), Series C.17, in: https://link.springer.com/article/10.1007/s40032-022-00834-8 [20 July 2023].
49 National Renewable Energy Laboratory (NREL) 2018: Assessing the Wind Energy Potential in Bangladesh: Enabling Wind Energy Development with Data Products, Sept 2018, in: https://www.nrel.gov/docs/fy18osti/71077.pdf [14 July 2023].
50 Department of Renewable Energy, MoEA 2021: Bhutan's first 180kW Pilot Grid-Tied Ground-Mounted Solar Power Plant at Rubesa, Wangdue Phodrang, 2 Sept 2021, in: https://ne-np.facebook.com/111899110484048/posts/bhutans-first-180kw-pilot-grid-tied-ground-mounted-solar-power-plant-at-rubesa-w/365495328457757/ [5 June 2023].
51 DHPS 2019: Power system master plan 2040 in Bhutan, MoEA.
52 NEC 2020: Third National Communication from Bhutan to the UNFCCC, Vulnerability and Adaptation Assessment.
53 Gyelmo, Dawa 2016: Bhutan diversifies its renewables with wind turbines, The Third Pole, 16 Feb 2016, in: https://www.thethirdpole.net/en/climate/bhutan-diversifies-its-renewables-with-wind-turbines/ [4 Sept 2023].
54 NSB 2017: Population and housing census of Bhutan.
55 DRE 2020: Domestic Biogas Implementation Guideline, MoEA.
56 IRENA 2019: Renewables Readiness Assessment Kingdom of Bhutan.
57 Owusu, Phebe Asantewaa /Asumadu-Sarkodie, Samuel 2016 | Dubey, Shashi (Reviewing Editor) 2016: A review of renewable energy sources, sustainability issues and climate change mitigation, Cogent Engineering, 3:1, in: https://doi.org/gdjzps [4 Sept 2023].
58 Dincer, Ibrahim 2000: Renewable energy and sustainable development: a crucial review, Renewable & Sustainable Energy Reviews, 4, pp.157-175, in: https://doi.org/dq9ck4 [4 Sept 2023].
59 Kumar. J, Charles Rajesh/M. A. Majid. 2020: Renewable Energy for Sustainable Development in India: Current Status, Future Prospects, Challenges, Employment, and Investment Opportunities, Energy, Sustainability and Society, 10(1), pp.1–36, in: https://doi.org/gkm5g6 [4 Sept 2023].
60 NEC 2020, N.51.
61 RGoB 2017: 12th Five Year Plan (2018-2023) Guideline.
62 DRE 2016: Renewable Energy Master Plan 2016, MoEA.
63 Bhonsale, Mihir 2020: Bhutan: Diversifying renewable energy sources, Observer Research Foundation, 14 Oct 2020, in: https://www.orfonline.org/expert-speak/bhutan-diversifying-renewable-energy-sources/ [4 Sept 2023].
64 ADB 2014: Green Power for Bhutan: Clean Energy Crosses

Borders to Reach Poor Households, ADB, Jun 2014, in: http://hdl.handle.net/11540/692 [4 Sept 2023].

65 Future Water, in: https://www.futurewater.eu/projectcountry/bhutan/ [5 Jul 2023].

66 UNESCAP 2021: Situational Assessment for Household Energy Needs in Bhutan, ESCAP, 14 Sept 2021, in: https://www.unescap.org/kp/2021/situational-assessment-household-energy-needs-bhutan [5 Jul 2023].

67 Ministry of New and Renewable Energy 2023: Annual Report 2022-23, in: https://mnre.gov.in/img/documents/uploads/file_s-1683099362708.pdf [8 Jun 2023].

68 Ibid.

69 Ibid.

70 Visit the portal for National Portal for Rooftop Solar for a detailed note on the subject in https://solarrooftop.gov.in/ [13 Jun 2023].

71 To know more about India's green hydrogen programme, see Ministry of New and Renewable Energy 2023: National Green Hydrogen Mission, in: https://mnre.gov.in/img/documents/uploads/file_f-1673581748609.pdf [13 Jun 2023].

72 Ministry of New and Renewable Energy, 2023, N.67.

73 Ministry of New and Renewable Energy n.d.: Empowering Women in Renewable Energy, in: https://mnre.gov.in/ministry_of_new_and_renewable_women_energy_government_of_india [13 Jun 2023].

74 The Hindu 2022: India's first fully solar village lights up the lives of poor residents, 1 Nov 2022, in: https://www.thehindu.com/sci-tech/energy-and-environment/indias-first-fully-solar-village-lights-up-the-lives-of-poor-residents/article66081134.ece [13 Jun 2023].

