Dialogue Social Science Review (DSSR)

www.thedssr.com

ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 3 No. 2 (February) (2025)

Wind Energy Integration into the SAARC Region: A Comprehensive Review of Optimal Wind Sites for a Sustainable Super Smart Grid

Basit Ahmad (Corresponding Author)
Department of Electrical Engineering, NFC (Institute of Engineering and Technology) Multan. Email: basitahmad3884@gmail.com

Dr. Saqib Ali
Department of Electrical Engineering, University of Zagreb, Croatia.
Email: Sali@fsb.hr

Maryam Muneer
Department of Electrical Engineering, National University of Computer and Emerging Sciences, Chiniot-Faisalabad Campus. Email: engrmaryammuneer44@gmail.com

Arooj Fatima
Department of Electrical Engineering, University of Engineering and Technology, Lahore. Email: aroojfatimah@gmail.com

Naveed Abbas
Department of Electrical Engineering Technology, Karakoram International University, Gilgit, Pakistan. Email: Naveedhaider416@gmail.com

Abstract
Approximately 25% of global population residues in South Asia. The power generation of these population relies heavily on Non-renewable energy sources, resulting in large greenhouse gases emission into the atmosphere. In order to protect the environment, the SAARC countries has decided to construct an extremely intelligent smart grid to share electricity across SAARC nations based on sustainable energy sources but the ability of these nations to develop such a super power grid is unclear because of the absence of Effective strategic assessment and an insufficient information about the potential sites of RERs. This review delivers an extensive impression of the wind energy and identify the exact locations of high wind potential within the SAARC region. We use wind speed readings, satellite data, and geographic information systems (GIS) to give an in-depth investigation of wind patterns and yearly changes in wind resources across member countries. The research further investigates numerous socioeconomic factors affecting wind energy development and discussing obstacles like infrastructure limits, financial difficulties, and laws and regulations. Successful case of public-private alliances and worldwide collaboration are showcase to illustrate pathways for growth. The result of this research provides different perspectives to policy makers and practitioners for strategic decisions regarding SAARC super smart grid.

Dialogue Social Science Review (DSSR)

www.thedssr.com

ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 3 No. 2 (February) (2025)

Keywords: Wind potential sites, Super smart grid, Fossil fuels, World-wide collaboration, SAARC, Strategic decisions.

Introduction

The South Asian Association for Regional Cooperation (SAARC) is an international diplomatic organization composed of eight member republics: Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka [1]. Pakistan and the South Asian nations covers 3.5% of the Earth's geographical territory and accommodates 25% of the global population [2]. In order to generate electricity these nations utilizes significant quantities of non-renewable resources, leading to numerous issues, including the depletion of fossil fuels, rising fuel prices, reduced human lifespan, and the continual discharge of hazardous pollutants throughout the whole environment [3]. South Asia has a large number of sustainable energy resources that may be exploited to supply its electricity demands in an environmentally friendly manner for hundreds of years. Figure 1 displays the overall possible of reusable dynamism in the SAARC area.

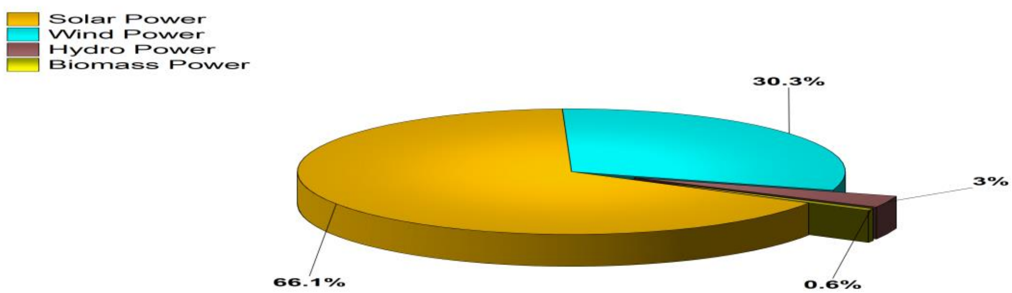


Figure 1: Total Renewable Potential in SAARC Region [4].

Pakistan has a mounted power volume of 38,573 MW [5]. Natural gas, hydropower, coal and furnace oil are important source of energy generation. However, more than 25 million citizens in Pakistan are without access to electricity. Most of Pakistan's electricity comes from burning fossil fuels [6]. India has an operational capacity of 383,325.95 MW. India presently books for additional 79% of South Asia's entire energy consumption. Over 50% of the petroleum cast-off for dynamism generation is coal [7]. The exhaustion of fossil fuels may result in significant challenges, including difficulty in satisfying demand [8]. In Bangladesh, the installed power generation capacity was 22,023 MW, mostly sourced from gas, furnace oil, coal, and diesel generators [9]. Bangladesh imports approximately 20% of power from India [10]. Bangladesh cannot fulfill its growing energy demands without heavily depending on fossil fuels. However, when fossil fuels deplete, significant challenges may arise, including the need to import expensive fuels, an escalation in carbon dioxide emissions, and inefficiencies associated with the combustion of fossil fuels [11]. In Srilanka, the installed power production capacity was 4265 MW. Furnace oil is the primary source of power generation. Srilanka imports expensive oil from other countries to generate energy [12]. In 1969, the Sri

Dialogue Social Science Review (DSSR)

www.thedssr.com

ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 3 No. 2 (February) (2025)

Lankan prime minster Sirima Bandaranaike took a significant step and established **Ceylon Electricity Board**. **The main role of CEB was to enhance the efficiency of** power generation and transmission**.** In Afghanistan, the total build-in electricity generation capacity was 1,467 MW, including 426 MW from hydroelectric sources, 376 MW from gas, 365 MW from renewable energy, and 300 MW from coal [13]. In 2011, Afghanistan ranking lies lowest on globally per capita power usage. Utilizing renewable energy resources is an excellent method to aid Afghanistan in addressing its energy difficulties and environmental challenges [14]. In Maldives, 60% of the total power, 400 MW, produced across all island settlements is offset by the current capacity of 87.7 MW, using 375 MUs compared to 285 MUs from outside territories [15]. The Maldives relies on imports of gasoline and oil to provide almost all of its electricity requirements [16]. In Bhutan, hydroelectric power dominates the nation's energy portfolio with a capacity of 2,334 MW. The diesel generator generate 19 MW and wind energy at 2 MW [17][18]. In Nepal, hydropower is the main source of power production almost 90%. The power distribution system of Nepal is not very good that's why only 66% of Nepal population connected to power stations. Carbon dioxide (CO_2) is a major greenhouse gas released from fossil fuel-based electricity production [19]. Table 1 summarize CO_2 emissions in SAAR region [20]. The majority of the power production is dependent on fossil fuels. Furthermore, solar, wind, and biomass power's actual installed capacity is very small in comparison to their overall attainable potential.

Table 1: The SAARC region's potential for renewable energy and CO_2 emissions

	Built-in capacity	**Exhaust (kg/MWh)**	**Power Production hours**	**Overall Exhaust (million kg)**	**Percent of CO_2 Exhaust**	**Total renewable energy potential (MW)**
Oil/Diesel	21320 MW	900	720	13,815	5.37%	-
Coal	212637 MW	1,300	720	199,028	77.37%	-
Nuclear	8329 MW	35	720	210	0.08%	-
Natural gas	49754 MW	1,000	720	35,823	13.93%	-
Power Hydro	62308 MW	20	720	897	0.35%	**385,769**

power						
Wind power	34167 MW	41	720	1,009	0.39%	**3,887,288**
Solar power	39904 MW	190	720	5,459	2.12%	**8,484,358**
Biomass	10539 MW	130	720	986	0.38%	**70,712**
Total	**438,958MW**			**257,228**		**12,828,127**

The Super Smart infrastructure is a large-scale power infrastructure that is being proposed as a means of connecting Europe to the IPS/UPS systems in the CIS countries, the Middle East, and Northern Africa [22]. An SSG is a complex dynamism supply and diffusion system intended to efficiently convey considerable amounts of electricity transversely widespread spaces, often covering areas or whole zones. The SAARC super smart grid will tackle the many issues faced by power networks in South Asia. These problems contain substantial load flaking, inadequate power supply in many areas, and the release of toxic substances that contaminate the environment and lead to several illnesses. The main resources for energy group in the SAARC area are natural gas, oil, coal, and hydroelectric power [23]. The increased usage of fossil fuels produces several problems, including antagonistic things on human well-being and heightened CO_2 emissions in the global environment. The production and delivery of electricity via renewable energy sources may successfully mitigate these issues in future years.

With a rapidly growing population and increasing energy demands, the SAARC nations face immense challenges in balancing energy needs with environmental protection. The heavy reliance on fossil fuels in the region has led to environmental degradation, including rising CO_2 emissions and air pollution, which subsidize to worldwide weather change and harm public health. By focusing on maintainable dynamism solutions, the region has the potential to reduce its dependence on non-renewable resources and mitigate the long-term negative effects on both the economy and the environment. Harnessing renewable energy sources such as solar, wind, and hydropower could significantly enhance energy security, reduce carbon footprints, and support the region's commitment to meeting international climate targets. The implementation of a Super Smart Grid infrastructure could further streamline energy distribution, promote regional cooperation, and ensure a more reliable, equitable, and efficient energy system. The significance of this research lies in its potential to inform policymakers, industry stakeholders, and international organizations about the urgent need for transition

Dialogue Social Science Review (DSSR)

www.thedssr.com

ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 3 No. 2 (February) (2025)

strategies toward renewable energy in the SAARC region, which would not only address local challenges but also contribute to global sustainability goals

SAARC	South Asian Association for Regional Cooperation	NTPC	National Thermal Power Corporation
RERs	Renewable Energy Resources	MOU	Memorandum of Understanding
SSG	Super Smart Grid	WNREDA	West Bengal Renewable Energy
CIS	Commonwealth of Independent States	WBGEDC	West Bengal Green Energy
CO2	Carbon Dioxide	CEB	Ceylon Electricity Board
CPPA-G	Central Power Purchasing Age	RFP	Request for Proposal
HVDC	High Voltage Direct Current	DOE	United State Department of Energy
GOP	Government of Pakistan	USAID	U.S Agency International Development
AEDB	Alternative Energy Development Board	GIS	Geographic Information System
PMD	Pakistan Meteorological Department	ACEP	Afghanistan Clean Energy Program
KAMM	Karlsruhe Atmospheric Mesoscale Model	WRAP	Wind Resource Assessment Program
LULC	Land Use Land Cover	WEST	Wind Energy Study Project
AWFS	Advanced Wide Field Sensor	WBHPP	West Bengal Hydro-Power Project
CUF	Capacity Utilization Factor	NSB	National Stock Exchange of Bhutan
CWET	Centre for Wind Energy Technology	EEZ	Exclusive Economic Zone
PLF	Plan Load Factor	VR	Virtual Reality
CDM	Clean Development Mechanism	CCT	Critical Clearance Time

Pakistan

In order to ensure that the nation's fundamental electrical needs may be satisfied with the assistance of renewable energy sources, the government of Pakistan has made the decision to establish wind power projects throughout the whole country. The scientist M. Jibran from the Pakistan Meteorology Department performed research revealing that the coasts of Sindh and Balochistan, together with selected regions of the northern

Dialogue Social Science Review (DSSR)
www.thedssr.com
ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 3 No. 2 (February) (2025)

provinces, has significant potential for wind generation [24]. The PMD analysis indicates that some areas in Balochistan, including as Gwadar and Makran, as well as places in Sindh, including Thatta, Karachi, Jamshoro, and Badin, are optimal locations for wind energy in Pakistan [25].
The district Karachi, Thatta, Badin, and Jamshoro, are divided into four regions (zones) are shown in Figure 2. In this paper we examined and assessed, monthly and seasonal wind speed patterns for each zone.

