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SOUTH ASIA REGIONAL INITIATIVE FOR ENERGY INTEGRATION (SARI/EI)

Potential for Power Trade in Western Part of South Asia : Techno-Economic Rationale

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Abbreviations

AC	Alternating Current
ADB	Asian Development Bank
APPC	Average Power PurchaseCost
BDT	Bangladeshi Taka
BPDB	Bangladesh Power Development Board
BU	Billion Units
CAGR	Compound Annual Growth Rate
CASA	Central Asia South Asia
CBET	Cross-Border Electricity Trade
CEA	Central Electricity Authority
D/C	Double Circuit
EPS	Electric Power Survey
FO	Furnace Oil
GW	Gigawatt
GWh	Gigawatt Hours
HSD	High Speed Diesel
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
IEX	Indian Energy Exchange
IPP	Independent Power Producers
kM	Kilometer
kV	Kilovolt
MW	Megawatt

MWh	Megawatt Hour
NTDC	National Transmission and Dispatch Company Ltd
NTPC	National Thermal Power Corporation
PEPCO	Pakistan Power Electric Company
PPA	Power Purchase Agreements
PXIL	Power Exchange India Limited
SAARC	South Asian Association for Regional Cooperation
SAFTA	South Asian Free Trade Area
SEC	SAARC Energy Centre
SPV	Special Purpose Vehicle
T/L	Transmission Line
TWh	Tera Watt hour or 1 Billion kWh
USD	United States Dollars
WBSEDCL	West Bengal State Electricity Distribution Company

Preface

South Asia Regional Initiative for Energy Integration (SARI/EI), a program of USAID being implemented by Integrated Research and Action for Development (IRADe), aims to promote the integration of energy systems and also to enhance Cross-Border Electricity Trade (CBET) among the South Asian countries. The program focuses on three key outcomes for the overall socio-economic progress of the region:

- Harmonisation/coordination of policy, regulatory, and legal issues
- Advancement of transmission systems interconnections
- Establishment of South Asia Regional Electricity Markets

The eight South Asian nations (Afghanistan, Bangladesh, Bhutan, India, the Maldives, Nepal, Pakistan, and Sri Lanka) collectively account for over one-fifth of the world's population. All the South Asian countries are currently facing power and energy shortages which is negatively impacting their economy. Adequate supply of energy is a pre-requisite for all the development pursuits in South Asia ranging from economic progress to scientific research, education, healthcare, quality of life, and prosperity in the region. In the recent past, South Asia has been one of the fastest growing regions in the world, with an average annual growth rate of 6 per cent as measured by GDP per capita. Despite this impressive macroeconomic growth, the energy sector in the South Asian region has not been able to keep pace, and continues to experience chronic problems like shortage of supply and poor quality of service. Given this dilemma the only long-term solution is the sustained increase in regional energy cooperation and advancing/accelerating CBET among South Asian nations.

The integration of power grid and CBET to the extent of 2300 MW in the eastern part of South Asia is already established, between Bangladesh-India (600 MW), Bhutan-India (1416 MW), and Nepal-India (~500 MW), though there is a huge potential of CBET in the region and trade is likely to enhance in future.

Therefore, the integration of power system in the western part of South Asia will be an important step in the direction of advancing/accelerating CBET in the South Asia Region. The future prospects for CBET are immense; from a completely integrated South Asian grid, where power could be traded across the region,subsquentely to a pan inter-regional integration between Central Asian and South East Asia.

This study report describes the current landscape and evaluates the future options of potential for power trade in western part of South Asia.

1 Introduction

1.1 Objective of the Study

South Asia Regional Initiative for Energy Integration (SARI/EI) program of USAID is working towards promoting the development of integrated regional power market in South Asia to facilitate power trade amongst the SAARC countries. The past efforts under this program have brought about a recognition of the benefits of Cross-Border Electricity Trade (CBET) in the region for meeting electricity requirements of respective countries and also addressing the energy security of the region.

This study is an endeavor to complement the increasing acceptance of CBET in the South Asian region for sustainable development of the power sector in the region. Within South Asia, there have been several successful initiatives for interconnection on the eastern side, involving India, Bhutan, Bangladesh and now Nepal. A truly integrated South Asian regional power grid will be realised once there is connectivity on the western side of South Asia involving India, Pakistan and Afghanistan.

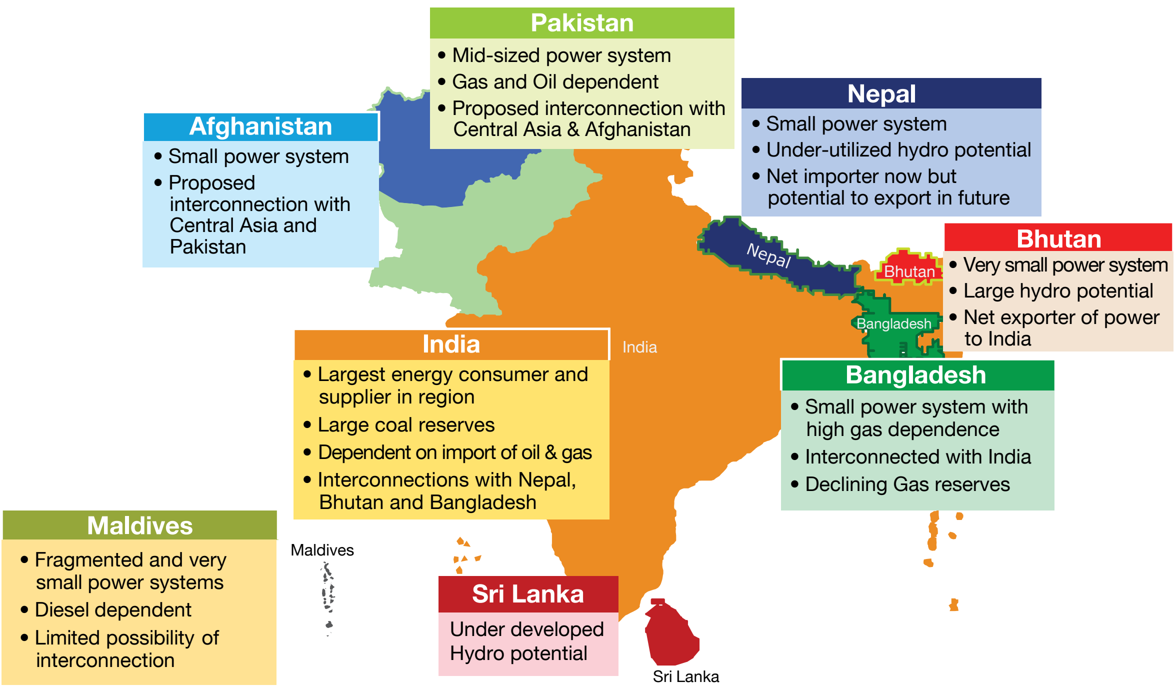
A key element of integrating the power system in the western part of South Asia is the India – Pakistan interconnection, which has been the subject of various studies since 1990s and several pre-feasibility studies have been undertaken in the past to identify the most suitable connectivity between the two countries. This report evaluates the profiles/options for power transmission interconnection and power trading opportunities among the western part of South Asian countries in the changing context and provides conclusions on the potential for power trade based on the techno-economic rationale of the possible alternatives.

2 South Asian Cross Border Energy Trade

2.1 Background

The regional cooperation offers an ideal platform to achieve sustainable growth through sharing of available natural resources in the region. In the context of energy sector, it is applicable to the SAARC member countries, where there is a vast diversity of available energy resources, particularly hydropower and renewable, which are still under development. The figure -1 provides a snapshot of power systems in South Asia:

Figure 1: Power Sector Profile



The region is endowed with limited fossil fuels but ample hydro resources. In addition to the conventional energy resources, there are huge renewable energy resources such as solar and wind, as shown in table-1 on next page.

The dominance of certain fuel types– coal in India, gas in Bangladesh, petroleum in Pakistan, hydro power in Bhutan and Nepal - leads to over-dependence on these resources at a country level and leaves them vulnerable to supply side risks. There is a need to have diversity in energy supply mix as well as improve the energy access for the large population in these countries who are deprived of the benefits of electricity. There is also a need to balance the conventional sources with the renewable energy resources for managing the climate change effects in the sub-continent.

All the countries in the region are facing similar challenges of rising cost of electricity supply and has an urgent need to improve the access to electricity for a large section of population. There are huge

Table 1: Energy Resource Potential in South Asia

Country/ Fuel Source	Coal (Million Tonnes)	Oil (Million Barrels)	Natural Gas (Trillion Cubic Feet)	Biomass (Million Tonnes)	Hydropower (MW)	Solar (kwh/ sq m/ day)	Wind (MW)
Afghanistan	440	NA	15	18–27	25,000	NA	Limited
Bhutan	2	0	0	27	30,000	2.5-5	4,825
Bangladesh	884	12	8	0.08	330	3.8-6.5	Limited
India	90,085	5,700	39	139	1,50,000	4-7	151,918
Maldives	0	0	0	0.06	0	NA	NA
Nepal	NA	0	0	27	83,000	3.6-6.2	3,000
Pakistan	17,550	324	33	-	59,000	5.3	24,000
Sri Lanka	NA	150	0	12	2,000	NA	25,000
Total	**1,08,961**	**6,186**	**95**	**223-232**	**3,49,000**		

Source: Background Paper on Cross-Border Electricity Trade in South Asia: Key Policy, Regulatory Issues/Challenges and the Way Forward, Jan 2016 - IRADe

opportunities for optimisation of resources through interconnected power systems across the region which can address these challenges. The regional energy trade has the potential to deliver significant economic benefits as well as improve the reliability of power in an environment friendly manner.

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All the countries in the region are facing similar challenges of rising cost of electricity supply and has an urgent need to improvethe access to electricity for a large section of population. There are huge opportunities for optimisation of resources through interconnected power systems across the region which can address these challenges. The regional energy trade has the potential to deliver significant economic benefits as well as improve the reliability of power in an environment friendly manner.

2.2 Key CBET Initiatives in South Asian Region

Over the past decade, there has been a growing realisationamongst the SAARC nations, on the importance of improving the energy situation in their respective geographies and the role which the regional Cross Border Energy Trade can play in meeting their individual electricity needs. The agreement for a South Asian Free Trade Area (SAFTA), signed in 2004, envisioned a transition towards a common market. The SAARC Energy Centre (SEC); established in 2006 as a Special Purpose Vehicle (SPV) with its base in Islamabad, Pakistan; also has a focus on regional energy sector cooperation in South Asia. Further, the SAARC Inter-governmental Framework Agreement on Energy (electricity) Cooperation, signed among SAARC member states, lays the foundation for deeper power sector cooperation and enhancing CBET in the region.

The key initiatives for power trading in South Asia have predominantly been the bilateral arrangements between countries. The bilateral arrangements between India-Bhutan and India-Nepal for generation and transmission system have provided opportunities to unleash the huge hydropower potential available in both Bhutan and Nepal. This clean source of energy can be used to meet the growing electricity demand in South Asia. More recently, the development and growth in the India-Bangladesh power trade has opened new avenues for a collaborative regional market. The table-2 below illustrates the existing and proposed interconnections for CBET between South Asian countries.

