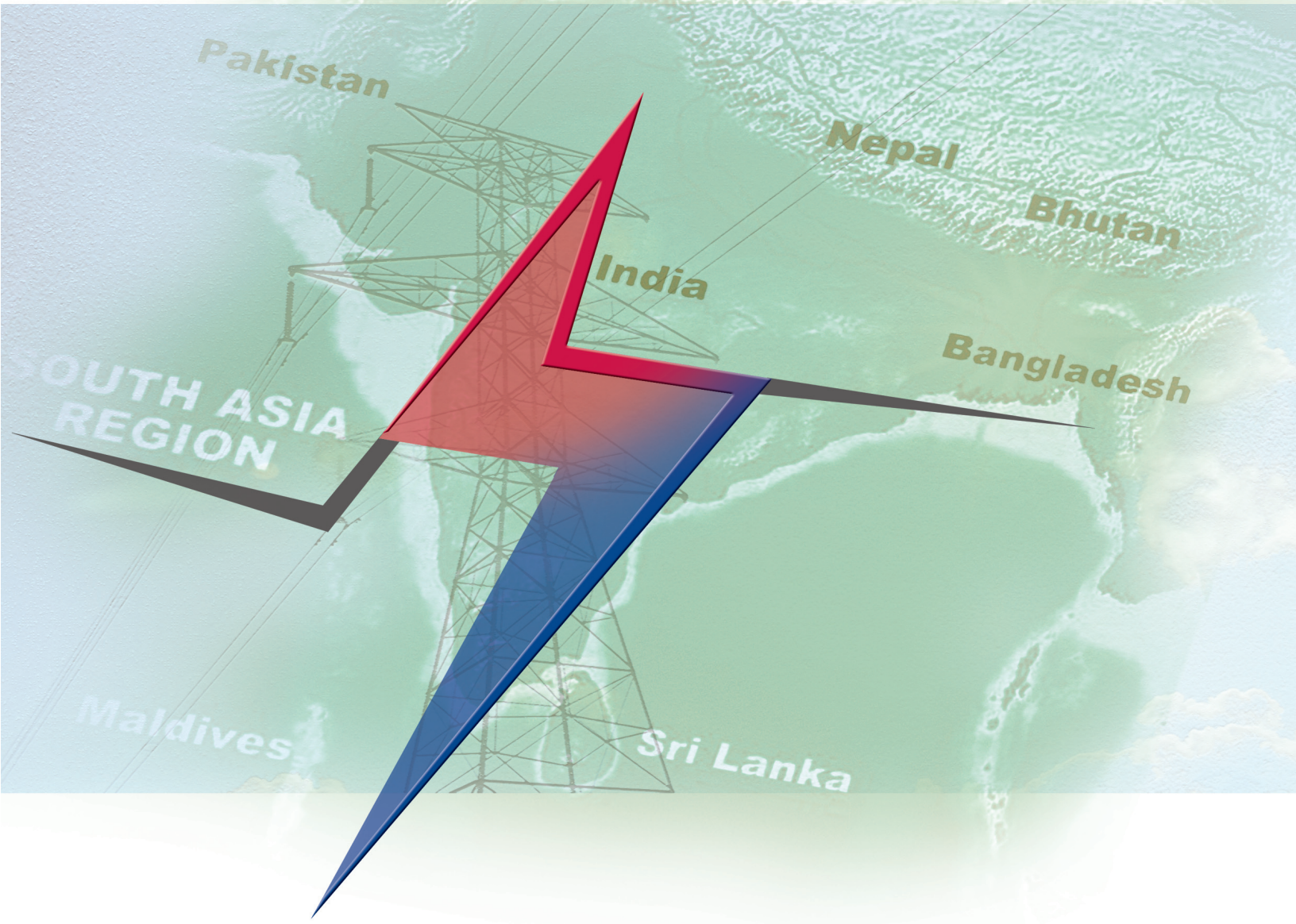
USAID
FROM THE AMERICAN PEOPLE

SARI/EI

IRADe Integrated Research and Action for Development

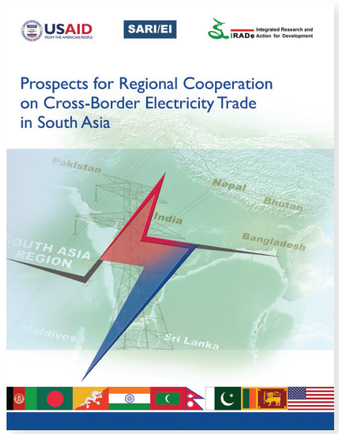
Prospects for Regional Cooperation on Cross-Border Electricity Trade in South Asia



Background Paper prepared by:

IIT Kanpur
Dr. Anoop Singh,
Associate Professor

SARI/EI Project Secretariat, IRADe
Dr. Jyoti Parikh
Mr. K.K. Agrawal
Ms. Dipti Khare
Mr. Rajiv Ratna Panda
Ms. Pallavi Mohla



Contents

Preface

The South Asia region is going through a phase of economic transformation from low growth to high growth. It is well established that energy demand and growth are interlinked with each other; therefore energy demand in this region is going to increase substantially to keep its growth story intact. Cross-border electricity trade could emerge as a strong viable long-term solution to increase the supply of energy in the region. South Asia's electricity security is one of the steps critical to regional stability.

South Asian nations should capitalize on the complementarities of their resource base and differential power demand to satisfy their energy needs. There is approximately 350GW of hydro power potential existing in the region, which can be exploited. Concurrently, since climate change has emerged as a key global development challenge of the 21st century, policies and programs facilitating regional energy trade and the large-scale adoption and deployment of clean and renewable energy will need to play a central role in South Asia in meeting climate challenges and, at the same time, fulfilling energy requirements.

There are various issues that affect cross-border electricity trade in the region. The development of cross-border physical infrastructure and its complementary regulatory, policy, pricing, and market mechanisms are to evolve in the South Asian regional context. Each participating country needs to adopt complementary national energy policies, with interconnection being an integral element. There is a need to harmonize policy, legal, and regulatory aspects in the South Asian context so that risks can be minimized. A promising development in recent years is the introduction of power trading and advanced power exchanges in India, which brings in transparency in price mechanism. A South Asia power exchange can provide a 'fair, neutral, robust, transparent and quick' price discovery process, creating an orderly marketplace for all buyers and sellers in South Asia. The extension of these exchanges through the establishment of a South Asia Regional Electricity Exchange is considered a feasible option to enable cross-border energy trade.

This paper is prepared to provide basic information regarding the energy situation in South Asian countries in the context of cross-border power trade:

- Why the region needs to work for it;
- What is already there or planned;
- How are other countries integrating their grids; and
- What is the road map towards integration.

The idea behind the background paper is to generate debate and also seek views and suggestions for furthering the objectives. I hope this paper will be able to initiate thought-provoking discussions among stakeholders to bring a fruitful result in the direction of South Asia energy integration.

We welcome your valuable suggestions.

Dr. Jyoti Parikh
Executive Director, IRADe

Executive Summary

Energy remains one of the key inputs to socio-economic progress in developing societies. South Asian nations, namely Afghanistan, Bangladesh, Bhutan, India, the Maldives, Nepal, Pakistan, and Sri Lanka, have so far lagged far behind their developed counterparts in terms of access to clean, reliable, and affordable energy, especially electricity. The existing power shortages and growing import of fossil fuels impose a heavy cost of energy insecurity to the region. The energy endowments of South Asia are limited and dispersed across the region, with large unexploited hydro-electric potential in some parts and growing dependence on fossil fuels in other parts. Sections 1, 2, and 3 highlight the role of electricity in socio-economic development and energy security, and the need for electrifying millions of unlit homes and to meet the future demand for electricity.

Limited and disperse resources available to generate electricity across the South Asian countries present a challenge to meet the growing demand of electricity in these countries. Differences in resource basket, along with variation in the load curves across the nations, present gainful opportunities for regional-level coordination in electricity generation and its use. This would require coordinated investment in generation and cross-border electrical interconnections. Growing dependence on the imported fossil fuel for electricity generation, amid the considerable hydro potential in the region, points to significant energy security benefits for regional cooperation in the power sector. Risk to hydro-dominated systems can be reduced during the dry winter season or drought conditions. Section 4 provides the context of regional power sector cooperation in South Asia.

The Interconnection of two electrical systems with diverse generation mix and demand characteristics can bring operational, economic, as well as environmental benefits to the respective country as well as to the region as a whole. There are also benefits to the global environment as there would be an improvement in operational efficiency of thermal generation with an appropriate mix of hydro resources available in the region. An interconnected power system can more economically address the daily as well as seasonal variation in electricity demand in the respective countries. The requirement for reserve in the interconnected system can also be minimized at the regional level. Section 5 identifies the various technical, operational, economic, and environmental benefits of a regionally interconnected electricity market.

The world over, a number of initiatives have led to regional level cooperation in the electricity sector. These include the Greater Mekong Sub-Region (GMS), Southern African Power Pool (SAPP), South East Europe Gulf Coast Countries (GCC), Nile Basin Initiative (NBI), and so on. Drivers for such regional cooperation include greater system reliability, regionally coordinated investment in generation, enhanced energy security of the region, lower reserves requirement for the individual power systems, and synergetic operation of national power systems to take into account differences in terms of generation resources and demand characteristics. Some of these initiatives, namely the SAPP and the GMS, have a history of bilateral arrangements that later led to the development of a regional power sector cooperation, sometimes riding over the political differences. The SAPP has also moved ahead to embrace a multi-country Day Ahead Market (DAM), though it is facing transmission congestion as investment in cross-border transmission could not keep pace with growing opportunities for cross-border trade. Section 6 provides a brief discussion on international experience to regional power sector cooperation.

The existing status of power sector across the South Asian counties is presented in Section 7.This also highlights the major electricity supply issues, including the current status of cross-border electricity

trade. Given that the power sector in most of the South Asian countries has witnessed a process of reform and restructuring, we present a brief discussion on it, highlighting some of the reforms in the context of power market development. We note that the extent and scope of such reforms vary across countries and, hence, an approach to regional power market development should take into account the individual limitations to reform, although a broad-level regional harmonization on some of the components of market reform would still be necessary. The experience with power market development in India can be instrumental in this context. Section 8 provides a brief discussion on the process of reform in the South Asian countries.

Realising the potential for cross-border cooperation in the power sector, India and Bhutan and India and Nepal have taken a number of initiatives to develop cross-border exchange of electricity. A cross-border interconnection between Bangladesh and India has been set up and that between India and Sri Lanka is being evaluated. The existing experience shows that participating nations have benefited from such cooperation. This has contributed to the improved electricity access in Bhutan and is a significant source of export revenues. Nepal, which is facing severe power shortages despite a high hydro-electric potential, imports electricity from India, including that under a commercial trade arrangement to address the power shortages there. Apart from this, some of the South Asian nations, particularly Afghanistan and Pakistan, are interconnected to Central Asian countries, thereby highlighting the future potential for enhanced cooperation between Central Asian and South Asian countries. Various cross-border interconnections and electricity trade arrangements are discussed in Section 9.

Multilateral institutions (the World Bank and ADB), regional entities such as the SAARC Energy Center and bilateral agencies such as the USAID have placed significant emphasis on strengthening regional cooperation in the energy sector in South Asia (Section 10). This has resulted in fruitful studies outlining the approach, benefits, and the issues in achieving that target. It is expected that the Task Forces established under the Cross-Border Energy Trade (CBET) project would apply a bottom-up approach to identify various technical, operational, economic, policy and regulatory issues in developing a regional power market, as well as propose an implementation strategy. Such an approach has been envisaged under SARI/EI.

The time is opportune for the South Asian countries to graduate from the bilateral approach to a multi-lateral approach to develop a regional power market to benefit from the synergies in the integrated development of the operation of the power system in the region while addressing the domestic needs of each country. International experience demonstrates that nations with political differences have also come together towards the greater cause of developing the power sector for the benefit of the local population in the region.

However, to move towards a free, fair, and transparent regional power market there are various issues that need to be addressed. In the South Asian context, risks associated with intra-regional, cross-border energy projects would be greatly minimized if each participating country adopted a complementary national energy policy, with interconnection being an integral element. Therefore, efforts must be made to harmonize policy, legal, and regulatory issues, which will create the enabling systemic conditions for a sustainable market for investment. Similarly, for integrated power system operation, a harmonized framework for coordinated grid operation and operation protocols needs to be developed. This will ensure the smooth, reliable, and safe operation of the regional grid. To address these issues, Section 11 outlines a broad strategy to take forward the existing efforts to develop a regional power market in South Asia.

1. Introduction: Energy in South Asia

The countries of South Asia (SA),[1] comprising Afghanistan, Bangladesh, Bhutan, India, the Maldives, Pakistan, Nepal, and Sri Lanka, are home to 23 per cent of the world's population. The region is far behind its developed counterparts in terms of economic well-being as well as access to clean energy, particularly electricity and its consumption. South Asia has limited fossil fuels but ample hydro resources. There is, however, a disparity in the distribution of these across the region (Table 1). Limited oil and gas resources have led to a growing dependency on imports. Electricity generation largely depends on available domestic resources. Some countries of the region depend significantly on coal while others are dependent on hydro resources to generate electricity.

Table 1 Energy Resource Endowments in South Asia

Country	Coal (million tons)	Oil (million barrels)	Natural Gas (trillion cubic feet)	Biomass (million tons)	Hydro Power* (Gigawatts)
Afghanistan	440	NA	15	18–27	25
Bhutan	2	0	0	26.6	30
Bangladesh	884	12	8	0.08	0.33
India	90,085	5,700	39	139	150
Maldives	0	0	0	0.06	0
Nepal	NA	0	0	27.04	83
Pakistan	17,550	324	33	NA	59
Sri Lanka	NA	150	0	12	2
Total	108,961	5,906	95	223	349.33

Source: ADB (2012)

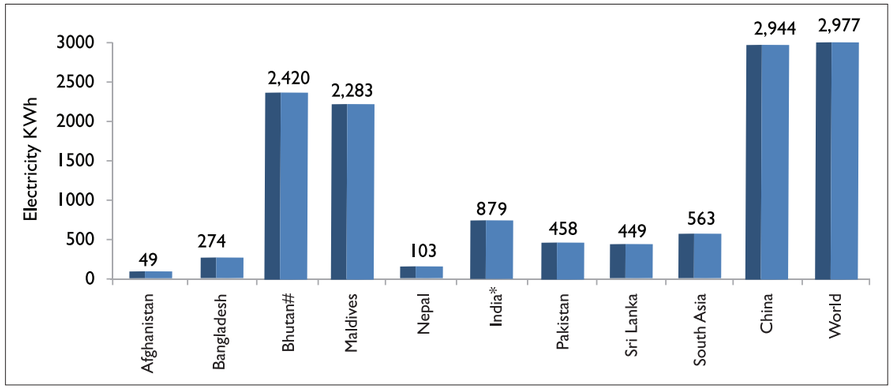
*Note: As per ADB (2012), the estimated hydro-electric potential of the region was only 294.33 GW due to lower estimates for Nepal and Pakistan. The above estimate is based on SAARC Secretariat (2010) for Bangladesh, Bhutan, India, Nepal, Sri Lanka; CWC (2005) for Indian States and WAPDA (2011) for Pakistan.

Bhutan and Nepal depend on Himalayan-fed hydro resources. Bangladesh, the Maldives, and Sri Lanka are largely dependent on fossil fuels. Afghanistan is struggling to rebuild its hydro-electric capacity, but investments for new capacity are yet to catch up with requirements. In transit to the further creation of capacity, it is importing electricity from trans-border linkages. The two large economies, namely India and Pakistan, depend on a mix of hydro and fossil fuel-based capacity, though they are increasingly becoming more dependent on fossil fuels.

The current per capita electricity consumption in the South Asian region is very low (Figure 1) in comparison to developed economies. However, this is expected to increase with economic activity, improved access to electricity, and changes in lifestyle. South Asian countries depend heavily on imported fossil energy and lag behind their developed counterparts in terms of electricity access as well as electricity consumption per capita. As South Asia marches towards economic prosperity and social well-being, the gap in electricity access and its consumption needs to be narrowed. The region

[1]These nations are currrently member of the South Asian Association for Regional Cooperation (SAARC).

Figure 1 **Per Capita Electricity Consumption in South Asia**



Notes: # - 2011; * - 2011-12

Source: IRENA (2009) for Afghanistan and the Maldives; RGoB (2012) for Bhutan; CEA (2013a) for India and World Bank (2013) for other countries.

has a vast potential of renewable energy sources such as hydro power, wind power, and solar power. Regional cooperation provides an ideal opportunity to enable sustainable growth by synergizing the development of resources. Such cooperation in the energy sector will help South Asian countries to strengthen national energy security, reduce the costs of energy supplies, and adopt clean energy sources to meet the growth in electricity demand in the future.

South Asian nations have a common goal to increase electricity access, reduce shortages, and provide an affordable supply of electricity with an increasing share of cleaner sources of energy. With the exception of Bhutan, nations in South Asia face an electricity supply deficit; Nepal had an electric shortage of as high as 44 per cent during 2011-12. The region faces the challenge of having to tide over these shortages and provide sufficient means to meet the growing electricity demand.

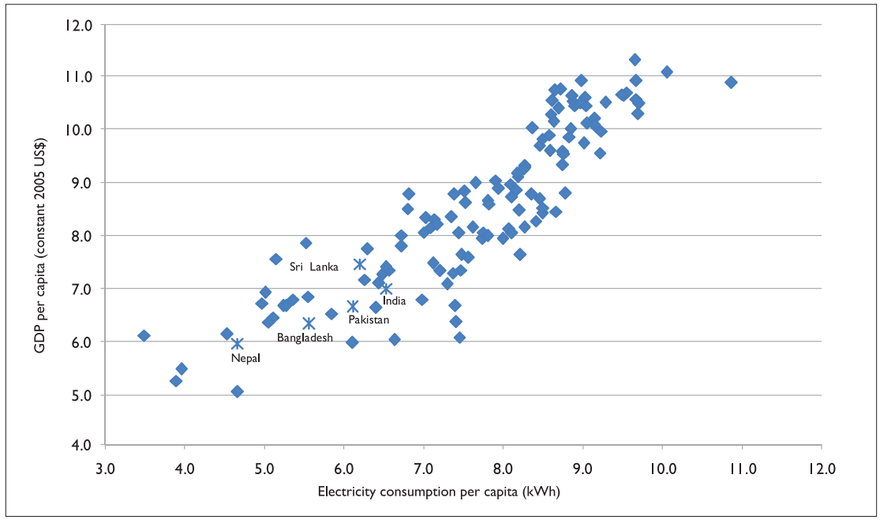
There are further challenges such as the unevenly distributed sources of generation, accessibility to the generation sources from the load centers, and local and global environmental issues. The growing environmental concern relating to the use of fossil fuels in the generation of electricity, particularly by the larger economies of the region, necessitates an improvement in efficiency for the generation and operation of power systems as well as increase in the share of hydro and renewable resources. The electricity generation options for some of the larger economies may include greater reliance on fossil fuel, thereby further increasing the load on the environment, both local and global. While appropriate steps are being taken to improve efficiency and to increase the share of renewables, access to clean resources in the region can bring dividends to the importing as well as exporting nations.

Given the experience from bilateral electricity trade between selected South Asian countries and the international experience in developing regional power markets, there is merit in the South Asian nations coming together to develop a regional power market. This paper discusses the current power sector context in South Asia, the existing bilateral electricity trade experience, and the international experience in this context. It also highlights the benefits of regional cooperation in the power sector and outlines the strategy to identify the operational, policy, regulatory, and market issues involved.

2. Energy and Socio-economic Development

Access to and the availability of energy, including electricity, is of great relevance to the socio-economic development of a nation. A developing economy witnesses changes in the structure of the economy where the share of the energy-consuming industrial and services sector finds an increasing role. This places a significant demand for energy, including electricity. The increasing use of electricity in agriculture and the electrification of households equipped with energy-consuming appliances further leads to a growth in demand. A lack of investment in electricity generation also inhibits the investment in manufacturing and other economic activities, thus limiting the GDP growth opportunities of a nation. Figure 2 shows that the high per capita income countries exhibit high per capita commercial energy consumption. This highlights the relevance of the argument that South Asian countries need to increase their electricity supply in order to support their economic growth in the future.

Figure 2 **Electricity and GDP Relationship (log scale)**



Source: World Bank (2013)

Economic growth and social welfare among the developing countries in the South Asian region continues to be hindered by a slow growth of energy/electricity supply, leading to shortages and poor energy access. The growing economies place a considerable demand for electricity in the region. Electricity supply has, however, not been able to match this demand, resulting in large demand-supply gaps and frequent power interruptions. During April to August 2012-13, the Indian power sector witnessed an energy shortfall of 6.7 per cent and a peak shortage of 6.2 per cent (CEA, 2013). These shortages are inflicting a significant cost to the economy leading to a loss of economic output (Table 2). To meet these shortages, industrial, commercial, as well as domestic users of electricity are forced to invest in costly alternate sources of generation/storage of electricity locally, which leads to a growing burden of import of oil and stress on the local environment.

