CHAPTER 1

ADDRESSING CLIMATE CHANGE AND ENERGY SECURITY THROUGH ENERGY COOPERATION: CHALLENGES AND OPPORTUNITIES IN SOUTH ASIA

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Abstract: South Asia is at a crossroads with growing population, rising per capita income, expanding economies, and increasing energy demand. With growing industrial, commercial, and transport sectors along with rising urban and middle-income consumers, the energy use is increasing at unprecedented rates to meet the ambitious poverty-reduction targets. All countries of the region are facing critical scenarios ranging from depleting indigenous energy resources for developing long-term energy cooperation plans to ensuring energy security. South Asian countries are highly dependent on imported fuels, especially liquid hydrocarbon, for transport. For instance, India, Pakistan, and Bangladesh meet less of their energy demand with indigenous sources and thus face mounting energy import

bills. Maldives depends on oil products to meet its energy needs. Nepal and Bhutan have huge hydroelectric potential. At the same time, there is a very wide variation in the energy consumption levels in South Asian countries. The high potential of hydropower in South Asia can reduce the reliance of the region on importing fossil fuel, increase the demand from indigenous resources, raise the energy security level, and reduce the emission levels. Therefore, energy security is vital for improved economic growth and to attain poverty reduction in the region, and thus calling for development and utilization of locally available renewable energy along with intraregional energy cooperation to help mitigate individual country energy security risks in the context of climate change is required.

Keywords: Climate change, Energy security, Energy trade, Regional cooperation, South Asia

1. INTRODUCTION

Sustainable energy access (SEA) implies reliable and affordable access to people and communities of cleaner and more efficient modern energy services for cooking and lighting, which offers increased employment opportunities and improved livelihood via economic diversification, upgrading value chains, more efficient food production, and improved water management through better coping mechanisms and climate adaptation strategies (EUEI PDF, 2017). Energy security is defined as assurance of sufficient energy supplies to permit the national economy to function in a politically acceptable manner (Willrich, 1976). The International Energy Agency defined energy security as the uninterrupted availability of energy sources at an affordable price (IEA, 2014a), whereas sustainable energy security refers to “provisioning of uninterrupted energy services in an affordable, equitable, efficient, and environmentally benign manner” (Narula, 2014). SEA is a fundamental development goal (SE4All, 2017), whereas inadequate energy access poses greater constraints and fewer options for the most vulnerable groups in adapting to climate change. Improvements in energy access can improve adaptive capacity and build local resilience. Both adaptation and mitigation approaches in the energy sector can reduce climate risks in a more cost-effective and socially responsive manner and lead to climate-compatible development. Recently, renewable energy systems offer new investment opportunities through

international financing in developing countries; however, this is confronted with governance challenges in energy infrastructure.

South Asia comprises Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka, had a population of 1.8 billion in 2018, and faces a major challenge in accelerating economic growth and reducing poverty in the context of increased climate risks. In South Asia, warming is likely to be above the global mean temperatures. The intraseasonal variations in mean temperatures significantly impact hydropower resources of the region. Substantial annual variability in rainfall has been observed during the southwest monsoon season in South Asian countries. In India, primary energy demand is projected to more than double by 2030 from 3.2% per annum in 2000–2005, at a projected annual gross domestic product (GDP) growth of 6.3%, to become the world's third-largest carbon dioxide emitter (IEA, 2011). Energy demand for accessing irrigation water will increase due to higher temperatures, prolonged droughts, depleting water tables, and provision of heavily subsidized power to Indian farmers. In Bangladesh, the projected climatic changes can affect both energy supply and demand during peak hours in hot summer seasons. Regular cyclones and floods cause power supply failures and infrastructure damage, which can have severe impacts on energy demand when the system is already suffering from 600–1,200 megawatts (MW) of “load shedding” (REIN, 2009). Bhutan is highly vulnerable to climate change, glacier melting, and perturbation in natural water resources due to its dependence on hydropower resources for 99% of the electricity supply and 31% of national revenue (RGoB, 2011). Maldives is faced by a barrier to grid connection and is dependent on imported fossil fuel for tourism; therefore, renewable energy development, particularly solar and wind energy, is vital for its survival and growth (Musthafa, 2011).

Increased climate variability has a severe effect on hydropower plants in Nepal that supply 91% of power, that is, more than 85% of the population depends on traditional energy sources and 18 million people lack access to electricity (ADB, 2009). The melting of glaciers causes a reduction in stream flows and poses significant risks to hydropower development and the associated energy supply in Nepal. An increase in the mean temperature by 0.06°C per annum would decrease the hydropower potential in Nepal by the end of the century (Chaulagain, 2006). In Sri Lanka, 46% of energy

needs are met by hydropower, which has been tapped fully; however, rainfall fluctuations have affected hydropower generation. Therefore, Sri Lanka relied heavily on increased investment in thermal power plants and non-conventional renewable sources to meet its energy requirements (Rathnayake *et al.*, 2009). As can be seen from the above examples, climate change affects energy security in South Asia both on the supply side as well as the demand one. Bangladesh, Bhutan, India, and Nepal are projected to experience a $> 2^{\circ}\text{C}$ rise in temperature by 2050 and an approximately 4.8°C by 2100. South Asia could lose about 1.8% of its annual GDP by 2050 and 8.8% by 2100 due to climate risks. To avoid these losses, the region needs an average adaptation expenditure increase of 0.48% and 0.86%, respectively, by 2050 and 2100 (IPCC, 2013). Therefore, climate proofing measures in key sectors including energy call for climate-resilient development. In brief, climate change is hampering the energy security of the South Asian region, for which renewable energy must be developed for rapid socioeconomic transformation and poverty reduction. With the above background, an attempt has been made in this chapter to examine the challenges of climate change and energy security through regional energy cooperation in developing South Asian countries.

