En Route for the Accomplishment of SDG-7 in South Asian Countries: A Retrospective Study

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Abstract

With one-fifth of the world's population, South Asian nations are home to 37 percent of the world's poor and 50 percent of the world's hungry children. This region experiences enormous development and infrastructure challenges. The paper investigates the progress of South Asian countries on Sustainable Development Goal-7, which is associated with access to modern energy to all. The present research also highlights significant issues and challenges behind the slow progress of South Asian countries on SDG-7. This study indicates that Bhutan and India are top-performing countries; however, Pakistan and Afghanistan are lower-performing countries on SDG-7 among all other South Asian countries. It has also been observed that South Asian countries have a narrow focus on renewable energy. South Asian nations will address their energy shortages issue and save a lot of money by using renewable energy instead of importing hydrocarbons.

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South Asian nations must diversify their main energy consumption patterns to achieve SDG-7. They may address their energy concerns at the policy, economic, technological, and information levels and boost cross-border energy commerce.

Keywords: Cooking fuel, energy accessibility, fossil fuel, regional trade, South Asian countries, sustainable development goals.

1 Introduction

Asia is the largest of the world's seven continents. South Asia is its central part; the principal boundaries are the Indian Ocean, the Himalayas, and Afghanistan. This region is home to 2 billion populaces living in eight countries: Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka. South Asia region experiences climate change issues, human pressures, changing hydrology and land resources, change in the production of food grain, drinking water scarcity, and environmental pollution (S. Deshmukh, 2011). The SDGs states the planned vision for the future of the development of the world. Its implementation is required at the global, regional, sub-regional, national and local levels. Figure 1 illustrates sustainable development goals in a concise form.

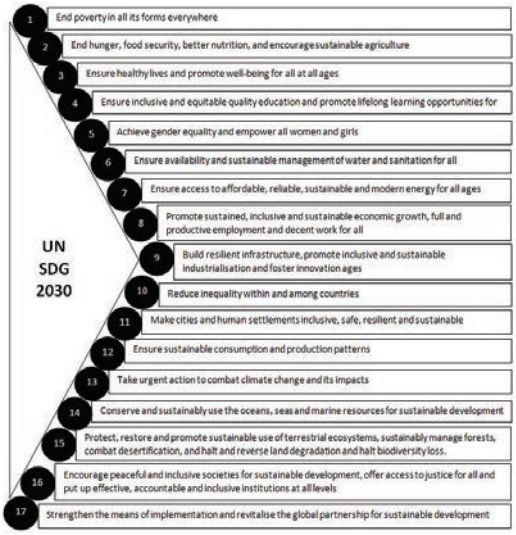

Figure 1 Sustainable development goals in a concise form (Katekar et al., 2020).

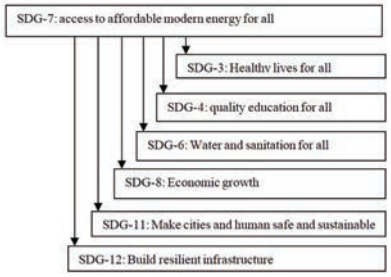

Figure 2 Interlinking of SDG-7 with other SDGs (Katekar et al., 2020).

Energy is a driving force to the economy of every country. The growing South Asian population has enormously raised the demand for energy resources; consequently, the region faces an energy shortage. SDG-7 ensures access to reliable, inexpensive, sustainable, and modern energy for everyone. Attainment of SDG-7 is essential for accomplishing other SDGs such as SDG-3, 4, 6, 8, and 12, as shown in Figure 2 (Katekar et al., 2020).

This study aims to investigate the progress of South Asian countries on SDG-7. What is the present energy scenario of South Asian countries? Which one is the best performing South Asian Country on SDG-7? What are the present and future challenges in South Asian countries to attain SDG-7 up to 2030? This paper deals with such questions. In the forthcoming sections, the manuscript overviews the current energy scenario of South Asian countries and energy accessible to their societies. After that, it investigates the progress of South Asian countries on SDG-7 and macro and micro-level initiatives taken by South Asian countries to achieve SDG-7 up to 2030. The manuscript ends with conclusions and future recommendations.

2 Methodology

Several peer-reviewed research papers of international repute and reports published by the Government of South Asian countries have been collected from several websites. They are categorized based on state, energy sources, and usage of cooking fuels, national initiatives for energy security, sustainable developments, and policies. All papers and reports have been read multiple times, and significant findings were noted down. Various facts and figures are compared to investigate the progress of South Asian countries on SDG-7 and to understand present and future challenges to attain SDG-7 up to 2030. Footsteps used during the present work are shown in Figure 3.

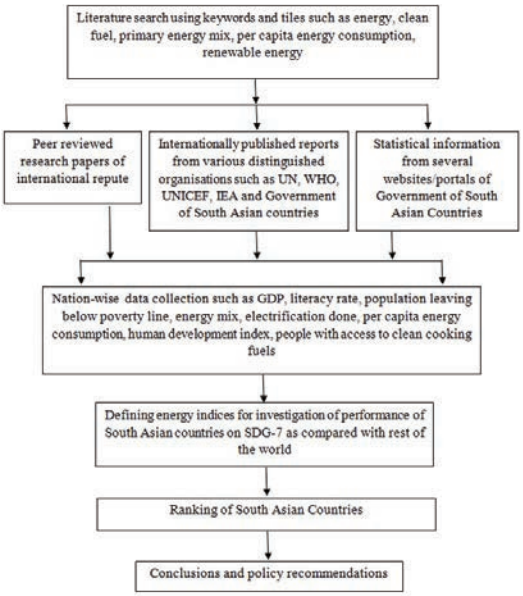

Figure 3 Methodology.

3 South Asia's Energy Scenario

According to many statistics produced by South Asian governments, the area suffers energy constraints to maintain economic development. The majority of the people in this region live in rural and isolated places. They don't have access to power or renewable energy. Even now, they primarily utilise biomass for cooking and other household purposes.

South Asian nations rely heavily on fossil fuels to meet their energy needs. They are responsible for the high cost of fossil fuel imports. This section depicts the energy condition and progress of South Asian countries concerning SDG-7.

3.1 Sri Lanka

Sri Lanka meets its immediate energy needs mainly via the use of petroleum products. Sri Lanka's significant energy mix is seen in Figure 4. In 2017, fossil fuels accounted for 43% of total energy consumption, with biomass accounting for 37%, coal 11%, hydro 6%, and renewable energy accounting for 3%. In 2017, the country's most notable accomplishment was the electrification of 100 percent houses (ADB and UNDP, 2017).

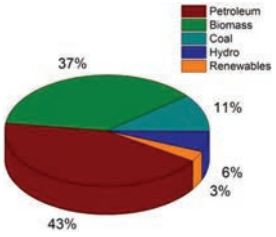

Figure 4 The primary energy mix of Sri Lanka (ADB and UNDP, 2017).