Table 2 Loss of Economic Output due to Electrical Outages

Country	Value lost due to electrical outages (as a % of sales)
Afghanistan (2008)	6.49
Bangladesh (2007)	10.56
Bhutan (2009)	4.33
India (2006)	6.62
Nepal (2009)	26.95
Pakistan (2007)	9.16
Sri Lanka (2011)	3.00

Source: World Bank (2013)

To keep pace with the growing economies of South Asia and to be able to meet the increasing electricity demand of a large population, and also to reduce its vulnerability to imported fossil fuel, regional cooperation in the power sector will be beneficial for all. The South Asian countries should come together to provide secure, reliable, sustainable, and reasonably priced electric power. In this context, the need for harnessing regional resources to generate electricity and to optimize the use of existing resources at the regional level gains even more importance.

3. Drivers for Regional Cooperation in the Power Sector: Energy Security for South Asia

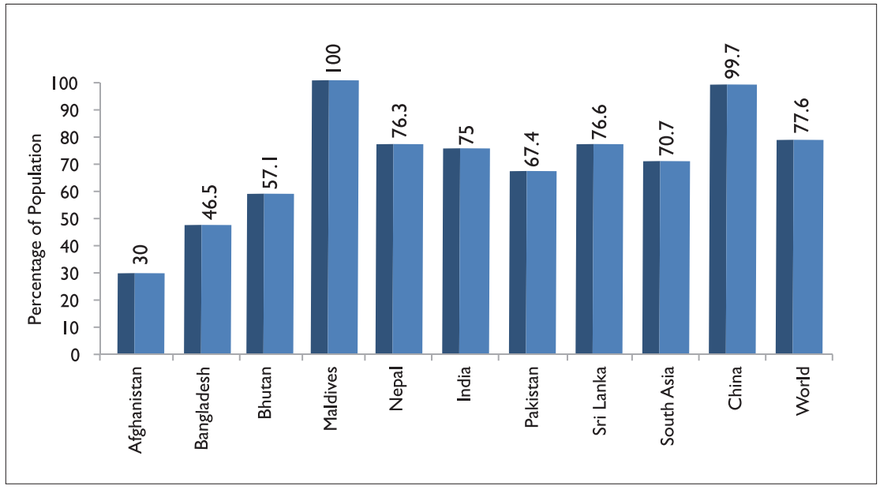
The South Asia region as a whole is rich in various energy resources, with enough potential for hydro, wind or solar energy sources. A major part of these resources have, however, remained unexploited for a number of reasons. Inadequate availability of indigenous energy supplies, combined with the large population base, makes the region highly dependent on energy imports.

3.1 Access to Electricity

Energy security can be described as the ability of a nation to secure sustainable energy supplies to meet its energy needs at a reasonable cost to society. In the context of the electricity sector, access to electricity and its unreliable supply outline the energy security aspect for the population at large. A large proportion of the population continues to lack access to this clean form of energy (Figure 3). Even those with access to it continue to face power shortages and poor quality of supply. Lack of investment in generation, grid extension, problems associated with fuel availability for power plants, and poor financial state of the sector in many South Asian countries continue to hinder the efforts to improve access and availability of electricity. The economic cost of this shortage is reflected in lost economic output and productivity of the sectors (Table 2).

South Asian countries are staring at a large and growing quantum of fossil fuel imports. This emphasizes the need for enhancing energy supplies to meet the growing demand, developing sustainable energy resources, and ensuring the affordability of energy.

Figure 3 Access to Electricity in South Asia (2010)



Source: IRENA (2009) for the Maldives; RGoB (2006) for Bhutan; World Bank (2013) for other countries.

Lack of access to electricity and its unreliable supply to millions of South Asians has attracted the attention of the policy-makers as well as development agencies. This not only requires an investment in the extension of the grid but also necessitates a growth in electricity supply. The development of significant generation capacity in Bhutan has, for instance, enabled the government to provide electricity access to its population.

The vulnerability of the poor sections of society in their ability to access clean energy resources and be able to consume a minimum required quantity cannot be ruled out. Economic generation of power and the economic extension of the grid to serve consumers in various parts of the South Asian region is feasible through regional cooperation in the sector.

3.2 Demand-Supply Gap

The developing economies of South Asia are expected to witness moderate to high economic growth in the future. This would also place a considerable demand on the growth of electricity availability. The projected demand for electricity is expected to grow at a CAGR of 7.4 per cent (Table 3). Given the current status of energy resources in individual countries, this goal presents a challenge to the policy-makers.

A greater percentage of the power generation in the region is dependent on fossil fuels. A two-fold increase in electricity demand would lead to a significant environmental burden. The need for sustainable growth in the power sector in the region, thus becomes an important driver for promoting regional power sector cooperation in South Asia.

Table 3 **Projected Electricity Demand (GWh)**

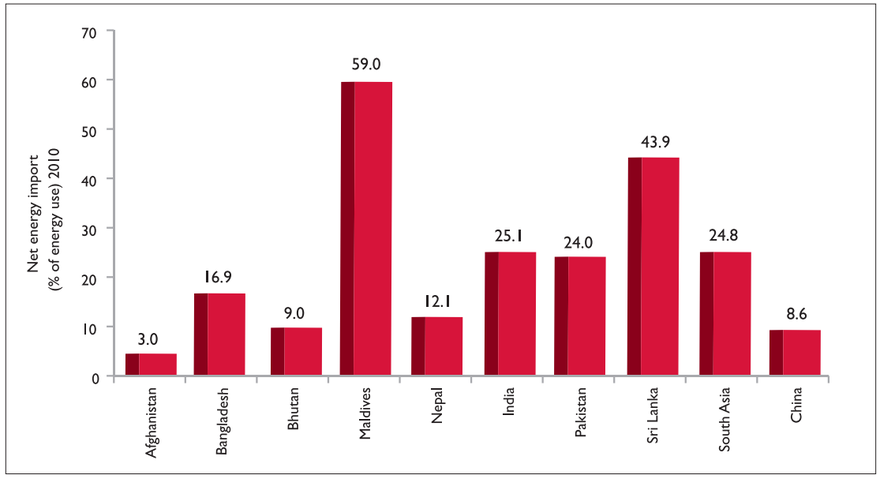
	Demand (GWh)		
	Year 2010	Year 2020	CAGR
Afghanistan	2,600	6,750	10%
Bangladesh	28,470	67,400	9%
Bhutan	1,749	3,430	7%
India	938,000	1,845,000	7%
Maldives	800	1,300	5%
Nepal	3,200	6,910	8%
Pakistan	95,000	246,000	10%
Sri Lanka	10,718	21,040	7%
Total	1,080,537	2,197,830	7.4%

Source: Wijayatunga & Fernando (2013)

3.3 High and Growing Dependence on Fossil Fuel Import

To meet the growing demand for fossil energy, primarily for electricity generation, transport, and industrial consumers, is reflected in the high share of imported energy in the total energy use in South Asian countries (Figure 4). An increasing proportion of oil import is also being used to run millions of diesel-based agricultural pumps and back-up electricity support due to an unreliable grid supply. Countries with a proportionately large share of diesel-based grid-connected generation capacity (especially the Maldives, Nepal, and Sri Lanka) also face the challenge of passing on the increasing oil cost to the consumers.

Figure 4 **Net Energy Import as a Percentage of Total Energy Use in South Asia**



Source: World Bank (2013)

To address the unreliable supply of electricity from the grid, telecom operators install diesel-based generators to power telecom towers. Fuel consumption by the telecom towers' diesel generators in India is estimated to be over 2 billion litres (TRAI, 2011), making it the second largest consumer of diesel in the country. Further, coal import for power plants in India during 2012-13 reached 62.5 million tons (CEA, 2013b). Sri Lanka remains most vulnerable to energy security due to a high dependence on energy imports. Import dependent countries in South Asia also face macroeconomic stress to balance of payment in case of slowdown in exports or inward investments. To protect themselves from the increasing and fluctuating oil prices and single-fuel dependence, South Asian nations should ensure energy security by developing the region's energy resources for electricity supply and investing in regional cross-border transmission infrastructure. Regional energy cooperation can supplement their respective national programs and projects to boost growth and energy security.

3.4 Sustainable Power Sector Development

The presence of a large coal-based generation capacity, the use of oil in diesel pumps in agriculture and back-up electricity generators are together imposing an increasing burden on the environment, both local and global. Although South Asian countries are not obligated to reduce the emissions of greenhouse gases, they are expected to be at the receiving end of the impact of climate change. Apart from an improvement in the efficiency of existing and new generating plants and electrical appliances, a higher share of hydro-electric capacity can significantly reduce the carbon footprint of the power sector.

Regional energy cooperation can help tap the available hydro and renewable resources, and improve the system's efficiency by exploiting opportunities to trade electricity. This would reduce the overall emissions from the sector at the regional level. Better utilization of thermal capacities, particularly in the winter season, when output from hydro-electric plants is less, would also improve their thermal efficiency, thereby reducing the emission intensity of a unit of electricity production from such plants.

The experience with the development of renewable energy resources, particularly off-grid application for remote areas, can benefit the region as a whole. Regional experience with the development and implementation of energy efficiency programs can provide useful inputs for the development of similar programs at a national or regional level.

With a majority of the population residing in villages, South Asia's population is largely dependent on traditional fuels for cooking, lighting, and heating. In Afghanistan, 85 per cent of energy needs are met by traditional fuels such as fuel wood, animal dung, and agricultural wastes; this dependence is about 87 per cent in Nepal. Women have to travel long distances to collect fire wood in the rural areas, which are not yet electrified. Having access to electricity will result in improved health and women empowerment as women will have more time to devote to education and other important issues.

3.5 Synergies in Power System Development and Operation

The region currently witnesses power shortages and there is a limited capacity for reserves in the national power systems. As the situation improves, the regulatory requirement could necessitate a certain degree of reserves in the power system. Inter-connected power systems can significantly reduce the costs of maintaining these reserves across the region. Further, smaller nations cannot exploit economies of scale. By pooling cross-border electricity requirements, the economies of scale in generation and investment can be exploited, thus reducing the cost of supply to the exporting nation.