2. LITERATURE REVIEW

Few studies have made a serious attempt to clarify the concept of energy security. Andrews-Speed *et al.* (2002) defined energy security as the availability of energy at all times, in various forms, in sufficient quantities, and at affordable prices. Energy security means that there is no loss of welfare due to change in price or physical availability of energy, that there is reliable supply of energy at an affordable price to support the requisite economic activities, and that there is availability, accessibility, affordability, and acceptability of energy (APEREC, 2007). Energy security is concerned with energy supply, sufficiency, surety, survivability, and sustainability (Sovacool, 2011), each of which has different implications for different countries and is linked to the level of development, geographical location, natural endowments, political system, and international relations (Luft *et al.*, 2011). Yao and Chang (2014) provide an indicator for energy security covering availability, applicability, acceptability, and affordability and defined energy security as “an ‘energy

secure' nation is a nation that has affordable energy resources with an adequate amount of fossil fuels, nuclear energy, and renewable resources, technologies applicable to energy harnessing and utilization, and, at the same time, addresses social and environmental concerns".

Energy security is measured through energy intensity, energy efficiency, import dependence, and supply–demand index. Traditional understanding of energy security is too limited and needs to be understood in terms of new challenges, including environment, technology, demand management, and local socio-cultural and political aspects (Von Hippel *et al.*, 2009). Recently, challenges of energy security have been linked with existing policy orthodoxies. The link between climate policies and energy security is also increasingly gaining importance (Bazillian *et al.*, 2013). Energy security has three sets of linkages: energy and growth, energy and poverty, and energy and the environment. Energy security implies robustness against disruptions of energy supply at temporal and spatial scales. Prolonged disruptions in energy supply would create serious economic problems for most economies. Fossil fuel scarcity and declining reserves indicate the necessity for sustainable transition to renewal energy resources, which are far more evenly distributed, less traded, less vulnerable to price volatility, and can enhance energy security.

The Paris Agreement emphasizes real and ambitious emission reductions and a commitment to transitioning to low-carbon economies. Emission reductions from the energy sector will be at the core of climate change mitigation (IEA, 2015a) for which developing countries can contribute on a voluntary basis to the Green Climate Fund (GCF) (UNFCCC, 2015). Diverse energy systems that rely on multiple sources of primary energy are more robust when faced with shocks, constraints, and crises that affect forms of supply (IEA, 2015a). In this context, market integration is an essential tool to reduce the cost of maintaining adequate capacity and increasing reliability of the electric system (IEA, 2014b). Reliance on imports may be beneficial if there is effective regional integration. Besides, economies of scale in power generation capital costs are possible through grid interconnection to allow for larger power plants to be developed to meet the increased demand. Therefore, energy security cooperation helps in securing reliable energy supply at an economical rate without disruption and with the guarantee of safe delivery of energy resources.

3. ENERGY STATUS IN SOUTH ASIA

World energy demand is expected to increase by more than 25% (IEA, 2018a), and global electricity demand is likely to rise by 60% to reach 34,500 TWh by 2040, which is an increase double the rate of primary energy demand. Global growth in electricity supply is dominated by wind and natural gas (23% each) and solar photovoltaics (PVs) (20%), whereas the share of fossil fuels in power generation is likely to decrease to around 50% in 2040 from 66% in 2018; the share of renewables is expected to increase from 24% in 2016 to 40% in 2040 compared to nuclear energy at 10% (IEA, 2018b). Energy poverty compels millions of women and children to spend significant time collecting firewood (IEA, 2010), thus highlighting the need to call for robust policies to promote access to modern energy services and break the vicious cycle of energy poverty (IEA, 2018a).

In India, coal provides 45% of the primary energy mix, with 340 million tons of coal equivalent (Mtce) produced in 2013, targeted to rise to 1.5 billion tons by 2020 (IEA, 2015b). The coal investment rose by over 10% in 2016 to increase coal generation and reduce thermal coal imports, thereby making India the second-largest coal producer in the world. In 2017, with changes in policies, there has been underdevelopment in coal power capacity and 452 gigawatts (GW) of coal plants were cancelled between 2010 and 2017. In 2018, India was still the second largest producer of coal power. The state-owned Coal India, a public sector company, accounts for more than 80% of coal production with increased investment in coal mining. Due to the new policies of “round-the-clock energy for all” and “Make in India”, India is targeting 1.5 billion tons (Gt) of coal output by 2020 with major new coal supplies confined to domestic production. India’s coal-fired power generation is likely to increase by 50% in 2020 and less than 5 TWh by 2040 (IEA, 2016a).

In India, coal imports are rising to overcome the rising demand–supply gap in coking and non-coking coal. International coal prices have been volatile in the recent past (IMF, 2013), which makes domestic coal consumption in India vulnerable to rising import dependence and demanding increasing coal handling capacity of ports to manage these rising imports. High dependence on fossil causes 77% greenhouse gas emissions from the energy sector in India (MoEF, 2010). There are large environmental costs of coal use in India being incurred by the communities exposed to particulate and dust

emissions, changes in land-use pattern; damage to forests, land, biodiversity, and aquatic ecosystems; contamination of water supplies; loss of livelihood; displacement; and numerous health problems. The high erosion at waste disposal sites leads to highly acidic runoff and seepage, thereby damaging terrestrial and aquatic ecosystems. Heavy dependence on coal and massive CO₂ emissions in India are attributed to coal burning, which can exacerbate climate change.

India has adopted plans to significantly expand electricity capacity to meet the projected increasing demand. In 2014, the domestic crude oil production in India was low, at 0.9 million barrels per day (mb/d), compared to the demand for oil products at 3.8 mb/d, resulting in substantial import demand. Gas is the cornerstone of India's future energy policy. India's proven gas reserves are 1.12 trillion cubic meters (tcm), which is 0.6% of the world's proven reserves (IEA, 2011). In India, gas meets 9.07% of primary energy demand for power generation and manufacturing fertilizers. Natural gas contributed 6% to the Indian energy mix in 2013 and was used for power generation and production of fertilizers. Continuous economic growth and lower oil and gas prices will result in increased demand for natural gas in India (IEA, 2015b). For instance, the demand for gas is likely to increase by 4.5% per annum, from 59 billion cubic meters (bcm) in 2009 to 186 bcm in 2035 (IEA, 2011). Gas-fired power generation is projected to increase from 2015 to 2040 (IEA, 2016a).