Table 2: South Asian Region Interconnections

Interconnection	Key Features
Bhutan– India	• Total export capacity of around 1,416 MW from Tala, Chukha and Kurichhu • Transmission and associated infrastructure for Punasangchhu I & II (2220 MW) and Mangdechu (720 MW) HEPs under construction • Capacity of 10,000 MW for export to India to be developed in Bhutan under the Umbrella Agreement signed between the two countries
Bangladesh–India	• 500 MW power is being supplied from India via 400 kV Behrampur- Bheramara line with HVDC station at Bheramara • 400 kV (charged at 132 kV) Tripura – Comilla transmission line to transfer 100 MW power to Bangladesh in radial mode • Augmentation of HVDC back to back station capacity at Bheramara by 500 MW under construction
Nepal– India	• Multiple interconnections at 11 kV to 132 kV with capacity of around 150 MW • 400 kV Muzaffarpur- Dhalkebar line (currently charged at 220 kV) will ultimately have capacity of around 1000 MW

2.3 CBET Experience in South Asia

2.3.1 BANGLADESH – INDIA ELECTRICITY TRADE

The cross border electricity trade between Bangladesh and India was initiated in October 2013 with the commissioning of Bheramara (Bangladesh)– Baharampur (India) 400 kV back-to-back HVDC link of 500 MW capacity comprising of following elements:

- Bangladesh side: 27 km of Baharampur (India) – Bheramara (Bangladesh) 400 kV double circuit line, a 3 km loop-in, loop-out of Ishurdi – Khulna South 230 kV doublecircuit line at Bheramara and a 500 MW HVDC back-to-back station and 230 kV switching station at Bheramara
- India side: 71 km of Baharampur (India) – Bheramara (Bangladesh) 400 kV double circuit line, a 3 km loop-in, loop-out of Farakka – Jeerat 400 kV single circuit line at Baharampur and 400 kV switching station at Baharampur

Bangladesh power sector had faced several challenges in the recent past. These included:

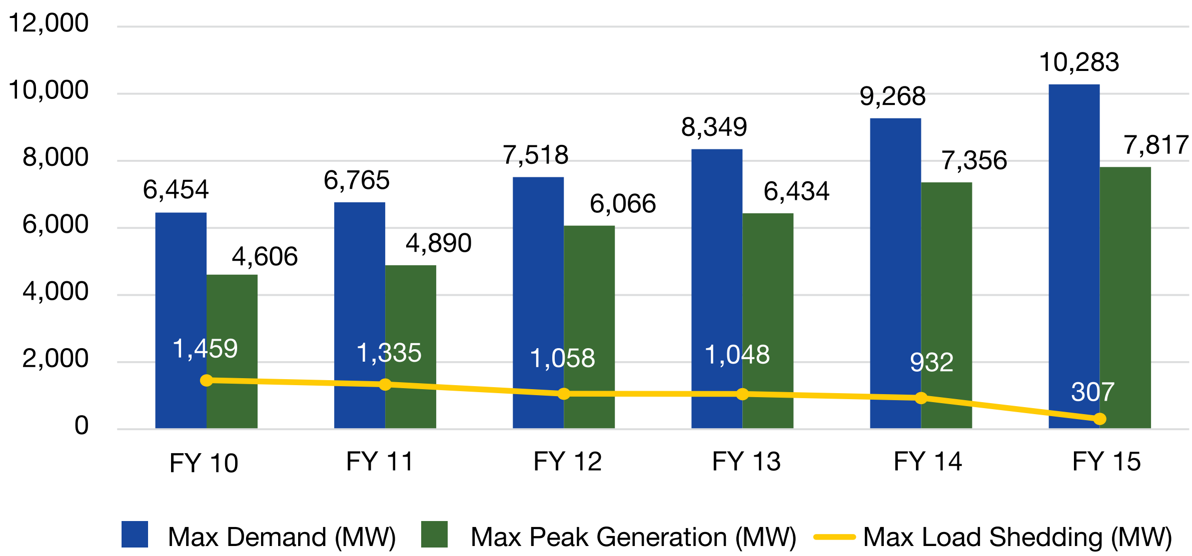
- Huge power deficit, which is likely to continue in the medium-term, due to growing demand and limited access to new generation sources in the short to medium-term
- Increased procurement cost of power due to reduced availability of gas which resulted in dependence on petroleum/ oil based generation
- Rising demand for electricity combined with the need to improve energy access for the large section of population

The Bangladesh – India interconnection has been beneficial to Bangladesh in solving several prevailing problems being faced by its power sector:

1. Reduced load shedding due to increased availability of power from India

The Bangladesh utilities had to resort to load shedding for all categories of consumers due to reduced generation capacity. The addition of 500 MW from import of Indian power has improved the overall load shedding situation since 2013.

Figure 2: Load Shedding in Bangladesh

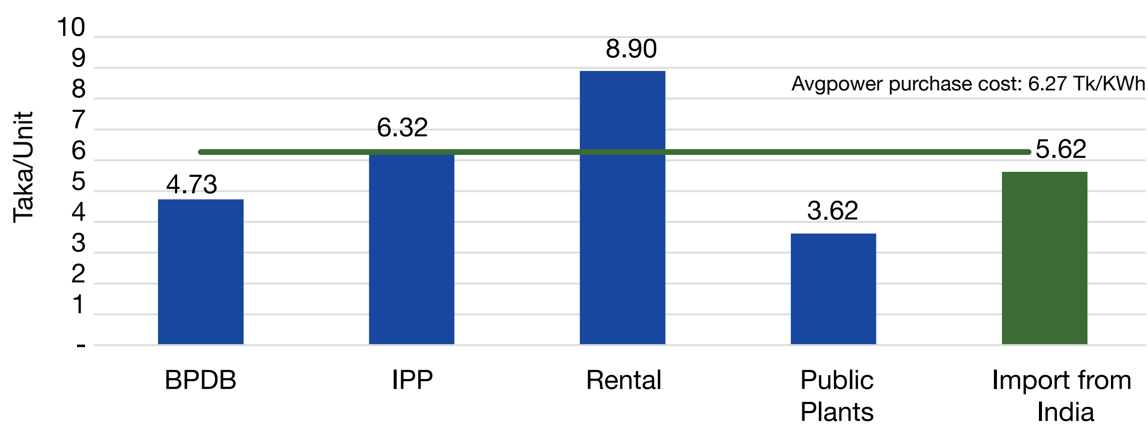


Source: BPDB Annual Report 2014-15

2. Reduction in power purchase cost

The tariff of power imported from India is lower than the average power purchase cost in Bangladesh. Hence, the overall procurement cost of power for Bangladesh Power Development Board (BPDB), who is the sole procurer of power in Bangladesh, has reduced as the import from India is at a lower rate than the Average Power Procurement Cost (APPC). The estimated savings from the energy transfer would be around USD 500 Million per year (Shahi 2014).

Figure 3: Power Purchase Cost in Bangladesh



Source: BPDB Annual Report 2015

In addition, India and Bangladesh have recently commissioned the 27 km 400 kV double circuit transmission line from Comilla in Bangladesh to Tripura in India along with associated works at Comilla

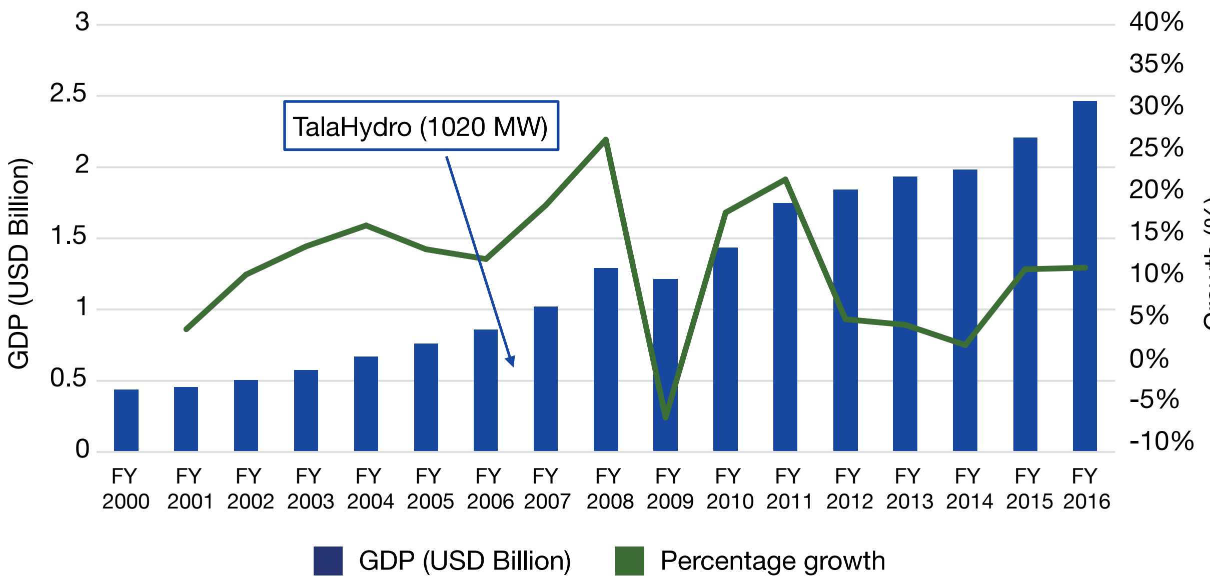
(132 kV bay extension and 18 km 132 kV transmission line) to import 100 MW power from Palatana power station in Tripura in radial mode. The estimated project cost of extension of transmission line is BDT 1,720 Million (USD 22 Million).

The benefits of the cross border trade has been recognised by both the countries and has resulted in proposal to ramp up the transmission capacity. The Asian Development Bank (ADB) financed the project to augment the existing Bheramara HVDC Station Capacity by additional 500 MW to facilitate overall 1000 MW of power transfer between Bangladesh and India through the existing interconnection, which is currently under implementation and is likely to be completed by 2019.

2.3.2 BHUTAN - INDIA ELECTRICITY TRADE

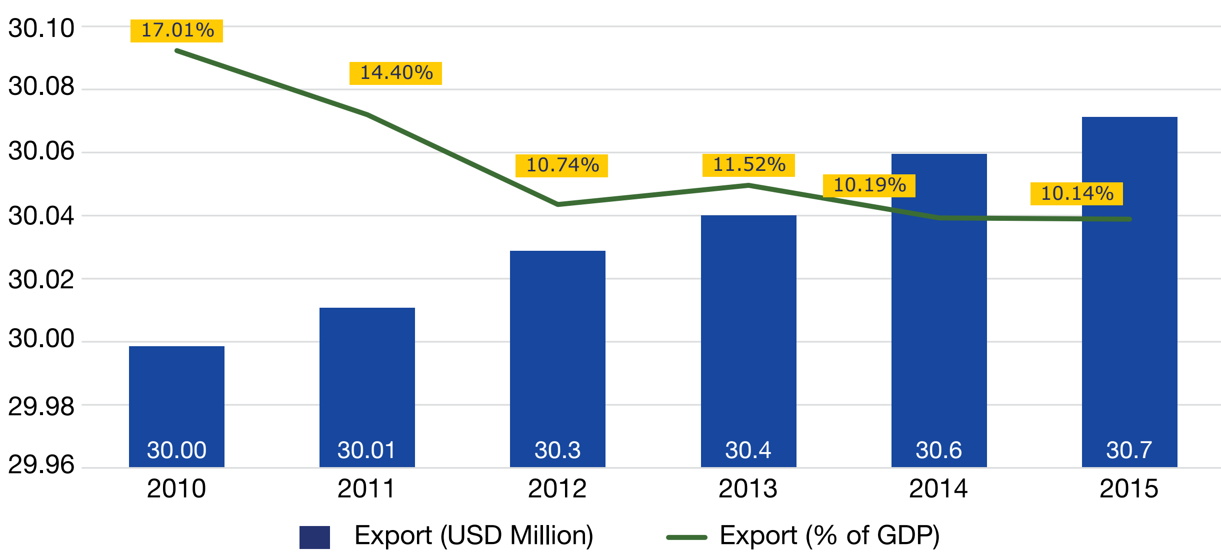
Bhutan has a huge hydro potential but has limited demand. The Cross Border Energy Trade has provided Bhutan an access to growing Indian power market. Since year 2003, hydropower development has significantly contributed to Bhutan's GDP as shown in the figure below:

Figure 4: Bhutan GDP Growth



Source: IMF Estimates

Figure 5: Electricity Export to India (USD Million)



Source: Bhutan Power Sector Report

The energy sales within Bhutan has reached three times over past one decade and has also led to development of energy intensive industries like Cement, Iron and Steel, Carbide, etc. The electricity access has improved in Bhutan (76 per cent in 2012) as a result of hydropower development.

The electricity exports to India have also been steadily rising over the last decade. In addition to contributing to the GDP (more than 10 per cent), the development of hydropower potential has also indirectly contributed to the overall development of Bhutanese economy.

2.4 Case for CBET in Western Part of South Asia

In South Asia, the power systems in India-Bangladesh-Bhutan-Nepal have been interconnected over past decade as a result of several bilateral initiatives. This has opened up opportunities for the evolution of aneastern sub-regional grid within South Asia. The huge hydropower potential in Bhutan (estimated capacity developed to be 11 GW by 2020) and Nepal (economic potential is estimated to be 42 GW), can be developed and transmitted to load centers to meet the exponentially increasing electricity demand in Bangladesh and India.

On its western side, Pakistan already has limited connectivity to Iran's power system and is also an integral part of the CASA 1000 scheme. Under this scheme,over 3 Terawatt hours (TWh) of hydroelectricity is proposed to be transferred during the summer months from Central Asian countries of Kyrgyz Republic and Tajikistan to Pakistan through Afghanistan in South Asia. Currently, there is no connectivity for power transfer between Pakistan and India. The interconnection on the western side involving India, Pakistan and Afghanistan is important for the overall evolution of the South Asian regional grid.

The interconnection between Pakistan and India has the potential to bring about an integration in the power systems of Central Asian countries and South Asian countries. The hydropower potential in these countries can complement the predominantly coal based thermal power generation in India to create a stable power system, which is mutually beneficial to the constituents of both the regions. According to ADB report (2013)[1], the benefits from CASA 1000 project in conjunction with India-Pakistan interconnection can yield substantive savings exceeding USD 1 Billion, primarily through reduction in unserved energy in Afghanistan, Pakistan and India.

In the short to medium-term, the interconnection between Pakistan and India can benefit Pakistan and possibly Afghanistan in meeting the generation deficit at a competitive price. In the long-term, the interconnected system in South Asia will provide opportunities for the new capacity additions within Pakistan to seek power deficient markets in South and Central Asia. The South Asian regional grid will improve the electricity access for the population while driving the development of efficient and diverse generation capacities.