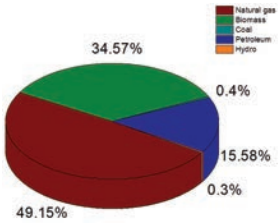

Figure 5 The primary energy mix of Bangladesh (Hydrocarbon Unit of Energy and Mineral Resources Division, 2019).

Bio-energy accounts for a significant portion of residential and business energy usage. The inhabitants of Sri Lanka utilised 12 million tonnes of biomass in 2017 (SAARC, 2018). Sri Lanka's coal consumption has grown by 4.9 MTOE since 2010. By 2030, oil is expected to become a significant energy source, accounting for 42.9 percent of the central energy mix (Farabi-Asl, 2019).

3.2 Bangladesh

Bangladesh's annual energy consumption is estimated to be at 47 MTOE. Energy consumption is growing at a pace of 6% each year, according to the study. Homes have admittance to electrical energy in around 90% of cases (SAARC, 2018). Natural gas accounts for 49.2 percent of the leading energy mix, followed by biomass (34.6 percent), petroleum (15.6 percent), coal (0.4 percent), and hydro (0.3 percent), as illustrated in Figure 5 (Hydrocarbon Unit of Energy and Mineral Resources Division, 2019).

According to the Ministry of Power, Energy and Mineral Resources' January 2019 report; thus, consumption of imported LNG is likely to increase, as illustrated in Figure 6 (Adnan et al., 2018).

The nation imports around 6.6 million metric tonnes of crude oil and other refined petroleum products per year to meet its energy needs for

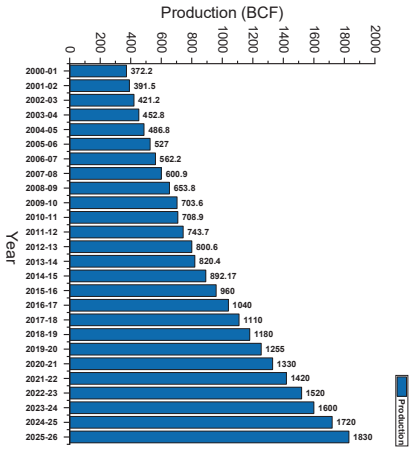

Figure 6 Annual natural gas consumption rate (Adnan et al., 2018).

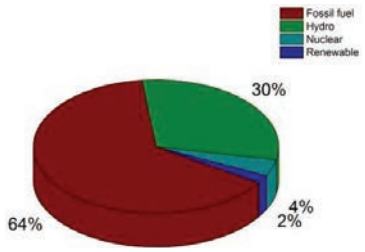

Figure 7 The primary energy mix of Pakistan (Irfan et al., 2020).

power production and transportation (Adnan et al., 2018). The government is encouraging biogas for cooking and electricity production to lessen reliance on imported fossil fuels. Biogas now generates 1 MW of energy, while solar systems produce roughly 325 MW of power (Adnan et al., 2018).

3.3 Pakistan

Pakistan is primarily using oil and gas to satisfy its energy demand. 64% of electricity is produced by using oil and gas (SAARC, 2018). According to the Pakistan Economic Survey 2018-19, fossil fuels make up 64% of the primary energy mix, while hydro and nuclear make up 27% and 7%, respectively. As indicated in Figure 7, renewable energy accounts for just 2% of overall energy output.

According to several official figures, Pakistan's per capita energy usage grew from 500 to 960 kWh between 2012 and 2018, as seen in Figure 8.

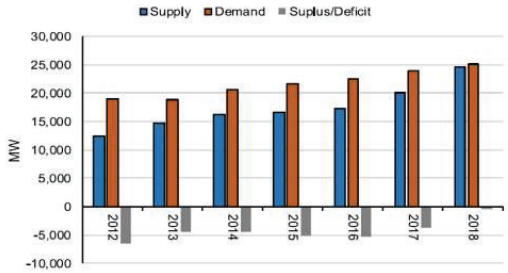

Figure 8 Power supply from 2012-18 (Irfan et al., 2020).

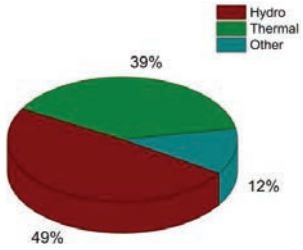

Figure 9 The primary energy mix of Afghanistan (Ahmadzai and McKinna, 2018).

Natural gas will be the dominant energy source by 2035, accounting for 43.8 percent of the total energy mix. Pakistan will become increasingly reliant on imported gas to meet this need (Irfan et al., 2020).

3.4 Afghanistan

According to a United Nations study from 2018, Afghanistan is the world's least developed nation. Only around a third of the country is now electrified. Only 10% of rural families have access to electricity (SAARC, 2018). People generally use charcoal, wood, agricultural, and animal waste for cooking and other household heating applications. The country's total power generating capacity is estimated to be at 519 MW. As indicated in Figure 9, hydropower provides 49%, thermal provide 39%, and dispersed generators offer 12% to the central energy mix (Ahmadzai and McKinna, 2018).

Around 80% of Afghanistan's fossil fuels are imported. Between 2007 and 2015, the amount spent on fossil fuel imports surged by 14 times. In 2032, Afghanistan's energy consumption is expected to be 3500 MW (Organization, 2018). As illustrated in Figure 10, the nation can produce 67 GW of wind power, 23 GW of hydropower, and 222 GW of solar electricity. Furthermore, natural gas resources are expected to be at 36.462 trillion cubic feet.

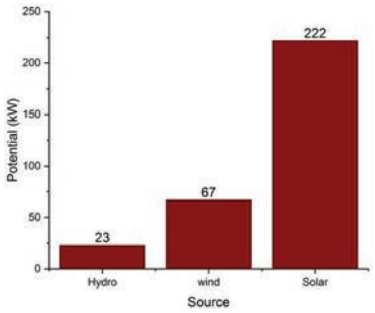

Figure 10 The renewable energy potential of Afghanistan (Organization, 2018).

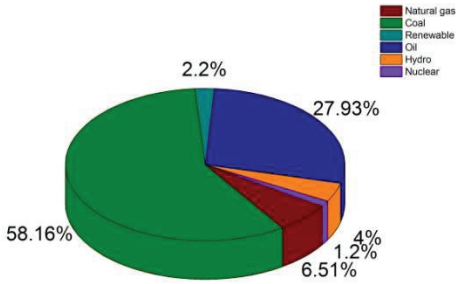

Figure 11 The primary energy mix of India (Ali, 2018).

The strategic utilisation of these resources will help Afghanistan's energy industry become self-sufficient and develop the economy (Organization, 2018).

3.5 India

India imports crude oil and natural gas to meet more than 70% of its primary energy requirements. Coal provides 58.1 percent, natural gas 6.5 percent, oil 27.9%, hydro 4 percent, renewable 2.2 percent, and nuclear 1.2 percent of the primary energy mix (Figure 11) (Ali, 2018).

At present, about 304 million Indians lack access to electricity, and 800 million people lack access to clean cooking fuels (Agency, 2020). By 2022, the government plans to maintain 175 GW of renewable energy installed capacity, provide 24-hour power to all homes, and reduce oil and gas imports by 10%. The Indian government's strategy to meet energy demand in 2030 is seen in Figure 12 (NITI Aayog and IEEJ, 2017). It demonstrates that the government is emphasising the use of renewable energy to promote long-term development.

