



Research paper

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

Akash Kumar Shukla, K. Sudhakar \*, Prashant Baredar

*Energy Centre, Maulana Azad National Institute of Technology Bhopal, Bhopal, India*

Received 22 November 2016; received in revised form 10 December 2016; accepted 11 December 2016

Available online

**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.

© 2017 Tomsk Polytechnic University. Production and hosting by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

**Keywords:** Energy; Solar energy; Renewable energy

**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**

\* Corresponding author. Energy Centre, Maulana Azad National Institute of Technology Bhopal, Bhopal, India.

E-mail address: [sudhakar.i@manit.ac.in](mailto:sudhakar.i@manit.ac.in) (K. Sudhakar).

<http://dx.doi.org/10.1016/j.reffit.2016.12.003>

2405-6537/© 2017 Tomsk Polytechnic University. Production and hosting by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>). Peer review under responsibility of Tomsk Polytechnic University.

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 <sub>2</sub> 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

show the 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

Table 2  
Summary of negative impacts of renewable energy technologies.

Types of energy	Negative impacts
Solar power system	<ul style="list-style-type: none"> <li>Requires sizeable amount of land</li> <li>Poses environmental hazards if the production process is not handled appropriately</li> </ul>
Hydro	<ul style="list-style-type: none"> <li>Native population displacement</li> <li>Soil erosion</li> <li>Reduced agriculture land</li> <li>Ecosystem disturbance</li> </ul>
Wind	<ul style="list-style-type: none"> <li>Alteration in migrating birds flight path</li> <li>Electromagnetic interference for radio signals</li> <li>Consequential noise from rotating blades</li> <li>Eyesore to the landscape</li> </ul>
Biomass/Biogas	<ul style="list-style-type: none"> <li>Fuel source uncertain and requires land for waste production</li> <li>Facility requires sizeable amount of land and water</li> <li>Affect surrounding biodiversity</li> <li>Emission of GHG such as deadly methane and CO<sub>2</sub></li> </ul>

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

– 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 nonsolid 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%.

### 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.

متن کامل مقاله

دریافت فوری ←

**ISI**Articles

مرجع مقالات تخصصی ایران

- ✓ امکان دانلود نسخه تمام متن مقالات انگلیسی
- ✓ امکان دانلود نسخه ترجمه شده مقالات
- ✓ پذیرش سفارش ترجمه تخصصی
- ✓ امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
- ✓ امکان دانلود رایگان ۲ صفحه اول هر مقاله
- ✓ امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
- ✓ دانلود فوری مقاله پس از پرداخت آنلاین
- ✓ پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات