

A comparative review of China, India and Pakistan renewable energy sectors and sharing opportunities



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ABSTRACT

China, India and Pakistan (CIP) contain almost 40% of the world population and constitute a developing region which is desperately seeking energy resources to fulfill the growing economy requirements. CIP are three main countries of South Eastern Asia with nuclear capability and have greater potential of energy sharing for the regional prosperity and socio economic development. The total energy consumption of China and India is 3682.15 Million tons of Oil Equivalent (MTOE) which is approximately 28% of the world. The energy consumption of Pakistan is far less i.e. 85.75 MTOE however, it can play a pivotal role by providing energy sharing opportunities in the region. This paper presents a comparative and comprehensive review of CIP renewable energy sectors and possible sharing opportunities. Cleaner and abundant Renewable Energy Sources (RES) like hydro, solar, wind, biomass, nuclear and geothermal have been discussed and compared in context of CIP energy requirements. CIP relations and energy sharing opportunities have also been elaborated in context of regional peace and security situation. Exploitation of the CIP energy potential and energy sharing opportunities might contribute to global peace and prosperity.

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1. Introduction

Energy has been a key requirement for mankind since its creation on the planet. Increasing population and modernization race have increased the overall energy requirements and per capita energy consumption, respectively. Modernization and per

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capita energy consumption have stimulated effect on each other i.e. increase in one gives rise to the other. Per capita consumption of some countries is shown in Table 1. According to which China is leading India and Pakistan in per capita consumption [1,2].

Worldwide per capita consumption shows that a significant amount of energy is being used in each and every sector of the society. Per capita energy consumption is directly proportional to the economic growth of a country. The countries like China, France and USA have the highest energy consumption per capita, as a result these countries have rapid economic growth rate [3,4].

To enrich industrial progress, most popular form of energy being used nowadays is electricity. Modern electric power system is an interconnected network comprising of power generation, transmission, distribution and utilization. Power is often generated in remote areas from where transmission network is stretched to transmit the power to load centers. The received power is then distributed to consumers through distribution network. Electrical energy is a key requirement of modern society. Therefore, it is necessary to highlight each possible electricity production resource. By the end of year 2012, global power generation capacity was 22,668 TW h. The largest contributors were fossil fuels (67.9%) and other resources include: nuclear (10.9%), hydro power (16.2%) and other renewables (5%), as depicted in Fig. 1.

The available resources of fossil fuels on the globe are depleting rapidly causing dramatic leaning in their prices which will be economically inappropriate. On the other hand, use of fossil fuels has adverse impact on the environment because of the emissions of the harmful gases like CO₂, SO_x, and NO_x usually known as greenhouse gases (GHG) [5,6]. China is the leading country in GHG with 8205.86 Million tons (Mt) and India is at third place with 1954.02 Mt of CO₂ emission [7]. Accumulation of these gases in the atmosphere has triggered some serious environmental issues like

increased level of environmental pollution and remarkable change in the climate of the planet. According to the US Environmental Protection Agency (EPA) the net GHG emission has been increased by 42% during 1990–2012 due to human activities [8]. Electricity generation through fossil fuels is the largest contributor in GHG emission [9]. To minimize this adverse effects on the environment, the European commission of climate action set a target of reducing GHG emissions at least 20% below the year 1990 [10]. To address the economic and environmental issues associated with fossil fuels and to achieve the goal of reducing GHG emissions, Renewable Energy Sources (RES) are the best possible solutions to meet the growing energy demand. RES, although produce green energy, are not free of complications. High capital costs, intermittency, difficulties in storage and complications in grid connectivity are the major obstacles in adoption of renewable energy [11]. Some developed countries are including renewable energy in their power systems at a greater pace but many countries are continuously adding significant amount of fossil fuel capacity, resulting in lower growth rate of renewable energy. Therefore owing to barriers in adoption of renewable energy, global power sector still relies on fossil fuels.

China, India and Pakistan (CIP) contain almost 40% of the world population and constitute a developing region which is desperately seeking energy resources to fulfill the growing economy requirements. On the other hand the contribution of CIP in energy consumption is approximately 29% of the entire world [7]. CIP are three main countries of South Eastern Asia with nuclear capability and have greater potential of energy sharing for the regional prosperity and socio economic development.

This paper presents a comparative and comprehensive review of CIP renewable energy sectors and possible energy sharing opportunities. Exploitation of these sharing opportunities is necessary for acceleration of regional economic development. It will also contribute in global peace and prosperity by fulfilling the energy requirements of the world's 40% population. Our approach is to compare the RES in South Eastern Asia and to explore the energy sharing opportunities in context of regional peace and security. The paper also includes future energy demands and renewable energy targets of CIP. Furthermore, the work also presents comparison of CIP renewable energy sectors in light of recent data and analytical graphs. Rest of the paper is arranged as follows. Section 2 presents the brief overview of CIP energy sectors and energy mix. Section 3 describes the detailed discussion of energy resources and various phases of energy projects in CIP. Section 4 elaborates the energy sharing opportunities among CIP. Section 5 concludes the discussion.

Table 1

Comparison of per capita electricity consumption of some countries.

Country	Per capita electricity consumption in kW h
USA	13,361
France	7756
Germany	7217
China	2942
Turkey	2474
India	644
Sri Lanka	636.3
Pakistan	457
Afghanistan	119.8
Bangladesh	278.1
Nepal	454.1

Global Power Generation Mix

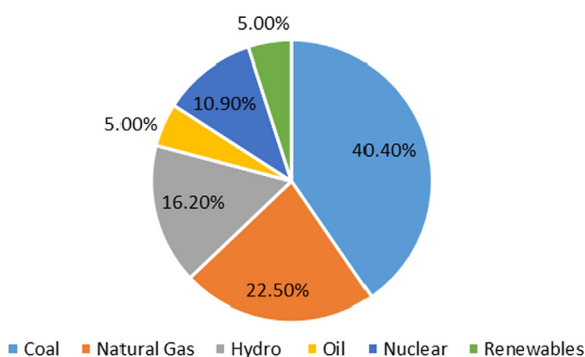


Fig. 1. Share of global energy resources.

2. Overview of CIP energy mix

Pakistan is a developing country having population around 185.1 million people and is facing severe economic and energy crises [12]. Power sector of Pakistan relies on conventional sources of generation. During the year 2007–2008, electricity generated was around 95,860 GW h and stayed at 95.4 GW h for the year 2009. The share of thermal power was 66.5% followed by hydel (29.9%) and nuclear (3.4%). In thermal power, gas had the largest share (34.3%) followed by oil (32.1%) and coal (0.1%). According to Hydrocarbon Development Institute of Pakistan, electricity generated was reduced to 94,653 GW h during 2010–11 [13]. The share of thermal power was 62.5% followed by hydro (33.6%) and nuclear (3.9%). In thermal power, oil had the largest share (27.3%) followed by natural gas (27.3%) and coal (0.1%). Some of the major factors influencing power sector are limited fuel resources, declining economy, lack of capital investment, external and

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