75 UN News 2022: India's first solar-powered village promotes green energy, sustainability and self-reliance, 22 October 2022, in: https://news.un.org/en/story/2022/10/1129802 [13 Jun 2023].

76 Ministry of New and Renewable Energy: Bio Energy, in: https://mnre.gov.in/bio-energy/current-status [13 Jun 2023].

77 Ministry of New and Renewable Energy: Evaluation Study for the Assessment of Biomass Power and Bagasse Power Potential in India, Mar 2021, in: https://mnre.gov.in/img/documents/uploads/file_s-1685625362098.pdf [13 Jun 2023].

78 Ministry of New and Renewable Energy: Draft Policy for Repowering of the Wind Power Projects, 17 Oct 2022, in: https://mnre.gov.in/img/documents/uploads/file_f-1666005996212.pdf [13 Jun 2023].

79 Ibid.

80 Ministry of New and Renewable Energy n.d.: Strategy Paper for Establishment of Offshore Wind Energy Projects, in: https://mnre.gov.in/img/documents/uploads/file_f-1657274400252.pdf [13 Jun 2023].

81 NITI Aayog 2019 : SDG India Index & Dashboard 2019-20, 2 Nov 2019, p. 56, in: https://www.niti.gov.in/sites/default/files/SDG-India-Index-2.0_27-Dec.pdf [13 Jun 2023].

82 NITI Aayog 2022 : Affordable and Clean Energy, in: https://sdgindiaindex.niti.gov.in/#/ranking [6 Jul 2023].

83 According to the NITI Aayog, it "has the twin mandate to oversee the adoption and monitoring of the SDGs in the country and promote competitive and cooperative federalism among States and UTs." See NITI Aayog 2022: Annual Report 2022-23, in: https://www.niti.gov.in/sites/default/files/2023-02/Annual-Report-2022-2023-English_06022023_compressed.pdf [13 Jun 2023].

84 NITI Aayog 2019 : SDG India Index & Dashboard 2019-20, 2 Nov 2019, in: https://www.niti.gov.in/sites/default/files/SDG-India-Index-2.0_27-Dec.pdf [13 Jun 2023].

85 NITI Aayog 2022: The Indian Model of SDG Localization, in: https://www.niti.gov.in/sites/default/files/2022-08/The_Indian_Model_of_SDG_Localisation_13072022.pdf [13 Jun 2023].

86 NITI Aayog, 2019, N.81.

87 World Economic Forum 2020: Why India is the new hotspot for renewable energy investors, 14 Jan 2020, in: https://www.weforum.org/agenda/2020/01/india-new-hotspot-renewable-energy-investors/ [13 Jun 2023].

88 Garg, Vibhuti/Buckley, Tim/Srivastava, Shantanu 2022: India's renewable energy journey: Short-term hiccups but long-term trajectory intact", Institute for Energy Economics and Financial Analysis, 12 Oct 2022, in: https://ieefa.org/resources/indias-renewable-energy-journey-short-term-hiccups-long-term-trajectory-intact [13 Jun 2023].

89 ADB 2023: Ensuring a Just Transition is Key to India's Energy Transition Goals, 28 April 2023, in: https://www.adb.org/news/features/ensuring-just-transition-key-india-energy-transition-goals [13 Jun 2023].
The report, while looking at the challenges, also commends India's efforts in the introduction. According to the report: "India has scaled up its renewable energy capacity by 250 % between 2014 and 2021. It now ranks fourth in renewable energy capacity in the world. Nevertheless, India is further embarking on a sweeping energy transition effort to replace fossil fuel use in the industrial sector. Focused on investing in energy efficiency, expanding renewable energy generation, and the use of green hydrogen for energy storage, India expects to reduce its dependency on fossil fuels in the medium term. The Government of India will actively pursue these goals through initiatives such as the proposed solar cities and parks, National Green Hydrogen Mission, and the Green Energy Corridor. It is also rolling out policy measures and incentives that enable the uptake of green energy and technology, including the production-linked incentive (PLI) scheme for entities that set up manufacturing facilities for clean technology."

90 UN Climate Change Conference UK 2021: Supporting the Conditions for a Just Transition, 4 Nov 2021, in: https://webarchive.nationalarchives.gov.uk/ukgwa/20230313132211/https://ukcop26.org/supporting-the-conditions-for-a-just-transition-internationally/ [13 Jun 2023].