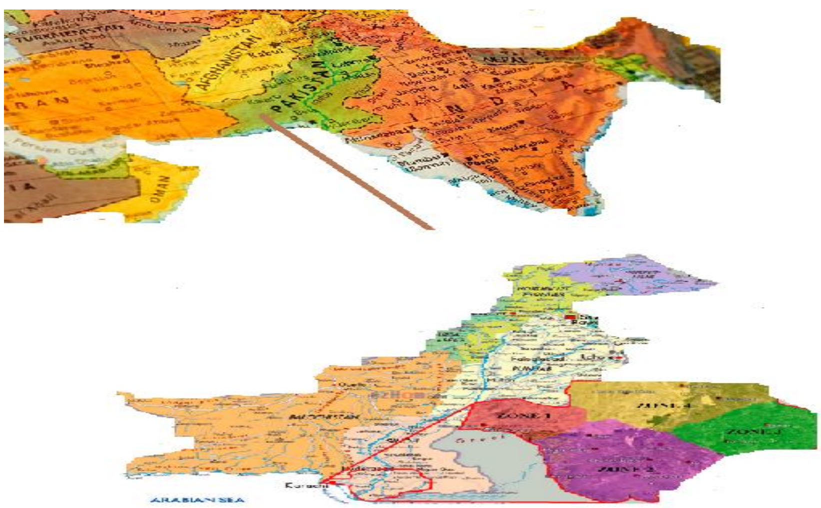


Figure 2: An Examination of Four Separate Regions of Sindh [26].

Wind Potential in Southern Sindh

Region 1_ Karachi

Region 1 is divided into Karachi and Hawke's Bay. At an elevation of 50 m, the mean wind velocity at Hawke's Bay and the Karachi (DHA site) was 5.47 m/s and 5.98 m/s. During the monsoon season, DHA Karachi and Hawke's Bay saw the highest average wind speed in July [27]. The greatest speed recorded for Hawke's Bay was 7.1 m/s, whereas the maximum speed recorded for DHA Karachi was 9.0 m/s, as shown in Figure 3. The lowest wind speeds recorded in November were 3.6 m/s in DHA Karachi and 3.2 m/s in Hawke's Bay.

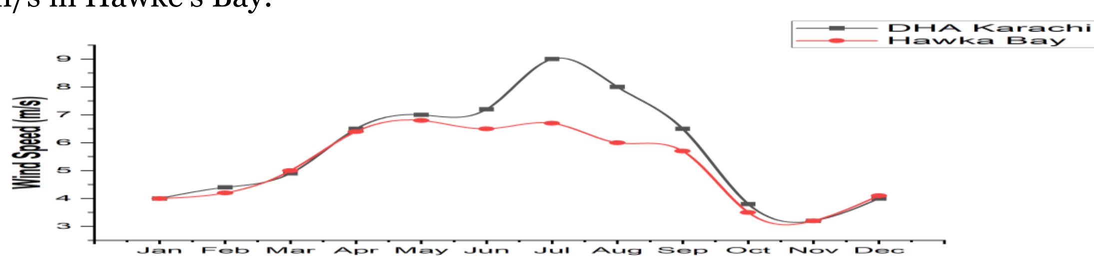


Figure 3: Yearly Wind Velocity for Region 1 (Karachi) [27]

Region 2_ Thatta

Dialogue Social Science Review (DSSR)
www.thedssr.com
ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 3 No. 2 (February) (2025)

Region 2 is divided into Shah Bandar, Mirpur Sakro, Chuhar Jamali, Gharo, Jati, Keti Bandar, and Sajawal. Chuhar Jamali has the minimal mean wind velocity in Zone 2, at 5.8 m/s, Although Keti Bandar has the maximal mean velocity of 7.1 meters per second [28][29]. Gharo and Mirpur Sakro, on the other hand, have the minimal and maximal monthly wind velocity, with 3.8 meters per second and 10.7 meters per second, respectively, as shown in Figure 4.

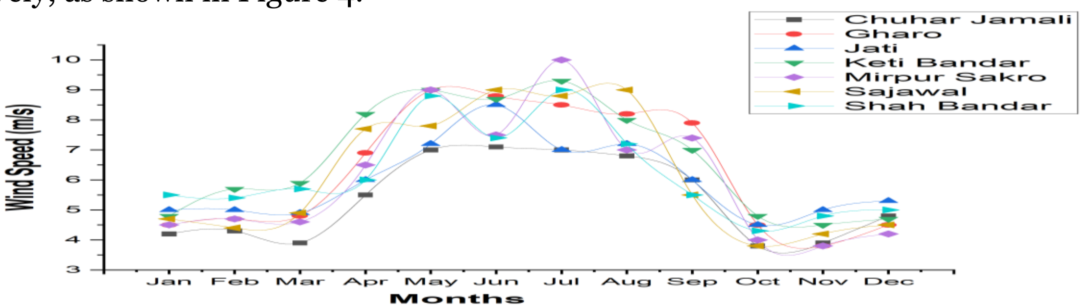


Figure 4: Yearly Wind Velocity for Region 2 (Thatta) [26].

Region 3_ Badin

Region 3 consists of Golarchi and Talhar. At an elevation of 50 meters, the mean wind speed was 6.7 m/s in Golarchi and 6.3 m/s in Talhar. In June, Talhar recorded a peak speed of 10.3 m/s, while Golarchi maintained a maximal speed of 9.4 m/s in both June and July [30]. Figure 5 presents comparison of wind velocities between the two regions.

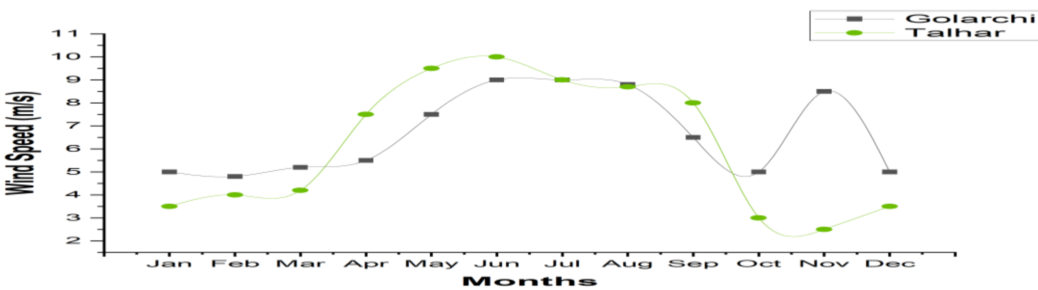


Figure 5: Yearly Wind Velocity for Region 3 (Badin) [26].

Region 4_ Jamshoro:

This region comprises Jamshoro, Nooriabad, and Thano Bula Khan. Figure 6 demonstrates that Jamshoro, Nooriabad, and Thano Bula Khan had peak wind speeds of 14.9, 11.6, and 10.8 m/s, respectively, whilst the minimum wind speeds recorded were

Dialogue Social Science Review (DSSR)
www.thedssr.com
ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 3 No. 2 (February) (2025)

5.2, and 3.7 m/s.

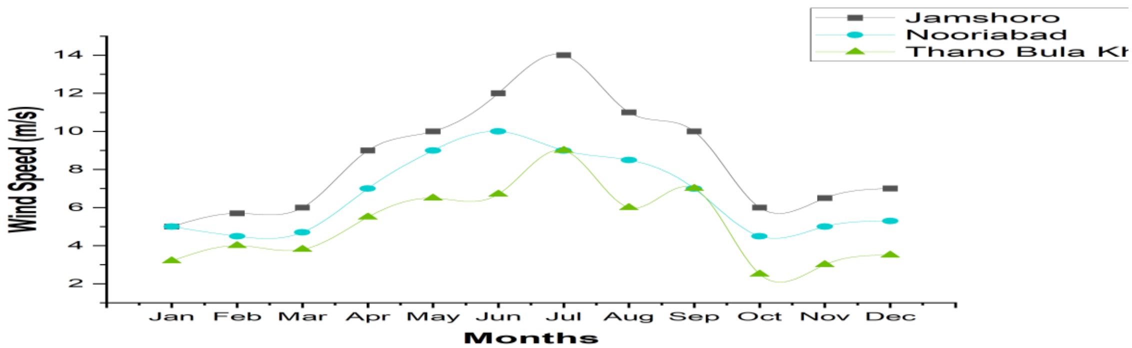


Figure 6: Yearly Wind Velocity for Region 4 (Jamshoro) [26].

Wind potential in Southern Balochistan

Balochistan is situated in the southern part of Pakistan. This is one of the most potential locations for wind energy development in the country. Balochistan wind energy potential is projected to be approximately 50,000 MW [31]. The Jeevani and Gwadar areas in Balochistan situated near the coastal strip are the most notable wind corridors. These sites have regular wind speeds of more than 7 m/s, making them suitable for wind energy harvesting. In 2017, a 50MW wind power plant was established and become operational in Jeevani [32]. The **Lasbela** district is another area with high wind potential due to its location near the coast and consistent wind patterns. Several wind energy projects are already operational in Balochistan, such as the **Jeevani Wind Power Project** and **Gwadar Wind Power Project.** The Sindh-Balochistan Wind Corridor, which covers from the south of Sindh to the north of Balochistan, has been highlighted as a key area for future wind farm development.