[1] RDTA 7529: South Asian Regional Power Exchange Study – Final Report

3 Country Profile

In the following section, the current and future profiles of power sector in India and Pakistan have been assessed to understand and evaluate the power trading potential between the two countries.

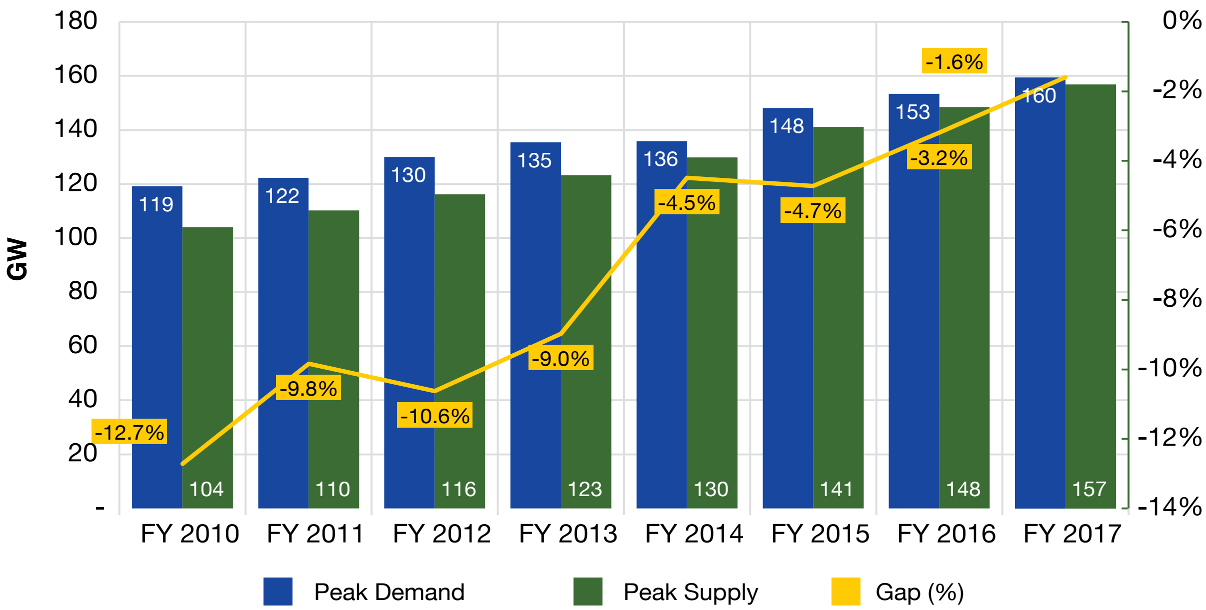
3.1 INDIA

India's power generation capacity currently stands at 303 GW (June, 2016) and has fourth rank in the world. This is a significant increase from 145 GW at the end of FY2006, with a Compound Annual Growth Rate (CAGR) of 7.7 per cent. The energy mix for India is dominated by coal which accounts for 59 per cent of the total installed capacity.The supply situation in India has drastically improved over the last two years. The peak demand supply deficit has progressively come down over last 5 years and India is likely to have peak surplus during FY 2017. The coal supply has also improved with surplus coal capacity being available. The dominance of coal in India's energy portfolio is likely to continue in the foreseeable future as well. Renewable Energy has been one of the fastest growing segments of the power sector,accounting for 17.6 per cent of the current installed capacity. The growth in Renewable Energy is likely to continue over a long-term period, given the ambitious targets which have been set for solar and wind segments.

3.1.1 DEMAND-SUPPLY SCENARIO – PAN INDIA

The peak demand supply scenario has improved in India over the last few years as a result of accelerated generation capacity additions and a complementary slowdown in the demand growth. For FY 2017, the situation is likely to turn with peak surplus of 2.57 per cent as shown in the figure below:

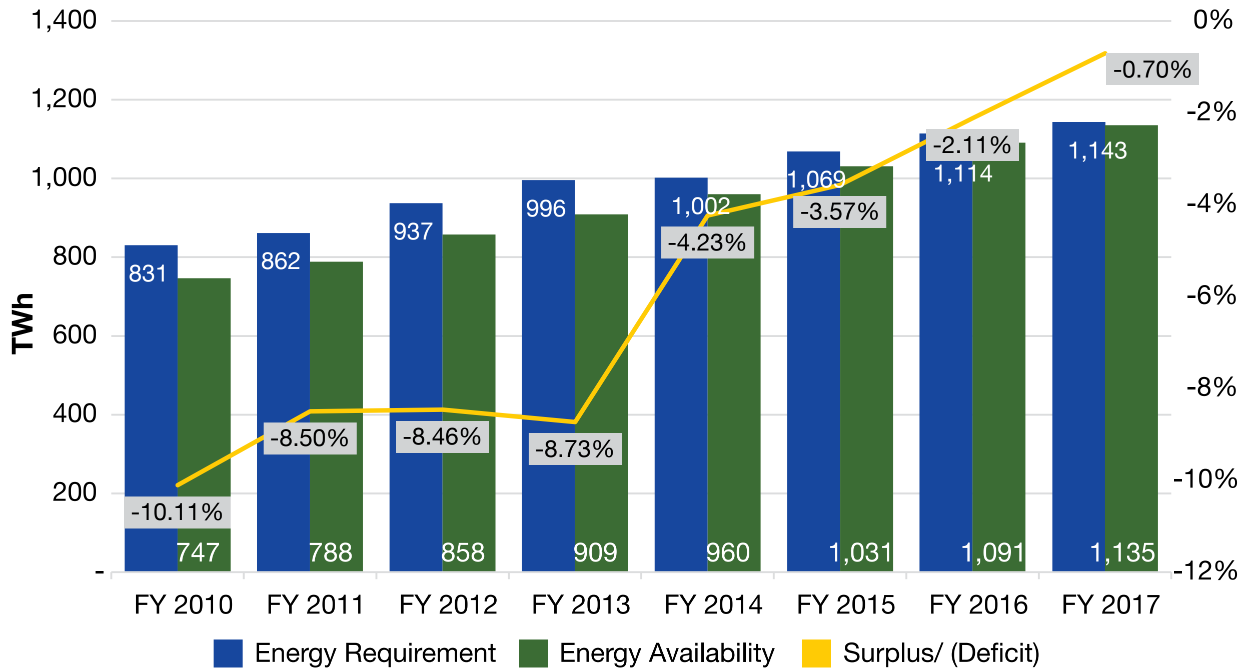
Figure 6: Peak Demand-Supply Scenario in India



Source: Ministry of Power, Government of India

A similar trend is also seen in the electricity generation and availability. India's electricity deficit has gradually decreased over the past decade, from ~10 per cent in 2010 to 2.1per cent in 2016. The country is likely to experience energy surplus during 2016-17 as shown in the figure below

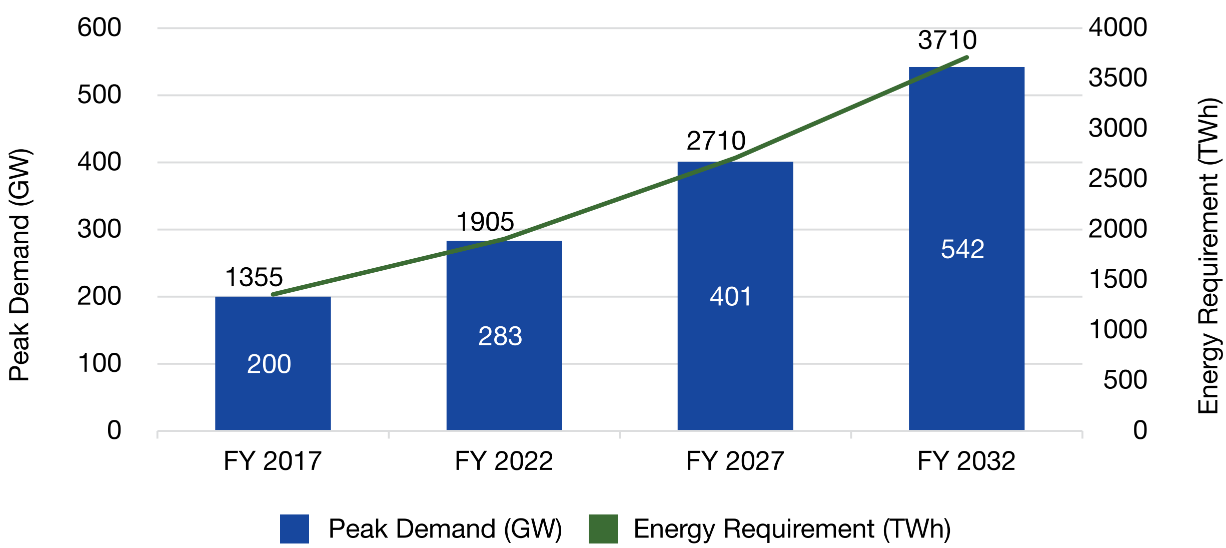
Figure 7: Energy Availability Scenario in India



Source: Ministry of Power, Government of India

The 18th Electric Power Survey (EPS) report has analysed the future demand-supply and energy situation for India. The report estimates that India's peak demand would be around 541 GW in year 2032 and electrical energy requirement of around 3,700 TWh as illustrated in the figure below.

Figure 8: Peak Demand and Energy Requirement Forecast - India

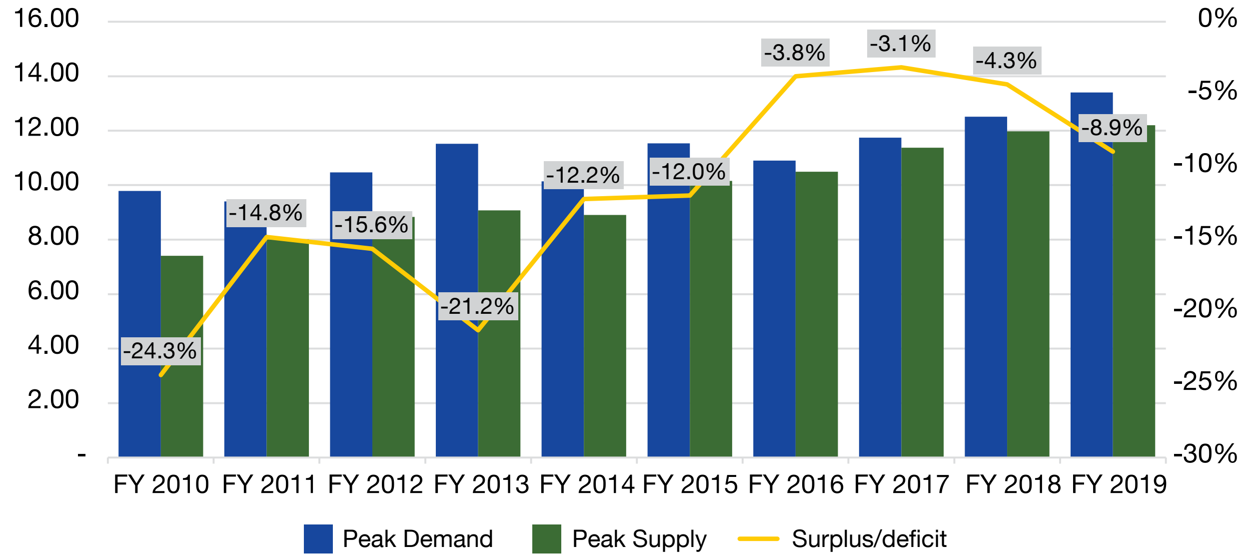


Source: 18th EPS Report, Central Electricity Authority

3.1.2 DEMAND-SUPPLY SCENARIO – PUNJAB (INDIA)

Punjab has one of the highest per capita electricity consumption states in India and has been able to achieve 100 per cent electrification within the state. The peak demand supply gap for the state has been progressively coming down over the last five years as shown below:

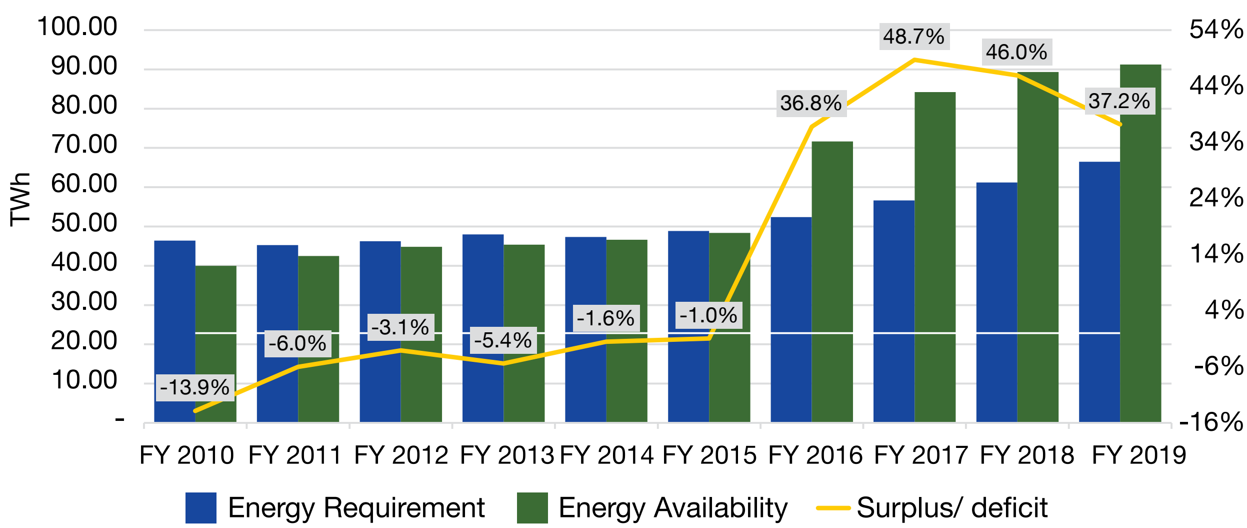
Figure 9: Demand-Supply Scenario in Punjab (India) (GW)