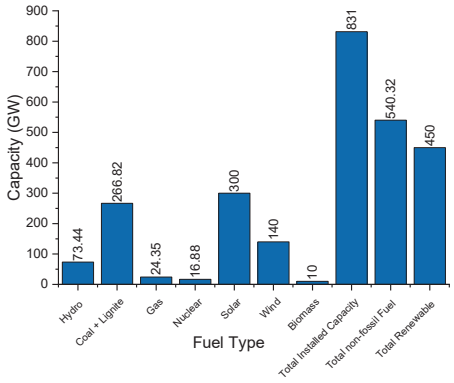

Figure 12 Projected electricity capacity in 2030 (NITI Aayog and IEEJ, 2017).

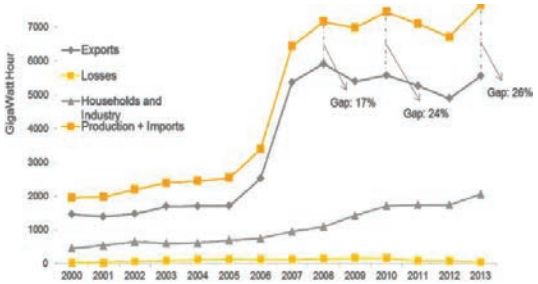

Figure 13 Power demand and supply scenario (IRENA, 2019).

3.6 Bhutan

Bhutan has no substantial fossil fuel sources; instead, it produces 99.5 percent of its electricity from hydropower, with the rest coming from imported liquid fuel. Bhutan purchases liquid fossil fuels for autos and other critical applications (Alam et al., 2017). The nation supplies power to all homes and exports the remainder to neighbouring countries. However, exports are insufficient, and the difference between exports and total domestic electrical generation is widening, rising from 17% in 2008 to 26% in 2013, resulting in an economic loss (Figure 13). According to several government assessments, kerosene and liquefied petroleum gas usage in metropolitan areas would increase dramatically by 2035. In 2035, the demand for oil and coal will climb to 9.9% and 11.6%, respectively. Renewable energy sources have many promises in Bhutan. Except for a few solar projects, these resources have not been used until now (IRENA, 2019).

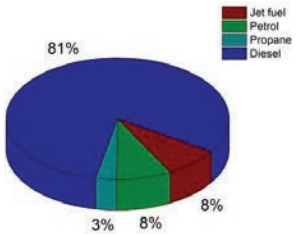

Figure 14 The primary energy mix of Maldives (Ministry of Environment and Energy, 2017).

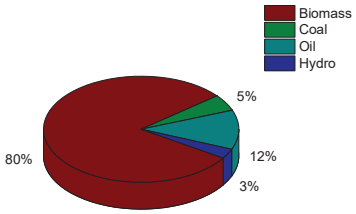

Figure 15 Primary energy supply mix, 2014 (Shrestha, 2014).

3.7 Maldives

Diesel fuel is used to provide 80% of the Maldives' primary energy demand and the transportation sector's energy needs (Figure 14). Electricity is produced independently on each island using diesel generators. Since 2008, the country has provided all inhabitants with access to 100 percent power. By 2020, the Maldives government wants to produce 60 percent of the country's power from solar panels to fulfil future energy demand (Ministry of Environment and Energy, 2017).

3.8 Nepal

Biomass is the primary source of energy in Nepal. Its 80% energy demand is satisfied using biomass, 3% using hydro, and the rest of the amount is generated using imported fossil fuel, as shown in Figure 15. Nepal spends a significant portion of its revenue on petroleum imports (Shrestha, 2014).

4 Energy Accessibility

Many activities, such as cooking, lighting, operating enterprises, and the agricultural sector, need energy. It's also necessary for providing public

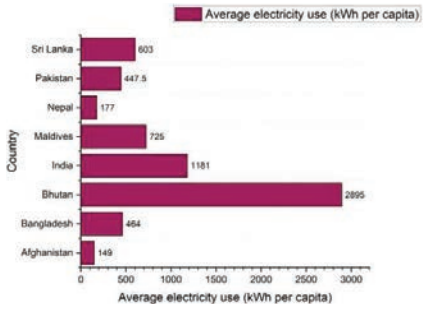

Figure 16 Per capita energy consumptions of South Asian countries.

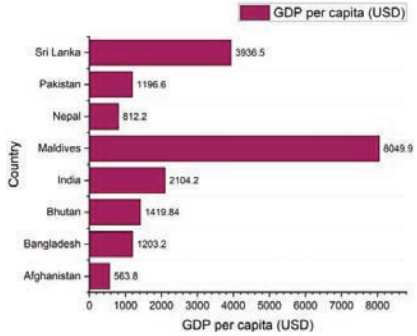

Figure 17 GDP per capita of South Asian Countries.

services like health care and education. The non-existence of access to energy services reduces economic growth potential and widens the divide between the affluent and the poor (Jinturkar et al., 2014). This section depicts the availability of cooking and electrical energy to the people of South Asia.

4.1 Access to Electricity

Bhutan has the greatest, and Afghanistan has the lowest energy consumption per capita among the South Asian nations, as seen in Figure 16. Afghanistan's inhabitants have limited access to energy. Hence the country's economic development is slow, as seen in Figure 17.

Figure 18 demonstrates that South Asian nations, except for Bhutan, utilise fossil fuels to generate power. Bhutan primarily generates energy via hydropower. For electrical production, the Maldives rely entirely on imported fuel. People in Bhutan and Sri Lanka are connected to the grid 100 percent of the time.

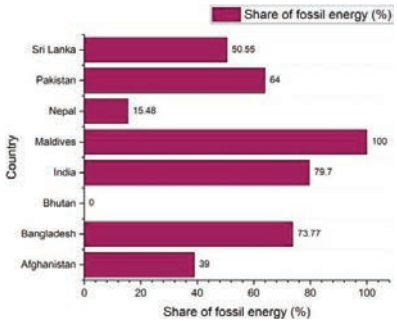

Figure 18 Fossil fuel share in electricity production.

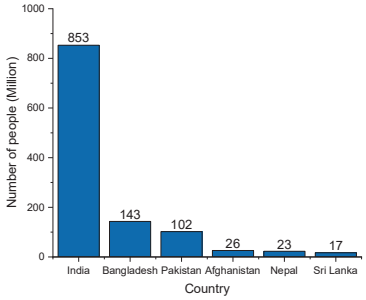

Figure 19 People without access to clean cooking fuel (Pacific, 2018).

4.2 Access to Energy for Cooking and Other Domestic Use

According to 2018, Economic and Social Survey of Asia and the Pacific (ESCAP), about 2.1 billion people in Asia lack clean cooking fuel sources. The population of major Asian nations lacks access to a clean cooking energy source, as indicated in Figure 19. More than 100 million people in India, Bangladesh, and Pakistan do not have access to a clean cooking energy source (Pacific, 2018).