91 International Labour Organization 2021: ILO welcomes COP26 Just Transition Declaration, 5 Nov 2021, in: https://www.ilo.org/global/about-the-ilo/newsroom/news/WCMS_826717/lang--en/index.htm [13 Jun 2023].

92 PIB Delhi 2021: Statement by Prime Minister Narendar Modi at the Glasgow Summit, 11 Nov 2021, in: https://pib.gov.in/PressReleseDetail.aspx?PRID=1768712 [13 Jun 2023].

93 For an external report on India's challenges, see "Powering India's Power Vision 2030." https://www.adlittle.com/sites/default/files/reports/ADL_Indias_energy_vision_2030_2022.pdf [13 Jun 2023].
94 Alam, Shafiqul 2023: Cross-border electricity trade among BBIN countries offers mutual benefits, IEEFA, 28 Feb 2023, in: https://ieefa.org/resources/cross-border-electricity-trade-among-bbin-countries-offers-mutual-benefits [13 Jun 2023].
95 The report says: "The BBIN region offers variability in demand for energy. For example, during December, January and February, Bhutan has a high demand for electricity as opposed to low demand from June to September of the year […]. Comparably, Nepal has high energy demand from January to February. As a result, Nepal and Bhutan, predominantly dependent on hydropower, face power capacity shortages due to water scarcity during winter. The scenario for Bangladesh is the opposite, as it has high energy demand from April to June and a significantly lower requirement from November to February. Some regions of India have high electricity demand from January to March or October to December. Hence, countries in the BBIN region can complement each other and meet individual energy requirements based on their demand profiles and current power system capacities."
96 Alam, Shafiqul, 2023, N.94.
97 The World Bank 2020: Maldives Building Back Better Through Clean Energy, 11 Dec 2020, in: https://www.worldbank.org/en/news/feature/2020/12/11/maldives-building-back-better-through-clean-energy [6 June 2023].
98 Chen, Guanzhe/Jain, Amit/Stolp, Simon 2023: Why the Maldives 5 MW Solar project is a game Challenger, World Bank Blogs, 12 Jan 2023, in: https://blogs.worldbank.org/endpovertyinsouthasia/why-maldives-5-mw-solar-project-game-changer [6 June 2023].
99 SwimSol n.d.a: Offshore floating solar panels at LUX Resort, in: https://swimsol.com/solar-projects/offshore-solar-panels-sea-maldives-lux/ [6 June 2023].
100 The World Bank, 2020, N.97.
101 Maldives Insider 2014: Maldives opens world's first fully solar powered resort, 1 Dec 2014, in: https://maldives.net.mv/12065/maldives-opens-worlds-first-fully-solar-powered-resort/ [6 June 2023].
102 President's Office 2020: President Ibrahim Mohamed Solih Outlines Maldives' Climate Commitments at Climate Ambition Summit, 12 Dec 2020, in: https://presidency.gov.mv/Press/Article/24110 [6 June 2023].
103 President's Office 2020: Remarks Delivered by His Excellency President Ibrahim Mohamed Solih at the 2020 Climate Ambition Summit, 12 Dec 2020, in: https://presidency.gov.mv/Press/Article/24111 [6 June 2023].
104 Chen, 2023, N.98.
105 Ibid.
106 Ibid.
107 Ibid.
108 Ibid.
109 The World Bank, 2020, N.97, p.4.
110 Mohamed, Shahudha 2022: Solar panel installation on Hulhule-Hulhumale highway begins, Atoll Times, 24 Oct 2022, in: https://atolltimes.mv/post/news/832 [6 June 2023].
111 Cliamte Investment Funds (CIF) 2020: MALDIVES: POISED ON THE ROAD TO RENEWABLES, CIF, 22 Jul 2020 in: https://www.cif.org/news/maldives-poised-road-renewables [6 June 2023].
112 The World Bank, 2020, N.94, p.4.
113 Ibid.
114 PSM News 2023: Solar panel installation on Hulhulé-Hulhumalé link road nears completion, 10 Apr 2023, in: https://psmnews.mv/en/119392 [6 June 2023]
115 Ministry of Environment, Climate Change and Technology 2016: Preparing Outer Islands for Sustainable Energy Development (POISED), 2 Aug 2016, in: https://www.environment.gov.mv/v2/en/project/304 [6 June 2023]
116 STELCO 2022: Rooftop Solar Installation on K.Gaafaru Powerhouse, 16 Mar 2022, in: https://stelco.com.mv/archives/9473 [6 June 2023]
117 Ibid.
118 RaajjeMV 2020: STELCO introduces their Green Life Solar Pod, 31 Dec 2020, in: https://raajje.mv/92944 [6 June 2023]
119 PSM News 2022: STELCO launches Avikatha rooftop solar project, 20 Jun 2022, in: https://psmnews.mv/en/104679 [6 June 2023]
120 SwimSol n.d.b: RECENT SWIMSOL SOLAR ENERGY PROJECTS, in: https://swimsol.com/solar-projects-offshore-solarsea-and-rooftop/ [6 June 2023]
121 Ibid.
122 SwimSol, n.d.a, N.99.
123 Renewable Energy – Maldives (REM) n.d.: Home, in: https://renewableenergymaldives.com.mv [6 June 2023]
124 Ibid.
125 Avi Tech n.d. : Avi Technologies, in: https://avitech.com.mv/about [6 June 2023]
126 Ibid.
127 Avi Tech n.d. : Projects, in: https://avitech.com.mv/projects [6 June 2023]
128 Addu High School 2023: Interview, May 2023.
129 Ecogreen Maldives n.d.: Projects, in: https://ecogreenmaldives.com/#projects [6 June 2023]
130 Sajid, Ali 2023: Interview, Eco Green Director/Engineer, 15 Apr 2023.
131 The World Bank, 2020, N.97.
132 ADB 2020: Hydropower Development and Economic Growth in Nepal, Jun 2020, in: https://www.adb.org/publications/hydropower-development-economic-growth-nepal [10 May 2023].
133 Maharjan, Nasala 2021: Time for a renewable energy dialogue in Nepal, Nepal Economic Forum, 14 Jul 2021, in: https://nepaleconomicforum.org/time-for-a-renewable-energy-dialogue-in-nepal/ [21 Apr 2023].
134 Rijal, Prahlad 2019: Nepal's gasoline consumption almost doubles in five years, The Kathmandu Post, 30 Apr 2019, in: https://kathmandupost.com/money/2019/04/30/nepals-gasoline-consumption-almost-doubles-in-five-years [2 May 2023].
135 UNFCCC 2021: Nepal's Long-term Strategy for Net-zero Emissions, 31 Oct 2021, in: https://unfccc.int/sites/default/

