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Research paper

Renewable energy resources in South Asian countries: Challenges, policy and recommendations ☆

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ABSTRACT

In South Asia, a number of developing countries like India, Pakistan, Sri Lanka, Bhutan, Nepal, Afghanistan and Maldives are looking into inexhaustible and repeatable alternative energy sources such as solar, wind, hydro and biomass. Geographically, South Asian countries are located in a region of different climatic conditions such as tropical, humid etc. which provides easy access to a variety of renewable energy sources. The governments of South Asian countries have initiated renewable energy policies to encourage industries and individuals to employ renewable energy powered systems in power applications. This article provides an updated and comprehensive overview of the renewable energy status in the South Asian countries, and it includes an assessment of the region's renewable potential, current installed renewable energy capacity. This paper gives a brief description about energy scenario, renewable energy potential and challenges in South Asian countries. The study also provides the renewable energy policies and recommendation in South Asian countries.

1. Introduction

The development of renewable energy technologies is now widely recognized as a crucial component in providing an integrated solution to limit greenhouse gas emissions [1]. It is an important opportunity to foster innovation and promote economic growth while enhancing access to secure, clean, and affordable energy [2]. Developing countries like India, Pakistan, Sri Lanka, Bhutan, etc., are looking into inexhaustible and repeatable alternative energy sources such as solar, wind, hydro and biomass. South Asian countries' rapid population growth and economic development have increased the energy demand [3]. Currently the South Asian countries have initiated several efforts to move to alternative types of energy, specifically renewable energy, to reduce South Asian countries' overdependence on fossil fuels and manage the growing demand for energy [4]. There will be a large gap between the potential of fossil fuel supply and the energy demand to achieve the South Asian countries' new social and economic development target for 2020 set by their central government [5]. Further, the increasing attention on greenhouse gas mitigation requires coal generation to be replaced by low carbon technologies. So renewable energy is an inevitable choice for South Asian countries to secure their electricity supply and to facilitate greenhouse gas mitigation [6]. Many types of renewable energy resources such as wind and solar energy are constantly replenished and will never run out [7]. Renewable energy technologies range from solar power, wind power, hydroelectricity/micro hydro, biomass and biofuels for transportation. Tables 1 and 2 summarize the advantages and negative impacts of renewable energy technologies.

This paper focuses mainly on challenges, policy and recommendation for the South Asian countries. First of all, it tracks the energy scenario and potential of renewable energy resources in South Asian countries as well as the challenges for renewable energy development. Based on that, a list of policy and recommendations is suggested to all regulatory framework aspects, such as financial, legislative, political, research and development and environmental mechanisms.

2. Energy scenario in South Asian countries

Energy supply and security are major challenges on the road to development in the South Asian countries. Tables 3 and 4 show the

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Table 1
Advantages of renewable energy.

Type of energy	Application	Mitigation benefits	Adaptation benefits	Socio-economic development benefits
Solar energy	Cooking, lighting, and water heating	Less consumption of fuel wood, kerosene and batteries, improved local air quality	Illumination for rural education and access to information and communication technology	Improved quality of life as well as better health and sanitation through streetlights and boiled water
Hydro energy	Lighting, agricultural processing	Reduced greenhouse gases, protection of land	Improved social resilience	Improved agricultural yield
Wind energy	Power generation, crop processing, irrigation, and water pumping	Decreased dependence on wood/biogas, avoidance of CO_2 emissions	Reduced vulnerability to water scarcity, more adaptation choices through irrigated agriculture	Income generation, improved quality of life, reduced risks of vector borne diseases, improved water supply/food security, school attendance (especially for girls), reduced migration
Biomass	Electricity generation and heat	Reduced use of charcoal and fuel wood, less pressure on natural resources	Reduces the likelihood of deforestation and desertification	Creation of jobs and livelihood opportunities, reduced drudgery, reduction of incidents related to indoor air pollution and respiratory infections
Biogas	Thermal energy; production of sludge for fertilizer	Reduced use of charcoal, fuel wood, and liquefied petroleum gas; reduced use of pesticides and fertilizers	Reduces the likelihood of deforestation; adapting to soil erosion, aridity, and environmental degradation	Reduced drudgery, reduction of incidents related to IAP and respiratory infections; better prospects for agricultural productivity and income generation

comparison of per capita electricity consumption of South Asian countries and electricity consumptions and uses. Table 5 demonstrates that many South Asian countries depend on a single source to provide more than 50% of total electricity generation including India (Coal – 67.9%), Nepal (Hydropower – 99.9%), Bangladesh (Natural gas – 91.5%) and Sri Lanka (Oil – 50.2%).

Energy use traces the total amount of energy consumed by the end user. This includes domestic production as well as imports, etc [9,10]. While Indian and Pakistani consumers rely heavily on fossil fuels, a significant share of energy use in Nepal and Sri Lanka can be traced to combustible renewable and waste such as solid fuels and firewood. It is important to note that in many countries less than 5% of energy consumed came from renewable sources [11–13].