Source: PFA Reports on Punjab

The energy availability – requirement scenario in Punjab has been improving over the years. As far as energy requirement and the supply scenario is concerned, Punjab has shown tremendous improvement since 2010. The state has attained surplus energy due to generation capacity additions over the past few years. The energy deficit has decreased gradually from 6,449 GWh in 2010 to a negligible shortage in 2016.The scenario is likely to improve further, with the addition of thermal power projects in the state. The Power Finance Corporation (PFC) report on Punjab forecasts huge energy surplus within the state in the coming years as shown below:

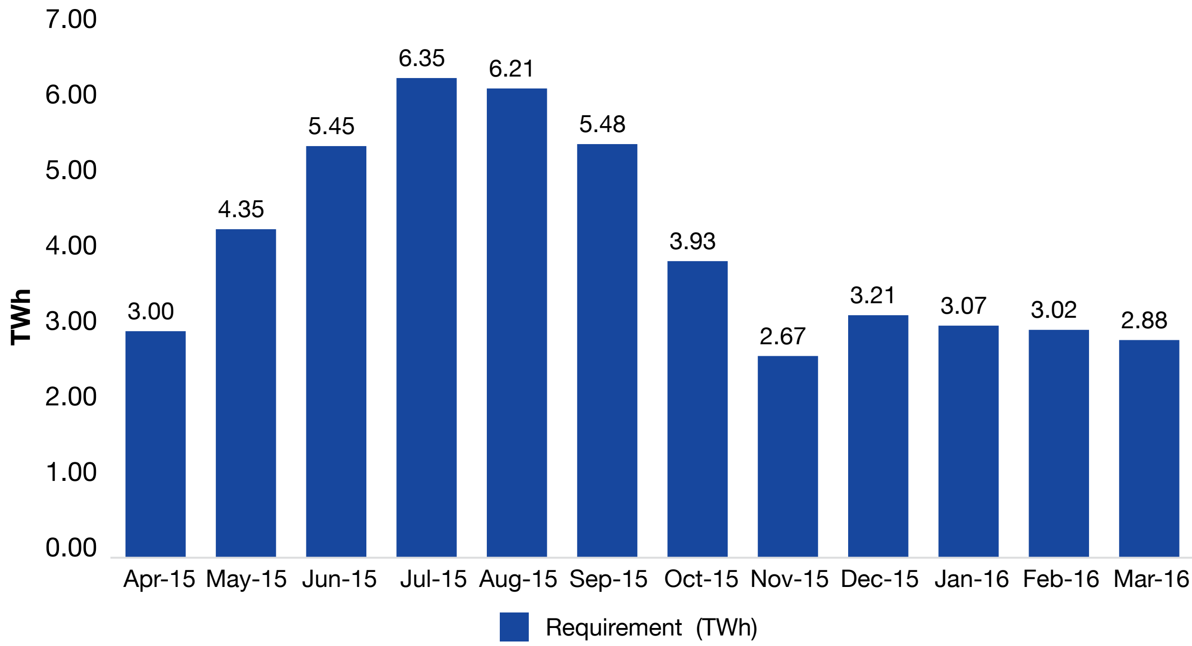
Figure 10: Punjab (India) Energy Availability (TWh)



Source: Power Finance Corporation report on Punjab

Punjab has a typical demand variation due to high agriculture load and the requirement is at its peak during the paddy season (June to September). Around 47 per cent of the total annual energy requirement is consumed during these four months and the requirement significantly drops during the remaining part of the year. The state has surplus energy during the non-paddy period, which is traded through bilateral arrangements with other states. The following figure shows the monthly energy profile of Punjab (India):

Figure 11: Energy Consumption Profile - Punjab (India)



Source: CEA Reports

There are significant opportunities for trading the surplus energy available with the state of Punjab in future. This surplus could be absorbed within the Northern Region in India or can be traded with utilities in other regions as well.

3.1.3 PRICING TRENDS IN INDIAN MARKET

The power market in India has various contracting arrangements available, which can determine the price of transactions based on open market mechanism, as shown in figure 12.

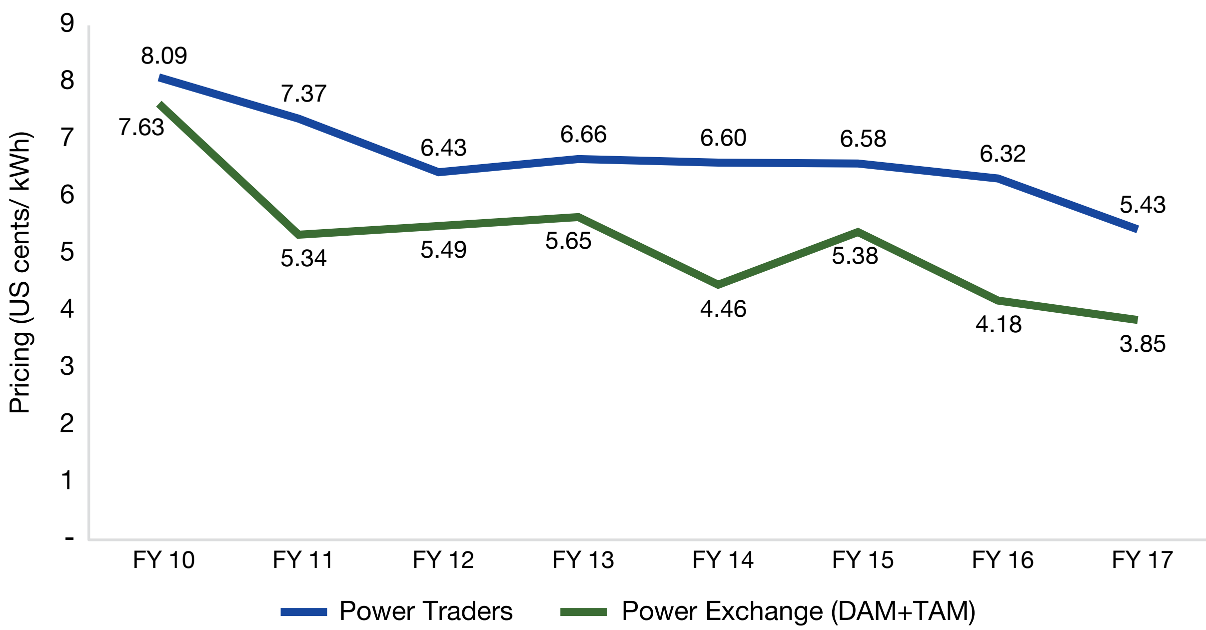
The power prices in Indian markets are regulated as per purchase by the state distribution companies are concerned. The generators can enter into long-term Power Purchase Agreements (PPA) with the buyers such as the distribution companies or power traders. The power utilities can also enter into medium to long-term PPAs to sell any surplus energy available with them. The licensed traders can act as intermediaries to buy and sell power both in the medium-term and long-term markets. In addition, the two Indian exchanges viz. Indian Energy Exchange (IEX) and Power Exchange India Limited (PXIL) allow for short-term and medium-term power transactions to be based on the demand and supply between the buyers and sellers. For the international power trade, there are several options which have been implemented in Indian context. The sale of power from generating stations in Bhutan is transacted through PTC India Ltd. which is a licensed trader. More recently, the sale of 80 MW of power from India to Nepal was implemented through NVVN, another licensed power trader. Similarly, when Bangladesh Power Development Board (BPDB) contracted for 500 MW of power in the first phase, 250 MW was affected through PTC India Ltd for a 3 year period and remaining 250 MW was sold from NTPC plants. The power sold by PTC India Ltd. was sourced from surplus power available with West Bengal State Electricity Distribution Company (WBSEDCL), just across the India- Bangladesh border.

Figure 12: Power Trading Arrangement in Indian Market

Long Term **Upto 25 Years**	**Power Purchase Agreements**	**89% -91%**
Medium Term **3 months-3 years**	**Bilateral Transactions** **Over the Counter Trading (OTC)** **Licensed traders (47)**	**5% -6%**
Short Term • **Contingency Transaction** • **Day Ahead Transaction** • **Collective Transaction** • **Bilateral Transaction** **Intraday -3 months**	**OTC Intraday-3 months** **Power Exchanges (2)** **1. Intra-day** **2. Day Ahead Market (DAM)** **3. Day Ahead Contingency (DAC)** **4. Daily** **5. Weekly**	**2% -3%**
Balancing Market **Real Time**	**Deviation Settlement Mechanism (DSM)**	**2% -3%**

The market price for power on the power exchange has been range bound over last 5 years as the demand has been suppressed and the utilities have not been procuring power from short-term market due to strict monitoring by the regulators on the power procurement costs. The pricing trends for the transactions done by the Traders, Power Exchange – Day Ahead Market and Term Ahead Market, DSM – real time energy charges for six years is shown below:

Figure 13: Indian Power Market - ST Price Trends

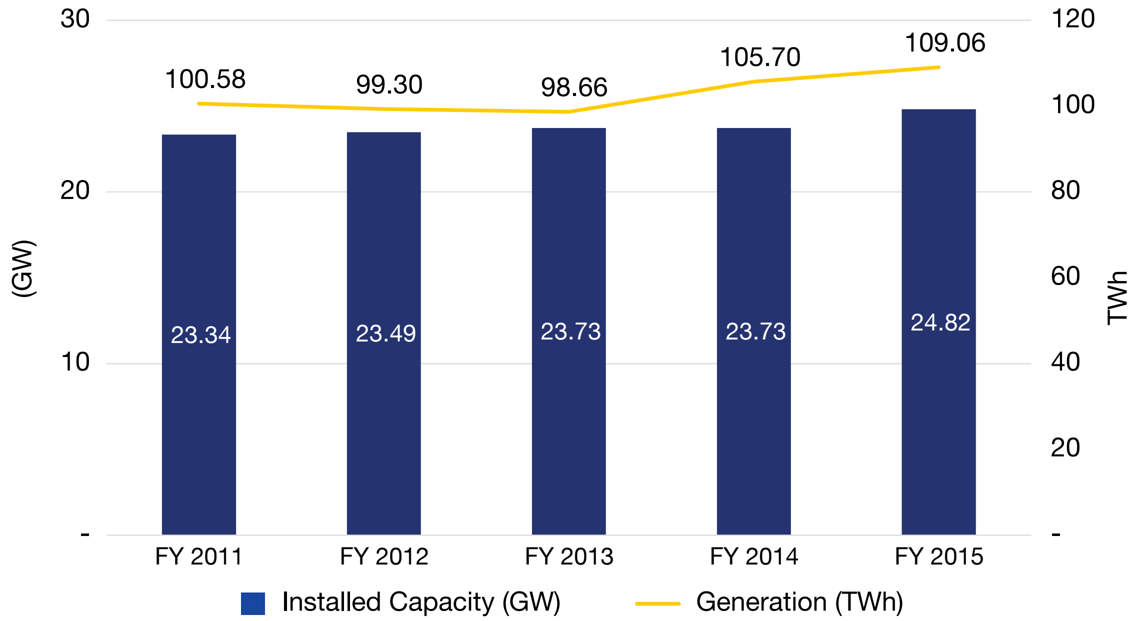


Source: CERC Monthly Monitoring Reports

3.2 PAKISTAN

The installed generation capacity in Pakistan has increased at a modest CAGR of 1.55 per cent between the period FY 2011 and FY 2015. The electricity generation during the same period has grown at CAGR of 2 per cent. The power sector profile of Pakistan is shown figure 14.