Hydropower, nuclear, and modern renewable sources of energy (solar, wind, and geothermal) have a very small role in the total energy mix of India's energy. In 2016, the contribution of renewable energy to total installed power capacity in India was 15% compared to thermal power (69%), hydropower (14%), other renewable power (15%), and nuclear energy (2%) (IEA, 2015c). India has more than doubled its renewal capacity to 44 GW since 2011 with increased investment in renewable energy (REN21, 2016) and has set a target for renewable power generation capacity to reach 175 GW by 2022 (IEA, 2017a), of which contribution by solar energy is expected to reach 100 GW, also leading to the creation of potentially four million jobs in this sector by 2050 (CEEW, 2016). By 2030, India has set the target of achieving 40% of cumulative electric power from non-fossil fuels, in tune with future increases in the share of clean energy (Government of India, 2017); by 2035, India is likely to generate 20% of its power from renewable

energy sources (IEA, 2011). In this direction, substantial increases have already been made in the generation of wind power (37%) and solar PV power (82%) in 2016 compared to 2015 (BP, 2017). India has set a target of 60 GW of installed wind capacity by 2022. There are 19 operational nuclear reactors in India, while six more are under construction (IEA, 2011).

International crude oil prices have dropped significantly since 2014 (IEA, 2016b). Low international oil prices will boost domestic demand in most countries in the region (World Bank, 2015) and help achieve additional GDP growth if oil prices remain low (ADB, 2014) and thus provide an opportunity to initiate energy subsidy reform in South Asian economies (ADB, 2015a). For instance, India is taking the opportunity of lower oil prices to diminish fossil fuel subsidies; removing the petrol subsidy in 2010 resulted in annual savings of \$1 billion, deregulation of diesel in 2014 caused annual savings of \$10 billion (ADB, 2015b), and phasing out subsidy in all oil-based transport fuels resulted in cutting of total subsidy bill by half from \$38 billion in 2014 to \$19 billion in 2015 (IEA, 2017a). Therefore, the removal of fossil fuel subsidies will have significant a impact on GDP and the energy sector (World Bank, 2015), and this could be redirected to more sustainable energy infrastructure. India has also been increasing its support to renewable energy sources by increasing subsidy to the tune of more than \$2 billion in 2015 in order to increase its renewables capacity (excluding large hydropower) by 2022 (IEA, 2017b).

India's CO₂ emissions increased by 4.7% to about 2.5 Gt CO₂ in 2016 due to strong annual GDP growth above 7.0% and population growth by 1.2% per annum along with increases in fossil fuel consumption. Since 2009, the largest increases were recorded in the consumption of natural gas (9.5%) followed by oil products (8.6%) and coal (3.9%), whereas the production of new renewable energy increased by about 45%. In recent past, the increase in coal-fired power plants has increased the CO₂ intensity and emissions in India. Between 2009 and 2016, the energy intensity of GDP has not decreased much, but the CO₂ intensity due to energy has increased by 29% due to rapid increase in coal consumption, resulting in significant increase in CO₂ emissions. These emissions are mainly from coal combustion, which accounted for 72% of total fossil fuel combustion emissions compared to 25% emissions from oil products (BP, 2017).

There is a need to reduce carbon intensity (excluding agriculture) by 20%–25% below 2005 levels by 2020 through concerted reforms in ongoing

fossil-fuel subsidies and increased taxation on domestic and imported coal, besides expanding the share of nuclear energy share from 3% in 2015 to 5% in 2020, 12% in 2030, and 25% in 2050. Thus, the major expansion of renewable sources will help diversify energy supply in India. However, keeping in view the growing demand, renewables will not eliminate fossil fuels from India's energy mix, and coal will account for 40% of energy mix in 2022 compared to 44% in 2013 while combined fossil fuels will provide 75% of total energy demand in 2022. India's energy-related CO₂ emissions will be 30% higher than 2013 by 2022 (2.4 Gt). Since 1990, India's primary energy demand has increased 2.5 times compared to GDP growth of 4 times, indicating a decoupling of energy consumption and economic growth due to rising commercial activities and public sector and switching to more efficient technologies and cleaner fuels. Energy demand per capita has grown more modestly by 1.7 times since 1990, and 240 million Indians were without access to modern and reliable energy in 2014 (IEA, 2015c). Therefore, it is essential to take advantage of the large, untapped, economically viable potential to improve energy efficiency and to secure the decoupling process. India aims to provide secure, affordable, and universal energy access to address development needs and environmental concerns by increasing the share of non-fossil fuel power generation capacity using technology and low-cost finance and to reduce the emissions intensity.

Concerted actions are needed to put India on the path toward a low-carbon development path. In India, power utilities are facing financing constraints and the electricity demand for cooling in residential sector is likely to increase by 8% per annum by 2040 (IEA, 2016a), which calls for reducing the capital cost and improving the cost-reflectiveness of electricity pricing. India's power system will require increased investment along with tariff reform, with the addition of electricity storage and smart metering technology (IEA, 2016b). In India, the increased deployment of renewables and improvements in energy efficiency are energy priorities. Securing finances for renewables will be a key challenge to meet energy policy goals. There is need for boosting the availability of low-cost, long-term debt to finance the necessary investment in the electricity system. The unreliable off-take of power and insufficient grid infrastructure hamper new renewables projects.

Investment in India's energy supply infrastructure will be about \$85 billion per annum up to 2022 and \$120 billion by 2030. Expanding renewables call for investment in solar and wind which will more than double from 2015 to

\$28 billion in 2022. India's future investment in the power sector should focus on a less carbon-intensive path. Investment in power transmission and distribution (T&D) infrastructure will be \$28 billion per annum up to 2030. Investment in energy efficiency will be more than 2.5 times the 2015 value by 2030. About 66% of efficiency-related investments will be in the transport sector to improve efficiency by 25% by 2030. The use of energy efficiency potential could help in total reduction of GHG emissions by 11% in 2030. The increasing investment for renewable energies has positive effects on increased electricity access. Off-grid renewable solutions such as solar home systems or small hydroelectric plants can boost electricity access significantly compared to on-grid renewables due to high integration costs and the resultant high electricity tariffs and affordability. Therefore, lower electricity tariffs in the residential sector may mitigate the problem and improve energy efficiency, but this requires careful monitoring to avoid unintended effects. Market reforms are essential for integration of high levels of variable renewables into power systems to ensure sufficient investment, failing which it will negatively impact the reliability of the power system (IEA, 2015b).

In India, the number of people without access to clean cooking fuels has increased. In 2017, more than 60% of households lacked access to clean cooking and still used biomass for cooking; therefore, more effective policies are needed (IRENA, IEA, and REN21, 2018). India's pledge to give free liquefied petroleum gas (LPG) connections to 50 million poor rural households by 2019, if achieved, would reduce the energy deficit significantly. In India, the energy mix will be more diversified in 2040 than 2018; however, diversity of the primary energy mix is not a complete indicator of energy security. India will require \$460 billion for imported oil and gas in 2040 compared to \$65 billion in 2015 (IEA, 2017a). The size of India's power system needs to almost quadruple by 2040 to keep pace with increasing electricity demand due to rising incomes and new connections to the grid. In India, demand for natural gas will increase nearly fourfold in 2040, of which 50% increase in gas demand will come from power generation. The ongoing gas pricing reforms strengthen the incentives for upstream gas developments, but even then most of India's conventional gas production will come from complex offshore projects (IEA, 2015b).

Currently, carbon capture and storage (CCS) has a very limited role in Indian power sector. Therefore, investment in gas has the potential to

decrease the carbon intensity of power generation by reducing dependence on coal even after 2030. Even then, the presence of huge coal reserves call for achieving emission reductions through investment in renewables and high-efficiency coal compared to renewables and gas (IEA, 2017a). In India, improved access to modern cooking energy through LPG has been implemented through unconditional cash transfers to 163.6 million registered households (MoF, 2016). Energy efficiency schemes will play a significant role in reducing emission intensity from the 33%–35% in 2005 to 40% of non-fossil-fuel-based power capacity by 2030 (MoEF, 2015).

Overall, India's current power generation capacity is very low compared to future power requirements. Coal is used for generating more than half of the power, followed by hydroelectricity. India's energy needs are estimated to rise at 3.1% per annum from 2009 to 2035, which is the fastest in the world (IEA, 2011). Fossil fuel will continue to dominate the energy sector, although the share of renewable energy sources and nuclear energy will increase in future (IEA, 2018a). India does not possess sufficient energy resources, and this scarcity will result in increased import dependency, primarily from West Asia, which is exposed to volatility and uncertainty in energy supplies. Besides, India's energy policy complicates and undermines the approach toward energy security. India's international energy cooperation is aimed primarily at energy security and secondarily at climate change. Bilateral efforts are essential for India in acquiring access to energy resources in other countries. Clean fossil technologies, renewable energy, and technology transfers are vital to increasing trade and investment and deepening cooperation to address energy security and emission reductions through bilateral and multilateral efforts.

The exploitation of the immense hydropower potential of South Asia can reduce the import of fossil fuels and emission levels and also raise the energy security level in the region (ADB, 2016). In Bangladesh, natural gas is the main energy source used for power and fertilizer production. More than half the households do not have any direct or indirect access to electricity. Bangladesh has substantial gas reserves, estimated at 28.4 trillion cubic feet (tcf), of which 20.5 tcf are recoverable. In Bangladesh, 973.2 billion cubic feet (bcf) gas was produced in 2015–2016, with 36.19% being the share of major public sector companies. In 2015–2016, 1,021,638 metric tons of coal was produced in Bangladesh from Barapukuria coal mine, which

has been mainly used to fuel its single coal-fired 250 MW power generation plant. The hydropower plant at Kaptai has a potential of 900 MW; however, the installed capacity is only 230 MW (Petrobanga, 2016). Bangladesh is fast running out of natural gas and has to rely on expensive imported coal and gas to meet the future energy demand, besides importing hydropower from Bhutan and Nepal via India. Currently, India is grappling with problems of excess hydropower capacity and perennial losses in distribution companies, whereas Bangladesh has significant demand for energy to fuel its growing economy and population. Therefore, India can be a sound hydropower trade partner for Bangladesh. Currently, Bangladesh also imports thermal power from India through cross-border transmission lines.

Power and gas outages are threatening welfare and development prospects in Bangladesh, and because of this the Government of Bangladesh attached top priority for a smooth supply of power and energy to ensure economic development. Bangladesh and India have also decided to set up two 1,320 MW coal-based power plants (Energy and Power, 2010). Coal mining causes immediate and long-term adverse effects on the local impoverished and marginalized communities due to massive piles of wastes and release of toxic air pollutants and greenhouse gases. Coal burning releases toxic air pollutants that cause respiratory ailments and coronary heart disease. Toxic clouds and large-scale emission caused by coal burning exacerbate climate change, thereby increasing water shortages, leading to lower crop yields, and increasing the risk of malaria and other vector- and water-borne diseases.

Bhutan has no proven gas, oil, or coal reserves and imports all of its petroleum product requirements from India (ADB, 2009). Of the 30,000 MW of hydroelectricity capacity per annum in Bhutan, 1,616 MW has been utilized with India's assistance (ADB, 2016). After domestic consumption, the surplus power was exported from Bhutan to eastern and northern India, which generated about 20% of revenue for Bhutan and constituted 40% of its exports to India; however, loans to build a hydropower facility is estimated to amount to 80% of its GDP. Nepal, on the other hand, has enormous hydropower potential. Despite this, domestic electricity supply does not match demand. Only 33% of Nepalese households are electrified. Nepal's hydropower energy increased 7.3% from 1990 to 2006, and the country is a net importer of electricity from India. Nepal has a total installed hydropower capacity of 659 MW, of which only 1.5% of its potential is realized (ADB,

2009). The instability of the Nepalese governments in recent years has not been conducive to establishing long-term objectives of energy security.