India

The mean yearly power offered per square meter of the area swept by the turbine is known as the wind speed density [33]. It is expressed in W/m2 and quantitatively evaluated at different elevations above mean ground level (AGL) [34]. In April 2010, the nationwide department of wind energy released a detailed wind atlas with a 5-kilometer resolution for different hub heights. The states anticipated to have the highest wind speed are Gujrat and Karnataka, with predicted capacities of 21.59 gigawatts and 17.5 gigawatts, respectively, within a wind speed density of 400–500 W/m² [35]. Most states have low wind speed density less than 100 W/m² like Andaman & Nicobar, which has a wind speed of 0.004 gigawatts.

A State-by-State Perspective on Wind Power:

Tamil Nadu

Tamil Nadu was India's first state to use wind power [36]. The Tamil state serves as a central hub for wind energy in India because of its pro-wind policies from the beginning of the Indian wind energy program. In 28 March 1999, the first wind farm with 250-KW was built in this state. A wind farm with a 250-KW turbine was built by M/s. Pandian on

ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 3 No. 2 (February) (2025)

March 28, 1990 [37]. It was the first wind farm in India built by a private company. Tamil Nadu has once again shown achievement in 2011 by establish 1,183 MW of wind farm in a single year [38].

Gujarat

In 1979, the public administration recognized the Gujarat Energy Development Agency (GEDA), which is similar to MEDA [39]. The first wind farm of Gujarat was established in 1985. The State actively promotes investment in wind energy by implementing several incentives, including elevated feed-in tariffs, as well as energy wheeling and banking provisions. In July 25, 2013 A state government introduce new wind power policy [40]. This new strategy is very beneficial for new investors in the field of wind energy.

Karnataka

The state of Karnataka has the greatest number of wind farms due to its complex terrain, mountains and small rives. This state have a large number of small and large wind mills. Among the state's major wind energy sites are Chirtadurga, Dharwad, Gadag and Belgaum. Chitradurga, which has over 20,000 wind turbines, is claimed to have India's highest Plant Load Factor (PLF) [41]. Chitradurga has an average PLF of 34%, which is much higher than other states' sites [42].

Maharashtra

After Tamil Nadu, Maharashtra ranks second in India for wind energy sector. The total installed capacity of Maharashtra was 4,098 MW [43]. Satara, Sangli, Dhule, and Panchgani are the major cities in Maharashtra with a large number of wind farms [44]. In 1980, the Maharashtra government established Maharashtra Energy Development body (MEDA) [45]. The main role of MEDA is to increase connected volume based on sustainable energy sources specially wind energy.

West Bengal

In 1993, the WNREDA has been established to promoting renewable energy projects and creating an enabling environment for their commercialization in the state [46]. Currently, only 1.1 MW of wind power is active in the state. In 2009, the WBGEDC planned a 40-50 MW wind power project to enhance the proportion of wind energy in West Bengal's energy mix [47]. This initiative, designated for 1,450 acres in the backwaters of the Bay of Bengal in Dadanpatra, Purba Medinipur district, seeks to substantially enhance the state's renewable energy potential. Table 2 shows the State wise yearly capacity increase.

Table 2: State wise annual capacity addition [41].

State	Gujarat	Karnataka	Maharashtra	West bengal	Tamil nadu	Others
UP TO MARCH'2002	181.4	69.3	400.3	1.1	877	3.2

2002-03	6.2	55.6	2	0	133.6	0
2003-04	28.9	84.9	6.2	0	371.2	0
2004-05	51.5	201.5	48.8	0	675.5	0
2005-06	84.6	143.8	545.1	0	857.55	0
2006-07	283.95	265.95	485.3	0	577.9	0
2007-08	616.36	190.3	268.15	0	380.67	0
2008-09	313.6	316	183	0	431.1	0
2009-10	297.1	145.4	138.9	0	602.2	0
2010-11	312.8	254.1	239.1	0	997.4	0
2011-12	789.9	206.7	416.5	0	1083.5	0
2012-13	208.3	201.7	288.5	0	174.6	0
2013-14	239.4	273.8	1076.2	0	113.8	0
TOTAL	3414	2409	4098	1.1	7276	3.2

Srilanka

Sri Lanka is an island country southeast of India. It has an area of about 65,610 square kilometres and more than 19 million people live there. Colombo is the industrial hub and the capital of Sri Lanka [48]. In 2001, more than 70% of the nation's energy demand was met by hydroelectric power plants. Victoria, Kotmale, and Randenigala are the three largest hydroelectric power plants, together contributing around 80% of the hydroelectric electricity in the energy mix [49]. In July 2001, research conducted by the NREL on the viability of wind power in Sri Lanka is a significant step towards the development of the country's renewable energy resources. NREL indicate that Sri Lanka has substantial wind energy potential in two main areas. First is the northwest coastal region, which contains Kalpitiya, Mannar, and Jaffna. Central highlands are another location with moderate wind speeds, including parts of Uva, Sabaragamuwa, and Central Provinces [50].

Wind Mapping of Srilanka

Southeastern Coastline

The southeastern coastline between Hambantota and Buthawa has garnered more attention than any other coastline in the country due to its too **high wind potential. The first wind farm of srilanka (3-MW) is also located in Hambantota [51].** Wind power equipment may be transported in this region more easily than in any other parts of the country. CEB successfully delivered 600-kW turbines to Hambantota as part of the pilot project construction [52].

Western Coastline

At a height of 40m, the NREL conducted a research between 2000 and 2001 and reveal that the mean wind speed of western coastline (Kalpitiya Peninsula) is 7.13m/s [53]. This shows that the western coastline has a great potential for generating wind energy. The NREL maps demonstrate that an excellent wind resource potential is present in the

Dialogue Social Science Review (DSSR)
www.thedssr.com
ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 3 No. 2 (February) (2025)

northern portion of the peninsula and nearby islands. The Kalpitiya Peninsula consists of mostly flat sandy areas that sustain low-lying flora and some coconut plantations [54]. The southwest and northeast monsoon winds are very strong in this area. The area doesn't have any national parks or reserves, and there is plenty of land for big wind power projects.

Northern Coastline

The Jaffna District is located in the northern region of Sri Lanka. NREL maps indicate that the wind resource potential of northern coastline (District Jaffna) is excellent, signifying robust wind potential [55]. The regional war in northern Sri Lanka has significantly impacted Jaffna. Because of this, the region's roads and electrical systems have been harmed [56]. As for Mannar Island, developing wind power probably won't be conceivable in the near upcoming until the area is stabilized and the infrastructure is fixed and improved. Figure 7 shows the area of northern coastline.

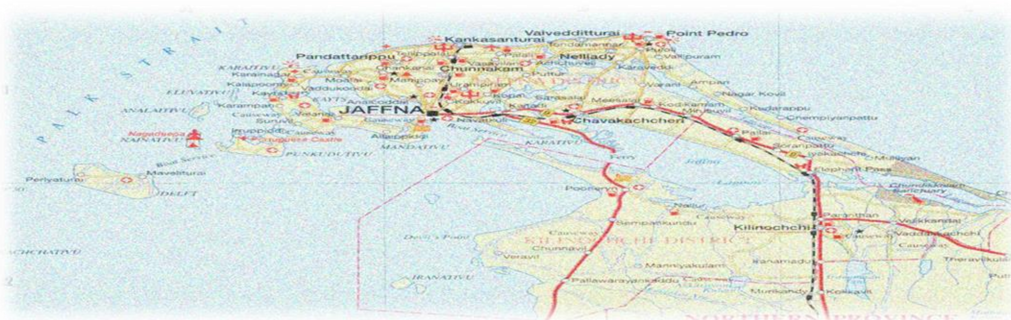


Figure 7: Northern Coastline (District Jaffna) [57].

Afghanistan

Afghanistan is located in Central Asia and has a population of 32.53 million [58]. Unfortunately almost 60% of Afghan population are not access to electricity. Only 10 to 15 percent of Afghans have regular access to power. In 2011, Afghanistan's gross power usage was 140 kWh per capita. By 2032, Afghanistan's peak power consumption is projected to reach 3500 MW [59]. Because of this, the government needs to build more power plants. The Afghan government has shown interest in attempts to harness electricity from renewable energy sources.

Wind Mapping of Afghanistan

An important step in evaluating Afghanistan's wind resource potential was the U.S. National Renewable Energy Laboratory's. In 2007, NREL publish Afghanistan wind map with a resolution of 1 km [60]. In order to build the framework for the country's wind energy growth, this map was created to assess wind energy potential at 50 meters. It helped identify important locations for future on-site wind measurement projects. Tetra Tech used multi-criteria geographic information system (GIS) to identify 10 prospective locations for future wind farm construction in Afghanistan. These sites mostly located in the province of Herat, Balkh and Kabul [61]. Figure 8 shows the map of the regions in Afghanistan that have the capacity to generate wind energy.

Dialogue Social Science Review (DSSR)
www.thedssr.com

ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 3 No. 2 (February) (2025)

Figure 8: Map of Afghan regions with potential for wind energy [62].

Potential of Wind in Baulk and Heart Province

Western Herat and Eastern Balkh are the two main wind resource regions in the country [63]. This study seeks to measure the feasibility of breeze generating facilities in the Baulk and Herat Provinces. In 2012, study provided detailed wind speed and direction data at 30, 40, and 50-meter heights, collected at ten-minute intermissions over the progression of a year [64]. This data was used to characterize the wind resources at Hotel Safid in Herat Province and Uljato in Balkh Province. Hotel Safid and Uljato have the greatest annual average wind speeds among the tested locations, making them optimal for wind energy development. Figure 9 shows wind speed on a monthly basis at Hotel Safid and Uljato in the year 2012.

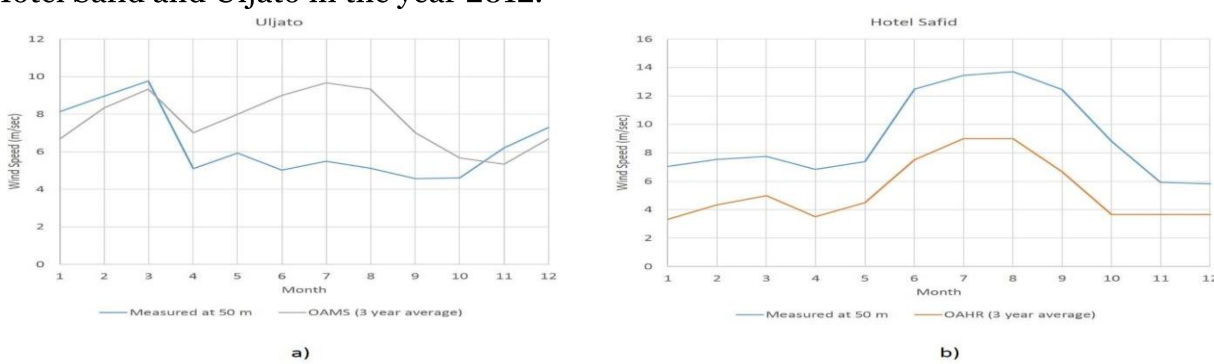


Figure 9: Wind speeds at Uljato and Hotel Safid [65].