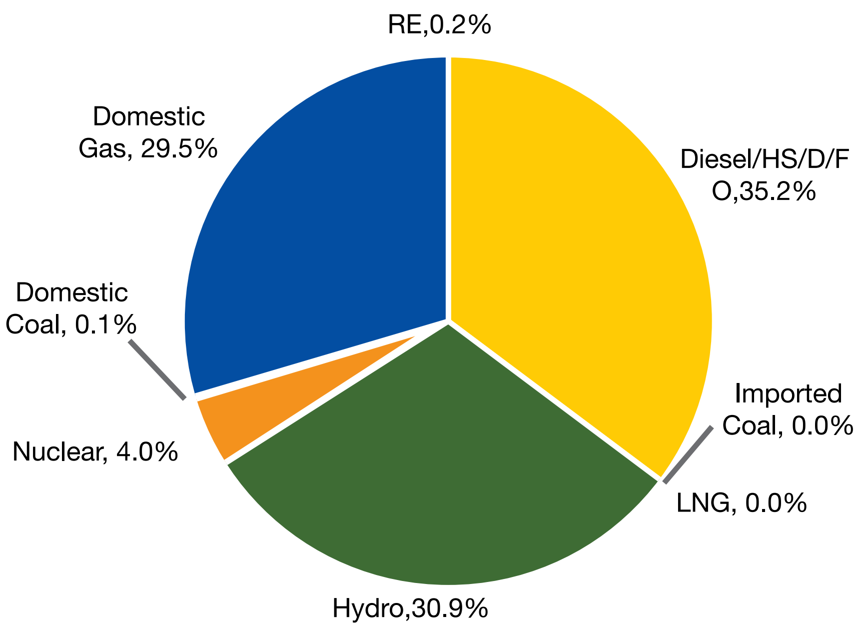
Figure 14: Pakistan Power Sector Profile



Source: State of industry Report, 2015

Pakistan's power sector has a high dependence on liquid fuels for power generation. About 35 per cent of its internal generation came from Diesel/HSD/FO, followed by 30.9 per cent from hydro and 29.5 per cent from domestic gas. It is expected that the contribution of liquid fuels would gradually decrease by 2020. At the same time, the proportion of domestic gas is expected to decrease to 18 per cent by 2034 and will be replaced by nuclear and hydro which would contribute around 7 per cent and 35 per cent respectively by 2034.

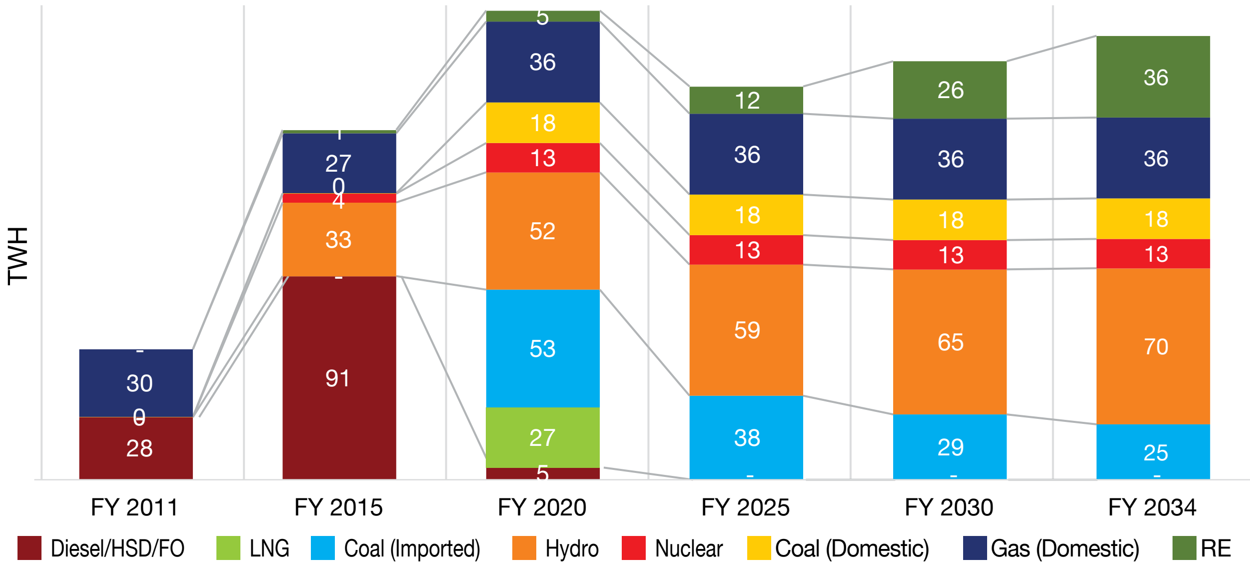
Figure 15: Generation mix of Pakistan (2014)



The total energy generation in Pakistan is expected to increase to 198 TWh against the overall demand of 370 TWh in 2034.[2] This would mean, around 172 TWh would have to be met through import of electricity from other countries.

[2] USAID report on Assessment of the Electricity Trading Potential in the South Asian Region, May 2016

Figure 16: Energy Mix by Fuel in Pakistan

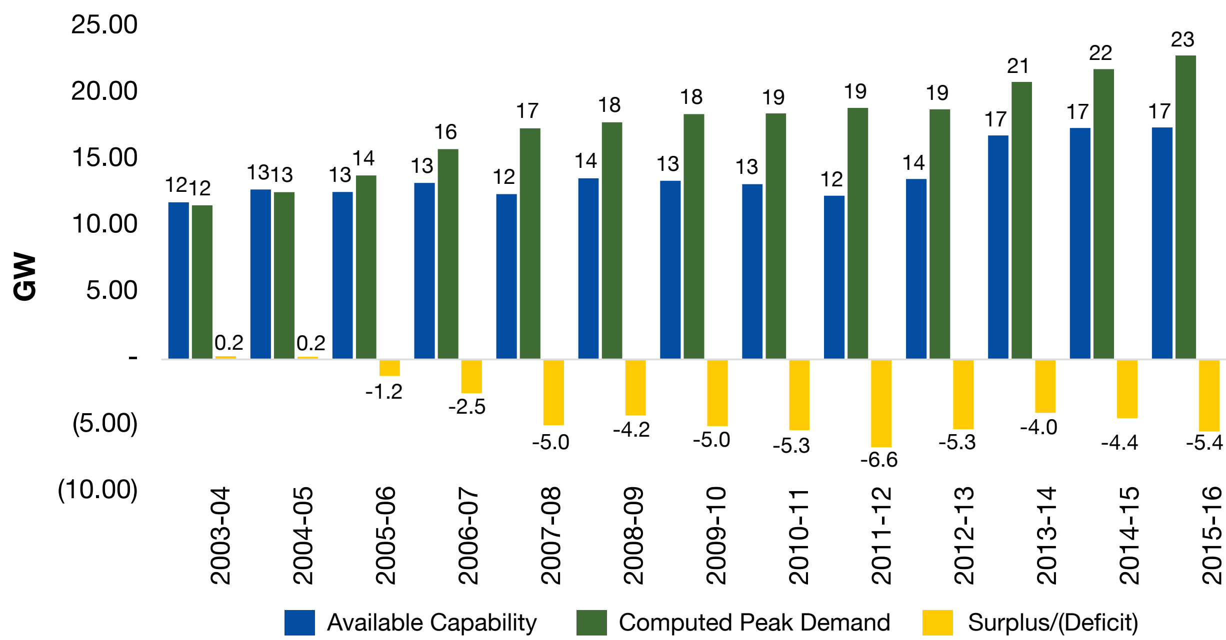


Source: SARI/EI report on Assessment of the Electricity Trading Potential in the South Asian Region, May 2016

3.2.1 DEMAND SUPPLY SCENARIO

There have been severe energy shortages in Pakistan since 2006. This can be attributed to lack of adequate generation capacity additions to meet the growing demand and challenges in maintaining some of the existing aging generating stations. The situation has caused huge demand supply gap resulting in load-shedding of electricity as shown below:

Figure 17: Pakistan Demand-Supply



Source: NTDC Presentation SAARC Perspective Workshop, Oct 2015

The increase in demand supply gap is attributed to several factors like, reduced availability from the existing thermal stations, on account of fuel supply - depletion in natural gas, delays in developing the hydro projects – less than 15 per cent of the total hydro potential of 60 GW has been developed so far. The increased usage of furnace oil and high speed diesel also led to exponential increase in generation cost which also adversely affected the affordability of generation.

The government has initiated a programme, with the assistance of China, where the energy sector has been given high priority to overcome energy shortages. The China-Pakistan Economic Corridor (CPEC) is expected to add 10,400 MW to the grid on priority basis. The projects include coal, hydro and wind. Not only that, it will augment supplies in a major way, but will also significantly change the energy mix, replacing expensive oil and resulting in reduction in the average cost of generation.

The situation is similar in the province of Punjab, which is also the most populous province in Pakistan and also contributes to 68 per cent of the total consumption in the country. The demand is growing at the rate of around 6-8 per cent per annum with the demand-supply gap estimated at around 4 GW. The generation, transmission, distribution and retail supply of electricity in Pakistan is undertaken by Pakistan Power Electric Company (PEPCO) with significant contribution to generation from various Independent Power Producers (IPPs).

The demand-supply gap will, however, remain almost the same in short to medium-term due to suppressed demand in the system, which is expected to grow at a rate of four to five per cent. However, in the long-run the situation may reverse and Pakistan can become power surplus if it can achieve its ambitious targets of adding 17000 MW power generation capacity under CPEC. This situation may allow Pakistan to export surplus power to India or other South Asian countries connected to Indian power transmission grid.

Pakistan has plans to add 22,383 MW capacity by the year FY 2020:

Table 3: Pakistan Generation Addition by FY 2020

Sponsors	Generation Addition (MW)
WAPDA Hydel	4,023
IPP Hydel	247
Sub-total hydel	4,270
GENCOs	1,320
IPP Thermal	12,713
Sub-total Thermal	14,033
Nuclear	680
Wind	1,500
Solar	900
CASA (Import)	1,000
Total	**22,383**

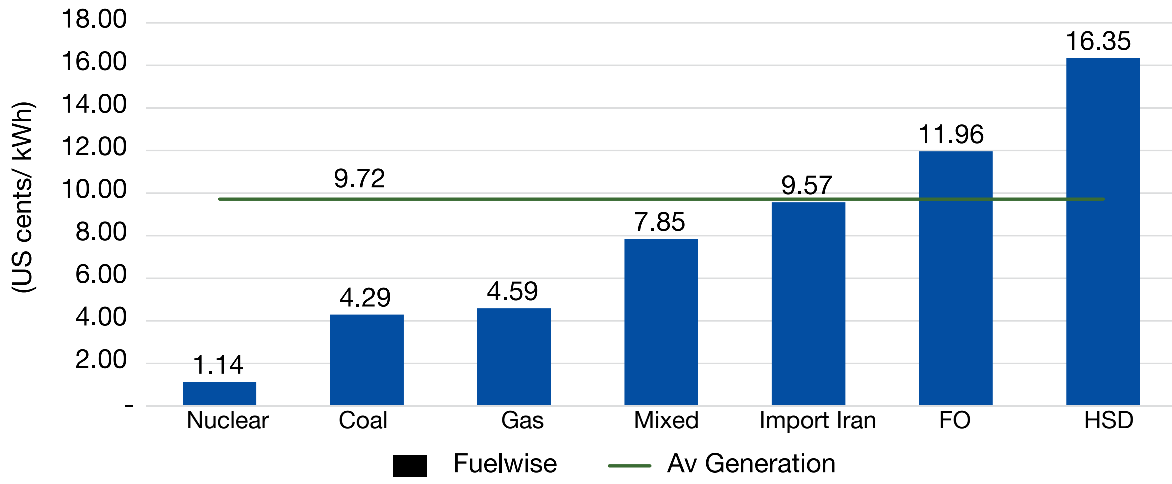
Source: NTDC 2015

3.2.2 ELECTRICITY PRICE

1. Existing Projects

Domestic coal has been the cheapest source of energy over the past years with an average generation cost of USD Cents 3.86 per kWh, followed by domestic gas at USD Cents 4.59 per kWh. The average generation cost has however remained high due to predominance of HSD in generation, the cost of which comes to USD Cents ~20.85 per kWh and Furnace Oil with a cost of USD Cents 15.23 per kWh in 2014. It is expected that the average generation cost in Pakistan will remain high over the coming years at ~USD Cents 9.39 per KWh. The following graph show the prices of electricity from various sources:

Figure 18: Fuel-wise Generation Tariff in Pakistan (2015)



Source: State of Industry Report 2015

2. Future Plants

The CASA – 1000 is scheduled to deliver the power at a levelised tariff ranging from US cents 9.38 to US cents 10.88 per kWh depending on the country of supply as shown in the table below:

Table 4: CASA Tariff

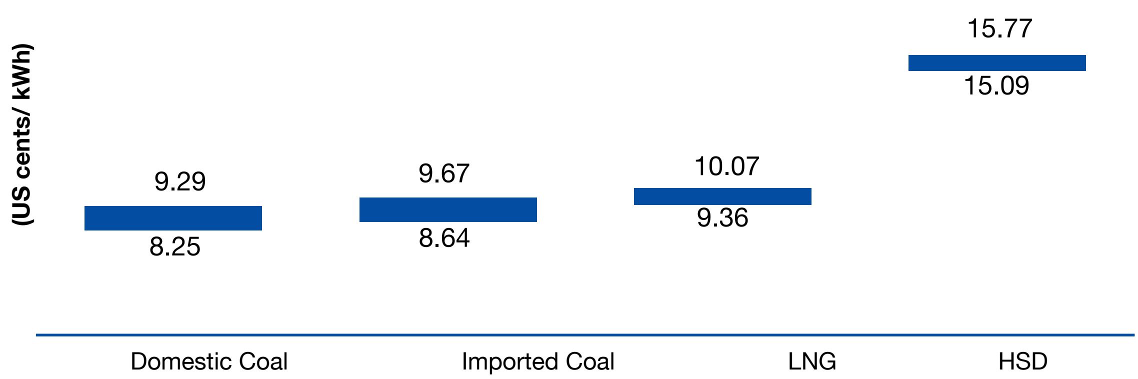
All figures in US Cents per kWh

Component	Energy from Tajikistan	Energy from Kyrgyz	Energy from non-member country
Transmission Tariff	2.98	2.98	2.98
Energy Tariff	5.15	5.15	5.15
Afghan Transit Fee	1.25	1.25	1.25
Tajikistan fee for Kyrgyz energy	-	0.1	-
Non-member country charge	-	-	1.5
Total	**9.38**	**9.48**	**10.88**

Source: NEPRA Pakistan

Within Pakistan, various sources of fuel are being explored to replace the costly oil based generation. The following figure shows the range of generation tariffs for the future projects based on fuels used:

Figure 19: Generation Tariffs for Future Plants



Source: NEPRA Pakistan

3.3 AFGHANISTAN

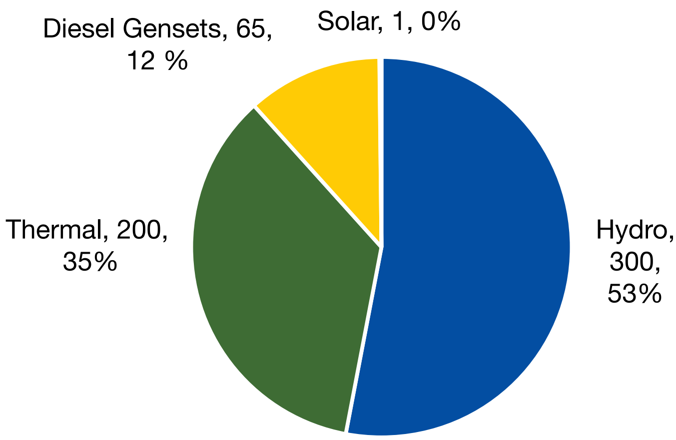
Afghanistan is rebuilding its energy sector and it has made 'providing sustainable energy to its population' a focus of its development efforts with the support of international community. Currently, only 43 per cent of the population is estimated to have access to electricity, with average per-capita use of 73 kWh per year. Even this low per-capita level of electricity access concealsa significant urban-rural disparity, as it is estimated that only 23 per cent of supplied electricity reaches the rural areas.

The Afghan energy sector not only suffers from limited power generation capacity but also its transmission and distribution systems are outdated. The rural population is mostly dependent on micro-hydro or PV based solar power projects. The dependence on the traditional biomass (wood and dung) is still very high, at around 85 per cent of primary energy, which adversely impacts the environment. It is supplemented by the use of diesel generators in off-grid areas as well as to compensate for power outages. Lack of access to affordable energy is limiting the economic, social and educational opportunities, particularly for the poor and those in rural areas.

The installed capacity of Afghanistan's power system was 566 MW in 2016. This comprised of 53 per cent hydro, 35.34 per cent diesel or HFO based thermal power plants, 0.2 per cent solar and small diesel generator sets constituted about 12 per cent. However, due to political instability and conflicts in the last two decades, generation capacity addition have been limited and majority of electricity consumption (77 per cent of total consumption, i.e. 4,454 GWh) is met through power import from neighbouring countries.

Afghanistan comprises 10 isolated grids or islands supplied by different power systems through 220 kV and 110 kV links. Different parts of Afghanistan imports power from Iran, Tajikistan, Turkmenistan, and Uzbekistan. Currently, there are five transmission lines that are used for power import from Turkmenistan, Uzbekistan and Tajikistan and three lines for import of power from Iran.

Figure 20: Afghanistan's Installed Capacity (MW) - 2016

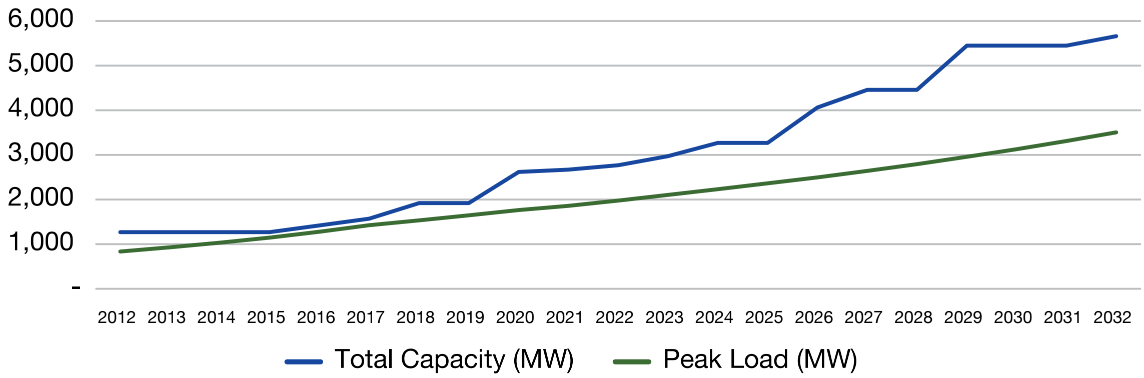


Source: CAREC: Study for Power Sector Financing Road Map; DABS report on Afghanistan Power Sector Overview

3.3.1 DEMAND SUPPLY SCENARIO

Currently, Afghanistan's energy demand-supply gap is around 50 per cent and the same trend is expected to continue till 2020. The reliance on the import of power from neighboring countries would continue and the country is set to further gain from intra-regional CBET projects like CASA-1000 Project which will enable to have links with Pakistan and will transfer central Asia's hydro power to Pakistan.

Figure 21: Afghanistan's Energy Supply Scenario



Source: Afghanistan Power Master Plan 2013 (ADB)

According to the Afghanistan Power Sector Master Plan, 2013, the total demand in Afghanistan will increase on an average by 5.7 per cent per annum to reach 18,400 GWh in 2032. The total peak demand in 2032 is expected to stand at around 3,500 MW. The total capacity (including imports from neighbouring countries) is likely to increase from 1,270 MW in 2013 to 5,659 MW in 2032. In energy terms, the situation is likely to improve with the commissioning of CASA Interconnection in 2020. The following figure provides the peak demand and supply scenario for Afghanistan.

3.3.2 TRANSMISSION INTERCONNECTIONS

The following interconnections are in operation or have been proposed[3]

1. **Interconnection with Tajikistan**

The existing 220 kV double circuit import line from Tajikistan is designed for a rating of about 600 MW. Further, Tajikistan will be providing power to Afghanistan through the CASA-1000 link.

2. **CASA-1000**

The Central Asia South Asia Electricity Transmission and Trade Project (CASA-1000), covering Afghanistan, Kyrgyz Republic, Pakistan and Tajikistan, will put in place the commercial and institutional arrangements as well as the infrastructure required for 1,300 Mega Watts (MW) of electricity trade. The total project cost as per World Bank report is estimated at USD 1.17 billion. The CASA-1000 electricity transmission system will help transform the region and signifies an important step toward realizing the planned Central Asia-South Asia Regional Electricity Market (CASAREM).

3. **Interconnection with Turkmenistan**

Turkmenistan Interconnection Project is proposed to be developed in three stages. The first phase is under implementation and involves construction of a 500 kV line from Atamyrat (TKM) to Sheberghan (AFG) via Andkhoy (AFG). This will allow the import of 300 MW on the 220 kV level throughout the year and completion is expected by 2017. The second phase; for an additional 200 MW of firm capacity summing up to 500 MW, by upgrading to 500 kV, including a back-to-back converter at Pul-e-Chomri; would be available by 2020. In the third phase; an additional 500 MW summing up to 1000 MW, by adding a second back-to-back converter at Pul-e-Chomri; is scheduled for 2025.

[3] Afghanistan Power Sector Master Plan Addendum Report (2014)

4 CBET Potential in Western Part of South Asia

4.1 Past Studies

Over the last decade, several pre-feasibility studies have been conducted for the cross border energy trade interconnection between India and Pakistan and also for interconnection with Central Asian countries. These studies have assessed the technical, financial and economic feasibility of the power trade in western part of South Asia. Some of the key highlights of these studies include:

1. CASA-1000 Project Central Asia- South Asia Regional Power Connectivity: The idea of Central Asia – South Asia Transmission Interconnection Project (CASA-1000) was conceived in 2008 to transmit 1300 MW of surplus electricity (May to Sept) from existing hydel resources in Tajikistan and Kyrgyz Republic through Afghanistan to Pakistan. Out of 1300 MW of expected power, 300 MW is reserved for Afghanistan and 1000 MW will be consumed by Pakistan.
2. The ADB 2013 report[4] suggests that the short-term power transfers between India and Pakistan also has a significant economic potential. According to the report, the fuel cost savings for a single year alone can fund the development of transmission. The estimated interconnection cost for a 200 MW transmission line of 45 km length at 220 kV would be USD 50 million and going upto USD 150 million for 400 kV[5] in long-term, (2012 estimate). The annual benefits estimated for the 400 kV interconnection was USD 491 million, which includes fuel cost savings.
3. The World Bank Policy Research Paper[6] published in June 2015 shows that the grid interconnection capacity potential between India and Pakistan would be 14,900 MW by the year 2040 in a no-carbon constraint scenario. In this scenario, the energy transfer from Pakistan to India would be 300 TWh and energy transfer from India to Pakistan would be 397 TWh during the period 2015-40. In a full regional trading scenario with carbon constraints, the interconnection capacity potential would be 11,000 MW by 2040, while the export from Pakistan during the period 2015-40 would be 314 TWh, as against an import of 225 TWh by Pakistan from India.
4. The SARI/EI/IRADe report on Assessment of the Electricity Trading Potential in the South Asian Region (May 2016) estimates the trading potential between India and Pakistan to be in excess of 44 TWh from 2021 onwards, with India being the net exporter of power for the forecast period upto 2034 as shown in the figure on next page:

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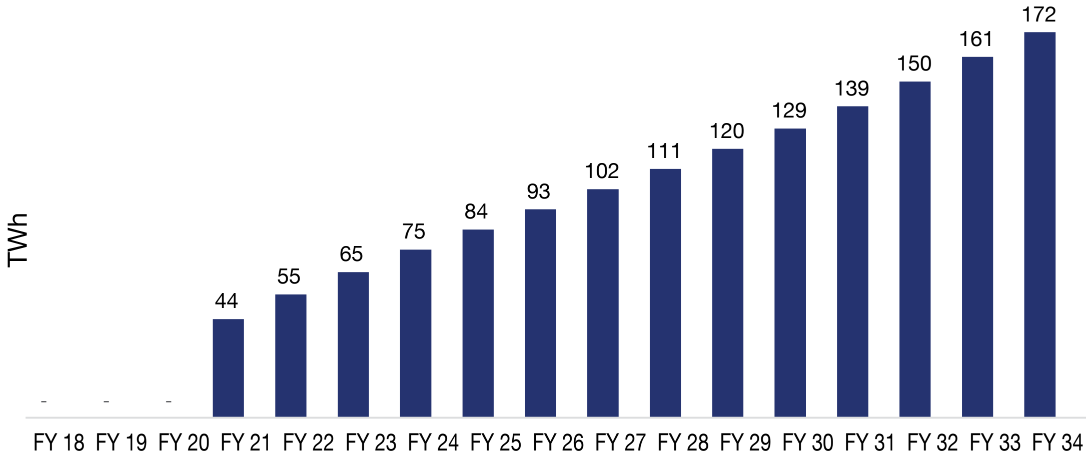
[4] ADB Report: RETA – Study on South Asia Regional Power Exchange (Jun 2013)

[5] similar to Bangladesh line, HVDC back to back

[6] World Bank Policy Research Paper: How Much Could South Asia Benefit from Regional Electricity Cooperation and Trade? – Govinda Timilsina et al (2015)

Figure 22: Power Trading Potential between India and Pakistan (2018-2034)



Source: SARI/EI report on Assessment of the Electricity Trading Potential in the South Asian Region, May 2016

4.2 Power Trade Potential In Western Part of South Asia

Salient features emerging from the analysis of power sectors in India, Pakistan and Afghanistan are given below:

1. Short term (2017 to 2020)
    - India is likely to become energy surplus with the state of Punjab (India) being surplus in peak capacity and energy at least for 8 months.
    - Pakistan will have overall energy deficit and will continue to depend on high-cost units like diesel/FO/HSD etc., to meet its demand in absence of sufficient transmission links with neighboring countries.
    - Afghanistan will continue to be the net importer of electricity from the Central Asia and will have to rely on high-cost domestic generation from oil-based plants. Lack of interconnections with Pakistan will limit the potential of power export from South Asian region.
    - Electricity trade can start between Pakistan and India with export of upto 200 MW power by India in the short-term. The trading of electricity is constrained by the lack of transmission infrastructure between the two countries. A phased approach for the interconnection needs to be considered.

2. Medium term (2021 to 2025)
    - Development of CASA 1000 interconnection project will facilitate greater imports of electricity by Afghanistan from Central Asia, and possibly from South Asia.
    - The electricity trading between India and Pakistan could increase with augmentation of interconnections and can be increased to 500 MW in the medium-term. Pakistan could also act as transit for export of power from India to Afghanistan.

3. Long-term (Beyond 2025):
    - Pakistan can also trade its surplus power to India or other South Asian countries if its ambitious target of power generation is realised.
    - For incremental demand, Pakistan may rely on imports rather than building its own capacity, as importing coal-based power from India could work out to be economical than generation from an imported coal based power plant in Pakistan.

- Afghanistan can explore electricity import options from South Asia in addition to the already planned capacities in Central Asian region. More transmission interconnections through Pakistan could be planned which would link with the rest of the South Asian region.

4.3 Interconnection Options

4.3.1 INDIA - PAKISTAN

There are several options for interconnection between India and Pakistan which have been identified since 1990s. The key amongst them are:

- 400 kV AC transmission line between Amritsar (Punjab, India) and Lahore (Punjab, Pakistan) and back-to-back HVDC sub-station in Pakistan - Cost Estimates as per study funded by World Bank in 2012-13: US$ 119.4 million
- 220 kV AC transmission line between Patti (India) – Dinanath (Pakistan) interconnection (250 MW)
- AC transmission line between Mundra (Gujarat, India) and Karachi(Pakistan) and back-to-back HVDC sub-station in Pakistan

All recent studies indicate that interconnection between the provinces of Punjab on either side of border would be most appropriate, taking into consideration factors like demand–supply scenario, cost of interconnection etc. The 400 kV AC transmission line between Amritsar (Punjab, India) and Lahore (Punjab, Pakistan) and back-to-back HVDC sub-station in Pakistan has been proposed as per the World Bank pre-feasibility study carried out in 2012-13. The following elements of interconnection have been proposed:

- 400/220 kV HVDC Back-to-back Convertor Station in Pakistan
- 400 kV D/C Transmission Line from Balachak near Amritsar to Pakistan-India Border
- 400 kV D/C Transmission Line (approx. 10 km) from Convertor Station to Pakistan-India Border
- 220 kV D/C Transmission Line from Ghazi Road to Convertor Station

4.3.2 AFGHANISTAN - PAKISTAN

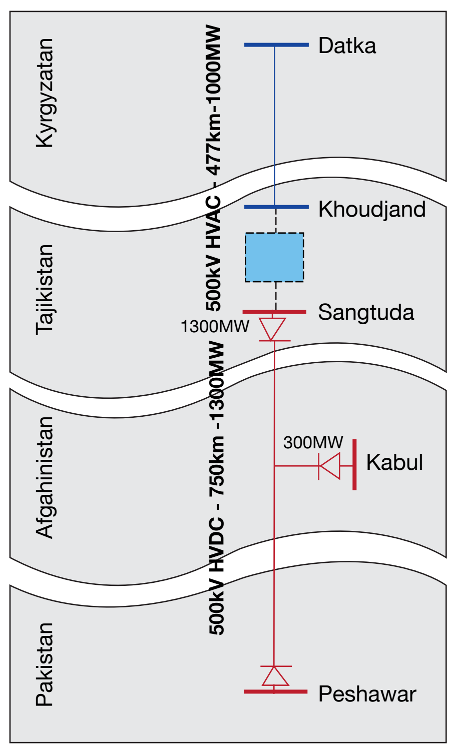
1. Central Asia South Asia (CASA 1000) Project

The CASA-1000 project will include:

- 500 kV AC line from Datka (in the Kyrgyz Republic) to Sugd-500 (477 kilometres away in Tajikistan)
- 1300 MW AC-DC Convertor Station at Sangtuda (Tajikistan)
- 750 kilometre High Voltage DC line from Sangtuda (Tajikistan) to Nowshera (Pakistan)
- 1300 MW DC-AC Convertor Station at Nowshera

Hydropower plants (HPP) in Kyrgyzstan and Tajikistan will supply the electricity for CASA-1000. The project cost is estimated to

Figure 23: CASA 1000 Project



Source: Central Asia - South Asia Electricity Transmission And Trade (CASA-1000) Project Feasibility Study Update Report SNC Lavlin

Tajikistan Internal AC Grid

AC/DC Converter Station

be USD 1.16 Billion and is being supported by the World Bank Group, Islamic Development Bank, United States Agency for International Development (USAID), US State Department, United Kingdom Department for International Development (DFID), Australian Agency for International Development (AusAID) and other donor communities.

The proposed CASA 1000 transmission has the flexibility of bidirectional flows on the system. As a result, Afghanistan system can provide power to Pakistan in case Tajikistan/Kyrgyz system is unable to provide the full 1,300 MW of export power. Similarly, Afghanistan can import power from Pakistan in case of need.

2. Turkmenistan-Afghanistan-Pakistan 500 kV Line (TAP-500)

The proposed Turkmenistan-Afghanistan-Pakistan 500kV Line (TAP-500) project will facilitate year-round power export from Turkmenistan to both Afghanistan and Pakistan. By 2020, Turkmenistan expects to generate 3,500 MW of excess power to be available for export. The tripartite agreement has been signed by the three head of states in December 2015.

5 Techno-Economic Rationale

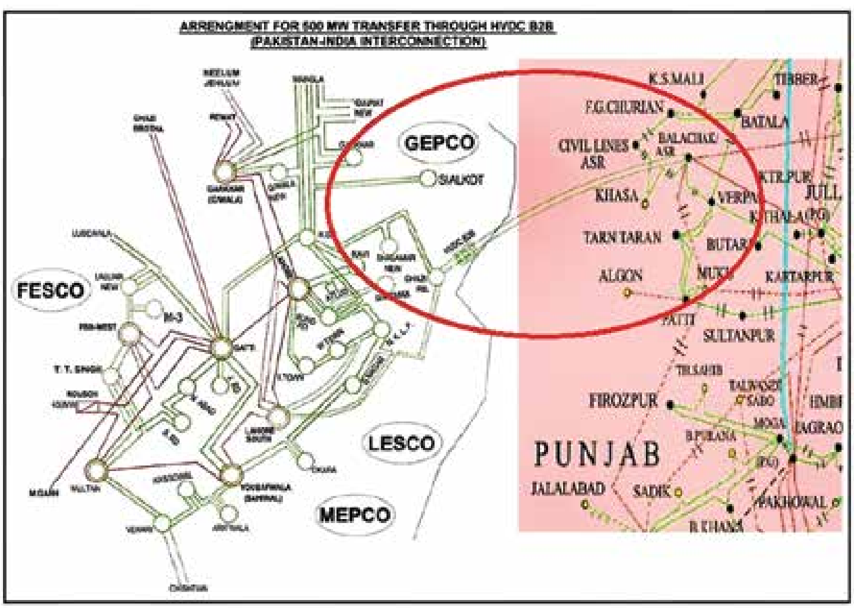
5.1 Proposed Interconnection Between India and Pakistan

5.1.1 TECHNICAL ASSESSMENT

The proposed connection is required to have back-to-back HVDC sub-station, to make the asynchronous connection between India and Pakistan, which operate on different frequencies. The project is likely to take up to36-40 months for implementation, as the construction of HVDC back-to-back station shall have longer gestation period of about 36 months, while the transmission network can be completed in about 24 months. The following technical interface has been considered for carrying out the techno-economic analysis for 400 kV AC transmission line between Amritsar (Punjab, India) and Lahore (Punjab, Pakistan) and back-to-back HVDC sub-station in Pakistan:

- 400 kV D/C Transmission Line (approximately 26 kms) from Balachak near Amritsar (India) to Pakistan -India Border
- 400 kV D/C Transmission Line (approximately 10 kms) from Convertor Station in Lahore to Pakistan -India Border
- 400/220 kV HVDC back–to–back Substation in Lahore for asynchronous interconnection mode
- 220 kV D/C Transmission Line from Ghazi Road to Convertor Station
- Cost Estimates as per study funded by World Bank in 2012-13: US$ 119.4 million

Figure 24: Pakistan – India Interconnection



Source: NTDCL, Pakistan

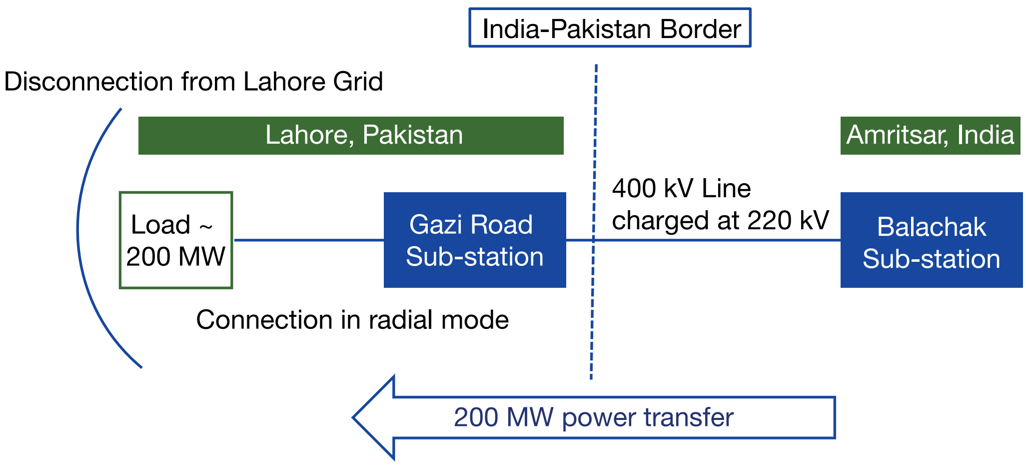
A possible option would be to connect the systems in radial mode at 220 kV voltage level in the interim period till commissioning of HVDC sub-station. The connection with HVDC link between Balachak sub-station in Amritsar, Punjab (India) and Gazi Road sub-station in Lahore (Pakistan) is shown in the Figure 25 below.

The following stages of development of the interconnection have been considered for economic analysis

1. **Stage 1 -Supply of power to Lahore from India in radial mode**

Under radial mode of operation, a portion of Lahore Grid shall have to be isolated and connected to Indian Grid through the 400 kV double circuit transmission line, which would initially be charged at 220 kV. Around 150-200 MW load can be segregated for supply of power from India as shown below:

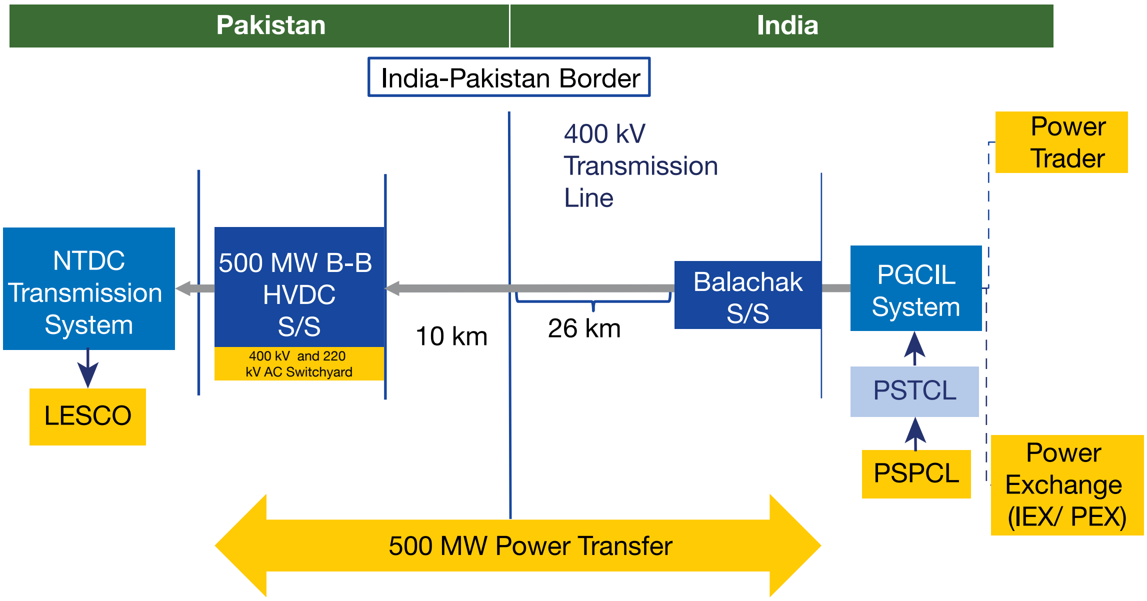
Figure 25: Stage 1 – 200 MW Transfer Capacity in Radial Mode



2. Stage 2: Development of 500 MW HVDC back-to-back sub-station

The construction of back-to-back HVDC sub-station would enhance the power transfer capacity between the two countries to 500 MW within three to four years.