Besides India, other South Asian countries too have diversified energy resources, but lack the vision to grasp the intensity of the power supply–demand gap collectively and individually. The region has tapped only 9% of the estimated 437,000 MW of hydropower (World Bank, 2014a). The potential of oil resources is 5,576 million tons, 3,600 million tons, and 0.96 million tons of oil equivalent, respectively, in India, Pakistan, and Bangladesh; that of gas resources is 120 bcm and 7,985 bcm, respectively, in Afghanistan and Pakistan; and that of coal reserves amounts to 245,690 million tons, 185,000 million tons, and 2,715 million tons, respectively, in India, Pakistan, and Bangladesh (World Bank, 2014b). The usage of energy sources shows significant variation across South Asia. South Asian countries meet less of their demands with indigenous fuel sources, and dependence on imports for meeting commercial energy demand is more than 80% in Nepal and Sri Lanka and 30% in India and Pakistan (World Bank, 2013).

South Asia has inadequate domestic energy resources to satisfy the growing demand, which is likely to increase to 7.4% by 2020; therefore, the region is facing energy insecurity. For instance, power outages and shortages have been acute in Bangladesh, India, and Nepal (IEA, 2011), and Pakistan (IEA, 2010). Inadequate power supply imposes unserved energy costs to South Asian countries. India is set to contribute 25% to the projected increase in world energy demand, but even then per capita energy demand will be 40% below the world average in 2040 (IEA, 2015b). The population of India will surpass that of the People's Republic of China (PRC) by 2022 and expand its energy demand over the next several decades (UN, 2015). In India, rapid economic growth and urbanization put heavy pressure on energy resources. India is facing higher energy demand due to projected doubling of urban population between 2014 and 2050. This poses significant challenges for energy security and planning as 30% of the population lacks access to electricity, more than 70% depend on traditional biomass for cooking, and per capita consumption is less than one-third of the world average (IEA, 2015a).

Bangladesh, Bhutan, and India committed to absolute emission reduction and an increased share of renewable energy in the Intended Nationally Determined Contributions (INDCs) (ADB, 2016). Energy competition is required to be kept under control through regional cooperation to tackle

climate change and energy security, which is currently inadequate. Thus, there is urgent need for exploring energy security measures in South Asia (IEA, 2011). The optimum and efficient utilization of available energy resources can make the region achieve energy security and self-sustainability (World Bank, 2013). Some countries in the region have strategies for obtaining the requisite energy supplies to achieve long-term socio-economic goals. However, there are constraints to this, including low investment and limited capacity building in renewable energy technologies (Government of Bangladesh, 2012), less private sector participation (Government of Nepal, 2013), and the distrust between India and Pakistan to expand the existing bilateral energy trade, which must be addressed through regional cooperation. Existing regional power cooperation in South Asia needs to be strengthened by developing an energy ring. The energy trade in South Asia could be powered by the existing power plants and high-capacity transmission lines. Use of renewables, including hydropower, has huge potential in the region. However, meeting peak power demand from renewables (solar and wind energy) will be a challenge due to weather conditions. In this context, hydropower, domestic or imported, is the best suited, as it can generate electricity on short notice.

4. REGIONAL ENERGY COOPERATION

There are significant complementarities and synergies between energy production and consumption in South Asia. One country's surplus could be consumed profitably by the neighboring country's grid. The diversification of energy supplies in renewable energy sources will benefit the cooperating countries immensely. All this calls for the need to build trust, coordinate legislation, and exchange information for the development of an energy cooperation network in South Asia. The development of hydropower requires huge investment to meet the energy deficiency. Nepal and Bangladesh have been facing technical, financial, and geographical constraints. India has very high energy demand to realize its targeted high economic growth, for which a wide range of energy markets are being explored. Nepal, Bangladesh, and Bhutan would not be able to raise the necessary finances for hydropower development on their own and their time to get returns on such investment is substantially longer than in other sectors. Therefore, the northern countries would benefit from exporting their LNG and electricity to India.

Access to natural gas resources and exploitation of domestic deposits will be important for India and Pakistan in the medium and long term. The growing demand and projected energy deficits in India and Pakistan could be met from sizeable natural gas endowments in Bangladesh. There has been growing power shortages in the larger countries of South Asia. Therefore, the potential for electricity trade is high through integration of power systems. Bilateral trade in electricity is significant between Bhutan and India, which indicate sub-regional potential for electricity trade in South Asia. Energy security in South Asia calls for restructuring the internal energy consumption on the domestic supply side and engaging in energy trade to overcome power shortages during dry seasons. In South Asia, energy trade cooperation is inconceivable without India due to its location advantage that hinders any direct connection between Bangladesh, Bhutan, and Nepal. Bhutan and Nepal are landlocked countries and depend on India for transit.

Regional energy cooperation will help in building up of competition between local and regional power providers by opening up markets, knowledge exchange, and economies of scale in decentralized rural electrification. Unfortunately, regional practices or agreements on regional electricity and natural gas trade have not been implemented so far in South Asia. Currently, there are bilateral ties in energy cooperation between India and its northern neighbors Bangladesh, Bhutan, and Nepal. The need for South Asian energy cooperation is increasing due to rising urbanization, increasing dependence on fossil fuel imports, vulnerability to external shocks and price volatility, low access to electricity, and lack of hydropower markets with excess hydropower in Bhutan and Nepal.

The scope of development of the networks of interconnections already exists in the power sector in South Asian countries. Cross-border power purchase will produce numerous benefits including effective utilization of natural resources, increase in reliability of power supply, economy in operation and mutual support during contingencies, large-scale transformation in the sectors contributing to economic growth, single most effective building measure through the participation of multiple stakeholders, regional energy security through fuel diversification and a regional power grid, benefits from seasonal differential demands, technological transfer and human resources development, and regional-based practices to reduce environmental hazards.

The lack of investment in infrastructure is mainly due to political instability. Initiatives for the development of energy infrastructure include large-scale infrastructure investment, technical assistance, feasibility studies, and advisory services. These initiatives complement the ongoing bilateral energy, environmental, and economic development programmers such as hydropower development in Nepal, energy sector reforms in Bangladesh, distribution reforms in India, and the competitiveness initiative in Sri Lanka.

In the South Asian region, to overcome the barriers in power sector, huge investment is needed in the power sector to address this increasing demand. The dependence on fossil fuels should be reduced for environmental preservation. There is need for investment in alternative green energy to meet the demands of the industrial and commercial sectors to ensure energy security. Lack of financing is one of the major challenges for development of green energy projects such as hydropower, solar energy, and wind energy. The major obstacle for filling the financing gaps of green energy is lower rate of return of green projects compared to fossil fuels (Yoshino and Taghizadeh-Hesary, 2018). Electricity tariffs are often regulated by governments. It has to be kept low to serve every household as a necessary good. The sources of revenue from green energy come only from user charges. Hence, it is not very attractive for private investors. Yoshino *et al.* (2018) proposed a model for utilization of the tax revenue spillover of green energy supply by returning a portion of it to green energy projects in order to increase their rate of return. In addition, they propose a social community-based funding scheme for smaller scale green projects (e.g. solar energy and wind energy). Utilizing spillover effect in the form of tax return for funding green energy projects will increase the rate of return and make them feasible and of interest for the private investors.

The renewed focus on regional energy cooperation in South Asia in the context of climate change has been due to the discovery of gas resources in Gujarat, huge hydropower potential in Nepal, large undeveloped gas resources in Bangladesh and India, hydropower resources in Bhutan, India, and Nepal, and wind resources in Sri Lanka. The availability of reliable energy is directly correlated with production, productivity, and economic growth in South Asian countries. The political leadership in the region has been misguided on the issues related to effect of regional energy trade agreements on energy security. Currently, bilateral and populist politics are obstructing power and gas

trade in South Asia. Besides, climate change presents challenges and opportunities for regional energy cooperation in South Asia.

5. CHALLENGES OF ENERGY TRADE IN SOUTH ASIA

Regional markets evolve naturally when no impediments exist. Political support is the predominant condition for regional energy cooperation and integration. However, the political tension is not conducive to develop regional cooperation and trade. The aim is national self-sufficiency, which dilutes energy security. There is a severe lack of trust between South Asian countries. For instance, India and Pakistan have been locked in perpetual conflict since achieving Independence in 1947. Several attempts were made to initiate a peace process, for instance, the “Lahore Declaration” in 2001; however, Indo-Pakistan tensions still remain high, the deep-rooted suspicion is unaltered, and major outstanding issues remain unresolved. The state ownership of the energy utilities and their economic performance has been a major handicap for the development of regional trade. Most South Asian countries are energy deficient and lack the capacity to trade in electricity. Due to poor operational and financial performance of the power utilities, the cost of power has been rising and is not conducive for electricity trade among the countries.

There has been distrust among domestic populations in South Asian countries, which influences their actions and voting behavior. For instance, Sri Lanka was under the grip of ethnic conflict in 1980s, which led to serious Indo-Sri Lankan tensions. Over the course of time, Indo-Sri Lankan tension has reduced substantially, but distrust still remains. Despite economic agreements and a water sharing treaty, numerous issues remain unsettled between India and Bangladesh. Indo-Nepal relations were quite strained when the South Asian Association for Regional Cooperation (SAARC) was formed in 1985 followed by the Nepalese refusal to renew the transit treaty between the two nations in 1989 resulting in an economic blockade.

Besides, there has also been absence of infrastructure for electrical interconnections and gas pipelines across the borders, except between India and Nepal, India and Bhutan, and between Afghanistan and Central Asia and Iran. The barriers obstructing regional trade in South Asia are illustrated in Table 1.

Table 1: Barriers Obstructing Regional Trade in South Asia.

Technical barriers	Grid synchronization and grid codes Natural gas pipeline technology
Political barriers	Politicians opposed to electricity trade due to persisting distrust, conflicts, and tensions across borders, specifically between India and Pakistan
Cost barriers	Large-scale upfront investments
Financial barriers	Lack of funds and high risk
Social barriers	Strong distrust influences actions and voting behavior
Environmental barriers	Decreased water quality

Source: Author's compilation.

Low-carbon development is essential to address climate change, encourage economic growth, and increase energy security. Low-carbon policies need to be integrated with other policy priorities focusing on economic growth, energy security, energy access, innovation, technologies, and behavior change. Technological innovation is required to make the use of fossil fuel resources more efficient and develop alternative energy sources. When we are talking about low emission, it does not necessarily means that we should close all fossil fuel energy plants and instead make renewable energy projects — this is not rational. Our suggestion is a mixture of fossil fuels and renewables that maximize the energy security and the economic growth and minimize the emissions (Yoshino and Taghizadeh-Hesary, 2018).

Technological advances are needed for making renewable electricity generation cost competitive and energy efficient. Technological advances are required to store electric power and for coping with wind power, which is hampered due to lack of funds and qualified scientists and technicians. Therefore, technology transfer of low-carbon technologies from developed countries to developing countries is a top priority. The development of renewable energy is a win-win objective. It will help in reducing greenhouse gas emissions and provide cheaper energy. The transition to a low-carbon economy and the energy security in South Asia call for addressing the development, technological, policy, and environmental challenges (see Table 2). Even for development of technologies for more efficient use of fossil fuels and renewables, finance is a matter of concern. For example, Taghizadeh-Hesary *et al.* (2018), by looking at five major suppliers of solar module (namely, the

Table 2: Challenges Faced by the Energy Sector in South Asia.