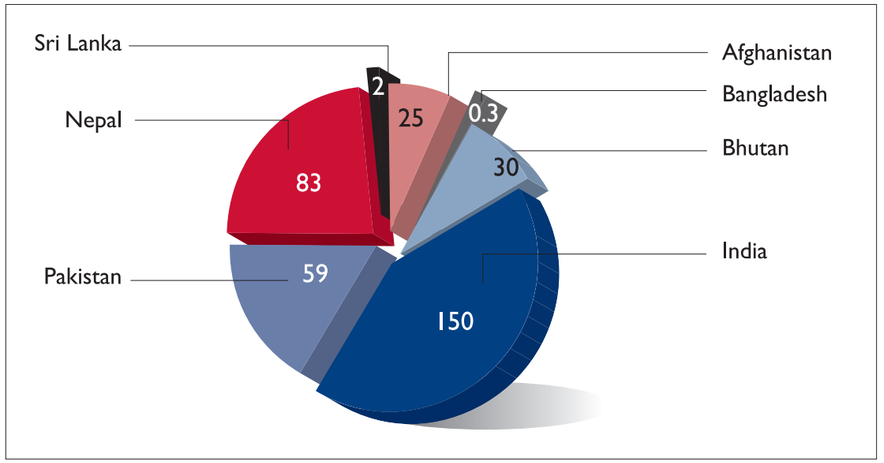
South Asian nations can also learn from each other about energy sector reforms and policies to attract private investment, which are crucial for the long-term financial sustainability of the sector and for developing the region's energy resources.

4. Prospects for Cross-Border Regional Electricity Trade in South Asia

In South Asia, the existing Cross-Border Electricity Trade (CBET) between India and its neighbors in the north, namely Bhutan and Nepal, provides a foundation for furthering this cooperation at the regional level. The existing electricity trade agreements are bilateral in nature and have benefited the participating nations. The ongoing projects and discussions to set up more border interconnection between Bangladesh and India, and India and Sri Lanka, reveal the potential for regional power sector cooperation. Building on the experience of bilateral electricity trade in the region, a multilateral framework for power sector cooperation can be developed.

Regional electricity cooperation may include the sharing of cross-border infrastructure, establishing regional power producers, and enhancing competition across regional markets. This would require, among others, investment in new border interconnections and the development of harmonized codes, policies, and regulations for the overall growth of the power sector. Given the significant potential of hydro-electricity generation potential in South Asia (Figure 5), it is expected that this would play a major role in any future strategy for regional power sector cooperation.

Figure 5 Hydro-electric Potential of Around 350GW in South Asia



Source: SAARC Secretariat (2010) for Bangladesh, Bhutan, India, Nepal, Sri Lanka; CWC (2005) for Indian States and WAPDA (2011) for Pakistan

Regional power sector cooperation has been embraced in many parts of the world. These include the Greater Mekong Sub-region (GMS), Southern African Power Pool (SAPP), South East Europe Gulf Coast Countries (GCC), Nile Basin Initiative (NBI), and so on. The drivers for such cooperation include improving the reliability of the interconnected power systems; optimizing generation mix; and exploiting opportunities for electricity trade due to seasonal and daily variations in demand.

The Greater Mekong Sub-region, comprising Cambodia, PRC (Yunnan Province and Guangxi Zhuang Autonomous Region), Lao PDR, Myanmar, Thailand, and Vietnam initiated an informal process towards regional cooperation in energy in 1995. This finally led to the expansion of regional integration of power grids and the sharing of generation capacities across the region. A Memorandum of Understanding (MoU) provides legitimacy for the implementation of Regional Power Trading Operation Agreements that help member states to meet their energy needs. A study of the Greater Mekong Sub-region in Southeast Asia suggests that regional cooperation in energy reduced their energy costs and will provide a benefit of USD 14.3 billion (discounted) during 2010-30 (ADB, 2010).

The potential for South Asia electricity cooperation has also drawn the attention of multilateral development agencies. The World Bank has identified avenues for regional cooperation in the power sector in a study (World Bank, 2008). This study explores the potential separately in two sub-regions, namely the eastern sub-region comprising Bangladesh, Bhutan, India, Nepal, and Sri Lanka, and the western sub-region, comprising Afghanistan and Pakistan. Table 4 summarizes the cooperation potential for the eastern sub-region.

Table 4 **Prospects for Electricity Trade in South Asia**

Importing Countries	Exporting Countries				
	India	Bhutan	Nepal	Bangladesh	Sri Lanka
India	X	Significant quantities of hydro power (H)	Significant hydro power export possible	Significant amount of gas or power possible; resource uncertainty	Some peak power support possible
Bhutan	Dry season support	X	Unlikely. Similarity of resources and seasonal shortages	Small amount of thermal power and gas; connection via India (L)	No scope
Nepal	Thermal power support. Dry season support.	Unlikely. Similarity of resources and seasonal shortages	X	Small amount of thermal power and gas; connection via India (L)	No scope
Bangladesh	HVDC back-to-back link. Sharing reserves; electricity swap	Some hydro power; connection via India (L)	Some hydro power; connection via India (L)	X	No scope
Sri Lanka	Dry season and thermal power support	Unlikely (far off)	Unlikely (far off)	Unlikely (far off)	X

Source: World Bank (2008)

It is clear that the transit of electricity through a third country would be incidental in some cases and, hence, a framework for cooperation should appropriately account for it. The SAARC Regional Energy Trade Study (SRETS) (SAARC Secretariat, 2010), supported by the Asian Development Bank (ADB), covered a wide range of energy cooperation opportunities, including the setting up a regional power market in South Asia and fast-tracking the cross-border interconnection projects that have already been identified. A recent study instituted by ADB, South Asia Regional Power Exchange Study (SRPES), under the Regional Research and Development Technical Assistance (R-RDTA 7529), examined the prospect of a regional power exchange to develop the electricity market in South Asia.

5. Benefits of Regionally Interconnected Power Systems

Beginning with islands of electrified towns, the last century witnessed the development of national transmission capacities to bring power generated at resource locations (near coal mines, hydro-electric plants in mountainous areas, and so on) to load centers across the country. The benefits of within country integration of power systems have been experienced by individual nations. Improved system reliability, economies of scale in developing generation capacities, and the development of national power markets are all the positive outcomes of an interconnected system. Cross-border interlinks further scale up this synergy and potential for system optimization.

Interconnected power systems can provide a more economic, reliable, and environmentally friendly outcome for all sub-systems. The economic benefit of the expansion of GMS interconnection was estimated to be USD 14.3 billion (discounted value over 2010-30) (ADB, 2010). Cross-border electric interconnections among South Asian countries present a potent opportunity, given the proximity of the transmission networks, the significant disparity in natural resources, and demand variation across the region. The power systems of Bhutan, India, and Nepal are already interconnected and Bangladesh is expected to be linked shortly. This has, so far, elicited only a small part of the potential benefits. Interconnections also provide a cost-effective way of enhancing the reliability of all sub-systems, and delaying, or reducing, the longer term need for capacity to maintain the reliability standard for individual sub-systems. Most of the South Asia region does not possess sufficient fossil fuel resources and suffers significant power shortages. At the same time, there are large unexploited renewable resources in the neighboring countries. Given the experience of the development of the power market in India, we find that even if all subsystems suffer from power shortages, there are still opportunities to trade electricity as it provides appropriate signals for the more economic utilization of existing capacities and utilizes change in consumption behavior to suit the market conditions. Differences in daily load conditions and seasonal variation in load as well as generation provide ample opportunities for the South Asians nations to optimize the use of regional resources even in the current circumstances (Table 6). Further, the competitive market framework developed in India also provides opportunities to entities (both generators and utilities) to effectively utilize such a mechanism to their advantage. The presence of a grid-interconnection helps to exploit opportunities for two-way trade in electricity. For example, Bhutan, a hydro-rich nation, imports thermal electricity, especially during the dry winter season. Similarly, Nepal has also exploited the power market in India to tide over power shortages there.

5.1 Technical, Operational, Economic, and Environmental Benefits of a Regional Electricity Market

Investment in cross-border interconnections can be justified if one is able to identify and assess the benefits of regional cooperation. This would then enable the decision-makers to make informed decisions based on benefits that are visible and quantifiable. These can broadly be categorized as technical, operational, environmental, financial, economic, and social sector benefits.

5.1.1 Technical and Operational Benefits

Technical and operational benefits arise out of the opportunities to optimally plan, implement, and operate the available/new generation and transmission capacity. The specific benefits are identified below.

Table 5 **Opportunities for Trade Due to Diversity in Demand and Supply**

System Characteristics	Opportunities
Peak time differences	While there is difference in time zone (15 to 30 minutes) between the countries of the region, the difference in daily load curve provide opportunities for optimizing load-generation balance across the region. Apart from this, difference in designated weekends and annual festivities also give similar opportunities.
Intra-seasonal differences	Monsoon season has sufficient to excess hydro power output, whereas in lean periods (dry winter season), more thermal power support can be provided.
Hydro thermal mix	Useful for balancing load in terms of peak and off-peak load during a day.

- **Optimal use of regional resources and system operation:** The existing hydro as well as thermal power plants can achieve better utilization by exploiting cross-border opportunities to meet the daily as well as seasonal variations in demand as well as generation. Differences in daily load curves arise due to geographical location across the latitude, local weather conditions, difference in lifestyle, festivities, and so on.

- **Economies of scale in the development of regional resources:** Countries with small electricity requirement cannot develop scale-efficient power plants unless a regional approach to share such capacities brings the desired economies of scale and hence lowers the cost of electricity generation.

- **Improved energy security and reliability of respective power systems:** Interconnected power systems improve the system's reliability through coordinated planning and operation. Further, reserves can be shared regionally, thus providing cost-effective reliability to grid operations. Interconnected systems can also address situations arising out of natural calamities that partly or fully handicap the specific generation plants.

- **Optimized transmission network:** The development of transmission networks need a desired system of way and have to address rehabilitation and resettlement issues. A high voltage transmission network not only provides scale efficiency but also reduces complexities associated with land procurement to set up these networks. Regional cooperation for cross-border electricity trade can provide the desired scale to sub-national transmission links.
- **Reduce environmental impact (global as well as local):** The optimal use of regional resources, particularly with higher share of hydro and renewable resources, and improved efficiency of system operation would not only reduce the system's cost but also the adverse environmental impact as compared to a non-cooperating scenario. However, care should be taken to ensure that benefits from large hydro-electric plants outweigh the environmental impacts.

- **Reduce fossil fuel imports:** Improved system reliability and the replacement of imported fossil fuels with hydro and renewable resources could reduce the import dependency of the electric system in the region. This may be replaced partially by the import of electricity, as applicable. Nevertheless, the countries would be isolated from volatility in global prices of oil, natural gas, and coal.