4.3 Cooking Fuel Accessibility of South Asia

4.3.1 Sri Lanka

In Sri Lanka, biomass is the principal source of cooking fuel. In a city, liquefied petroleum gas (LPG), electricity, and kerosene are often used for cooking. Ninety-five percent of urban families cook using LPG, whereas 95 percent of rural families cook using biomass. People in specific locations combine all of the sources (LPG, biomass). To prevent dangerous emissions

in kitchen air, the government is replacing biomass with LPG and kerosene. (Authority, 2017).

4.3.2 Bangladesh

In Bangladesh, according to the UNICEF-2015 Multiple Indicator Cluster Survey (MICS) 2012–2013, 88.2 percent of houses use solid fuels, and 67.6 percent of families use wood for cooking. Solid fuels are used by 58.3% of urban homes and 96 percent of rural households. Firewood is the most popular solid fuel for cooking, with about 50.5 percent of urban and 72 percent of rural homes uses it (Toufique et al., 2018).

4.3.3 Pakistan

Pakistanis have limited availability of commercial and clean cooking energy. For home cooking, they usually utilise charcoal, firewood, animal dung, and coal. In Pakistan, solid fuels are used for cooking in around 87 percent of rural dwellings and 13 percent urban homes. Cooking using LPG and electricity is confined to metropolitan areas (Naz et al., 2017).

4.3.4 Afghanistan

In Afghanistan, the most common cooking fuels are firewood, animal dung, grass, and LPG. In both rural and urban areas, firewood is the most common cooking fuel. In metropolitan regions, LPG is widely utilised by middle- and high-income households (Paudel et al., 2018).

4.3.5 India

53% of Indian households use LPG for cooking (Census, 2011), and about 840 million people depend on traditional biomass for culinary (Parikh et al., 2016). The usage of electricity for cooking is significantly less. The Indian government enhances clean cooking fuel by introducing programmes such as the Pradhan Mantri Ujjawala Yojana (PMUY), which offers low-income households free LPG connections (Council on Energy, 2017).

4.3.6 Bhutan

According to the Bhutan Living Standard Report (BLSS) 2012, residents in urban Bhutan cook using LPG, electricity, and firewood in proportions of 92 percent, 98 percent, and 2 percent, respectively. LPG, electricity, and firewood are used by 45 percent, 76 percent, and 51 percent of homes in rural Bhutan, respectively (Council on Energy, 2017). These numbers show that most of the people in rural and urban Bhutan use electricity for cooking.

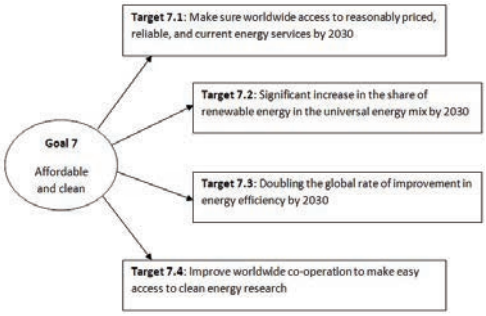

Figure 20 Specifics of sustainable development goal-7 (Nia et al., 2019).

4.3.7 Maldives

Kerosene, LPG, Diesel, and gasoline are used by the majority of Maldivians for cooking. In 2017, the country imported 14483 metric tons of cooking gas, 447555 metric tons of diesel, 57730 metric tons of gasoline, and 41666 metric tons of aviation gas, according to official import records Maldives government (Ministry of Environment and Energy, 2018).

4.3.8 Nepal

Most of the people of Nepal are living in rural areas. Surveys of household energy, 2016 show that wood is mainly used for cooking, space heating, and lighting. Only wealthy families use kerosene and LPG as cooking fuel (Lam et al., 2017).

5 Progress of South Asia on SDG-7

The Sustainable Development Goals (SDGs) of the United Nations aim to eradicate poverty and hunger and establish a more sustainable world. The globe adopted the 2030 Agenda for SDGs in September 2015. There are 17 Sustainable Development Goals (SDGs) in all, with 169 objectives to achieve. The SDG-7 is linked to energy, shown in Figure 20 (Nia et al., 2019).

Figure 21 shows the rank and score of South Asian countries globally. It shows that the public in South Asia is relatively underprivileged compared with other parts of the world. The main reason behind this is the wide infrastructure gap compared to other world countries (Kumar et al., 2016).

Energy is the first and foremost factor behind the attainment of SDGs. It means that the achievement of SDG-7 is significant to achieve other sustainable goals also. Figure 22 shows the interrelationship between educational

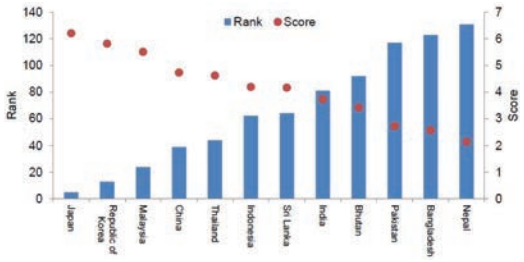

Figure 21 Rank and score of some Asia-Pacific countries (Kumar et al., 2016).

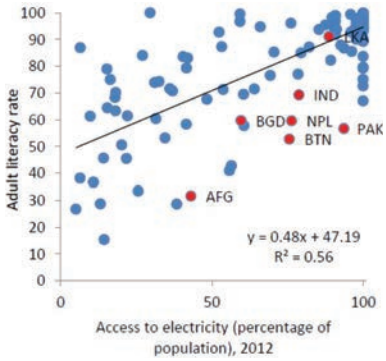

Figure 22 Relationship between electricity and educational attainment (Iftikhar et al., 2015).

achievement and the accessibility of electrical energy at schools, homes, and other public places. With good access to electricity, educational attainment is also high. The literacy rate is more significant in nations with improved energy availability (Iftikhar et al., 2015).

Similarly, the human development index also depends on people's access to energy. Figure 23 illustrates the relationship between the overall human development index and access to electricity. It shows that countries having better energy consumption per capita have a higher human development index.

Every country's socioeconomic progress requires that all families have access to electricity. Sri Lanka and Bhutan have succeeded in providing 100% electrical access to all country houses; other South Asian nations, as illustrated in Figure 24, have been close to attaining this objective in recent years.

South Asian nations may minimise their reliance on fossil fuels by using their enormous solar and wind energy potential. Cleaner energy, such as

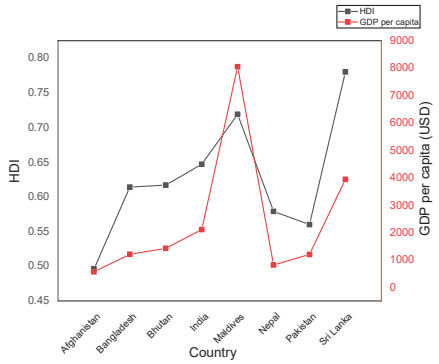

Figure 23 Energy consumption and human development index.

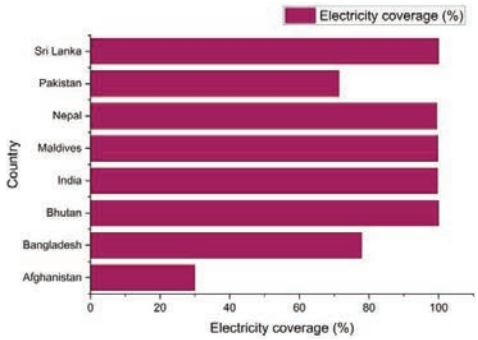

Figure 24 Electricity exposure in different South Asian countries.

natural gas, must be used, and clean coal technology must be used in coal-fired power plants. They may earn more carbon credits and, to some part, mitigate climate change by reducing their use of fossil fuels, i.e. achieving SDG-13. Except for Bhutan, most South Asian nations rely on fossil fuels and biomass for energy production, contributing significantly to GHG emissions (Cheng et al., 2011). As illustrated in Figure 25, India uses coal to produce 58 percent of its electricity and emits significant greenhouse gases into the environment.

It is also noticed from various government reports of South Asian countries that they do not focus on waste to energy conversion. Urban, semi-urban and rural waste, agriculture, and industrial waste can be used for energy generation indirectly in limited use to fulfil the use of a particular community in rural and remote regions, just like waste oil cooking stove for small hotels and restaurants (Jambhulkar et al., 2015).

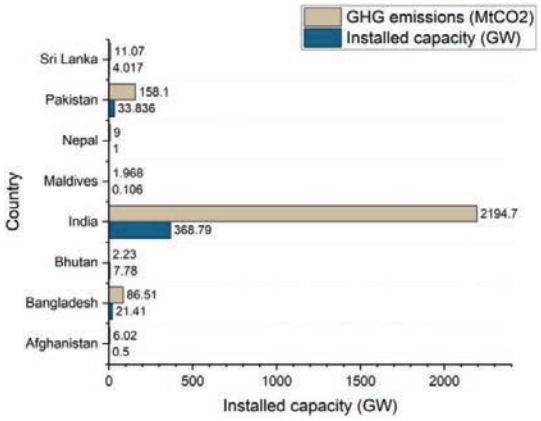

Figure 25 GHG emissions ($MtCO_2$).

Table 1 GDP and energy consumption

Reference Values to Calculate Indices	Share of Fossil Energy (%)	Share of Renewable Energy (%)	Average Electricity Use (kWh Per Capita)	GDP Per Capita (USD)	People with Access to Clean Fuel (%)
World	80	24	2674	17100	61

5.1 Progress of South Asian Countries as Compared with the Rest of the World

This sub-section assesses the progress of South Asian countries and compares their performance with the rest of the world. For this investigation, five different indices are defined, which are described in the forthcoming section. Reference values used to calculate indices are given in Table 1.

Renewable Energy Index (E_1)

To reduce the carbon footprint on the environment, renewable energy is the most prominent alternative solution. The renewable energy index (E_1) compares the utilization of renewable energy for electricity generation by South Asian countries compared with the rest of the world. Its higher value indicates that country has better utilization of renewable energy for electricity generation.

$$E_1 = \frac{\textit{Share of renewable energy in the country energy mix}}{\textit{Renewable energy share in world energy mix}} \tag{1}$$

Per Capita Energy Consumption Index (E_2)

Per capita energy consumption indicates the total energy consumed per person per year. It is an indicator of energy accessibility to ordinary people. Per capita, the energy consumption index (E_2) compares the energy consumption of a Nation concerning the world's energy consumption. Its higher value is desirable, which indicates better availability of energy to ordinary people of the country.

$$E_2 = \frac{\textit{Per capita energy consumption of country}}{\textit{World per capita energy consumption}} \tag{2}$$

Fossil Fuel Energy Consumption Index

Fossil fuel is the primary source of environmental pollution. The extensive use of fossil fuels indicates a more significant emission of carbon in the environment. The Fossil fuel energy consumption index (E_3) compares the share of fossil fuel in the country's primary energy mix concerning the world energy mix. Its lower value is always desirable, indicating that the government uses lower fossil fuel to fulfil its energy demand.

$$E_3 = \frac{\textit{Share of fossil fuel in energy mix of country}}{\textit{Share of fossil fuel in world energy mix}} \tag{3}$$

Gross Domestic Product (GDP) Index

Gross Domestic Product (GDP) rate is an indicator of the economic progress of the Nation. GDP is the closing value of the goods and services produced within the country over one year. Developed countries have a higher value of GDP. GDP index compares GDP per capita of the country with GDP per capita of the world. Its higher value is desirable.

$$E_4 = \frac{\textit{GDP per capita of country}}{\textit{GDP per capita of world}} \tag{4}$$

Clean Cocking Fuel Index (E_5)

Better availability of clean cooking fuel to the households improves public health by reducing indoor air pollution, greenhouse gases. The clean cooking fuel index (E_5) is the ratio of the percentage of people with access to clean fuel in the country to the percentage of people with access to clean cooking

Table 2 The values of energy indices for different South Asian countries

Country	Renewable Energy Index E_1	Per Capita Energy Consumption Index E_2	Fossil Fuel Consumption Index E_3	GDP Per Capita Index E_4	Clean Cooking Fuel Index E_5
Afghanistan	0.03	0.06	0.49	0.03	0.52
Bangladesh	0.13	0.17	0.92	0.07	1.28
Bhutan	4.17	1.08	0.00	0.08	0.86
India	0.72	0.44	1.00	0.12	0.80
Maldives	0.00	0.27	1.25	0.47	1.54
Nepal	3.52	0.07	0.19	0.05	0.49
Pakistan	0.18	0.17	0.80	0.07	0.75
Sri Lanka	1.33	0.23	0.63	0.23	0.46

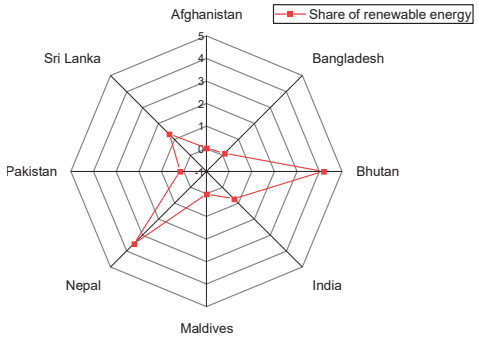

Figure 26 Renewable energy index (E_1).

fuel in the world. Its higher value is desirable, which states that higher numbers of people in the country have the accessibility to clean cooking fuel.

$$E_5 = \frac{\textit{Percentage of people with access to clean cooking fuel in the country}}{\textit{Percentage of people with access to clean cooking fuel in the world}} \tag{5}$$

To compare the progress of South Asian countries on SDG-7, these energy indices (defined above) are calculated and tabulated in Table 2.

Figure 26 shows the variation in the renewable energy index (E_1). In renewable energy utilization, Bhutan and Nepal are leading countries; however, Pakistan and Afghanistan have lower utilization of renewable energy for electricity generation. The Maldives is not generating electricity using renewable energy resources.

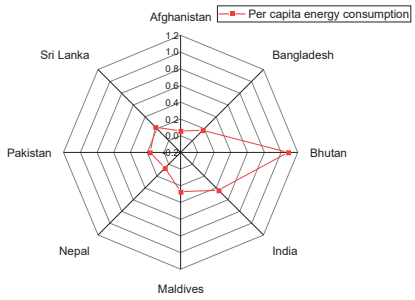

Figure 27 Energy consumption index (E_2).

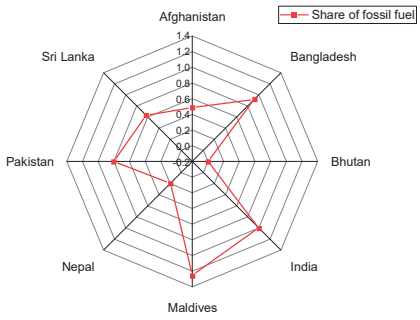

Figure 28 Fossil fuel index (E_3).

The per capita energy consumption index (E_2) is illustrated in Figure 27. It shows that Bhutan has the highest energy consumption index. Bhutan's per capita energy consumption is almost equal to the per capita energy consumption of the world. Other South Asian Countries have significantly lower per capita energy consumption (less than 50% of the world's per capita energy consumption). The lowest per capita energy consumption is found for Nepal and Afghanistan (less than 10% of the per capita energy consumption of the world).

The proportion of the quantity of fossil fuel used for electricity generation compared with the rest of the world is illustrated in Figure 28. Bhutan is not using any fossil fuel for electricity generation. Nepal is also using minimal fossil fuels for electricity generation. Higher fossil fuel consumption is recorded for India ($E_3 = 1$) and Maldives ($E_3 = 1.25$).

Figure 29 shows the variation in the GDP index (E_4) for South Asian countries. It shows that the GDP of South Asian countries is far less than the GDP of the world (less than 50% of the world). A higher and lower GDP

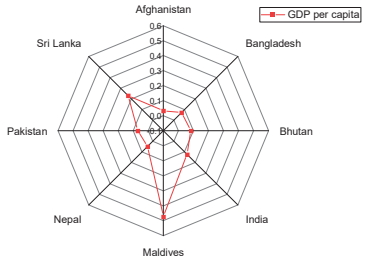

Figure 29 GDP index (E_4).

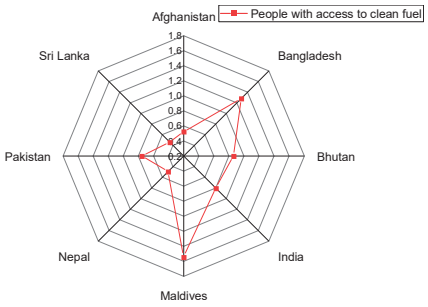

Figure 30 Clean fuel index (E_5).

index is recorded for Maldives ($E_4 = 0.47$) and Afghanistan ($E_4 = 0.03$), respectively.

Figure 30 shows a clean cooking fuel index (E_5) for South Asian countries. It represents a proportion of clean fuel availability to the people compared with fuel accessibility in the world. It depicts that Maldives (E5 = 1.54) and Sri Lanka (E5 = 0.46) have higher and lower clean fuel accessibility.

Table 3 represent the sequence of countries based on their performance in a particular cluster. It shows that Bhutan is a top-performing country in groups E1, E2, and E3; however, Maldives is a top-performing country in groups E_4 and E_5.

Based on the performance of the country in the particular cluster (described in Table 3), rank is allotted to the specific country. Rank varies from 1 to 8, as there are 8 South Asian countries considered in this study. The top and bottom performing countries for a specific cluster are assigned ranks 1 and 8, respectively. Moreover, the final score is calculated, and the final position is given to the country, as shown in Table 4.

Table 3 Energy indices

Index		E_1	E_2	E_3	E_4	E_5
Description of Index		Renewable Energy Index	Energy Consumption Index	Fossil Fuel Consumption Index	GDP Index	Clean Fuel Index
	Rank	High to Low	High to Low	Low to High	High to Low	High to Low
Name of country	1	Bhutan	Bhutan	Bhutan	Maldives	Maldives
	2	Nepal	India	Nepal	Sri Lanka	Bangladesh
	3	Sri Lanka	Maldives	Afghanistan	India	Bhutan
	4	India	Sri Lanka	Sri Lanka	Bhutan	India
	5	Pakistan	Bangladesh	Pakistan	Bangladesh	Pakistan
	6	Bangladesh	Pakistan	Bangladesh	Pakistan	Afghanistan
	7	Afghanistan	Nepal	India	Nepal	Nepal
	8	Maldives	Afghanistan	Maldives	Afghanistan	Sri Lanka

Table 4 Ranking of South Asian countries based on its performance of SDG-7

Country	The Rank of Country in E_1	The Rank of Country in E_2	The Rank of Country in E_3	The Rank of Country in E_4	The Rank of Country in E_5	Total Score	Final Rank as Per the Total Score
Bhutan	1	1	1	4	3	10	1
India	4	2	7	3	4	20	2
Sri Lanka	3	4	4	2	8	21	3
Maldives	8	3	8	1	1	21	3
Bangladesh	6	5	6	5	2	24	4
Nepal	2	7	2	7	7	25	5
Pakistan	5	6	5	6	5	27	6
Afghanistan	7	8	3	8	6	32	7

Based on the total score, the final ranking of countries (Top to bottom performing country) on SDG-7 is Bhutan, India, Sri Lanka, Maldives, Bangladesh, Nepal, Pakistan, and Afghanistan. Figure 31 graphically shows the rank and final score for different South Asian countries on SDG-7.

As per United Nations Development Program (UNDP), HDI measures average achievement in key dimensions of human development such as long and healthy life, being knowledgeable, and having a decent living standard. Table 5 compares the Human Development Index (HDI) and rank assigned to the country. Bhutan and India are top-performing countries on SDG-7 among

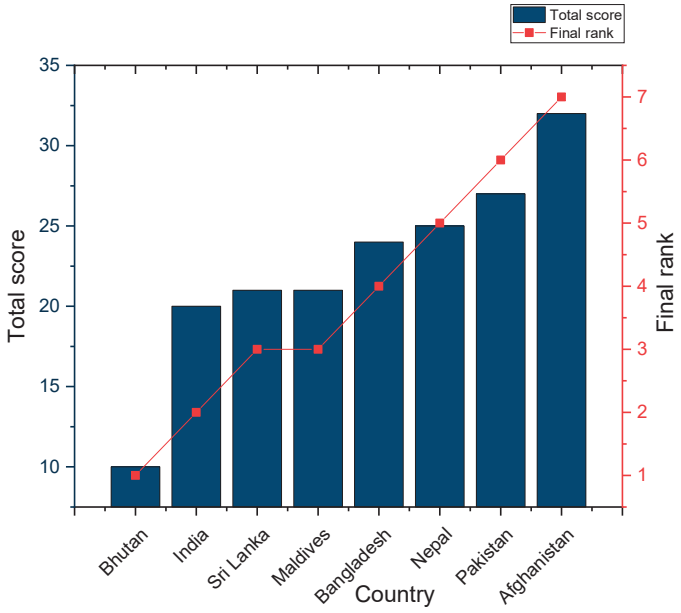

Figure 31 The rank of South Asian Country on the basis of SDG-7.