As shown in Fig. 1 , access to electrical energy varies from 41% in Afghanistan to 100% in Maldives in 2010. The average electrification rate in the region was 74%, which translated to 417 million people without electricity, constituting more than a third of the world 1.2 billion people lacking access [15]. Besides, access to non solid fuels is low in the local, averaging 38% in 2010 [14]. Subsequently, more than 1 billion people utilized solid fuel for cooking, compared with 2.8 billion around the world [16]. Access to non-solid fuel varies in South Asian countries; Maldives, and Bhutan report high figures, 92% and 60% individually, over the worldwide normal of 59%, while Bangladesh reported a level of 9%.

Table 2
Summary of negative impacts of renewable energy technologies.

Types of energy	Negative impacts
Solar power system	• Requires sizeable amount of land • Poses environmental hazards if the production process is not handled appropriately
Hydro	• Native population displacement • Soil erosion • Reduced agriculture land • Ecosystem disturbance
Wind	• Alteration in migrating birds flight path • Electromagnetic interference for radio signals • Consequential noise from rotating blades • Eyesore to the landscape
Biomass/Biogas	• Fuel source uncertain and requires land for waste production • Facility requires sizeable amount of land and water • Affect surrounding biodiversity • Emission of GHG such as deadly methane and CO_2

Table 3
Comparison of per capita electricity consumption of South Asian countries [1].

South Asian country	Per capita electricity consumption in kWh
India	644
Sri Lanka	636.3
Pakistan	457
Afghanistan	119.8
Bangladesh	278.1
Nepal	454.1

3. Renewable energy potential for South Asian countries

The South Asian countries have huge potential for renewable energy sources. Table 6 summarizes the renewable energy potential for solar power, hydro power and wind power [17]. Nepal alone has a huge hydropower potential of 83,000 MW, and even if energy demand increases at a rate of 10%, domestic demand will reach only 3500 MW by 2025. This presents a lucrative opportunity for Nepal for energy trade that will also help in enhancing the energy security in the South Asian countries as a whole [18,19]. Similarly, the massive solar power potential in India and wind power potential in Afghanistan can help the South Asian region go a long way in fulfilling its energy needs.

4. Challenges facing renewable energy development in South Asian region

Despite the huge potential and benefits of promoting renewable energy, there are obstacles at both the national and regional levels, which must be overcome. One of the challenges is low investment in renewable energy because it involves high initial capital costs, and the monetary benefits from such projects take time to materialize. The following are the challenges in renewable energy technologies:

Table 4
Electricity consumption and uses [2].

Country	Energy consumed (million tons of oil equivalent)	Fossil fuels (% of total use)	Combustible renewable and waste (% of total use)	Alternative and nuclear energy (% of total use)	Energy produce (million tons of oil equivalent)	Energy Use – Energy production (Mtoe)
India	749.4	72.3	24.7	3	540.9	208
Sri Lanka	10.4	48.7	47.4	3.9	5.3	5.1
Pakistan	84.8	60.9	34.6	4.5	65.1	19.7
Afghanistan	–	–	–	–	–	–
Bangladesh	31.3	71.5	28.2	0.2	26.1	5.2
Nepal	10.4	12.5	84.1	2.7	9	1.4

Table 5
Electricity generation [8].

Country	Electricity production (kWh billion)	Coal (% of total)	Natural gas (% of total)	Oil (% of total)	Hydropower (% of total)	Renewable energy (% of total)	Nuclear power (% of total)
India	1052.3	67.9	10.3	1.2	12.4	5	3.2
Sri Lanka	11.6	8.9	0	50.2	39.7	1.2	0
Pakistan	95.3	0.1	29	35.4	29.9	0	5.5
Afghanistan	–	–	–	–	–	–	–
Bangladesh	44.1	1.8	91.5	4.8	2	0	0
Nepal	3.3	0	0	0.1	99.9	0	0

4.1. Policy wise challenges

- Lack of incentives for private sector involvement and inconsistent policies.
- Absence of feed-in tariff structure.
- Fossil fuel subsidies.
- Weak environmental regulations.
- Low priority given to renewable energy in national planning and weak implementation framework.

4.2. Technical challenges

- Limited technical capacity to design, install, operate, manage and maintain renewable based modern energy services.
- Technological constraints for reliable and comprehensive mapping.
- Limited local manufacturing of specialized equipment.
- Lack of standardized technology.

4.3. Economical challenges

- Small economies of scale, high initial capital costs, and long payback periods.
- Lack of access to credit and insufficient government financial support.
- Limited knowledge on market potential.
- High installation costs at the end user level.
- High perceived risks and uncertainties.

4.4. Information and human resource wise challenges

- Lack of quality information about RE resources and technologies, EE, equipment suppliers, and potential financiers.
- Insufficient information available on renewable energy and energy efficiency for policy making and mobilizing civil society.
- Insufficient expertise in business management and marketing skills.