5.1.2 Economic and Financial Benefits

A number of technical and operational benefits lead to cost savings for utilities and, ultimately, for the consumers. Further, investments become more attractive and scale-efficient in terms of financing as well. These benefits should be visible upfront and evaluated to provide a push to the cause. The specific economic and financial benefits are briefly discussed below.

- **Cost-effective power system:** the optimal use of cost-effective regional resources would reduce the cost of the electric system and thus benefit the consumers. A regionally optimized choice of resource development will bring measurable economic benefits.
- **Better return to investors in generation assets:** The ability of investors to set up large scale-efficient plants and the diversification of the site will benefit investors.
- **Improvement in industrial productivity and competitiveness:** A reduction in power shortages and supply interruptions would improve industrial productivity due to more a reliable operation of production facilities. The lower cost of electricity supply to the manufacturing industry would also improve their global competitiveness.
- **Less exposure to volatile international energy prices:** A significant volatility in international oil, gas, and coal prices has accentuated the energy price risk to the economies of South Asia. Reduced reliance on such energy imports would address this exposure to some extent. A higher share of electricity generated from hydro resources would partially safeguard most of the economies from this risk.
- **Economic growth:** Unavailability of a reliable and affordable energy/electricity system is hurting the economic growth of the region. With an improved system of electricity, economies in the region can reap dividends in terms of high economic growth in the future. Further, higher economic activity and better industrial competitiveness would also improve the prospects for trade in goods and services. This may ultimately increase the revenue to the government and improve its ability to make investments in social infrastructure and other desirable schemes.
- **High export income:** Earnings from the export of electricity would provide the much needed funds to support the growing domestic demand for transport fuel, especially for smaller nations such as Bhutan and Nepal.

5.1.3 Environmental Benefits

Energy and the environment have a close relationship. Fossil fuel-based electricity generation has a significant impact on the local as well as global environment. Any step that improves the operational efficiency of thermal power plants or reduces the dependence on resources would benefit the environment.

- **Less impact on local and global environment:** A regional thrust to clean energy development would enhance the use of more hydro and renewable resources, thus reducing the adverse environmental impact of the fossil fuels that these resources would replace. The reduction in local pollutants will improve the worsening local environment due to SPM and other emissions. In the global context, this would mean an ultimate reduction in carbon emissions.

- **Reduced adverse impact of indoor air pollution:** Households without access to electricity in South Asia use kerosene lamps for lighting and firewood or coal for cooling and heating purposes. It has been established that this practice exposes the poor, especially women and young children, to harmful gases. Access to electricity and a reliable system would reduce this health burden on society.

- **Improvement in social indicators:** Access to electricity has a positive impact on education, access to clean water, health services, as well as security in local areas. These indirect benefits to society further push the argument for improving energy access in this region.

- **Renewable energy development:** A regional cooperation that allows for the sharing of best practices to develop renewable energy can facilitate the faster development of renewable energy resources in other nations. This will conserve non-renewable primary energy resources and improve the environment.

6. Regional Energy Cooperation: International Experience

The world is home to a number of regional power interconnection arrangements, some of which have been under operation for decades. Experiences from these regional initiatives have important relevance to the South Asian region. In this context, here we briefly discuss the experience in the development and operation of the following interconnected networks:

- Central American Electrical Interconnection System (SIEPAC)
- European Network of Transmission System Operators for Electricity (ENTSO-E)
- Greater Mekong Sub-region (GMS)
- Gulf Coast Countries (GCC)
- Nile Basin Initiative (NBI)
- South East Europe (SEE)
- Southern African Power Pool (SAPP)

The motivation for these cross-border interconnections include reliable system operation, lower reserve requirements, and optimized system operations that take into account daily and seasonal variations in demand and generation. It is observed that such initiatives are largely driven by the respective governments coming together to evolve a mechanism. A number of regional arrangements have been an outcome of bilateral cross-border arrangements that were meant to share generation capacities with the neighboring country. Over time, the growing of regional economic cooperation and efforts to identify the benefits of regional cooperation culminated in regional institutional arrangements, These work towards the development of regional interconnections, the progressive harmonization of the codes governing coordinated grid operations, and the evolution of a regional mechanism to enable bilateral trading, leading to the development of a regional competitive trading platform for electricity.

The international experiences show that regional power system interconnections and their coordinated operation provide various technical, economic, and environmental benefits to participants. Such interconnections allow electric utilities to optimize system operation and power procurement, and also improve the reliability of the individual systems. Southern African Power Pool (SAPP), created in 1995 under the aegis of the Southern African Development Community (SADC), presents a rather analogous situation to the South Asian region. The SAPP experience demonstrates that trade in power, and the reliable and economical operation of the integrated system, is feasible even in the presence of a historical baggage of political differences. Table 7 summarizes the key aspects of the international experience in regional cooperation in the power sector.

Africa is home to a number of regional arrangements for the trade of power, with SAPP being the largest among these. SAPP had constituted a capacity of 49,877MW, including a share of 83 per cent thermal and 17 per cent hydro. South Africa has a dominant position with an overall share of 82 per cent of the regional capacity (ICA, 2011). Between 2001 and 2007, the region witnessed the emergence of the short-term energy market (STEM), although with a modest quantum of trade. This

Table 6 **International Experience with Regionally Interconnected Power Systems**

Regional Entity	Formal Creation	Participating Members	Motivation/ Driver	Trading Status
ENTSO-E	2011	41 Transmission System Operators (TSOs) from 34 countries.	Security of supply, seamless, pan-European electricity market, a secure integration of renewable resources, and a reliable future-oriented grid, adequate to energy policy goals.	428,161GWh (2012)
GCC	2001	(6) United Arab Emirates, Bahrain, Saudi Arabia, Oman, Qatar, and Kuwait.	Share reserve capacity, thereby reducing the generation investment needs in the region.	First in 2010 and intermittent
GMS	1995—Electric Power Forum (EPF)	(7) Cambodia, PRC (Yunnan Province and Guangxi Zhuang Autonomous Region), Lao PDR, Myanmar, Thailand, and Vietnam.	Efficient, environmentally sound growth of power sector; support to regional projects, and electricity trade as means for these objectives.	34,139GWh (2010)
NBI	1999	(9) Egypt, Sudan, Ethiopia, Uganda, Kenya, Rwanda, Burundi, DR Congo, and Tanzania. Eritrea (Observer).	Ensure coordinated investment in the power sector in the Nile Basin to meet the region's social and economic development objectives.	
SAPP	1995	(9) Botswana, Democratic Republic of Congo, Lesotho, Mozambique, Namibia, South Africa, Swaziland, Zambia, and Zimbabwe; (3) non-operating members —Angola, Malawi, and Tanzania.	Development of a safe, efficient, reliable, and stable interconnected electrical system and a regional power trading mechanism.	10,409MWh (2011-12)
SEE	2005	(9) Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Kosovo, Macedonia, Montenegro, Romania, and Serbia.	Create a regionally integrated electricity market, forming part of the wider EU single market.	Dry run (2006-09), 2010
SIEPAC	1999	(6) Guatemala, El Salvador, Honduras, Costa Rica, Nicaragua, and Panama.	Create an integrated regional electricity market in Central America.	

Source: Compiled by the author

led to the development of a Day Ahead Market (DAM), which was launched officially in 2009. Increasing congestion in the cross-border interconnections in SAPP points to the fact the investment in cross-border interconnections could not keep pace with the growing trade opportunities.

The genesis of SAPP could be found in the 1950s and 1960s, which witnessed the development of interconnections projects between the Democratic Republic of the Congo (DRC) and Zambia, and Zambia and Zimbabwe. Later, in 1975, interconnection between Mozambique and South Africa was established; this played a crucial role in resolving the 1991-92 drought-induced power crises in Zimbabwe and Zambia. It also led to the development of interconnections between Zimbabwe and the Cahora Bassa hydro-electric project, and between Zimbabwe and the Matimba coal-fired plant in South Africa (via Botswana, ECA, 2010b). Regional interchange imbalances are handled through a mechanism similar to the scheme for UI, currently in place in the Indian power system. The imbalance energy rates are set based on the pool's highest and average generation costs.

Nearer to home, South East Asia also witnessed an evolution of historical bilateral cross-border trade to a framework for regional power sector cooperation. In 1971, export of power from the Nam Ngum hydropower plant (HPP) in Lao PDR to northeast Thailand marked the first cross-border electricity trade in the region. More cross-border interconnections were later developed betwen Thailand-Cambodia, Myanmar-Yunnan province in China, Vietnam-Cambodia and Vietnam-Yunnan province in China. Subsequent to an initiative led by ADB, this led to an agreement for a formal institutional arrangement in 1995 (ECA, 2010).

In spite of the historical regional political context and the motivation for regional cooperation, these experiences highlight the technical possibility of connecting large and small power systems and of operating the cross-border interconnections in a coordinated manner. The benefits are recognizable upfront and these often lead to a regional mechanism. Investment in cross-border interconnections are primarily undertaken by the transmission utilities in the respective countries. In the presence of such interconnections, the private sector identifies opportunities for investment in generation.

7. Status of the Power Sector in South Asia

South Asia is bounded by the Himalayas in the north and the Indian Ocean in the south. The Himalayan river basins account for most of the hydro-electric potential of the region. The area is endowed with coal resources but lacks significant oil and natural gas resources, leading to growing imports. Its renewable energy potential is recognized and is now beginning to be exploited.

7.1 Afghanistan

Afghanistan is suitably endowed with the hydro-electric potential to meet the needs of its population. It currently has a generation capacity of 489MW, which is largely accounted for by hydro-electricity followed by diesel-based plants. However, historical turmoil has damaged many existing generation assets and has also spoiled the atmosphere for private investments. Poor access to electricity and an insufficient national transmission network leaves much to be developed in the near future. The short-term needs of the country are being met through electricity import. In 2011, the nation imported 2,246.2GWh electricity from Iran, Uzbekistan, Turkmenistan, and Tajikistan (AIEC, 2013).

7.2 Bangladesh

Bangladesh currently has a total generation capacity of 8,525MW. Electricity generation is majorly dependent on natural gas, an indigenous energy resource with very little hydro and renewable capacity. More than three-quarters of the nation's commercial energy demand is being met by natural gas. As of 2011, 79 natural gas wells are present in the 23 operational gas fields, which were producing over 2,000 million cubic feet of gas per day (MMCFD). It is well short of the demand of over 2,500 MMCFD, a number which is growing by around seven per cent each year. Depleting natural gas resources and limited hydro potential remain a challenge. The government has proposed 100 per cent electrification by 2020. To meet this target, the country needs to invest in significant generation capacity and also make effective use of off-grid solutions to provide electricity access to inhabitations spread over the delta region.