files/resource/NepalLTLEDS.pdf [16 May 2023].

136 Rai, Nirjan/Neupane, Saumitra/Lama, Saurab 2021: Political Economy of Mainstreaming Renewable Energy in Nepal, Nepal Renewable Energy Programme, Jun 2021, in: https://pei.center/wp-content/uploads/2022/06/Political-Economy-of-Mainstreaming-Renewable-Energy-in-Nepal.pdf [5 Apr 2023].

137 Republica 2023a: Tapping surplus electricity for prosperity, 18 Apr 2023, in: https://myrepublica.nagariknetwork.com/news/tapping-surplus-electricity-for-prosperity/ [5 Apr 2023].

138 Ibid.

139 Republica 2023b: Import of LPG sees a decline, 24 Mar 2023, in: https://myrepublica.nagariknetwork.com/news/import-of-lpg-decreases/ [5 Apr 2023].

140 WECS 2013: NEPAL: National Energy Strategy of Nepal 2013, Water and Energy Commission Secretariat, Government of Nepal, in: https://policy.asiapacificenergy.org/node/3783 [6 Jun 2023].

141 AEPC 2023: Alternative Energy Promotion Centre, in: https://www.aepc.gov.np [10 Apr 2023].

142 Sunuwar, Yashoda 2023: Nepal's electricity production capacity hits over 2,577 MW, Urja Khabar, in: https://www.urjakhabar.com/en/news/0803570866 [15 May 2023].

143 Rebpulica 2023c: Nepal within an inch of transforming into electricity self-reliant economy, 16 May 2023, in: https://myrepublica.nagariknetwork.com/news/nepal-within-an-inch-of-transforming-into-energy-self-reliant-economy/ [16 May 2023].

144 Ibid.

145 ADB 2017: Nepal Energy Sector Assessment, Strategy, and Road Map, Aug 2017, in: https://www.adb.org/publications/nepal-energy-strategy-roadmap [19 Apr 2023].

146 Rebpulica 2023c, N.143.

147 WECS 2022: Energy Sector Synopsis Report 2021/2022, Nepal in Data, Water and Energy Commission Secretariat, Government of Nepal, Jun 2022, in: https://wecs.gov.np/source/Energy%20Sector%20Synopsis%20Report%2C%202022.pdf [21 Apr 2023].