Bangladesh

Bangladesh is a **coastal** country bounded to the south by the Bay of Bengal, to the southeast by Myanmar, and three borders are connected to India. The total population of Bangladesh is around 133 million [66]. It is estimated that around 68% of the population in Bangladesh is linked to the electrical grid [67]. In 2012, the Bangladesh Power Development Board performed research indicating that energy consumption is rising daily, with demand growing by around 300 MW annually [68]. Because of these facts, numerous organizations have been working hard to develop renewable energy sources for Bangladesh's rural places. In Bangladesh, where there are a lot of rivers and mountains, wind energy is an excellent option to fulfil its power requirements [69]. The Bangladesh Advanced Studies conducted a research and reveal that the wind patterns in Bangladesh show varying speeds across the country. The typical wind speed is between

Dialogue Social Science Review (DSSR)

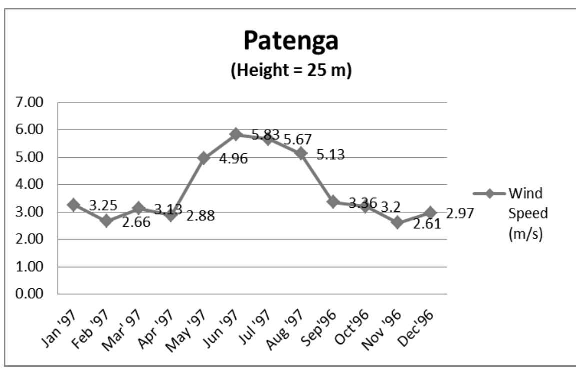
www.thedssr.com

ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 3 No. 2 (February) (2025)

3 and 6 m/s in June and July seeing the highest wind speeds [70]. The finest locations for wind energy are those that are located near the shore, where the annual average wind speediness is higher than 5 m/s and the height is 30 meters. Wind speeds in the northeastern region of Bangladesh are more than 4.5 m/s, whereas wind speeds in other regions are about 3.5 m/s [71]. For optimal power extraction, the location must exhibit a minimum wind velocity of 7 m/s [72]. After height adjustment, it was discovered that at 30 m, there is a significant potential for harvesting wind power for energy production in areas such as Patenga, Cox's Bazar, Teknaf, Char Fassion, Kuakata, Kutubdia, etc.

WEST Project

An initiative known as the Wind Energy Study initiative (WEST) was launched by the government of Bangladesh. Six WEST stations: Patenga, Cox's Bazar, Teknaf, Char Fassion, Kuakata, and Kutubdia record monthly average wind speeds at a height of 25 meters. These stations are shown in Figures 11 (a) through 11 (f) [73].



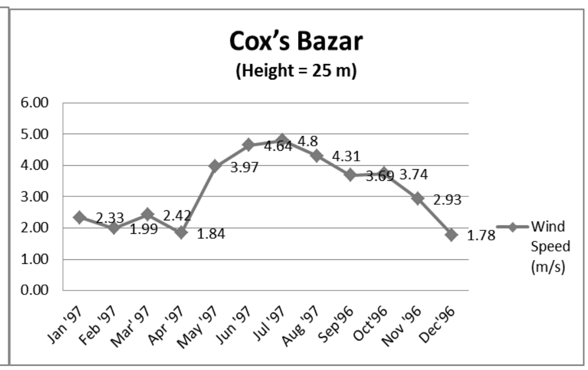
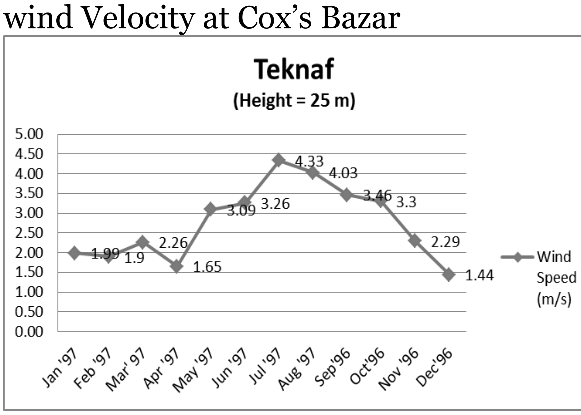


Figure 10 (a): Mean wind velocity at Patenga **Figure 10 (b):** Mean wind Velocity at Cox's Bazar



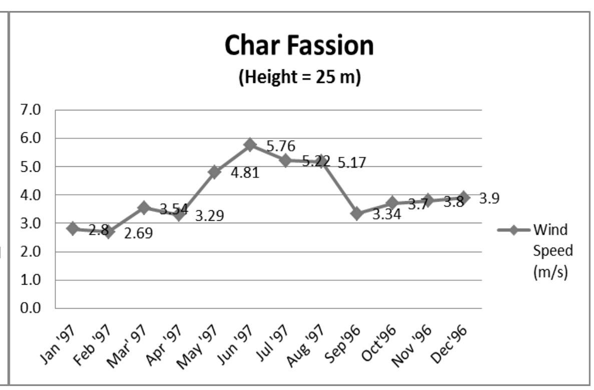
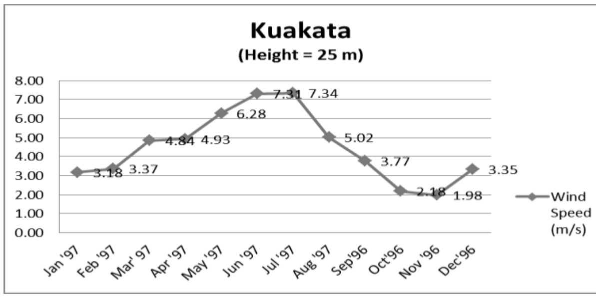


Figure 10 (c): Mean wind velocity at Teknaf **Figure 10 (d):** Mean wind velocity at Char Fassion

Dialogue Social Science Review (DSSR)
www.thedssr.com
ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 3 No. 2 (February) (2025)



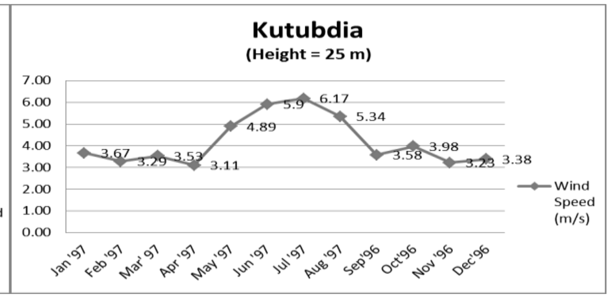


Figure 10 (e): Mean wind Velocity at Kuakata **Figure 10 (f):** Mean wind velocity at Kutubdia

The mean monthly wind velocity varies from 3 to 5 meters per second, with Kuakata having the highest and Teknaf having the lowest, according to Figure 11. Despite these variations, the findings suggest that wind energy can be harnessed from all six locations throughout the year.

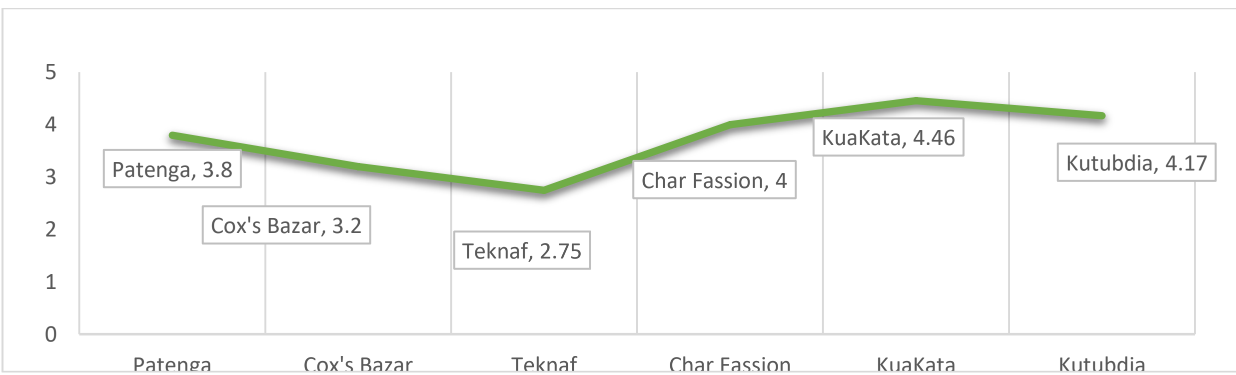


Figure 11: Yearly average wind velocity at six WEST station [74].

Bhutan

Bhutan is a minor republic located near Eastern Himalayan The population of Bhutan is 683,403 [75]. In Bhutan, the forest covers 72.5% of the land. Hydroelectric is the primary source of power in Bhutan. According to the NSB (2010) report hydroelectricity sales contributed for 45% of the country's earnings in 2008. The built-in capacity of power generation in Bhutan is 1488.698 MW. Bhutan's two primary energy sources are biomass (fuel wood) and hydroelectricity also seen in figure 12.

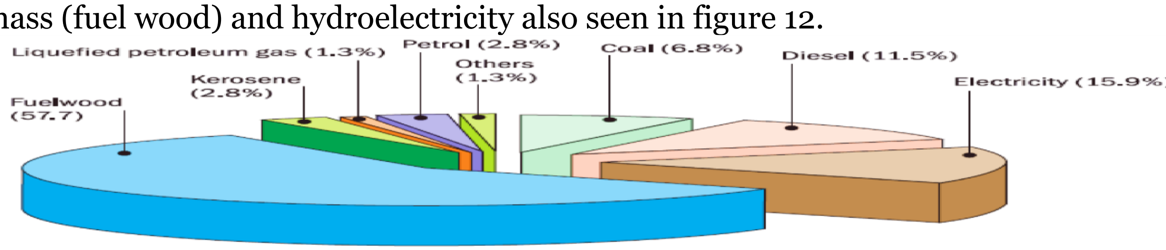


Figure 12: Total energy sources in Bhutan [76].