7.3 Bhutan

Bhutan is well endowed with hydro resources to meet the current and future electricity requirements of its population. Only 1,488MW out of the total estimated potential of 30,000MW has been developed so far. The country plans to achieve 100 per cent electrification in 2013 and is expected to meet this demand through domestic resources. The development of the hydro-electric potential of Bhutan through a cooperative agreement with India now contributes significantly to its export earnings and government revenues.

7.4 India

The existing power generation capacity of India (227,347MW as on August 31, 2013) is insufficient to meet the existing as well as growing demand for electricity. Increasing dependence on coal for electricity generation is placing a significant burden on the local as well as global environment. Environmental aspects of coal mining further highlight the concern for coal as a source of primary fuel electricity generation. However, coal is expected to remain the primary fuel for electricity generation in the country. To address environmental concerns, India has a program to use supercritical technology for

developing large ultra-mega power projects (4,000MW each); some of these are based on better quality imported coal. India has also been able to develop significant wind and, more recently, solar resources. To meet its growing need for electricity and bring a more desired hydro-thermal mix, the country needs to develop its domestic hydro resources. It has also entered into cooperative agreements with Bhutan and Nepal to help develop the hydro-electric potential in these countries for the import of power and also help meet the electricity needs of both countries.

7.5 The Maldives

The island nation of the Maldives is on a fast track to modernization and urbanization, with a major dependence on tourism as an economic mainstay. The Maldives is the only country in the region without any fuel resources of its own. It imports all its fuels in refined form and in very small quantities, which makes it even more expensive. Its electricity requirements are met primarily through oil-based generation. Renewable energy is used to power navigational lights, communication transceivers on fishing boats, and for providing power supply to the remote installations on the national telecommunication network. The country is geographically separated from the mainland and is unlikely to be connected to the regional grid in an economic manner. However, it can benefit from the experience of other nations in fruitfully developing its renewable energy potential and thus reduce its dependence on oil imports.

7.6 Nepal

The Himalayan nation of Nepal is well endowed with hydro resources that it can effectively develop to meet the growing electricity needs of its population. The country currently has over 522.7MW of operational generation capacity, including 469.29MW of hydro and 53.41MW of thermal plants. The vast hydro potential is being developed with the help of the private sector. The Nepal Electricity Authority has entered into a power purchase agreement with privately owned plants for 179.97MW; projects totalling 544.5MW are under construction. Further, a total of 465.24MW projects are under various stages of development. The development of mega-scale power projects have, however, been treading a slow pace, thus adding to the shortages in the country. Nepal is currently a net importer of electricity from India.

7.7 Pakistan

Pakistan had a total generation capacity of 23,641MW by the end of 2012. This is dominated by gas (26.2 per cent) and oil-based (34.1 per cent) generation capacity. Pakistan is endowed with hydro, coal, as well as natural gas resources. It lacks the oil resources to meet the country's requirements, thus leading to a significant dependence on oil imports. The country has significant gas reserves, but the demand is expected to surpass domestic supply. It is working on three major gas import pipelines (Turkmenistan-Afghanistan; Iran; and Qatar-Pakistan) and liquefied natural gas imports. There are also efforts to exploit lignite in the Thar Desert region.

7.8 Sri Lanka

On January 2013, Sri Lanka's electricity generation capacity primarily comprised 1,584MW of hydro, 1,638MW of oil and coal-based, and 90MW of renewable energy-based generation capacity. As the country's hydro resources have been mostly developed, future capacity growth can only be realized from plants based on imported fossil fuels or renewable energy. Its growing dependence on imported fossil fuel is placing a significant burden on the economy. The country has thus embarked on an ambitious renewable energy development program. Sri Lanka's energy security concerns are significant and can be addressed to some extent by electric interconnection with India.

8. Power Sector Reform and Market Development

The power sector across most of the South Asian countries is facing various challenges, including operational inefficiency and the financial weakness of the utilities. The respective governments have initiated a process of reform in the power sector, which led to the reorganization of the sector as well as the setting up of independent regulatory institutions (Table 7).

There has been limited attempt in the reform process to develop a competitive power market, which could be precursor to the development of a competitive power market in South Asia. India has taken significant steps to develop a competitive power market in the country (Singh, 2010a, 2006). De-licensing the recognition of trading and non-discriminatory open access of networks has paved the way for the development of a complete power market in India. The Central Electricity Regulatory Commission (CERC) has granted licenses to operate power exchanges in the country. Two power exchanges, the India Energy Exchange and Power Exchange India Ltd., are under operation. The emergence of a

Table 7 **Power Sector Reform in South Asia**

	Key Law/Policy	Regulatory Institution
Afghanistan	Power Consumption Law (PCL), 1982	–
Bangladesh	Bangladesh Energy Regulatory Commission Act, 2003	Bangladesh Energy Regulatory Commission (BERC)
Bhutan	Electricity Act of Bhutan, 2001	Bhutan Electricity Authority (BEA)
India	Electricity Act, 2003	Central Electricity Regulatory Commission (CERC) and State Electricity Regulatory Commission (SERC)
Nepal	Electricity Act, 2049 (1992)	(proposed under draft Electricity Act, 2065)
Pakistan	Regulation of Generation, Transmission, and Distribution of Electric Power Act 1997	National Electric Power Regulatory Authority (NEPRA)
Sri Lanka	Sri Lanka Electricity Act No. 20 of 2009	Public Utilities Commission of Sri Lanka (PUCSL)

Source: Compiled by author

competitive market in the Indian power sector demonstrates that there are opportunities for the trade of power in the presence of power shortages in the country. In 2012-13, the total volume of short-term transactions reached 98.94 billion units (BUs), accounting for about 11 per cent of the total electricity generation in the country. Bilateral short-term transactions between discoms, through traders, power exchange, and unscheduled interchange (UI) transactions account for 14.52 BU (14.7 per cent), 24.76 BU (36.9 per cent), 23.54 BU (23.8 per cent), and 36.12 BU (25.0 per cent), respectively, of such transactions (CERC, 2013).

In order to ensure the cost-effective development of renewable energy resources and to provide a platform for the trade of green attributes of renewable energy, a market for renewable energy certificates (RECs) has been developed in India (Singh, 2010b, 2009). The RECs are traded on the power exchanges and provide an opportunity for obligated entities to purchase the required number of certificates. The platform can easily be extended to give similar opportunities for trade in green electricity in other South Asian countries to meet the respective targets in their countries, if any.

9. Current Status of Power Sector Cooperation in South Asia

The historical cross-border cooperation between Bhutan-India and India-Nepal have demonstrated their effectiveness in the regional context. Subsequently, a number of initiatives have emerged in parts of the region, highlighting the willingness of the respective countries to explore cross-border cooperation, although in a bilateral manner. Here, we briefly discuss some of the existing bilateral cooperation aimed at cross-border power exchange. These proposals are under various phases of discussion/planning/ implementation. Some of these are summarized in Table 8.

Table 8 Cross-border Transmission Interconnections: Proposed and Under Implementation

S. No.	Countries	Interconnection Description	Capacity (MW)	Status
1	Bhutan-India	Grid reinforcement to evacuate power from Punatsangchhu I and II	Reinforcement of 2,100MW	
2	Nepal-India	Dhalkebar-Muzaffarpur 400kV line	1,000MW	Under implementation
3	Sri Lanka-India	400kV, 127 km HVDC line with submarine cable	500MW in the short term	Planning
4	Bangladesh-India	400kV HVDC back-to-back asynchronous link	500MW	Completed
5	India-Pakistan	220kV in the short term (could be upgraded to 400kV later)	250-500MW	Yet to be formally discussed

Source: Compiled by author

The existing bilateral cross-border arrangements among the South Asian countries are briefly discussed below:

- **Afghanistan-Central Asia cooperation:** Afghanistan's electricity generation capacity is limited; part of it was damaged in the strife that struck the country. It is currently dependent on electricity imports from Iran, Tajikistan, Uzbekistan, and Turkmenistan and imported 2,246.2GWh electricity from Iran, Uzbekistan, Turkmenistan, and Tajikistan in 2011. Transmission links with Tajikistan and Turkmenistan are being upgraded to allow a greater import of power. It is expected that the country would remain heavily dependent on electricity imports in the short run, till the investment climate improves.

- **Pakistan-Central Asia cooperation:** Pakistan currently imports about 25MW power from Iran to its Gwadar port area. This is likely to increase to about 100MW when the proposed 220kV link is completed. The proposal to develop Central Asia South Asia interconnection, called CASA 1000, would link the surplus region of Central Asia with the deficit areas in South Asia. Once the link is in place, it may also be extended up to India and beyond.

- **India-Nepal cooperation:** Cooperation between India and Nepal in the power sector dates back to the 1960s when India assisted the development of a 1MW hydro-power plant in Pokhra, which was commissioned in 1968. Both countries share a long border, which has 22 radial links at 132/33/11kV from one system to the other. This allows them to exploit economies in providing electricity access to areas in one country, which are contiguous to the existing grid of the other. The development of a number of power projects has been under discussion with the Indian government. The need for adequate cross-border interconnections has been realized to enable the export of power for the future development of power projects in Nepal. The second Nepal-India inter-country cross-border transmission interconnection, called the Dhalkebar-Muzaffarpur 400kV line project, includes the strengthening of the sub-national transmission network in Nepal and the development of cross-border interconnection. This would add 1,000MW of cross-border transfer capability as per the availability and demand in the respective countries.

- **Bhutan-India cooperation:** Cooperation in the electricity sector of the two countries began in 1974 with an agreement to develop 336MW Chukha hydro-electric power projects, which were commissioned in 1988-89. This was followed with the development of Kurichu (60MW) and Tala (1,020MW) hydro-electric power projects. In 2006, Bhutan and India entered into an umbrella agreement to develop hydro power projects and associated transmission systems as well as trade in electricity through public and private sector participation. Under the agreement, India has agreed to import at least 5,000MW power from Bhutan by 2020. Bhutan's export earnings from sale of power to India reached 9,798.3 Nu in 2011-12. This accounted for 11.4 per cent of the country's GDP. The development of hydro power projects in Bhutan has also prompted its government to target for 100 per cent electrification by the end of 2013.