Table 5 Human development index (HDI)-2018 of South Asian countries (UNDP-2019)

Country	HDI	Rank on SDG-7 Achievement
Bhutan	0.617	1
India	0.647	2
Sri Lanka	0.780	3
Maldives	0.719	3
Bangladesh	0.614	4
Nepal	0.579	5
Pakistan	0.560	6
Afghanistan	0.496	7

all other South Asian countries; their HDI is also higher; however, Pakistan and Afghanistan are lower-performing countries. Their HDI is also found to be higher be lower.

Figure 32 illustrates the average values of energy indices. It shows that South Asian countries perform better on the renewable energy index than the rest of the world ($E_1 = 1.26$); however, based on the GDP per capita index, South Asian countries are performing very poor ($E_4 = 0.14$). Similarly, South Asian countries have low energy per capita index ($E_2 = 0.31$).

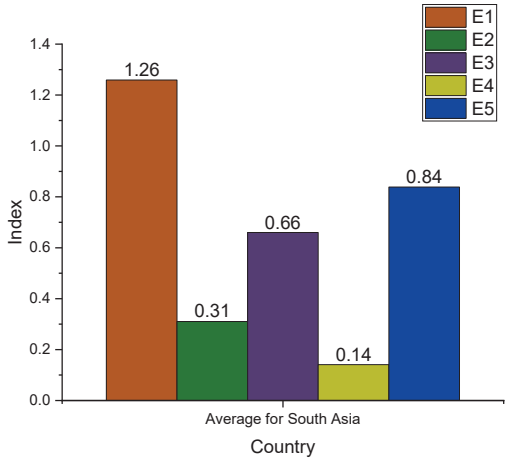

Figure 32 Average indices for South Asia.

It shows that many people of South Asia do not have good accessibility to energy. Therefore, the first and foremost task is that South Asian countries must improve their per capita energy consumption index (E_2) and GDP per capita index (E_4) to attain SDG-7 as early as possible.

6 Initiatives and Challenges

6.1 Barriers and Challenges

Various reports published by South Asian countries illustrates that maximum energy sources such as natural gas, coal, hydropower, renewable energy are not fully utilized (M. K. Deshmukh and Deshmukh, 2006). In the central energy mix, there is a reliance on a single available fuel. India is reliant on coal energy, whereas Bangladesh and Pakistan are reliant on gas. Nepal and Bhutan have hydroelectric power plants. Despite the abundance of renewable energy sources in the area, they have not been fully used (Figure 33). Except for Bhutan and Nepal, all other South Asian nations use renewable energy inefficiently (Kharbanda and Panda, 2016).

It is equally essential that governments of South Asian countries promote solar PV systems, solar cookers, solar distillation, and portable biogas plants for kitchen waste to cater to households' energy needs (Bhujade et al., 2017). There are many challenges in front of south Asian countries to attain SDG-7, such as (Table 6):

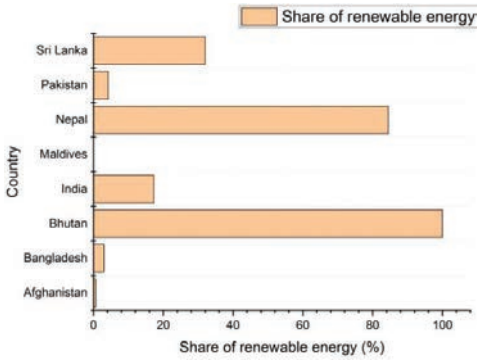

Figure 33 Renewable energy utilization.

Table 6 Several challenges to attain SDG-7 (Katekar et al., 2020; Koyama, 2016; Lo, 2017)

Policy Level Challenges	Technical Challenges	Economic Challenges	Information Challenges
• The use of renewable energy is given less importance in countrywide scheduling • Renewable energy policies are poorly implemented • Massive fuel financial support is provided • There are no incentives for involvement in renewable energy programmes • There is no feed-in tariff structure	• Limited technical expertise to develop, instal, operate, and maintain renewable energy services due to insufficient local production of specialised equipment • Technology that isn't standardised	• High installation and capital costs of renewable energy technology • High risks and uncertainties • Long payback times • Insufficient market information • Insufficient government funding assistance	• Inadequate understanding of renewable energy technology, equipment providers, and financiers • Limited capacity for renewable energy data collecting, analysis, and project development • Inadequate infrastructure for training • Policymakers don't have enough knowledge of renewable energy. • Inadequate company management and marketing abilities

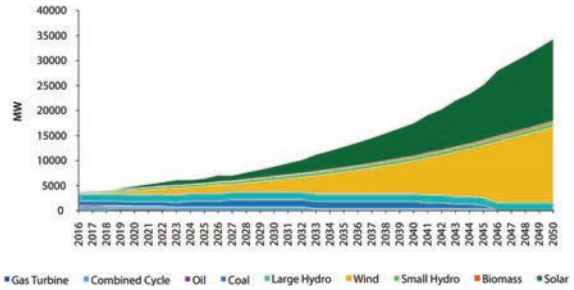

Figure 34 Electricity generation mix progression (SAARC, 2018).

After understanding the challenges to attain SDG-7, South Asian countries have developed a road map to achieve SDG-7. They have brought supportive policies to promote clean energy for electricity generation, transportation and cooking. This section illustrates various initiatives taken by south Asian Countries to attain SDG-7.

6.2 Initiatives at National Levels

6.2.1 Sri Lanka

Sri Lanka promised to utilise entirely renewable energy for electrical production by 2050 at the UNFCCC Conference of Parties in Morocco. Sri Lanka intends to employ renewable energy for power production until 2050, as shown in Figure 34. The Sri Lankan government estimates that using renewable energy instead of imported fossil fuels would save US$ 18 to US$ 19 billion by 2050 (ADB and UNDP, 2017).

The government of Sri Lanka has begun a mandatory energy labelling scheme for regularly used items. In addition, the government has enacted the 2009 Code of Practice for Energy Efficient Buildings. To improve energy efficiency, a National Energy Management Plan has been devised. The government is currently concentrating on small-scale hydropower and wind generating projects (Ferriello, 2012).

6.2.2 Bangladesh

Bangladesh's government is supporting the adoption of efficient cookstoves to minimise indoor pollution. This programme is currently gaining traction. By January 2017, over one million clean stoves had been installed in households. The government has begun the second phase of this initiative, which will see an additional 4 million stoves installed over the following five years, with 30 million stoves installed by 2030 (Government of the

People's Republic of Bangladesh, 2012). The nation is moving on with plans to develop a coalfield in the Phulbari, Dighipara, Khalashpir, and Jamalganj regions to ensure future energy security (Adnan et al., 2018). The government formed the Power System Master Plan 2010 was developed by the government to provide energy to all inhabitants by 2021(Farabi-Asl, 2019).

6.2.3 Pakistan

The Pakistani government has established the Centre for Renewable Energy Technologies (PCRET) to encourage biogas as a healthy cooking option. Pakistan Domestic Biogas Program (PDBP) partnered with the Netherlands Development Organization, Winrock International, and the United Nations Development Program in 2009. (UNDP). By 2014, they have erected a 5360 biogas plant in Central Panjab (Ghimire, 2007; Pandey and Bajgain, 2007; Tareen et al., 2019). To expand renewable energy available in the national grid system, Pakistan adopted the National Power Policy-2013 and Vision-2025. The government also enacts the Pakistan Energy Efficiency and Conservation Act, ensuring that equipment performance is standardised. Private investment was also encouraged to augment current capacity by 2,000 megawatts (MW) by 2016 (Irfan et al., 2020; Rafique and Rehman, 2017).

6.2.4 Afghanistan

Afghanistan is emerging resource-based power projects by tapping wind and hydropower potential to cater to the country's energy requirements. The Government is also launching diesel-based and thermal power plants to cater to the present and future energy demand. The Government has started various programs such as the North East Power System in 2006 and the Western Urban Energy Program to fulfil the country's energy demand (Farabi-Asl, 2019).

6.2.5 India

The Government of India has started the Unnat Chulha Abhiyan (UCA) to reduce indoor pollution to target 2.75 million people in 2014–2017 (S. Deshmukh et al., 2014). The Indian government has undertaken many fruitful schemes, such as (Alagh, 2020; NITI Aayog and IEEJ, 2017; Parikh et al., 2016):

- To transfers subsidies directly to families and to reduce subsidy leakages, the Indian Ministry of Petroleum and Natural Gas (MoPNG) manages the Pratyaksha Hastaantarit Laabh (PAHAL) scheme-2014, which

- The Pradhan Mantri Ujjawala Yojana (PMUY)-2016 provides LPG connections to women from low-income families.
- In March 2016, MoPNG launched the "Give it up" scheme, which allows people to surrender LPG subsidies voluntarily.
- The Ujjwala Plus Scheme (UPS), which MoPNG manages, provides free LPG connections to low-income families.
- The SAHAJ-2015 will enable people to apply for new LPG connections online.
- The Deendayal Upadhyaya Gram Jyoti Yojana (DDUGJY) initiative aims to enhance rural access to energy.
- The Pradhan Mantri Sahaj Bijli Har Ghar Yojana (SAUBHAGYA) initiative seeks to electrify every home in the country.

6.2.6 Bhutan

Bhutan government decided to develop about 20 MW using renewable energy by 2020–25 (Department of Renewable Energy, 2016). Following are the few schemes are undertaken by the government for energy sustainability (Development Bank, 2017; Lam et al., 2017; Shrestha, 2014):

- The Bhutan Biogas Project (BBP) and Bhutan Sustainable Rural Biomass Energy (BSRBE) programmes to promote biogas and better cooking stoves in rural regions.
- The National Water Plan 2005
- The Ten-Year Hydropower Development Plan 2009
- The Twenty-Year Hydropower Development Plan 2009
- The Three-Year Plan of 2013
- The National Water Plan 2005

6.2.7 Maldives

The government of the Maldives has chosen to minimise its reliance on imported fossil fuels. By 2020, the government wants to add 20 MW of solar power, and by 2050, it wants to generate all of its energy from renewable sources. The government also promotes integrated transportation networks and green building designs (Investment, 2018).

6.2.8 Nepal

Nepal's national Government is focusing on the maximum utilization of hydropower potential for future energy security. Hydropower development will provide clean energy to enhance economic and social development in rural and urban areas. Nepal is planning to export electrical power to

neighbouring countries for revenue generation. The Government is also planning to use its wind and solar energy potential (Development Bank, 2017).

6.3 Regional Energy Trade

Energy trading is a viable option for South Asian nations' energy security. The Inter-Governmental Framework Agreement (IFA) for energy cooperation is the South Asian Association for Regional Cooperation (SAARC). It was formed to alleviate the electrical shortages in South Asian nations. The SAARC members accepted recommendations for developing a regional power market during the 16th SAARC Summit in 2010. During the 18th SAARC Summit in November 2014, all South Asian nations decided to construct a local energy grid. The following are some of the current energy trade agreements between South Asian countries (Office, 2013; Rahman et al., 2011; SAARC, 2018):

- Afghanistan, China, Azerbaijan, Kazakhstan, Kyrgyzstan, Mongolia, Pakistan, Tajikistan, Turkmenistan, and Uzbekistan signed the Central Asia Regional Economic Cooperation Programme in 1997
- India and Bangladesh power trade in 2014
- Turkmenistan-Afghanistan-Pakistan-India (TAPI) is a future natural gas delivery project.
- The Central Asia-South Asia 1000 MW project entails constructing almost 1200 km of power transmission lines to transmit power from the Kyrgyz Republic and Tajikistan to Afghanistan and Pakistan.
- Pakistani and Iranian energy trade
- Afghanistan brought 230.14 GWh of energy from Tajikistan, Turkmenistan, Uzbekistan, and Iran in 2006

7 Conclusions and Policy Implication

This paper presents progress and challenges to attain SDG-7 by South Asian countries. From this study, the following conclusions are drawn:

- Bhutan and Sri Lanka have achieved 100 percent power access for their citizens, as required by SDG-7; nevertheless, other nations have progressed toward this target in recent years.
- Bhutan and Nepal are found to be leading countries among other South Asian countries in renewable energy utilization. Bhutan is not using any fossil fuel for electricity generation.

- Bhutan has a higher per capita energy consumption. Other South Asian Countries have significantly lower per capita energy consumption (less than 50% of the world's per capita energy consumption).
- The people of Maldives and Sri Lanka have higher and lower clean fuel accessibility, respectively. item Based on the total score, the final ranking of countries on SDG-7 is Bhutan, India, Sri Lanka, Maldives, Bangladesh, Nepal, Pakistan, and Afghanistan.
- Bhutan and India are top-performing countries on SDG-7 among all other South Asian countries; their HDI is also higher; however, Pakistan and Afghanistan are lower-performing countries. Their HDI is also found to be higher be lower.
- South Asian countries must improve their per capita energy consumption index (E_2) and GDP per capita index (E_4) to attain SDG-7 as early as possible.
- South Asian countries have a narrow focus on renewable energy. Despite abundant renewable energy sources available across the region, they have not been efficiently tapped.

Following are the few recommendations for effective implementation and attainment of SDG-7 for South Asian Countries:

- South Asia must have a divergence of fuel in primary energy consumption patterns. Presently, there is vast supremacy of one fuel in the energy mix for countries.
- The governments of South Asian countries must promote the use of solar PV systems, solar cookers, solar distillation, and portable biogas plants for kitchen waste to cater to the energy need of households.
- South Asian countries must increase energy trade across the cross border.

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