Bhutan took a big step toward diversifying its energy sources when it created the Renewable Energy Department on November 1, 2011. This was part of its plan to speed up the growth of renewable energy sources. Bhutan has found that wind supremacy

Dialogue Social Science Review (DSSR)
www.thedssr.com
ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 3 No. 2 (February) (2025)

might be an excellent source of clean energy. The Bhutan National Renewable Laboratory has made a wind resources map of Bhutan's and utilized meteorological data obtained from 12 locations around the nation [77]. The data collecting duration for the stations varied between one to four years. Using this information, the Bhutan National Renewable Laboratory was able to determine the average wind speed and power generation on both monthly and yearly basis. [78]. Figure 13 depicts the wind power map showing the wind potential areas in Bhutan.

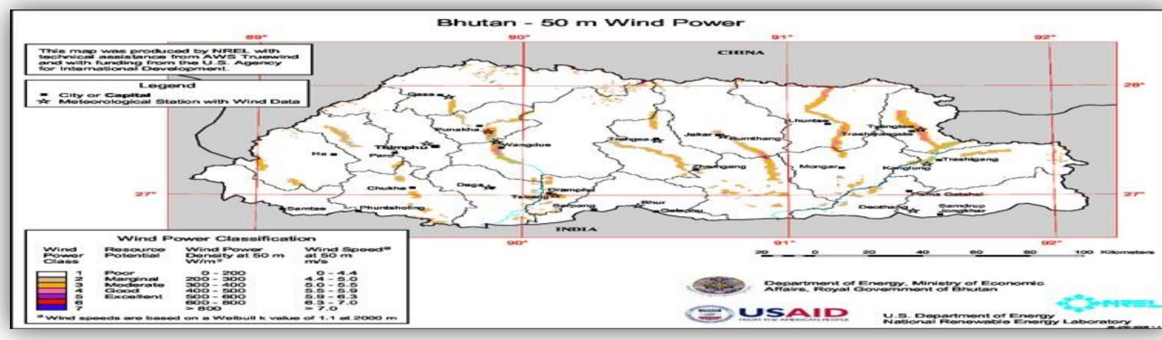


Figure 13: Yearly wind power density at 50m height [79].

Wangdue Valley is an ideal site for wind energy investigations due to its favorable wind resources and strategic location near key highways and transmission lines. These factors make it a promising area for potential wind energy development [80]. Although the wind resource potential in Chukha is lower compared to the Wangdue Valley. The Chukha valley proximity to Phuntsholing makes it a worthwhile area for further investigation. This strategic location may offer advantages for future wind energy development despite the comparatively lower wind resource [81]. The route connecting Phuntsholing and Wangdue provides the opportunity to cut logistics costs by coordinating wind measuring and project development efforts in these locations.

Nepal

Nepal is a landlocked country surrounded between India (South, East, and West) and China (North) with an area of 147,181 square kilometers. Approximately 68% of Nepal land is covered with hills and slopes [82]. According to Nepal Renewable Board, the Nepal is facing persistent power outages only 68% population of Nepal have access to electricity [83]. The predominant source of energy in Nepal is fossil fuels. The over use of fossil fuels leads to ecological degradation. In Nepal, finding alternative energy sources is crucial right now in order to address the energy crisis. The use of renewable energy sources particular wind energy presents a potentially effective answer to these issues. Wind power development in Nepal began in the 1970s, with the first 20 kW wind turbine erected at Kagbeni, Mustang District, in 1989 [84]. KAPEG plays a significant part for the improvement of small scale wind turbine sector in Nepal. KAPEG conducts seminars and conferences both nationally and internationally in collaboration with RISO to advance the Nepal wind energy sector.

Dialogue Social Science Review (DSSR)
www.thedssr.com
ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 3 No. 2 (February) (2025)

Wind Mapping of Nepal

This map evaluated the wind resources of 10 sample locations in which two sites from the mountain areas, five from hill region and the three from Terai region. The data were collected all 10 sites from the Department of Hydrology and Meteorology (DHM) [85]. Wind speed data recorded at an elevation of 10 meters at hourly intervals over a twelve-month period is used. Figure 14 (map) shows the location of all 10 sites.

Figure 14: Geographical coordinates of all ten locations [86].

Three stations situated in a high-altitude (Mountains) location include Jumla Airport and Simikot Airport, with elevations ranging from 2,375 meters to 2,975 meters [87]. The frequency of wind speeds above 3 m/s is 30.2% in Jumla and 15.1% in Humla [88]. The mean wind velocities in the hilly regions of Kathmandu airport, Thankot Kathmandu, Chainpur Bajhang, Patan Baitadi and Pokhara airport are 1.18 m/s, 2.19 m/s, 3.3 m/s, 3.5 m/s, and 1.96 m/s [89]. Among the three localities in the Terai area, Nepalgunj exhibits the lowest average speed of 0.5 m/s followed by Simara at 2.4 m/s and Biratnagar at 2.8 m/s [90]. In Nepalgunj, just 3.8% of hours annually encounter wind speeds over 3 m/s, whereas Simara records 8.7%, and Biratnagar 13.7% of hours with productive wind speeds above the threshold [91]. The results indicate that wind speeds are greater in the eastern Terai compared to the western Terai, resulting in more technically viable wind energy resources in the eastern region.

Maldives

The Maldives is an island republic located in the Indian Ocean and has no physical boundaries with any country [92]. The Maldives is one of the most beautiful country in the world. This tropical paradise is made up of around 1,192 coral islands divided into 26 atolls, making it one of the most scattered nations in the world [93]. The Maldives has a population of around 530,000, with roughly one-third living in the capital city, Malé [94]. The Maldives' energy demands are mostly fulfilled by diesel-powered generators, which generate around 95% of the electricity needed on the islands [95]. Due to a lack of fossil fuel resources, the Maldives imports almost all of its energy, making it one of the most fuel-dependent countries in the world. This dependence on diesel causes high energy prices, supply disruptions, and environmental issues owing to greenhouse gas emissions [96]. Given the environmental risks and high costs involved with diesel imports, the Maldives has established aggressive renewable energy objectives. The government has pledged to achieve net-zero emissions by 2030, replacing a major percentage of its diesel-powered electricity with solar, wind, and battery storage options [97]. The Maldives offers excellent wind energy potential,

Dialogue Social Science Review (DSSR)
www.thedssr.com
ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 3 No. 2 (February) (2025)

because to its position in the Indian Ocean, where it receives continuous monsoon winds [98]. However, the country's distinctive geology and dispersed islands need smart site selection to maximize wind energy potential while minimizing environmental and visual drawbacks.

Prime Sites for Wind Power in the Maldives

Figure 15 illustrates the wind resource map together with the designations of the Maldives' atolls.

1- North Maalhus Madulu.
2- South Maalhusmadulu.
3- South Miladhunmadulu.
4- Faadippolhu Atolls.

These sites have the greatest resource of wind energy in Maldives. The wind resource in the northern and southern regions of the Maldives is suitable for small-scale wind energy applications and moderately favorable for large-scale projects [99]. However, the resource is slightly weaker to the north and south of specific areas while regions like North Thiladhunmathi, South Thiladhunmathi, North Ari, and Male' Atolls still offer potential for wind energy [100][101]. Although Male' has a modest wind resource for small-scale applications while favorable areas for wind projects can be found extending as far south as Addu Atoll.

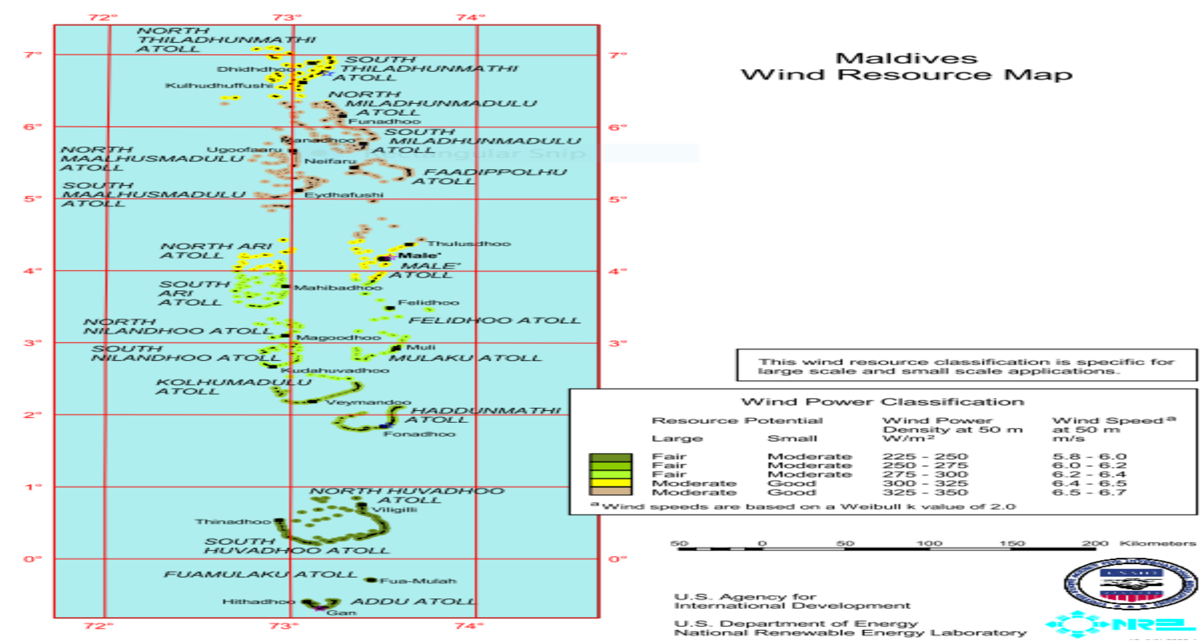


Figure 15: Wind resource map of Maldives [102].

Discussion

The results of this research provide crucial insights into the wind energy potential within the SAARC region, highlighting significant opportunities for sustainable energy integration across member countries. As identified through wind speed readings,

Dialogue Social Science Review (DSSR)
www.thedssr.com
ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 3 No. 2 (February) (2025)

satellite data, and GIS-based analysis, various regions within the SAARC countries exhibit high potential for wind energy generation, particularly along coastal areas and certain elevated inland locations. These findings align with existing literature on global wind energy hotspots, affirming that South Asia possesses substantial yet underutilized wind resources. However, the successful integration of these resources into a regional super-smart grid system faces multiple challenges.