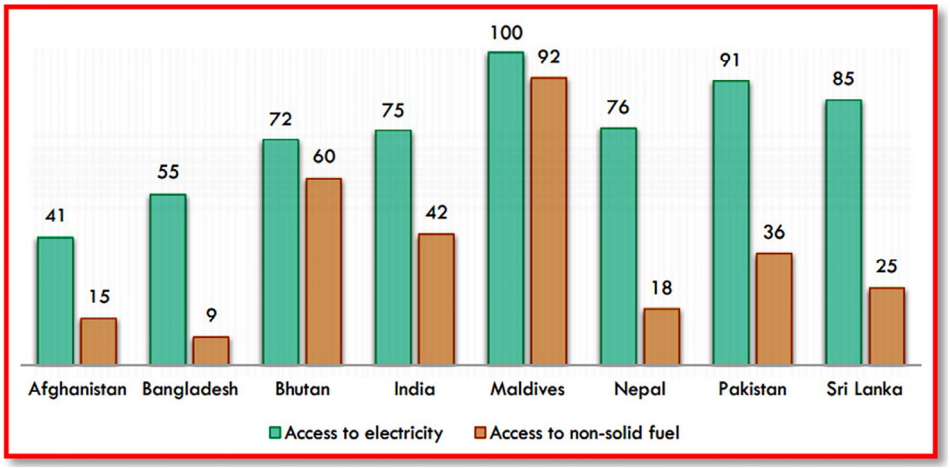

Fig. 1. Access to electricity and non-solid fuels (% of population) – 2014 [14].

Table 6
Renewable energy potential.

Country	Solar power potential (kWh/m^2/day)	Hydro power potential (MW)	Wind power potential (MW)
India	5.0	150,000	102,778
Sri Lanka	5.0	2,000	24,000
Pakistan	5.3	59,000	131,800
Afghanistan	6.5	25,000	158,000
Bangladesh	5.0	330	–
Nepal	4.0	83,000	–

- Lack of expertise and services in system design, installation, operation and maintenance of renewable energy and energy efficiency technologies.
- Limitation in country capacity for RE data collection, analysis, and project development.

5. Policy responses in South Asian countries

5.1. Establishment of renewable energy plan and target

- Energy planning processes usually include a study of sectorial demand and supply, forecasts of the trends of input–output items, based on economics and technological models and strategies to diversify the sources of energy [20]. Most of the South Asian countries have published their targets and plans to include renewable sources in their energy mix, in addition to target regarding energy efficiency [21].

5.2. The mandatory connection and purchase policy

This mandatory connection and purchase policy is a landmark provision, because it ensured that there would be a market for the electricity generated by renewable sources and helped foster the clear long-term market demand that is needed for investment in large-scale energy infrastructure projects.

The Measures on Grid Company full purchase of electricity from renewable energy [22]:

- Require grid companies to promptly provide connection services to the renewable generation.
- Include a penalty provision in the event of grid company non-compliance with the mandatory connection and purchase policy.

5.3. Renewable energy development fund

The new renewable energy development fund includes both the renewable energy surcharges collected from grid companies, which is funded through government of South Asian countries and supports the following activities [23]:

- Promoting the localization of manufacturing for renewable energy equipment.
- Renewable energy programs for use in agricultural and herding areas.
- Construction of independent renewable electricity systems in remote areas and islands.
- Renewable energy resource exploration, evaluation, and related information systems.
- Science and technology research, standard setting and demonstration projects supporting sustainable solar PV integrated building design [24,25].

6. Recommendations

To address the challenges listed above, the following recommendations are suggested for the government of South Asian countries:

- Encouraging international cooperation of renewable energy products manufacturing and applications can provide advanced technologies, outstanding professionals, knowledge and management mechanisms of each participant. International cooperation prospects in renewable energy policies for social benefits optimization.
- Organizing public R&D programs for a concrete reduction of energy generation cost. The organization of public R&D programs at the central level, aiming at a concrete generation cost reduction can utilize intellectuals, research instruments, knowledge and other research resources across the country. It can provide a big picture of technology progress for renewable energy generation cost reduction so as to guide R&D teams to cooperate for the common target.
- Coordinating local renewable energy product manufacturing policies at the central level. Policies of South Asian countries are necessary and important to promote renewable energy development, appropriate for local conditions of economic development, social development and resources availability. However, policies seeking for short term returns can cause social benefits loss at the national level, since the intervention could bias the decision of investors.

7. Conclusions

- National and regional policies can play an important key role in supporting renewable energy development and implementation, helping South Asian countries to identify priorities and pathways for renewable energy market.
- It also expands their renewable energy roadmap to consider other policies and measure to predict problems resulting from high share of renewable energy in the energy portfolio and suitable solutions such as smart grid technologies.
- The governments of South Asian countries have announced various programs and policies to increase the awareness of the public about the significance of using renewable energy resources. Another major concern for initializing renewable energy projects is the contribution to GHG emission reduction and becoming a green developing country.
- In this regard national and international energy policies obviously show a great effort in energy scenarios; however, South Asia region still has a lot of potential in order to fully utilize renewable energy resources. Hence more collaboration between public and government needs to be performed to ensure a remarkable achievement.
- At the South Asia region level, renewable energy can attract investment, provide energy security through diversification, spur technological research and enhance stable economic growth. Besides, increasing the cost effective penetration of renewable energy into the electricity supply requires considerable cooperation among decision makers of the energy sector.

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