Major Challenges	Mechanisms
Development	<ul style="list-style-type: none">— Structural economic adjustments to accelerate development— Attaining rapid economic growth with low greenhouse gas emissions— Supportive policies, advanced technologies, and investment
Technology	<ul style="list-style-type: none">— More efficient use of fossil fuel resources— Development of alternative energy sources— Technological advances in clean energy technologies
Finance	<ul style="list-style-type: none">— Financial aid to build transmission infrastructure— Investment protection— Increasing rate of return by incentive mechanisms (such as spillover tax return)— Introducing social funding mechanisms
Policy	Energy policy focusing on employment, poverty, and gender
Environmental	Energy policy to protect the environment low-quality energy consumption patterns

Source: Author's compilation.

PRC, Japan, Germany, the Republic of Korea, and the US), found that access to cheap finance and significant R&D expenditures were major reasons behind their success in reducing the solar module prices and increasing the share of solar energy in the global energy basket.

South Asia is facing numerous infrastructural, institutional, operational, and financial challenges in the energy sector. Electricity distribution and losses are very high due to leakage, weak networks, and poor monitoring. The development of alternative and renewable energy sources and improvement in energy efficiency has been emphasized to mitigate climate change. Power sector reforms, including institutional restructuring and privatization, have been carried out in individual South Asian nations. The private sector has been given a leading role in power generation in all South Asian countries. There have been increased domestic and international investments in energy exploration and generation in Bangladesh, India, and Sri Lanka. Public sector reforms have also been carried out, including disinvestment and restructuring and moves toward more reasonable and competitive tariffs. Regulatory agencies have also been established. As a result, private contributions to the national generating capacity have increased to 20%–30%. The public sector is faced with costly power purchase

agreements due to commercially unviable tariffs due to political interference. There is a need to introduce reforms in the power distribution sector. Commercial distribution at viable tariff rates is required to attract private investment in generation. In brief, the power sector in South Asia is plagued with poor governance, inefficiencies, lack of transparency and accountability, and anti-competitive cross-subsidization policies.

6. PROSPECTS OF REGIONAL ENERGY COOPERATION

Energy cooperation and trade are necessary to address energy security in the context of climate change in South Asia. There has been mutual benefit from exports of power generation surpluses from Bangladesh, Bhutan, and Nepal to meet the huge power deficits in India. It will help in meeting energy demand and reducing electricity prices. The hydropower potential of Bhutan and Nepal could serve regional electricity needs and address their trade deficits with partner countries like India. Direct benefits from energy cooperation are investments in energy supply and demand technologies as well as environment outcomes. Indirect benefits include the development of water markets, infrastructure development, and increased agricultural productivity.

There has been bilateral energy cooperation between India and Nepal, and India and Bhutan, which is confined to hydroelectric power. The electricity trade between Bhutan and India is highly successful. Bhutan exports 75% of its electric power to India and import its petrol requirements from India. Bhutan has received technical and financial assistance from India for hydropower development. Currently, Bhutan exports energy from several hydropower projects to India. Recently, the two governments have signed agreement on hydropower development and trade involving public and private participation. Energy cooperation between two countries has resulted in increased merchandise trade, employment opportunities, construction, and socio-economic development. Successful bilateral relationship between Bhutan and India has been possible by political will, favorable bilateral financing, political stability, and good relations between the two countries.

However, Indo-Nepalese energy cooperation has not been as successful due to political and infrastructural challenges. Several projects have been identified for hydropower development cooperation in Nepal for which joint technical expert groups have been formed. Bhutan and Nepal have generated huge

revenues from electricity sales to India, which can serve as a means of redressing the trade imbalance between these two countries and India. India and Sri Lanka are exploring means to lay a transmission line to carry power from India to Sri Lanka, and in the reverse direction too depending on seasonal variations and load profiles. Bilateral energy cooperation in South Asia has been facilitated by the liberalization of the energy market, particularly in India.

7. CONCLUSION AND POLICY RECOMMENDATIONS

India's power sector is confronted by structural weaknesses such as poor financial health due to low average end-user tariffs, technical network losses, and high levels of non-payment for electricity use, which resulted in failure to cover the costs most often, owed to generators by distribution companies, and held back much-needed investment in network infrastructure. Due to increasing population growth and high policy priority to achieve universal electricity access, India will add about 600 million new electricity consumers by 2040. Therefore, besides power via the grid, mini-grid and off-grid will be viable power solutions to more than half of new electricity consumers in remote areas.

Communities living in close proximity to coal mines and coal plants are suffering from negative impacts, and the bulk of coal mining's environmental costs are imposed upon impoverished and marginalized communities. A transition away from coal can result in improved air emission and alleviate other associated environmental and social problems, but is likely to be politically difficult to implement and meet climate targets. Investment into low-emission coal technology provides cheap energy supply and energy access. However, low emissions coal technology is more costly compared to a traditional coal plant. Financial barriers along with other barriers prevent the use of low-emissions coal technology. Therefore, investment in low-emission coal technology has enormous potential to alleviate climate impact, if coal is to play a role in India's energy security and curb the steep projected increase in CO₂ emissions.

In this context, the ongoing policy reforms must be robust and transparent to implement price controls and renewables subsidy as well as phasing out fossil fuels' subsidy in India. There is need to incentivize investment in renewables over fossil-fuel alternatives to address environmental and health

costs of emissions of CO₂ and other pollutants. With the expected fall in technology costs in future, more and more new renewable energy projects will become economically competitive without subsidies as solar PVs will be competitive without subsidies in India before 2030.

Investment in more efficient technologies is needed to improve average coal plant efficiency significantly along with new coal mining investment to meet the two-and-a-half-times higher coal demand by 2040 compared to 2014. Not only this, India has also pledged to reduce its energy-related CO₂ emissions intensity by one-third below the 2005 levels by 2030. India needs cumulative investment of \$2.8 trillion in energy supply and \$0.8 trillion for improving energy efficiency, which requires effective coordination between multiple institutions and levels of government, robust energy regulatory framework, and a transparent and accountable system to win public consent for sustainable and affordable low-carbon energy, and more efficient and low-carbon energy technology cooperation and innovation to tackle global climate change (IEA, 2015b). In India, the rooftop solar energy has huge job creation potential whereas wind energy is more efficient in terms of technology cost differential. The increased deployment of renewable energy in India offers greater energy access and helps in reducing GHG emissions significantly.