Infrastructure Limitation

One of the primary challenge in SAARC region is infrastructure limitations. Although the wind energy potential is promising, the lack of adequate transmission infrastructure poses a significant barrier to the development of a unified super-smart grid. Many SAARC countries face challenges such as outdated power grids, limited inter-country transmission lines, and unreliable grid stability. Strengthening the existing grid infrastructure and constructing high-capacity transmission lines to connect high-wind potential areas to demand centers is essential.

Financial Barrier

In addition to infrastructure issues, financial barriers remain a major hurdle. The high initial capital investment required for wind energy projects, along with the fluctuating costs of wind turbine technology, presents a challenge for both public and private sector stakeholders. Developing financial models that combine public-private partnerships (PPPs), international financing, and government incentives could mitigate these financial obstacles. Furthermore, international financing from multilateral institutions such as the World Bank or Asian Development Bank could help bridge the financing gap, especially in the initial stages of wind energy infrastructure development.

Regulatory and Policy Framework

Regulatory and policy frameworks are also critical to the success of wind energy integration into the SAARC grid. Inconsistent regulatory policies and lack of standardization across countries complicate the development of cross-border energy projects. There is an urgent need for harmonization of regulatory frameworks that foster regional collaboration, incentivize wind energy investments, and ensure the adoption of best practices in energy generation. SAARC countries can draw upon successful international models, such as the European Union’s energy regulatory framework, to create a common set of standards and policies that promote cross-border energy trade.

Socioeconomic Factors

Socioeconomic factors further complicate the development of wind energy in the region. While wind energy offers long-term environmental and economic benefits, its success depends on local community support and workforce readiness. In many regions, there is a lack of awareness about the benefits of wind energy, and local communities may be skeptical of its environmental and economic benefits. Engaging local stakeholders in the decision-making process, providing training programs, and raising awareness about the

Dialogue Social Science Review (DSSR)
www.thedssr.com
ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 3 No. 2 (February) (2025)

advantages of wind energy can enhance public acceptance and create job opportunities in the renewable energy sector.

International Collaboration

The case studies of successful wind energy projects and international collaborations, such as the wind farms in Tamil Nadu (India) and Pakistan's Sindh province, illustrate the potential for cross-border cooperation and the sharing of best practices. These case studies show that through strategic partnerships and technology transfer, SAARC countries can accelerate the development of wind energy projects. Additionally, global cooperation, particularly with organizations like the International Renewable Energy Agency (IRENA), can provide technical expertise, knowledge sharing, and financial support for the region.

Conclusion

In existing literature many papers have been published till now related to the SAARC super smart grid based on renewable energy but no one can explain the exact location and potential sites of renewable energy in all SAARC region. This paper gives a comprehensive overview of wind energy and identifies specific places with significant wind potential within the SAARC region. Using satellite data, wind speed measurements, and geographical information systems (GIS), we give a complete study of wind patterns, capacity factors, and seasonal fluctuations in wind resources across member nations. When making strategic decisions about the SAARC super smart grid, policymakers and practitioners can benefit from the varied viewpoints offered by this research. Table 3 presents a summary of the comparison of existing review of wind potential in SAARC countries.

Table 3: Comparison of Existing Literature

Published Years	Reference	Pakistan	India	Bangladesh	Nepal	Srilanka	Maldives	Afghanistan	Bhuttan
2011	[103], [104]	×	✓	×	×	✓	×	×	×
2015	[105], [106]	✓	✓	×	×	×	×	×	×
2016	[107], [108]	×	×	✓	×	✓	×	×	×
2017	[109], [110]	×	×	✓	×	×	×	✓	×
2018	[111], [112]	✓	×	×	×	×	✓	✓	×
2019	[113], [114], [115], [116]	×	✓	×	✓	×	✓	×	✓

Dialogue Social Science Review (DSSR)
www.thedssr.com
ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 3 No. 2 (February) (2025)

2020	[117], [110], [118]	×	×	✓	×	×	×	✓	✓
2021	[119], [120], [121]	×	✓	×	✓	✓	×	×	×
2022	[122], [123]	✓	×	×	×	✓	×	×	×
2023	[124], [125]	×	×	✓	×	×	×	✓	×
2024	[126],[127]	×	×	✓	×	×	×	✓	×
Our Work 2025		✓	✓	✓	✓	✓	✓	✓	✓

References

Arif, A. (2018). Energising SAARC. *Strategic Studies*, *38*(2), 71-86.

Liaqat, M., Ghadi, Y., & Adnan, M. (2021). Multi-objective optimal power sharing model for futuristic SAARC super smart grids. *IEEE Access*, *10*, 328-351.

Moey, L. K., Goh, K. S., Tong, D. L., Chong, P. L., Adam, N. M., & Ahmad, K. A. (2020). A review on current energy usage and potential of sustainable energy in Southeast Asia countries. *Journal of Sustainability Science and Management*, *15*(2), 89-107.

Khan, I., Chowdhury, H., Rasjidin, R., Alam, F., Islam, T., & Islam, S. (2012). Review of wind energy utilization in South Asia. *Procedia engineering*, *49*, 213-220.

Abbas, S. Z., Kousar, A., Razzaq, S., Saeed, A., Alam, M., & Mahmood, A. (2018). Energy management in South Asia. *Energy strategy reviews*, *21*, 25-34.

Uddin, W., Khan, B., Shaukat, N., Majid, M., Mujtaba, G., Mehmood, A., ... & Almeshal, A. M. (2016). Biogas potential for electric power generation in Pakistan: A survey. *Renewable and Sustainable Energy Reviews*, *54*, 25-33.

Gulagi, A., Choudhary, P., Bogdanov, D., & Breyer, C. (2017). Electricity system based on 100% renewable energy for India and SAARC. *PLoS One*, *12*(7), e0180611.

Tripathi, L., Mishra, A. K., Dubey, A. K., Tripathi, C. B., & Baredar, P. (2016). Renewable energy: An overview on its contribution in current energy scenario of India. *Renewable and Sustainable Energy Reviews*, *60*, 226-233.

Khan, M. J., Iqbal, M. T., & Mahboob, S. (2004). A wind map of Bangladesh. *Renewable energy*, *29*(5), 643-660.

Azad, A. K., & Alam, M. M. (2012). Wind power for electricity generation in Bangladesh. *International journal of advanced renewable energy research*, *1*(3), 172-178.

Islam, M. T., Shahir, S. A., Uddin, T. I., & Saifullah, A. Z. A. (2014). Current energy scenario and future prospect of renewable energy in Bangladesh. *Renewable and Sustainable Energy Reviews*, *39*, 1074-1088.

Dialogue Social Science Review (DSSR)

www.thedssr.com

ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 3 No. 2 (February) (2025)

Jayasinghe, M., Selvanathan, E. A., & Selvanathan, S. (2021). Energy poverty in Sri Lanka. *Energy Economics*, *101*, 105450.

Chen, L. (2021). Environmental cost of sustainable development and climate change: can SAARC shift some liability with renewable energy and efficiency?. *Environmental Science and Pollution Research*, *28*, 67137-67149.

Shoaib, A., & Ariaratnam, S. (2016). A study of socioeconomic impacts of renewable energy projects in Afghanistan. *Procedia Engineering*, *145*, 995-1003.

Suski, A., Remy, T., Chattopadhyay, D., Song, C. S., Jaques, I., Keskes, T., & Li, Y. (2021). Analyzing electric vehicle load impact on power systems: modeling analysis and a case study for Maldives. *IEEE Access*, *9*, 125640-125657.

Van Alphen, K., Van Sark, W. G., & Hekkert, M. P. (2007). Renewable energy technologies in the Maldives—determining the potential. *Renewable and Sustainable Energy Reviews*, *11*(8), 1650-1674.

Ogino, K., Dash, S. K., & Nakayama, M. (2019). Change to hydropower development in Bhutan and Nepal. *Energy for Sustainable Development*, *50*, 1-17.

Kadeřábková, N. Biogas as a Potential Renewable Energy Source A Case of Bhutan.

Lamb, W. F., Wiedmann, T., Pongratz, J., Andrew, R., Crippa, M., Olivier, J. G., ... & Minx, J. (2021). A review of trends and drivers of greenhouse gas emissions by sector from 1990 to 2018. *Environmental research letters*, *16*(7), 073005.

Khaniya, B., Karunanayake, C., Gunathilake, M. B., & Rathnayake, U. (2020). Projection of future hydropower generation in samanalawewa power plant, Sri Lanka. *Mathematical Problems in Engineering*, *2020*(1), 8862067.

Rahman, M. M., Ahmed, R., Mashud, A. H. M., Malik, A. I., Miah, S., & Abedin, M. Z. (2022). Consumption-based CO2 emissions on sustainable development goals of SAARC region. *Sustainability*, *14*(3), 1467.

Tchao, E. T., Quansah, D. A., Klogo, G. S., Boafo-Effah, F., Kotei, S., Nartey, C., & Ofosu, W. K. (2021). On cloud-based systems and distributed platforms for smart grid integration: Challenges and prospects for Ghana's Grid Network. *Scientific African*, *12*, e00796.

Raza, A., Liaqat, M., Adnan, M., Iqbal, M. S., Jingzhao, L., & Ahmad, I. (2024). SAARC super smart grid: Navigating the future-unleashing the power of an energy-efficient integration of renewable energy resources in the saarc region. *Computers and Electrical Engineering*, *118*, 109405.

Mittal, A. (2023). Assessment of SAARC nations' solar energy potential for sustainable development. *Energy & Environment*, *34*(6), 2228-2255.

Ali, B., Abbas, G., Memon, A., Mirsaeidi, S., Koondhar, M. A., Chandio, S., & Channa, I. A. (2023). A comparative study to analyze wind potential of different wind corridors. *Energy Reports*, *9*, 1157-1170.

Asghar, R., Ullah, Z., Azeem, B., Aslam, S., Hashmi, M. H., Rasool, E., ... & Mustafa, K. (2022). Wind energy potential in Pakistan: A feasibility study in Sindh Province. *Energies*, *15*(22), 8333.

Karsli, V. M., & Geçit, C. (2003). An investigation on wind power potential of Nurdağı-Gaziantep, Turkey. *Renewable Energy*, *28*(5), 823-830.

Dialogue Social Science Review (DSSR)
www.thedssr.com
ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 3 No. 2 (February) (2025)

Ashraf, M. B., Siddiqui, M. A., & Yousuf, M. U. (2024). Autoregressive integrated moving average (ARIMA) modeling for wind resource assessment. *International Journal of Energy and Water Resources*, *8*(2), 187-198.

Mir, K. A., Purohit, P., & Mehmood, S. (2017). Sectoral assessment of greenhouse gas emissions in Pakistan. *Environmental Science and pollution research*, *24*, 27345-27355.