- **India-Bangladesh cooperation:** In January 2010, Bangladesh-India signed an MoU to exchange electricity through cross-border grid connectivity and to jointly invest in power generation in Bangladesh. This led to the development of a 400kV, 30km double-circuit HVDC line from Bheramara (Bangladesh) to Baharampur (India) and the establishment of a 500MW 400/230KV back-to-back HVDC substation at Bheramara. The link would initially be able to carry up to 500MW of power and will have an ultimate power flow capacity of 1,000MW. ADB is financing the Bangladesh portion of the project. The link is nearing completion and it is expected that NVVN, the trading arm of NTPC Ltd., would initially export up to 250MW of electricity.

- **India-Sri Lanka cooperation:** The proposed India-Sri Lanka 400kV HVDC grid interconnection involves the construction of a HVDC connection between Madurai in South India, and Anuradhapura in central Sri Lanka, through the Palk Strait. The link will have a proposed length of 285km, including 50km of submarine cables. It may initially transfer up to 500MW of power and may eventually be able to transfer up to 1,000MW. A pre-feasibility study was conducted by PGCIL in 2006. This also led to establishing broad technical and economic aspects of the project. The link is expected to provide peak transfer from India to Sri Lanka and off-peak transfer in the reverse direction. The pre-feasibility study estimated a high level total quantum of transfer (that is, both import and export) could be of 1,836MWhpa. Electric interconnection between India and Sri Lanka could provide peaking support to Sri Lanka, where peak demand has already exceeded its hydro capacity. On the other hand, Sri Lanka may have surplus off-peak power that may be economically utilized to displace thermal generation in India.

- **India-Pakistan cooperation:** The idea of developing a cross-border interconnection between India and Pakistan has been on the table for quite some time. This is expected to support the import of 500MW electricity from India to Pakistan via the Amritsar-Lahore interconnection. However, this has remained a victim of strained political relations between the two large nations.

10. Institutional Efforts for Power Sector Integration in South Asia

The economic and environmental benefits from regional power sector integration have been recognized by the respective national governments, mulilateral, and bilateral agencies. In the South Asian context, ADB, the World Bank, SAARC, and USAID have played a vital role in highlighting the need for regional cooperation in the energy sector, undertaking studies to identify various issues, mobilizing support from stakeholders, and providing financing for the implementation of the identified projects. A look at some of these initiatives:

10.1.1 SAARC

In January 2000, a Technical Committee on Energy was set up by SAARC. In January 2004, the Council of Ministers approved the creation of a specialized Working Group on Energy. During the first meeting of the SAARC Energy Ministers, held in Islamabad, Pakistan, on October 1, 2005, it was decided that an Expert Group would be constituted to deliberate on the options and potential of energy conservation and energy efficiency measures, and to formulate a road map for its implementation. The 13th SAARC summit decided to establish the SAARC Energy Center in Islamabad (discussed below). The government of India organized the South Asia Energy Dialog on March 5, 2007, to bring together experts, academic think-tank,s and other stakeholders in the region and to make recommendations to promote energy sector cooperation.The Energy Ministers in the third meeting held in Colombo, Sri Lanka, in January 2009, approved the concept of a South Asia Energy Ring. The SAARC, in its 17th summit, declared the formation of an Inter-governmental Framework Agreement for Energy Cooperation, and a Study on the Regional Power Exchange Concept and SAARC Market for Electricity.

10.1.2 SAARC-SEC

During the 12th SAARC summit held at Islamabad from January 4-6, 2004, the member countries decided to set up a SAARC Working Group on Energy (WG/E) with a mandate of developing and enhancing South Asian energy cooperation. The first meeting of the WG/E in June 2004 led to the adoption of a Plan of Action for regional energy cooperation including, inter alia, the possibility of setting up a SAARC Energy Center (SEC). During the first meeting of the SAARC Energy Ministers in October 2005, the Concept Paper on the Establishment of the SEC was discussed. This led to the setting up of the SEC in Islamabad in 2006. The center has since promoted regional cooperation in the energy sector among SAARC member countries and has contributed to the study of regional power sector cooperation.

10.1.3 BIMSTEC

The Bay of Bengal Initiative for Multisectoral Technical and Economic Cooperation (BIMSTEC) instituted the 'BIMSTEC Trans Power Exchange and Development Project' for power trade between BIMSTEC countries comprising Bangladesh, Bhutan, India, Nepal, Myanmar, Sri Lanka, and Thailand. An MoU was prepared based on the 'Declaration of First BIMSTEC Energy Ministers' Conference' held on October 4, 2005. This covered trans-power exchange and grid interconnection, hydropower development, energy security of the region, and the establishment of the BIMSTEC Energy Center (BEC). The fourth Task Force meeting on trans-power exchange, held in January 2013 in New Delhi, reviewed the draft MoU.

10.1.4 Asian Development Bank

ADB, through its South Asia Sub-Regional Economic Cooperation, has been supporting cross-border electricity trade in the region. ADB also supported SAARC in carrying out the SAARC Regional Energy Trade Study (SRETS), which identified four regional or sub-regional trade options: (i) power market (ii) petroleum refinery (iii) LNG terminal, and (iv) power plant. The SRETS report covers a wide range of energy cooperation opportunities, including the setting up of a power market in the SAARC region and the opportunities to fast-track cross-border interconnection projects that have already been identified. The outcome was endorsed by the SAARC Energy Ministers in 2011. As a follow-up to the SRETS study, SAARC has commissioned a study on Regional Power Exchange with the assistance of ADB. The final study report was endorsed by a SAARC intergovernmental meeting of technical experts held in November 2012. It is expected to be published in 2013. ADB is also part-funding the Dhalkebar-Muzaffarpur 400kV cross-border interconnection project between Nepal and India.

10.1.5 The World Bank

The World Bank instituted a wider study on the various aspects of regional cooperation in South Asia, including energy. The report, titled 'Potential and Prospects for Regional Energy Trade in the South Asia Region', identified the main opportunities for the development of regional trade in the electricity and natural gas sectors. The report also identified policies to promote cross-border energy trade. More recently, the World Bank instituted a study on 'Assessment of Opportunities and Challenges to Increased Regional Energy Cooperation in South Asia'.

10.1.6 USAID-SARI/E and SARI/EI

The SARI/E program, started by the USAID in 2000, has consistently strived for the promotion of energy security in the South Asian nations by working in three focus areas: cross border energy trade; energy market formation, and regional clean energy development. In 2012, the SARI/E program entered into its fourth and final phase, called the SARI/Energy Integration (SARI/EI) program. In this phase (2012-2017), the project's goal is to advance regional energy integration for enhancing cross-border energy trade. This would focus on the following three components:

- Harmonization of policy, legal, and regulatory mechanisms;
- Advancement of transmission system interconnections; and
- Establishment of South Asia Regional Electricity Markets.

The program would catalyze enabling systemic conditions for regional energy integration through the formation and support to three Task Forces (TFs) focusing on the three components mentioned above. The representatives of regional stakeholders such as national governments, national power transmission utilities, national electricity regulatory commissions, power market institutions, and organizations from respetive countries will be the members of the Task Forces. The TFs will showcase examples of the benefits of regional cooperation, leverage counterpart funding and resources, provide unbiased support for regional initiatives, present a platform to discuss cross-border trade, and promote cross-border infrastructure interconnections. They will also help create markets and mechanisms for transparent trade practices, clean energy access, efficiency, conservation, and renewable sources. The Project Steering Committee (PSC) is the program's apex body and provides overall strategic direction. The PSC comprises senior representatives from the respective governments of SARI/EI countries, independent energy experts/diplomats, SAARC Energy Center, and multilateral donors such as the ADB. IRADe's approach is to act as the secretariat and to provide technical inputs. It would also work towards consensus building among member countries to achieve the program objectives in a constructive manner. The key enablers would be coordinating policies, regulations, and interconnections. The activities of the TFs form the heart of the program. TF meetings will be focused, structured, demand-driven, and result in tangible outcomes. The TFs will be supported by demand-driven research and analysis, thus assisting their decision-making process.

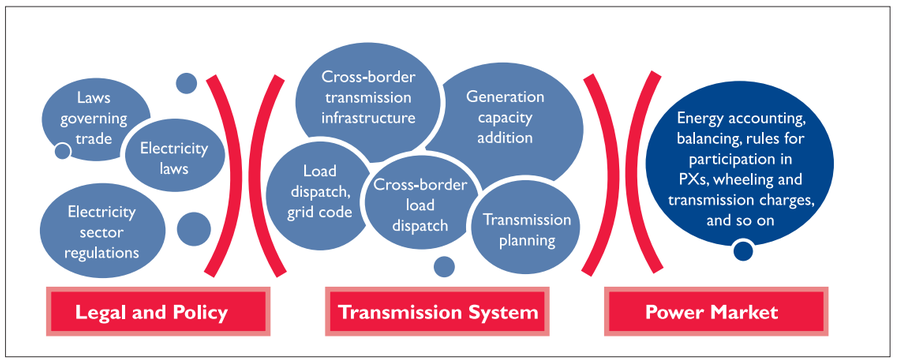
11. Strategy for Power Sector Integration in South Asia

Electricity sector integration in South Asia is in an evolutionary stage and awaits a structured approach to develop a regional power market. Although there are no formal market-based multilateral trading arrangements supported with a harmonized commercial, regulatory, and legal framework, successful bilateral trading arrangements in place between Bhutan and India, and India and Nepal highlight the benefits from such cooperation. This experience has motivated the development of an interconnectionbetween Bangladesh and India that has been completed, and between India and Sri Lanka, which is being evaluated and discussed.

Deeper power sector integration in the region will be driven by sound economics that would, in turn, depend on the demand-supply balance in each country. The economic rationale and the benefits to accrue would differ from country to country. Hydro resource development in Bhutan and Nepal will, for instance, be an attractive proposition only if the demand in the rest of the South Asian countries is sufficiently high and the delivered cost of power is economic relative to the importing countries' own resources. Bangladesh can benefit from a higher share of hydro resources in its generation portfolio if it can import hydro-electric power generated in nations richly endowed with hydro resources. Sri Lanka can improve its energy security by tapping electricity generation resources from India.

The existing and the proposed cross-border electric interlinkages in the South Asian region are the culmination of bilateral negotiations. The initial focus on a strong bilateral form of power trade would ensure the investment in viable interconnections. With gradual harmonization of electricity codes and balancing mechanisms, and the strengthening of institutional cooperation, short-term transactions through OTC/bilateral and energy exchanges would become increasingly feasible. The existing contract between the Nepal Electricity Authority and the PTC India Ltd. (an electricity trader registered in India) to import electricity on a commercial basis demonstrates the appropriateness of the market framework at a regional level.