148 Ibid.

149 Nepal 2022: NDC Nepal, 1 Jun 2022, in: https://unfccc.int/documents/494823 [21 Apr 2023].

150 WECS 2017: Electricity Demand Forecast Report (2015-2040), Water and Energy Commission Secretariat, Government of Nepal, Jan 2017, in: https://moewri.gov.np/storage/listies/May2020/electricity-demand-forecast-report-2014-2040.pdf [10 Apr 2023].

151 Ghimire, Pratik 2022: InDepth: Will there be demand for Nepal's excess electricity?, The Annapurna Express, 23 Jul 2022, in: https://theannapurnaexpress.com/news/indepth-will-there-be-demand-for-nepals-excess-electricity-7218 [25 Apr 2023].

152 Shrestha, Prithvi Man 2022: Nepal makes over Rs11 billion selling power to India, The Kathmandu Post, 21 Dec 2022, in: https://kathmandupost.com/national/2022/12/21/nepal-makes-over-rs11-billion-selling-power-to-india [25 Apr 2023].

153 Rebpulica 2023c, N.143.

154 Ibid.

155 Rebpulica 2023d: Nepal and Bangladesh to discuss investment modality for construction of Sunkoshi-3 Hydropower Project, 12 May 2023, in: https://myrepublica.nagariknetwork.com/news/nepal-and-bangladesh-to-discuss-investment-modality-for-construction-of-sunkoshi-3-hydropower-project/ [5 Apr 2023].

156 Rebpulica 2023e: Nepal and Bangladesh holding a bilateral energy talk in Dhaka in the second week of May, 9 Apr 2023, in: https://myrepublica.nagariknetwork.com/news/nepal-and-bangladesh-holding-a-bilateral-energy-talk-in-dhaka-in-the-second-week-of-may/ [5 Apr 2023].

157 The Express Tribune 2023: Solar grids bring relief to Sindh, 13 April 2023, in: https://tribune.com.pk/story/2411592/solar-grids-bring-relief-to-sindh [7 June 2023].

158 Finance Division, Government of Pakistan 2022: Pakistan Economic Survey 2021-22, p. 260, in: https://www.finance.gov.pk/survey/chapter_22/Economic%20Survey%202021-22.pdf [7 June 2023].

159 Ibid, p. 261.

160 Ibid.

161 Ibid.

162 Ibid.

163 International Trade Administration n.d.: Pakistan - Country Commercial Guide, in: https://www.trade.gov/country-commercial-guides/pakistan-renewable-energy [7 June 2023].

164 Finance Division, Government of Pakistan, 2022, N.158, p. 262.

165 Aslam, Hina/Nazir, Ahad/Zie, Ubaid ur Rehman 2022: Annual State of the Renewable Energy Report Pakistan 2021-22, Sustainable Policy Development Institute (SDPI), 7 Dec 2022, p.18, in: https://sdpi.org/annual-state-of-renewable-energy-report-pakistan/publication_detail [7 June 2023].

166 Power Division (Ministry of Energy) n.d.: Year Book 2021-2022, p.55, in: https://power.gov.pk/SiteImage/Publication/YEAR%20BOOK%202021-22%20(1).pdf [7 June 2023].

167 Aized, Tauseef/Rehman, Syed Muhammad Sohail/Kamran, Sajid et al. 2019: Design and analysis of wind pump for wind conditions in Pakistan, p.4, in: https://journals.sagepub.com/doi/pdf/10.1177/1687814019880405 [8 June 2023].

168 IRENA 2020: Global Renewables Outlook: Energy Transformation 2050, April 2020, p. 27, in: https://www.irena.org/publications/2020/Apr/Global-Renewables-Outlook-2020 [7 June 2023].

169 Indicative Generation Capacity Expansion Plan (IGCEP) 2021-30, pp. 22-23, in: https://nepra.org.pk/ [7 June 2023].

170 CDKN n.d: Greenhouse Gas Mitigation Options for Pakistan: Energy Sector, in: https://cdkn.org/sites/default/files/files/fact-sheet-Pakistan-Energy-sector-.pdf [7 June 2023].

171 Finance Division, Government of Pakistan, 2022, N.158, p. 261.

172 CDKN, n.d., N.170.

173 Finance Division, Government of Pakistan, 2022, N.158, p. 261.

174 Knight, Oliver 2021: Huge potential for solar and wind in Pakistan, World Bank Blogs, 22 Feb 2021, in: https://blogs.

worldbank.org/energy/huge-potential-solar-and-wind-pakistan [7 June 2023].