Alfatih, S. M., Hidayat, D. T., & Yaqin, M. A. Analysis and Design of an Integrated Accounting Information System with Otubus Company Cash Flow.

Aman, M. M., Jasmon, G. B., Ghufran, A., Bakar, A. H. A., & Mokhlis, H. (2013). Investigating possible wind energy potential to meet the power shortage in Karachi. *Renewable and Sustainable Energy Reviews*, *18*, 528-542.

Siddique, S., & Wazir, R. (2016). A review of the wind power developments in Pakistan. *Renewable and Sustainable Energy Reviews*, *57*, 351-361.

Shakkhar, M. M. (2022). *Performance Analysis of a Near-Shore Grid Connected Possible Wind Power Plant Model in Bangladesh* (Doctoral dissertation, Department of Electrical & Electronics Engineering, University of Dhaka).

Kutty, S. S., Khan, M. G., & Ahmed, M. R. (2019). Estimation of different wind characteristics parameters and accurate wind resource assessment for Kadavu, Fiji. *Aims Energy*, *7*(6).

Singh, U., Rizwan, M., Malik, H., & García Márquez, F. P. (2022). Wind energy scenario, success and initiatives towards renewable energy in India—A review. *Energies*, *15*(6), 2291.

Jagadeesh, A. (2000). Wind energy development in Tamil Nadu and Andhra Pradesh, India Institutional dynamics and barriers—A case study. *Energy Policy*, *28*(3), 157-168.

Sukkiramathi, K., & Seshaiah, C. V. (2020). Analysis of wind power potential by the three-parameter Weibull distribution to install a wind turbine. *Energy Exploration & Exploitation*, *38*(1), 158-174.

Nivedh, B. S., Devi, R. K., & Sreevalsan, E. (2013). Repowering of wind farms—a case study. *Wind Engineering*, *37*(2), 137-150.

De Costa, A., Vora, K. S., Ryan, K., Sankara Raman, P., Santacatterina, M., & Mavalankar, D. (2014). The state-led large scale public private partnership 'Chiranjeevi Program'to increase access to institutional delivery among poor women in Gujarat, India: How has it done? What can we learn?. *PLoS One*, *9*(5), e95704.

Parekh, S. R. (2008). Gujarat's Industrial Development A Perspective. *Gujarat, Perspectives of the Future*, 59.

Sangroya, D., & Nayak, J. K. (2015). Development of wind energy in India. *international journal of renewable energy research*, *5*(1), 1-13.

Sumair, M., Aized, T., Gardezi, S. A. R., Bhutta, M. M. A., Rehman, S. M. S., & Ur Rehman, S. U. (2021). Comparison of three probability distributions and techno-economic analysis of wind energy production along the coastal belt of Pakistan. *Energy Exploration & Exploitation*, *39*(6), 2191-2213.

ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 3 No. 2 (February) (2025)

Jagadeesh, A. (2000). Wind energy development in Tamil Nadu and Andhra Pradesh, India Institutional dynamics and barriers—A case study. *Energy Policy*, *28*(3), 157-168.

Pawar, S. K., Yelmar, M. N., & Mane, S. P. (2020). Spatio-Temporal Perspectives of Wind Power Energy Resource in Satara District. *Mukt Shabd Journal, ISSN NO: 2347*, *3150*, 5671-5772.

Owen, G. (1997). Who controls energy efficiency policy? A case study of the energy saving trust. *Energy policy*, *25*(11), 959-967.

Bhatia, P. (2023). India's state-led electricity transition: A review of techno-economic, socio-technical and political perspectives. *Energy Research & Social Science*, *102*, 103184.

Ledec, G. C., Rapp, K. W., & Aiello, R. G. (2011). *Greening the wind: environmental and social considerations for wind power development*. World Bank Publications.

Bond, R., & Hulme, D. (1999). Process approaches to development: theory and Sri Lankan practice. *World Development*, *27*(8), 1339-1358.

Kadher-Mohien, T. S. (2010). *Green Energy: Technology, Economics and Policy*. CRC Press.

Elliott, D., Schwartz, M., Scott, G., Haymes, S., Heimiller, D., & George, R. (2003). *Wind energy resource atlas of Sri Lanka and the Maldives* (No. NREL/TP-500-34518). National Renewable Energy Lab.(NREL), Golden, CO (United States).

Orgel, S. (1996). What is an Editor?. *Shakespeare Studies (Rosemont Publishing & Printing Corporation)*, *24*.

Archer, C. L., & Jacobson, M. Z. (2005). Evaluation of global wind power. *Journal of Geophysical Research: Atmospheres*, *110*(D12).

Kuruppu, V., De Silva, N., Edirisinghe, J., Udayanga, L., Gimhani, R., & Herath, I. Socio Economic Drivers of Vegetable Farming in Kalpitiya. *Applied Bio-Systems Technology*, 42.

Weerasinghe, V. P. A., Dilshara, R. M. P., Liyanage, P. M., & Perera, G. L. D. N. (2019). Identify a potential location for wind power plant in Jaffna District, Sri Lanka using GIS techniques. 4th International Research Symposium on Pure and Applied Sciences, Faculty of Science, University of Kelaniya, Sri Lanka.

Kadirgamar, A. (2017). *The failure of post-war reconstruction in Jaffna, Sri Lanka: Indebtedness, caste exclusion and the search for alternatives*. City University of New York.

Bandara, C. M. (1989). *A survey of the coastal zone of Sri Lanka*. Coast Conservation Department.

Tsagarakis, K. P., Mavragani, A., Jurelionis, A., Prodan, I., Andrian, T., Bajare, D., ... & Stasiuliene, L. (2018). Clean vs. green: Redefining renewable energy. Evidence from Latvia, Lithuania, and Romania. *Renewable Energy*, *121*, 412-419.

Tippayawong, N., Kantakanit, P., & Koonaphapdeelert, S. (2020). Characterization of hydrochar from hydrothermal carbonization of maize residues. *Energy Reports*, *6*, 114-118.

ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 3 No. 2 (February) (2025)

Slimankhil, A. K., Anwarzai, M. A., Sabory, N. R., Danish, M. S. S., Ahmadi, M., & Ahadi, M. H. (2020). Renewable energy potential for sustainable development in Afghanistan. *Journal of Sustainable Energy Revolution*, 8-15.

Malik, M. Z., Baloch, M. H., Ali, B., Khahro, S. H., Soomro, A. M., Abbas, G., & Zhang, S. (2021). Power supply to local communities through wind energy integration: An opportunity through China-Pakistan economic corridor (CPEC). *IEEE Access*, *9*, 66751-66768.

Mostafaeipour, A., Mishra, P., & Le, T. (2024). Unveiling Afghanistan's wind and hydrogen potential: a comparative study. *Environmental Science and Pollution Research*, *31*(42), 54417-54439.

Mehrad, A. T. (2021). Assessment of solar energy potential and development in Afghanistan. In *E3S Web of Conferences* (Vol. 239, p. 00012). EDP Sciences.

Ahmadzai, S., & McKinna, A. (2018). Afghanistan electrical energy and trans-boundary water systems analyses: Challenges and opportunities. *Energy Reports*, *4*, 435-469.

Ershad, A. M., Brecha, R. J., & Hallinan, K. (2016). Analysis of solar photovoltaic and wind power potential in Afghanistan. *Renewable Energy*, *85*, 445-453.

Szabo, S., Ahmad, S., & Adger, W. N. (2018). Population dynamics in the South-West of Bangladesh. *Ecosystem Services for Well-Being in Deltas: Integrated Assessment for Policy Analysis*, 349-365.

Taheruzzaman, M., & Janik, P. (2016). Electric energy access in Bangladesh. *Transactions on Environment and Electrical Engineering*, *1*(2), 6-17.

Das, N. K., Chakrabartty, J., Dey, M., Gupta, A. S., & Matin, M. A. (2020). Present energy scenario and future energy mix of Bangladesh. *Energy Strategy Reviews*, *32*, 100576.

Khan, A. H., Zafreen, K. R., Hossain, M. M., & Islam, M. (2015, September). A review of current renewable energy activities in Bangladesh. In *2015 3rd International Conference on Green Energy and Technology (ICGET)* (pp. 1-5). IEEE.

Hossain, I., Sarkar, A., & Pargal, S. (2017). *Demand-side energy efficiency opportunities in Bangladesh*. World Bank.

Miskat, M., Ahmed, A., Rahman, M. S., Chowdhury, H., Chowdhury, T., Chowdhury, P., ... & Park, Y. K. (2021). An overview of the hydropower production potential in Bangladesh to meet the energy requirements. *Environmental Engineering Research*, *26*(6).

Hassan, A., Rahman, M. S., Khan, F. T., Malik, M. B., & Ali, M. Z. (2012). Electricity challenge for sustainable future in Bangladesh. *APCBEE Procedia*, *1*, 346-350.

Saifullah, A. Z. A., Karim, M. A., & Karim, M. R. (2016). Wind energy potential in Bangladesh. *American Journal of Engineering Research (AJER)*, *5*(7), 85-94.

Nowreen, S., & Mohiuddin, M. (2017). An Assessment on Application of Indigenous Knowledge as Disaster Risk Reduction Strategies in Kutubdia, Cox's Bazaar, Bangladesh. *Dhaka University Journal of Science*, *65*(2), 125-131.

Tenzin, N., & Saini, R. P. (2019). Wind and solar resource potential assessment in Bhutan. *Int. J. Eng. Adv. Technol*, *8*(3), 391-395.

Dialogue Social Science Review (DSSR)

www.thedssr.com

ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 3 No. 2 (February) (2025)

Malla, A., & Dhananjayan, P. (2023). *Renewable energy in Nepal: Key findings and policy recommendations*. by International Centre for Integrated Mountain Development (ICIMOD) GPO Box 3226, Kathmandu, Nepal.

Gilman, P., Cowlin, S., & Heimiller, D. (2009). *Potential for Development of Solar and Wind Resource in Bhutan* (No. NREL/TP-6A2-46547). National Renewable Energy Lab.(NREL), Golden, CO (United States).

Dolkar, Y., Jamtsho, D., Adhikari, R., Wangdi, T., Dorji, S., Lhendup, T., & Lhamo, P. (2015, February). System Design and Performance Analysis of a Grid-Tied Solar PV Power System in Bhutan. In *2015 IEEE International Conference on Computational Intelligence & Communication Technology* (pp. 538-542). IEEE.

Gilman, P., Cowlin, S., & Heimiller, D. (2009). *Potential for Development of Solar and Wind Resource in Bhutan* (No. NREL/TP-6A2-46547). National Renewable Energy Lab.(NREL), Golden, CO (United States).