Figure 6 Key Issues for Enabling the Regional Power Market in South Asia



Experience from the regional integration of power systems across various parts of the world suggests that the development of a regional-level mechanism to enhance cross-border electricity trade would require the identification and harmonization of key technical, commercial, economic, and regulatory/ legal aspects. As a part of a recent study by the Asian Development Bank, a number of regulatory, policy, and legal issues influencing the development of a regional power market were identified, and specific short-, medium-, and long-term changes were identified for consideration by the respective countries (Singh, 2012). The identification of such issues through the process of a participative and consensus-based approach, involving the key stakeholders of each of the South Asian countries has been envisaged in SARI/EI. Figure 6 outlines some of the key issues to be addressed through this program.

The culmination and success of regional power sector cooperation would depend on strong political consensus and the continuity of political support. SARI/EI envisages consensus-building among respective government departments, ministries, private sectors, and organizations/agencies affiliated to the electricity sector across the participating nations to identify and address relevant issues. A broader regional energy cooperation framework may also include the sharing of regional best practices for implementing reforms in the sector, setting up independent regulatory institutions, implementing efficiency improvement programs, training of personnel, and testing of equipment.

12. Conclusions

Long-term energy security and improvement in electricity access and its availability is the prime driver for enhancing regional cooperation in the power sector. The existing experience in the region demonstrates the efficacy of cross-border transmission interconnections and coordinated investment in generation. International experience further strengthens the argument in favor of a regional framework to develop a competitive regional power market.

A number of studies in the past have identified some of the technical/operational, policy, and regulatory issues towards the development of a regional power market in South Asia. The next step will be to bring together the respective stakeholders from the South Asian countries to identify ways of taking the commonality of tasks ahead in their respective countries, while also harmonizing them at the regional level.

Effective regional cooperation in the electricity sector can only be achieved and sustained if the participating countries recognize the long-term benefits from the association and actually work towards harnessing it. Unless the respective goals of the participating countries are achieved, it is difficult to bring the nations to the negotiating table. For, ultimately, cooperation in the power sector presents a win-win situation for the South Asian region as a whole as well as for the participating countries.

References

ADB (2010), GMS RETA No 6440 (REG), Component 1, Module 1: Update of the GMS Regional Master Plan—Main report as a part of 'Facilitating Regional Power Trading and Environmentally Sustainable Development of Electricity Infrastructure in the Greater Mekong Sub-region' (RETA No. 6440), Asian Development Bank, Manila.

ADB (2012), Greater Mekong Sub-region Power Trade and Interconnection: Two Decades of Experience, Asian Development Bank, Manila.

AEIC (2013), Database Power Production and Supply Statistics, Afghan Energy Information Center. Accessed in September 2013 from http://www.afghaneic.org/database/view_annual_all.php.

CEA (2012), National Transmission Grid Master Plan for Bhutan (NTGMP), Central Electricity Authority, New Delhi.

CEA (2013a), Highlights of Power Sector, August 2013, Central Electricity Authority, New Delhi.

CEA (2013b), Electricity Generation during the month of March '13 and during the period April '12- March '13 2013, Operation Performance Monitoring Division, Central Electricity Authority, New Delhi. CWC (2005), Handbook of Water Resources Statistics, Central Water Commission, New Delhi.

CERC (2013), Report on Short-term Power Market in India, 2012-13, Economics Division, Central Electricity Regulatory Commission, New Delhi.

CWC (2005), Handbook of Water Resources Statistics, Central Water Commission, New Delhi.

ECA (2010a), The Potential of Regional Power Sector Integration: Greater Mekong Sub-region (GMS) Transmission & Trading Case Study, Economic Consulting Associates, London.

ECA (2010b), Southern African Power Pool (SAPP) Transmission & Trading Case Study, Economic Consulting Associates, London.

ENTSOE (2012), ENSTSOE Annual Report, ENTSO-E, Belgium.

ICA (2011), Regional Power Status in African Power Pools, The Infrastructure Consortium for Africa, c/o African Development Bank, Tunisia.

IRENA (2009), Renewable Energy Country Profile: Maldives, International Renewable Energy Agency (IRENA), Abu Dhabi, accessed in September 2013 from http://www.irena.org/REmaps/countryprofiles/asia/Maldives.pdf.

RGoB (2006), Results of Population & Housing Census of Bhutan 2005, Office of the Census Commissioner, Royal Government of Bhutan.

RGoB (2012), Statistical Yearbook of Bhutan 2012, National Statistics Bureau, Royal Government of Bhutan, Thimpu.

SAARC Secretariat (2010), SAARC Regional Energy Trade Study (SRETS), SAARC Secretariat, Kathmandu.

SAPP (2012), SAPP Annual Report, South Africa Power Pool, Harare.

Singh, Anoop, (2012), Chapter on 'Regulatory and Legal Issues' in Study on a South Asian Regional Power Exchange, part of RDTA 7529 Project Report, submitted to the Asian Development Bank, Manila.

Singh, Anoop, (2010a), Towards a Competitive Market for Electricity and Consumer Choice in Indian Power Sector, Energy Policy, 38 4196-4208.

Singh, Anoop, (2010b), Economics, Regulation, and Implementation Strategy for Renewable Energy Certificates in India, 42-57, in India Infrastructure Report 2010, Oxford University Press, New Delhi.

Singh, Anoop, (2009), Nationally Tradable Renewable Energy Credits for Renewable Portfolio Obligation in the Indian Power Sector, Renewable and Sustainable Energy Reviews 13, 643-652.

Singh, Anoop, (2006), Power Sector Reform in India: Current Issues and Prospects, Energy Policy, 34 (16), 2480-2490.

TRAI (2011), Consultation Paper on Green Telecommunications, Telecom Regulatory Authority of India, New Delhi.

Wijayatunga, Priyantha and Fernando, P.N. (2013), An Overview of Energy Cooperation in South Asia, Working Paper Series No. 19, Asian Development Bank, Manila.

World Bank (2008), Potential and Prospects for Regional Energy Trade in the South Asia Region, ESMAP Formal Report 334/08, The World Bank, Washington DC.

World Bank (2013), World Development Indicators, The World Bank, Washington DC. Accessed in September 2013 from http://databank.worldbank.org/data/views/variableSelection/selectvariables.aspx?source=world-development-indicators.

Individual websites of SAARC, the World Bank, Asian Development Bank, SARI/E, and power ministries/departments of respective countries.

Statistical Appendix Selected Economic, Social, Energy, and Environmental Statistics, 2010

Indicator Name	Afghanistan	Bangladesh	Bhutan	The Maldives	Nepal	India	Pakistan	Sri Lanka	South Asia	China	EU
Economic Indicators											
GDP growth (annual %)	8.2	6.1	7.4	5.7	4.8	9.6	4.1	8	8.7	10.4	2.2
GDP per capita, PPP (constant 2005 international $)	1,083	1,488	4,780	7,387	1,079	3,039	2,411	4,601	2,776	6,819	27,640
Social Indicators											
Population density (people per sq. km of land area)	53	1,142	19	1,053	209	412	225	329	342	143	120
Urban population (% of total)	23.2	27.9	34.8	40	16.7	30.9	35.9	15	30.6	49.2	73.8
Life expectancy at birth, total (years)	48.3	68.6	66.9	76.6	68.4	65.1	65.2	74.7	65.3	73.3	79.6
Land area (1,000 sq. km)	652	130	38	0.3	143	2,973	771	63	4,771	9,327	4,182
Energy and Environmental Indicators											
Energy imports, net (% of energy use)	3	16.9	9	59	12.1	25.1	24	43.9	24.8	8.6	51.3
Electricity production (million kWh)*		37,862			3,119	899,389	95,400	9,884	1,054,474	3,695,928	3,178,261
Electric power consumption (kWh per capita)*	49	274	2,420	2,283	91	570.9	449.3	412.9	516.9	2,631.40	6,063.60
Access to electricity (% of population)*	15.6	41			43.6	66.3	62.4	76.6	62.2	99.4	
Electric power transmission and distribution losses (% of output)*		2.3			31.5	24.4	19.7	14.6	23.1	4.9	5.9
Electricity production from hydro-electric sources (% of total)*		4.1			99.6	11.9	29.4	39.5	13.6	16.7	10.3
CO_2 emissions (metric tons per capita)*	0.2	0.3	0.6	3.2	0.1	1.7	0.9	0.6	1.4	5.8	7.2
Forest area (% of land area)	2.1	11.1	84.6	3.3	25.4	23	2.2	29.7	17.1	22.2	37.5

* Since data for 2010 is not available for these variables we have taken 2009 data; missing data fields are kept blank

Source: Compiled by the authors

Acknowledgments

The preparation of this Background Paper on 'Cross-Border Electricity Trade in South Asia: Prospects for Regional Cooperation' for the SARI/EI program would not have been possible without the valuable contribution of the multiple stakeholders involved. We are grateful to the United States Agency for International Development (USAID) for its generous support. We would like to express our sincere thanks to Mr. Jeremy Gustafson, Director, Clean Energy & Environment Office, USAID/India and Mr. Amol Bhutad, Regional Program Manager, SARI/EI, USAID/ India, for their valuable inputs and suggestions in finalizing this paper.

We also extend our heartfelt gratitude to Mr. S. Padmanaban (Padu), Former Regional Director of SARI/EI, who took a keen interest in developing the concept of this Background Paper.

We heartily thank Dr. Kirit S. Parikh, Former Member, Planning Commission,Government of India and Chairman, Project Steering Committee, SARI/EI, for his valuable suggestions and guidance all along.

We express our sincere thanks to Mr. Chandrashekhar Singh and Ms. Yogeeta Sharma for their timely inputs and persistent help.

We also acknowledge and express our appreciation for all those individuals whose names cannot be penned here but who offered invaluable insights and generous support throughout this exercise. We hope this document will serve as a valuable resource to delineate the road map for the creation of cross-border energy markets in South Asia.

About USAID

The United States Agency for International Development (USAID) is an independent government agency that provides economic, development, and humanitarian assistance around the world in support of the foreign policy goals of the United States. USAID's mission is to advance broad-based economic growth, democracy, and human progress in developing countries and emerging economies. To do so, it is partnering with governments and other actors, making innovative use of science, technology, and human capital to bring the most profound results to a greatest number of people.

About IRADe

IRADe is a fully autonomous advanced research institute, which aims to conduct research and policy analysis and connect various stakeholders including government, non-governmental organizations (NGOs), corporations, and academic and financial institutions. Its research covers many areas such as energy and power systems, urban development, climate change and environment, poverty alleviation and gender, food security and agriculture, as well as the policies that affect these areas.

For more information on the South Asia Regional Initiative for Energy Integration (SARI/EI) program, please visit the project website:

www.sari-energy.org