175 HelioSCSP 2019: Azelio signs MOU for reliable electricity supply in Pakistan, in: https://helioscsp.com/wp-content/uploads/2015/12/pakistan-dni.jpg [8 June 2023].

176 SDPI 2022: SDPI Renewable Energy Report, p. 27, in: https://sdpi.org/ [7 June 2023].

177 Pakistan Council of Renewable Energy Technologies, in: http://www.pcret.gov.pk/ [7 June 2023].

178 Government of Pakistan 2019: Alternate Renewable Energy Policy 2019, in: https://www.aedb.org/images/Draft_ARE_Policy_2019_-_Version_2_July_21_2019.pdf [7 June 2023].

179 Power Division (Ministry of Energy) n.d., N.166.

180 Aslam et al., 2022, N.165.

181 SDPI 2022, N.176.

182 Ministry of Planning, Development and Reform n.d.: Pakistan 2025: One Nation, One Vision, in: https://policy.asiapacificenergy.org/node/2910 [7 June 2023].

183 Aslam et al., 2022, N.165.

184 AEDB n.d.: AE technologies – Wind, in: https://www.aedb.org/ae-technologies/wind-power/wind-re [7 June 2023].

185 The Express Tribune 2023, N.157.

186 IGCEP dictates the integration of renewables based on different growth-based scenarios. The IGCEP was formulated by the NTDC and is subjected to the approval by NEPRA on a recurring basis.

187 Indicative Generation Capacity Expansion Plan (IGCEP) 2022-31, p.2, in: https://nepra.org.pk/ [7 June 2023].

188 Ibid.

189 Power Division (Ministry of Energy) n.d., N.166.

190 Ibid, p.53.

191 Salman, Siddiqui 2022: Pakistan eyes 14,000 MW Clean Energy, The Express Tribune, 18 Apr 2022, in: https://tribune.com.pk/story/2412426/pakistan-eyes-14000mw-clean-energy [7 June 2023].

192 Ghuman, Mushtaq 2023: Army decides to solarise its cantonments, in Business Recorder, 6 Mar 2023, in: https://www.brecorder.com/news/40229771 [7 June 2023].

193 The Express Tribune 2023, N.157.

194 Salman, 2022, N.191.

195 AEDB n.d.: USAID, in: https://www.aedb.org/international-cooperation/usaid [7 June 2023].

196 AEDB n.d.: ADB, in: https://www.aedb.org/international-cooperation/asian-development-bank [7 June 2023].

197 The Express Tribune 2023, N.157.

198 Ibid.

199 The Express Tribune 2022: PM Seeks Turkish Investment in 10,000 MW solar Project, 26 Nov, 2022, in: https://tribune.com.pk/story/2388311/pm-seeks-turkish-investment-in-10000mw-solar-project [7 June 2023].

200 Wijayatunga, Priyantha/Fernando, P. N. 2013: An Overview of Energy Cooperation in South Asia, ADB Working Papers Series, May 2013, p.22, in: https://www.adb.org/sites/default/files/publication/30262/overview-energy-cooperation-south-asia.pdf [7 June 2023].

201 Mittha, Maroof 2021: Renewable Energy Policy in Pakistan: A Critique, Courting The Law, 19 Apr 2021, in: https://courtingthelaw.com/2021/04/19/commentary/renewable-energy-policy-in-pakistan-a-critique/ [7 June 2023].

202 Aslam et al., 2022, N.165.

203 Mittha, 2021, N.201.

204 Interview with Dr. Muzaffar Ali, Chairman Energy Engineering Department, UET, Texila, 4 April 2023.

205 Interview with Dr. Akram Ali, Director HPTI WAPDA, Mangla, 5 April 2023.

206 Interview with Dr. Muzaffar Ali, Chairman Energy Engineering Department, UET, Texila.

207 Interview with Dr. Akram Ali, Director HPTI WAPDA, Mangla.

208 Salman, 2022, N.191.

209 Interview with Asim Riaz, Deputy Director, Ministry of Energy, 4 May 2023.

210 Aslam et al., 2022, N.165, p.9.

211 Ibid. p.6.

212 Panda, Rajiv R. 2022: Transforming Regional Electricity Markets in South and Southeast Asia for a Greener and More Sustainable Future, Clean EDGE Asia, 10 Dec 2022, in: https://www.nbr.org/publication/transforming-regional-electricity-markets-in-south-and-southeast-asia-for-a-greener-and-more-sustainable-future/ [1 May 2023].