Bangladesh and Nepal have initiated policy measures such as fiscal incentives, regulations, auctions, and exemptions from value-added taxes and import duties to support the deployment of distributed renewables, to increase electricity access, and to address barriers to the expansion of the off-grid market. Achieving universal access to electricity by 2030 will require deployment of decentralized solutions for electricity access to improve livelihoods, education and health services, food and water security, employment, and gender equality. Capital subsidies can be used in conventional energy technologies to reduce upfront capital costs with a clear cut policy on timing to phase out these subsidies. The South Asian countries will need huge investment of US\$1.7 trillion to US\$2.5 trillion to achieve self-reliance in power. Energy infrastructure development will need investment of US\$603 billion. Bangladesh, India, Nepal, Pakistan, and Sri Lanka are likely to invest about US\$40 billion, US\$468.8 billion, US\$7 billion, US\$96 billion and US\$9 billion respectively by 2020 (IEA, 2015b).

In South Asia, heavy investment is needed due to current low per capita electricity consumption, electricity shortage, poor access to electricity, and

significant potential of regional electricity market to meet development needs. Investment in power infrastructure development will require robust policies and laws to ensure power sector viability and investment protection including financing sources and options. The southern region has significant attraction for the investors in terms of potential economic growth, diversified and balanced fuel mix, vast renewable energy resources, and seasonal and environmental advantages. Investment will help tap the huge renewable energy potential in the South Asian region to increase power generation and preserve the environment. Energy security can be ensured through diversified energy trade in the region. This will require well-developed energy transmission infrastructure and increased system efficiency to boost industrial productivity and GDP gains, which will increase investment and lead to improvement in living standards and ensure social progress.

There exists huge potential for a win-win situation as well as untapped opportunities for intraregional energy trade in South Asia to attain energy security in the context of climate change. South Asian countries are highly dependent on energy imports from non-South Asian countries and vulnerable to external shocks in energy prices. Therefore, there is need for regional cooperation in the energy sector through bilateral and sub-regional initiatives. Regional energy cooperation in South Asia would require strong political will and agreement for mutually beneficial sustainable solutions. Due to existing complexities, there is need to pursue a gradual approach in selecting pilot projects and building up confidence to move from small to larger initiatives in regional energy cooperation.

International donors and organizations can be useful in capacity building of policymakers, fostering interaction of decision-makers at the highest level, supporting negotiations through provision of advisory and legal services, providing research support, and payment mechanisms. The regional energy cooperation agencies should promote regional cooperation together with governments and the private sector; bridge the gap due to barriers and distrust; provide counterpart funding, resources and unbiased support for regional initiatives; and showcase benefit of regional cooperation.

There is a need to move beyond bilateral arrangements. Cooperation could be promoted by interconnecting national networks, enabling power exchange, and sharing among countries in times of need and making better use of existing generation for establishing a power grid. There is a need to

focus on sub-regional trade in natural gas involving India, Iran and Pakistan, and Bangladesh, India and Myanmar, which can be addressed through political dialogue between governments, complemented by initiatives of private sector entities interested in such trade. Smooth India–Pakistan natural gas transit requires strong political will and cooperation on the part of both nations by diffusing political tensions through regular discussions.

There is a need for a mixture of projects for development of fossil fuels and renewables to ensure energy security, maximize economic growth, and minimize emissions. In this connection, finance is vital for development of technologies for more efficient use of fossil fuels and renewables. The benefits of investing in renewable energy include greater energy security, higher job creation potential of renewable energy, poverty reduction, and rural development. Innovative financing schemes should be developed by financial institutions in collaboration with project developers. Interaction between financiers and project developers could help bridge the knowledge gap on both sides; financiers would also gain a better understanding of renewables while project developers would have a better appreciation of prerequisites for raising financing for renewable energy investments.

In sum, South Asian countries have immense potential to ensure energy security through regional cooperation via friendly political and economic environment, foreign investment, and electricity interconnections. There is a need to strengthen the efforts in developing clean energy technologies and integrating renewable energy resources in South Asia through R&D and technology transfer for climate change adaptation and mitigation and to satisfy the growing energy demands. Community-based adaptation and knowledge sharing among the countries will strengthen local coping strategies and address climate risks and vulnerabilities. Climate financing and technology transfer are essential for adaptation and mitigation in South Asia through robust information dissemination and technical assistance. In this context, the GCF will help address major energy challenges posed by climate change involving all relevant stakeholders, including vulnerable groups. Innovative cleaner and climate-resilient technologies will help achieve reduction of greenhouse gas emissions for which regional cooperation is vital.

There is a need for the creation of an energy grid to connect the suppliers and the consumers in South Asian economies with overall coordination of

the SAARC by using finances from ADB and levying a transit fee for the security and functioning of the grid by concerned countries. Extensive renewable energy potential exists in South Asia, and it needs to be tapped by gaining expertise and knowledge in solar energy and wind energy, developing the technological abilities to compete with other energy options, interconnecting links between renewable projects and trans-boundary transmission grids, private sector participation, and supporting relaxed financial policies to meet the high initial cost and promoting hydropower trade. There is a need to conserve energy and improve energy efficiency in all sectors of the region.

Energy wastage, T&D losses, power theft, and inefficient public transport systems need to be addressed. Energy conservation in new buildings needs to be put in place and strictly enforced, thereby achieving energy efficiency. Power thefts need to be checked by enforcing strict legal and regulatory actions. The losses in T&D of energy need to be reduced by improving the energy grids and transmission system. Energy conservation initiatives have to be strictly enforced in all sectors. There is a need to embrace bold and enforceable energy efficiency standards in new vehicles, using hybrid and electronic vehicle technology and switching to compressed natural gas (CNG), improvement in mass transit systems and electrified railways, and switching to compact fluorescent lamps (CFLs). There is a need to review policies on energy subsidies and pricing so that the subsidy benefits go to the right people.

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