Wibecan, L., Fink, G., Tshering, L., Bruno, V., Patenaude, B., Nirola, D. K., ... & Bhutan Epilepsy Project. (2018). The economic burden of epilepsy in Bhutan. *Tropical Medicine & International Health*, *23*(4), 342-358.

Tortajada, C., & Saklani, U. (2018). Hydropower-based collaboration in South Asia: The case of India and Bhutan. *Energy Policy*, *117*, 316-325.

Action, P. Financing for Green and Inclusive Energy in Nepal.

ASIA, A. S. (2020). A Study on the Prospect of Hydropower to Hydrogen in Nepal.

Ghimire, M., & Poudel, R. C. (2010). Wind energy resource assessment and feasibility study of wind farm in kaligandaki riverbank of mustang district. *Nepal Journal of Science and Technology*, *11*, 159-166.

Shelton, M. L. (2009). *Hydroclimatology: perspectives and applications*. Cambridge university press.

Adhikari, P., Han, S. H., Kim, Y. K., Kim, T. W., Thapa, T. B., Subedi, N., ... & Oh, H. S. (2018). First molecular evidence of Mus musculus bactrianus in Nepal inferred from the mitochondrial DNA cytochrome B gene sequences. *Mitochondrial DNA Part A*, *29*(4), 561-566.

McIntosh, S., Babinsky, H., & Bertenyi, T. (2008, January). Unsteady power output of vertical axis wind turbines operating within a fluctuating free-stream. In *46th AIAA Aerospace Sciences Meeting and Exhibit* (p. 1324).

Karthikeya, B. R., Negi, P. S., & Srikanth, N. (2016). Wind resource assessment for urban renewable energy application in Singapore. *Renewable Energy*, *87*, 403-414.

Yang, Z., Liu, Y., & Li, C. (2011). Interpolation of missing wind data based on ANFIS. *Renewable Energy*, *36*(3), 993-998.

Akdağ, S. A., Bagiorgas, H. S., & Mihalakakou, G. (2010). Use of two-component Weibull mixtures in the analysis of wind speed in the Eastern Mediterranean. *Applied Energy*, *87*(8), 2566-2573.

Acker, T., & Chime, A. H. (2011). Wind modeling using WindPro and WAsP software. *Norther Arizon University, USA*, *1560000*(8.8), 510.

Hsiang, J., & Mendis, B. (2024). Countries without borders: reterritorializing the Maldives.

Dialogue Social Science Review (DSSR)
www.thedssr.com
ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 3 No. 2 (February) (2025)

Timilsina, G. R., & Shah, K. U. (2016). Filling the gaps: Policy supports and interventions for scaling up renewable energy development in Small Island Developing States. *Energy Policy*, *98*, 653-662.

Aguirre-Mendoza, A. M., Díaz-Mendoza, C., & Pasqualino, J. (2019). Renewable energy potential analysis in non-interconnected islands. Case study: Isla Grande, Corales del Rosario Archipelago, Colombia. *Ecological Engineering*, *130*, 252-262.

Shah, S. A. A., Zhou, P., Walasai, G. D., & Mohsin, M. (2019). Energy security and environmental sustainability index of South Asian countries: A composite index approach. *Ecological Indicators*, *106*, 105507.

Asrari, A., Ghasemi, A., & Javidi, M. H. (2012). Economic evaluation of hybrid renewable energy systems for rural electrification in Iran—A case study. *Renewable and Sustainable Energy Reviews*, *16*(5), 3123-3130.

Khurshid, H., Mohammed, B. S., Al-Yacoubya, A. M., Liew, M. S., & Zawawi, N. A. W. A. (2024). Analysis of hybrid offshore renewable energy sources for power generation: a literature review of hybrid solar, wind, and waves energy systems. *Developments in the Built Environment*, 100497.

Hafez, O., & Bhattacharya, K. (2012). Optimal planning and design of a renewable energy based supply system for microgrids. *Renewable Energy*, *45*, 7-15.

Jefferson, M. (2008). Accelerating the transition to sustainable energy systems. *Energy Policy*, *36*(11), 4116-4125.

Salman, A., & Yar, M. A. (2023). A Comparison of the SAARC Renewable Energy Policies: Analytical Approach.

Dornan, M., & Shah, K. U. (2016). Energy policy, aid, and the development of renewable energy resources in Small Island Developing States. *Energy policy*, *98*, 759-767.

Padrón, I., Avila, D., Marichal, G. N., & Rodríguez, J. A. (2019). Assessment of Hybrid Renewable Energy Systems to supplied energy to Autonomous Desalination Systems in two islands of the Canary Archipelago. *Renewable and Sustainable Energy Reviews*, *101*, 221-230.

Hossain, J., Sinha, V., & Kishore, V. V. N. (2011). A GIS based assessment of potential for windfarms in India. *Renewable energy*, *36*(12), 3257-3267.

AS, W., Nanayakkara, L. D. J. F., & Pushpakumara, C. (2011). The progress of Sri Lanka's renewable energy sector developments in mitigating the GHG emission. *Development*, *4*, 2.

Ali, S. H., Zuberi, M. J. S., Tariq, M. A., Baker, D., & Mohiuddin, A. (2015). A study to incorporate renewable energy technologies into the power portfolio of Karachi, Pakistan. *Renewable and Sustainable Energy Reviews*, *47*, 14-22.

Kar, S. K., & Sharma, A. (2015). Wind power developments in India. *Renewable and sustainable energy reviews*, *48*, 264-275.

Mondal, M., Didane, D. H., Ali, A. H. I., & Manshoor, B. (2022). Technical assessment of wind energy potentials in Bangladesh. *Journal of Advanced Research in Fluid Mechanics and Thermal Sciences*, *96*(2), 10-21.

Kulkarni, S., Deo, M. C., & Ghosh, S. (2016). Evaluation of wind extremes and wind potential under changing climate for Indian offshore using ensemble of 10 GCMs. *Ocean & Coastal Management*, *121*, 141-152.

Dialogue Social Science Review (DSSR)

www.thedssr.com

ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 3 No. 2 (February) (2025)

Shaikh, M. A., Chowdhury, K. M., Sen, S., & Islam, M. M. (2017, December). Potentiality of wind power generation along the Bangladesh coast. In *AIP Conference Proceedings* (Vol. 1919, No. 1). AIP Publishing.

Ershad, A. M. (2017). Institutional and policy assessment of renewable energy sector in Afghanistan. *Journal of renewable energy*, *2017*(1), 5723152.

Zhang, B., Wang, B., & Wang, Z. (2017). Role of renewable energy and non-renewable energy consumption on EKC: evidence from Pakistan. *Journal of cleaner production*, *156*, 855-864.

Contestabile, P., Di Lauro, E., Galli, P., Corselli, C., & Vicinanza, D. (2017). Offshore wind and wave energy assessment around Malè and Magoodhoo Island (Maldives). *Sustainability*, *9*(4), 613.

Shyam, B., & Kanakasabapathy, P. (2017, December). Renewable energy utilization in India—policies, opportunities and challenges. In *2017 International Conference on Technological Advancements in Power and Energy (TAP Energy)* (pp. 1-6). IEEE.

Al Irsyad, M. I., Halog, A. B., Nepal, R., & Koesrindartoto, D. P. (2017). Selecting tools for renewable energy analysis in developing countries: An expanded review. *Frontiers in energy research*, *5*, 34.

Liu, J., Mei, C., Wang, H., Shao, W., & Xiang, C. (2017). Mutual adaptability of renewable energy and water-supply systems in islands. *Energy Procedia*, *105*, 799-804.

Mottaleb, K. A., Ali, A., & Aryal, J. P. (2017). Energy consumption transition through the use of electricity for lighting and cooking: evidence from Bhutan. *Renewable energy focus*, *18*, 11-21.

Rahman, M. M., Nasrin, N., Chakraborty, S., Siddique, A., Bhowmik, S., & Barua, R. (2017). Renewable energy: the future of Bangladesh. *Int. Journal of Engineering Research and Application*, *7*(6), 2248-9622.

Alam, F., Alam, Q., Reza, S., Khurshid-ul-Alam, S. M., Saleque, K., & Chowdhury, H. (2017). Sourcing green power in Bhutan: A review. *Energy Procedia*, *110*, 586-591.

Shrimali, G., Srinivasan, S., Goel, S., & Nelson, D. (2017). The effectiveness of federal renewable policies in India. *Renewable and Sustainable Energy Reviews*, *70*, 538-550.

Proietti, S., Sdringola, P., Castellani, F., Astolfi, D., & Vuillermoz, E. (2017). On the contribution of renewable energies for feeding a high altitude Smart Mini Grid. *Applied Energy*, *185*, 1694-1701.

Fernando, W., Gupta, N., & Özveren, C. S. (2017, August). The electricity infrastructure in Sri Lanka then, now and hereafter. In *2017 52nd International Universities Power Engineering Conference (UPEC)* (pp. 1-6). IEEE.

Shukla, A. K., Sudhakar, K., & Baredar, P. (2017). Renewable energy resources in South Asian countries: Challenges, policy and recommendations. *Resource-Efficient Technologies*, *3*(3), 342-346.

Dialogue Social Science Review (DSSR)

www.thedssr.com

ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 3 No. 2 (February) (2025)

Selvakkumaran, S., & Limmeechokchai, B. (2017). Assessment of long-term low emission power generation in Sri Lanka and Thailand. *Sustainable Energy Technologies and Assessments*, *21*, 121-141.

Hossain, E., Rakin, A. S., Al Mamun, A., & Haque, S. (2017, December). Future of power generation in bangladesh: Present condition and future implications. In *2017 IEEE Region 10 Humanitarian Technology Conference (R10-HTC)* (pp. 275-278). IEEE.

Danish, M. S. S., Sabory, N. R., Danish, S. M. S., Senjyu, T., Ludin, G. A., Noorzad, A. S., & Yona, A. (2017). Electricity sector development trends in an after-war country: Afghanistan aspiration for an independent energy country. *Journal of Energy and Power Engineering*, *11*(1), 553-557.

Khalil, M. S. (2012). Renewable energy in Pakistan: opportunities and challenges. *Journal of Renewable and Sustainable Energy*, *16*(0), 13-20.

Panayotakis, S. (2012). *" The Story of Apollonius, King of Tyre": A Commentary* (Vol. 38). Walter de Gruyter.

Schmeling, G. (2004). The history of Apollonius king of Tyre. In *Latin Fiction* (pp. 119-129). Routledge.