213 Jayasooriya, Sanjeevi 2020: Private sector participation vital to meet growing energy needs, Sunday Observer, 19 Jan 2020, in: https://www.sundayobserver.lk/2020/01/19/business/private-sector-participation-vital-meet-growing-energy-needs [7 March 2023].

214 Ministry of Power and Energy 2015: Sri Lanka Energy Sector Development Plan for a Knowledge-based Economy 2015-2025, in: https://www.pucsl.gov.lk/wp-content/uploads/2018/09/ENERGY_EMPOWERED_NATION_2015_2025.pdf [3 March 2023].

215 Sri Lanka Sustainable Energy Authority (SLSEA) 2021: Renewable Energy Resource Development Plan 2021-2026, in: https://www.energy.gov.lk/images/renewable-energy/renewable-energy-resource-development-plan-en.pdf [15 March 2023].

216 Sri Lanka Sustainable Energy Authority (SLSEA): Wind Power, in: https://www.energy.gov.lk/en/renewable-energy/technologies/wind-power [10 March 2023].

217 Sri Lanka Sustainable Energy Authority (SLSEA): Solar Energy, in: https://www.energy.gov.lk/index.php/en/renewable-energy/technologies/solar-energy [5 April 2023].

218 Wijesena, G.H.D./Amarasinghe, A. 2018: Solar Energy and its Role in Sri Lanka, International Journal of Engineering Trends and Technology (IJETT), 65:3, pp. 142-148, here: p. 2, in: https://www.researchgate.net/publication/331064600_Solar_Energy_and_its_Role_in_Sri_Lanka [7 June 2023].

219 Sri Lanka Sustainable Energy Authority (SLSEA): Biomass, in: https://www.energy.gov.lk/index.php/en/renewable-energy/technologies/biomass [05 April 2023].

220 Regional Cooperation Council, EU 2010: Regional cooperation in energy sector – an economic necessity: Newsletter 5/2010 in: https://www.rcc.int/articles/28/regional-cooperation-in-energy-sector-an-economic-necessity [12 May 2023].

221 Panda, 2020, N.212, p.1.

222 World Bank Live Webinar 2022: Towards a Green, Clean and Energy-secure South Asia, 31 Jan 2022, in: https://live.

worldbank.org/regional-power-trade-towards-green-clean-and-energy-secure-south-asia [28 April 2023].

223 Wijenayake, Vositha 2023: Could renewable energy cooperation benefit Sri Lanka's energy sector? 16 Feb 2023, in: https://www.slycantrust.org/post/could-renewable-energy-cooperation-benefit-sri-lankas-energy-sector [27 February 2023].

224 US Agency for International Development (USAID) 2021: Strategy Paper for creation of South Asia Forum for Electricity Market (SAFEM) for promoting cross-border electricity trade, in: https://sari-energy.org/wp-content/uploads/2022/05/Strategy-paper-for-creation-of-SAFEM_Final.pdf [20 April 2023].

225 Asian Development Bank 2017: Harmonizing Electricity Laws in South Asia, 24 Oct 2017, in: https://www.saarcenergy.org/wp-content/uploads/2019/02/1.-ADB-Harmonizing-electricity-laws-in-South-Asia.pdf [11 March 2023].

226 Panda, 2020, N,212, p.1.

227 Ibid.

228 Ministry of External Affairs, Government of India 2010: Treaty Detail – MoU between India and Sri Lanka on the feasibility study for inter-connection of India-Sri Lanka electricity grids, in: https://www.mea.gov.in/TreatyDetail.htm?2221 [26 March 2023].

229 Daily News 2022: India, Sri Lanka sign agreement to build solar power plant in Sampur, 14 Mar 2022, in: https://www.dailynews.lk/2022/03/14/business/274688/india-sri-lanka-sign-agreement-build-solar-power-plant-sampur [25 April 2023].

230 Tennekoon, Sahan 2023: Korea to develop 1st floating solar power plants in SL, The Morning, 31 May 2023, in: https://www.themorning.lk/articles/98VYTIX2qQ6oW9JaDtWJ [01 June 2023].

231 U.S. Department of Commerce 2022: Sri Lanka – Country Commercial Guide, Energy, 13. Dec 2022, in: https://www.trade.gov/country-commercial-guides/sri-lanka-energy [12 March 2023].

232 National Renewable Energy Laboratory (NERL) 2018: Cross-Border Electricity Trade between India and Sri Lanka: Impact on Power System Operations, Dec 2018, in: https://www.nrel.gov/docs/fy19osti/71983.pdf [22 March 2023].

233 Ibid.

234 Cf. Ibid.

235 Griffiths, Steven 2019: Energy diplomacy in a time of energy transition, Energy Strategy Reviews 26, pp. 2-4, here: p.5, in: https://doi.org/khrp [22 March 2023].

236 Wijenayake, Vositha 2023.

237 Cf. Ibid.

238 Wijayatunga, Priyantha/Kolantharaj, Jaimes 2021: Powering Sri Lanka's Clean Energy Transition, Asian Development Bank, 18 Jun 2021 in: https://www.adb.org/news/op-ed/powering-sri-lanka-s-clean-energy-transition-priyantha-wijayatunga-and-jaimes-kolantharaj [03 April 2023].

List of Figures and Tables

List of Figures

List of Tables

Images

1. ‘lin2015’. PublicDomainPictures. (Pixabay). [download]. Available at: https://pixabay.com/photos/wind-turbines-rice-terraces-huaxi-7264973/ [Accessed 11 July 2023]
Appears on p.1 of this study.

2. ‘pond’. armyasad. (Pixabay). [download]. Available at: https://pixabay.com/photos/pond-green-spring-bangladesh-55176/ [Accessed 11 July 2023]
Appears on p.6 of this study.

3. ‘Solar and wind energy pilot sites in Rubesa, Wangdue Phodrang, Bhutan’. Department of Energy, Ministry of Energy & Natural Resources. Available at: https://www.facebook.com/111899110484048/posts/bhutans-first-180kw-pilot-grid-tied-ground-mounted-solar-power-plant-at-rubesa-w/365495328457757/ [Accessed 12 July 2023]
Appears on p.12 of this study.

4. ‘bada-bagh’. Glavo. (Pixabay). [download]. Available at: https://pixabay.com/photos/bada-bagh-temple-cultural-site-3181803/ [Accessed 11 July 2023]
Appears on p.18 of this study.

5. ‘manor-house’. AgEGlobalGroup. (Pixabay). [download]. Available at: https://pixabay.com/photos/manor-house-sri-lanka-hotel-pool-2359884/ [Accessed 11 July 2023]
Appears on p.26 of this study.

6. ‘gokyo-ri’. glorioushimalaya. (Pixabay). [download]. Available at: https://pixabay.com/photos/gokyo-ri-everest-region-lakes-4692458/ [Accessed 11 July 2023]
Appears on p.34 of this study.

7. ‘river’. asad_78. (Pixabay). [download]. Available at: https://pixabay.com/photos/river-neelam-pakistan-valley-2669180/ [Accessed 11 July 2023]
Appears on p.42 of this study.

8. ‘nine-arch-bridge’. Dark_shutterz. (Pixabay). [download]. Available at: https://pixabay.com/photos/nine-arch-bridge-railroad-bridge-5657721/ [Accessed 11 July 2023]
Appears on p.52 of this study.

9. ‘energy’. OpenClipart-Vectors. (Pixabay). [download]. Available at: https://pixabay.com/vectors/energy-wind-engine-power-159105/ [Accessed 11 July 2023]
Appears on p.68 of this study.

Imprint

Date of Publication: September 2023

Cover Illustration:
© Pixabay/lin2015
Other sources indicated accordingly.

Editor:
Dr. Frederick Kliem

Project Coordination:
Timm Anton

Design / Layout Implementation:
Michelle Tsz Ki Tong | With reference to KAS Design Guidelines

The publication was funded by the Federal Ministry of Economic Cooperation of the Federal Republic of Germany (BMZ).

KONRAD ADENAUER STIFTUNG

Konrad-Adenauer-Stiftung e.V.
Regional Programme Energy Security and Climate Change Asia-Pacific (RECAP)
Unit 3712, 37/F, Tower 1,
Lippo Centre, 89 Queensway,
Hong Kong SAR, China

Contact:
Dr. Frederick Kliem
+852 2882 2949
recap@kas.de
www.kas.de/recap
www.facebook.com/kasrecap
www.twitter.com/recapasia
www.instagram.com/kasrecap/
www.linkedin.com/company/kasrecap

Konrad-Adenauer-Stiftung e. V.
Regional Programme Energy Security and
Climate Change Asia-Pacific (RECAP)

kas.de/recap
fb.com/kasrecap
twitter.com/recapasia
instagr.am/kasrecap
linkedin.com/company/kasrecap