Figure 26: Stage 2 – 500 MW HVDC Sub-station



5.1.2 COST ESTIMATION FOR INDIA PAKISTAN INTERCONNECTION

The capital cost for the project has been estimated, based on the prevailing trends in South Asian market. The recent benchmark costs from the region have been considered.

Table 5: Reference Cost of Similar Projects

Project	Estimated Cost (USD Million)
India-Bangladesh HVDC Block–I • 125 km of 400 kV double circuit (D/C) T/L between substations at Baharampur (India) and Bheramara (Bangladesh) • 400kV switching station at Baharampur • 500MW back-to-back HVDC sub-station at Bheramara	USD 193 Million (excludes Indian side transmission line cost)*
India-Bangladesh HVDC Block-II • 500 MW back-to-back HVDC sub-station	USD 144 Million in 2015
CASA-1000 • 500 kV HVAC T/L from Kyrgyz to Tajikistan (477 km) • ±500 kV HVDC T/L from Tajikistan to Pakistan via Afghanistan (750 km) • 300 MW HVDC substation at Kabul in Afghanistan • 1300 MW HVDC convertor station at Tajikistan • 1300 MW HVDC convertor station at Peshawar	USD 1.17 Billion including 208 million IDC

* Revised cost estimates 2015

The total cost of interconnection including IDC and contingency for two stages is shown in the Table below:

Table 6: Interconnection Project Estimated Cost

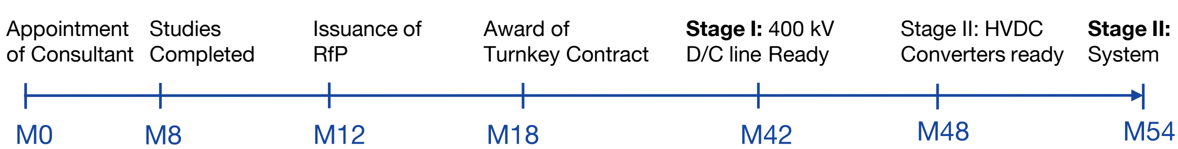
Cost of Proposed Interconnection	USD Million
Stage I	16.9
Stage II	108.1
Total	125.0

5.1.3 IMPLEMENTATION SCHEDULE

The project can be completed in 54 months but there are challenges in the implementation given the complexities in procurement and implementation due to the varying requirements in both countries.

The pre-award stage comprising of studies, finalisation of specifications and tender documents, award of EPC-turnkey Contracts could take up to 18 months. The execution time for StageI is expected to be 24 months post the award of contract. The StageIIis likely to take 36 months to complete from the award date. Indicative timelines for the proposed project is shown below.

Figure 27: Implementation Schedule



5.1.4 COST-BENEFIT ANALYSIS

1. Economic rationale of the Project

The South Asian countries are net importers of fossil fuels such as coal, oil and oil products from outside the region. Considerable benefits could be derived from tapping hydropower potential in Bhutan, India and Nepal and from utilising the differing seasonal load characteristics of the countries in the region. The interconnection of power transmission of these countries has been a priority in the past few years in order to utilise the resources available in the region. Regional interconnectivity could help countries manage power shortages, avoid power outages and improve system-wide efficiency. Currently, India imports power from Bhutan and exports power to Nepal and Bangladesh. The India–Pakistan cross border project, when implemented, will provide a successful example of power trading between two countries in the region, contribute towards meeting the goal of providing power to all, and bring economic benefits to the region.

Pakistan has experienced rapidly growing energy needs to sustain its growth, particularly in the industry sector. Lack of generation capacity additions and challenges in operating the existing generator due to fuel shortages have resulted in electricity sales in Pakistan not matching the demand. Peak deficit of over 5,000 MW was recorded in 2015. The government has planned several initiatives to minimise power shortages by planning hydropower capacity additions, relying on imported gas and petroleum and by preparing projects based on imported coal. Sourcing power from the South Asia region is another option that can provide a fast and efficient mechanism to offset shortages. The electrical grid interconnection facility between India and Pakistan will partially alleviate the current power crisis by providing 200–500 MW of power from India. The project will facilitate imports of cheap and reliable power from India for use in Pakistan, a significant part of the demand being attributed to industrial activities.

In Pakistan, around 30 per cent of electricity is produced from gas-based power plants and 35 per cent from petroleum products (Diesel and FO). The delays in capacity installation programmehas forced electricity utilities to resort to load shedding including industrial consumers which have been using captive generation facilities. The dependence on imported coal based plants is also increasing .

2. Key assumptions

India-Pakistan Electrical Grid Interconnection will allow an exchange of power between the two countries. It will initially facilitate the transmission of 200 MW of power from India to meet existing and future demands in Pakistan. This will be increased to 500 MW with establishment of HVDC station. This is the base case which has been used for the analysis.

The project cost and the benefits for the proposed interconnection has been worked out based on following assumptions:

- All costs are expressed in constant 2016 prices. The capital cost estimates include contingencies and financial charges during construction.
- The project cost includes investment and maintenance costs of Pakistan to India transmission line, cost of other associated facilities and annual payments to the Indian entities for delivery of power to Pakistan. The published reports have been relied upon for data.
- The project will be funded by multi-lateral agenciesand will be owned by the transmission licensees in the respective geographies.
- Power will be available for sale to Pakistan from the surplus with Punjab state in India and alternately through the medium-term contracting with the licensed power traders in India. In the short-term period, power could be purchased from the power exchange (s) in India to meet any short-fall in energy.

- The available power from India would be used for replacing the costlier fuels within Pakistan viz HSD/FO and imported coal. The additional power would be available for sale to the industrial consumers in case energy deficit situation prevails in the medium- term.
- No environmental and social costs or benefits have been quantified or used for the interconnection project.
- The information/data as existed in public domain and obtained and collected from various other primary and secondary sources as on July, 2016.

3. Economic Analysis

A period of 25 years has been assumed for the economic analysis and a standard 12 per cent discount rate was used to calculate the levelised tariff. Capital costs were spread over the first 3 years based on construction cycle of similar projects. Capacity utilisation of the transmission lines was assumed to be 85 per cent in estimating the quantity of power transmitted.

The following table shows the price comparison between various options for procurement of additional power for the period FY 19 to FY 34. The levelised cost of power procurement from India including the transmission tariff for Indian system and the transmission charges for the proposed interconnection have been compared with the power generation tariffs in Pakistan.

For the Indian system, the following power tariffs have been assumed for the base year (2016)

Table 7: Power Tariffs in India

Indian power market tariff	Tariff (US cents/kWh)
Long term PPA	6.32
Power Exchange	5.49
Power Traders	6.22

For Pakistan, while hydropower is the most economic source of electricity, domestic gas is next low cost resource, the availability of which is limited. The Furnace Oil-based and HSD-based generation is the costliest. Pakistan also has sizable coal reserves in Thar region, but currently there are constraints in coal production. The development of domestic coalfields will take time and the dependence on imported coal is likely to increase in order to replace the oil-based generation.

The feasibility of the interconnection has been assessed from the perspective of both Pakistan and the region. The Economic Internal Rate of Return (EIRR) of the transmission project has been calculated assuming a dedicated transmission line to evacuate power from a designated plant.

The resource cost savings have been considered for the base case as discussed above. The resource cost savings were based on the assumption that oil-based generators would be used along with imported coal-based plants in the absence of the project. In the base case, the resource cost savings were used to estimate the benefits. The levelisedcost of generation for imported coal has been conservatively estimated at 9.70US cents per kWh for the base-case calculation. With the Pakistan–India transmission network in place, Pakistan will be in a position to import power from India at a relatively cheaper cost in short to medium-term. The tariff for the power from traders in India is based on the available power in short to medium-term and the trading margin and transmission charges for delivery of power are based on the CERC-approved tariff methodology. Market based power purchase costs for medium and short-term power supply are considered. In FY 2016, the total tariff works out to about INR 4.2 per kWh. A 2 per cent annual escalation rate has been considered.

The economic cost–benefit analysis indicates that the base case results in an EIRR of 22.14 per cent. The project is likely to give a benefit of USD 210 Million against the total cost of 125 Million. The B/C ratio of the project works out to be 1.68. The project is economically viable in the base case. The following table shows the costs and benefits:

Table 8: Cost-Benefit of the Project

(All figures in US Million)

Year	Capital Cost & Operating Cost	Cost of Power Purchase	Total Cost	Gross Benefit	Net Benefit
2017 - 18	25.04	-	25.04	-	(25.04)
2018 - 19	51.16	-	51.16	-	(51.16)
2019 - 20	27.51	90.11	117.62	115.16	(2.46)
2020 - 21	0.98	204.63	205.61	257.05	51.44
2021 - 22	1.00	165.97	166.98	204.92	37.94
2022 - 23	1.02	134.63	135.65	163.36	27.71
2023 - 24	1.04	109.21	110.25	130.23	19.98
2024 - 25	1.06	88.59	89.65	103.82	14.16
2025 - 26	1.09	71.87	72.95	82.76	9.81
2026 - 27	1.11	58.30	59.41	65.98	6.57
2027 - 28	1.13	47.30	48.43	52.60	4.16
2028 - 29	1.15	38.38	39.53	41.93	2.40
2029 - 30	1.18	31.14	32.32	33.43	1.11
2030 - 31	1.20	25.27	26.47	26.65	0.18
2031 - 32	1.23	20.50	21.73	21.24	(0.49)
2032 - 33	1.25	16.64	17.89	16.93	(0.95)
2033 - 34	1.28	13.50	14.78	13.50	(1.28)
2034 - 35	1.31	10.96	12.26	10.76	(1.50)
2035 - 36	1.33	8.89	10.22	8.58	(1.64)
2036 - 37	1.36	7.22	8.58	6.84	(1.74)
2037 - 38	1.39	5.86	7.24	5.45	(1.79)
2038 - 39	1.42	4.75	6.17	4.35	(1.82)
2039 - 40	1.45	3.86	5.30	3.47	(1.84)
2040 - 41	1.48	3.13	4.61	2.76	(1.85)
2041 - 42	1.51	2.54	4.05	2.20	(1.85)
2042 - 43	1.54	2.06	3.60	1.76	(1.85)
2043 - 44	1.57	1.67	3.25	1.40	(1.85)
2044 - 45	1.51	1.36	2.86	1.12	(1.75)

A sensitivity analysis has been undertaken based on the sale of power to the industrial consumers in the Lahore area. The levelised tariff of US cents 11.72 per kWh has been assumed based on the existing applicable tariff for the industrial category for the analysis. This gives a significantly higher EIRR and B/C ratio (3.33). The project is sensitive to cost escalations and lower levels of utilisation. A 10 per cent cost increase would give an EIRR of 17.1 per cent and a utilisation below 75 per cent will result in negative EIRR.

The surplus power situation in Northern India is likely to continue and given the relatively small quantum of power requirement, the risk of outage on account of lack of power availability is remote.

Given the development of the trading market in India as well as the level of marginal cost of electricity in Pakistan, it is not expected that the line will remain unutilised over its life once built. Overall, the analysis shows that the project is economically viable and provides stable benefits under various scenarios.

5.2 CASA 1000 Interconnection between Afghanistan and Pakistan

The techno-commercial analysis for the CASA 1000 project was assessed by SNC Lavalin and Final Feasibility Study Report submitted in February 2011.

SNCLavalin was commissioned to prepare a feasibility study, in two phases, for the regional interconnection. The final Phase 1 report was submitted in December 2007 and the Phase 2 report, in January 2009.

The key excerpts from the feasibility report are as below:

5.2.1 TECHNICAL ASSESSMENT

The HVDC link between Tajikistan, Afghanistan and Pakistan is comprised of 1,300 MW converters in Tajikistan and Pakistan, a 300 MW converter in Afghanistan and a 1,300 MW, 750 km transmission line. The CASA project also includes an HVAC transmission line between the Kyrgyz Republic and Tajikistan, 477 km long and rated at 1,000 MW.

The project is based on the expectation that sufficient surplus power is available in the countries in the north to represent a substantial potential for trade with the countries in the south. Moreover, the cost of electricity in the sending countries is below the long-run marginal cost in the receiving countries, providing a justifiable rationale to invest in the transmission interconnection.

5.2.2 COST ESTIMATES

According to SNC Lavalin estimates, the cost of the recommended project is USD 873 Million (Feb 2011 report estimates), excluding Interest During Construction (IDC). IDC amounts to an additional USD 80 million. The project is found to be economically viable based on a 10 per cent discount rate with a Benefit/Cost ratio of 1.3 per cent and anEIRR of 15.6 per cent.

Way Forward

The overall CBET potential for the South Asia is very large. The eastern part of the region has seen significant developments in creation of the transmission infrastructure which has the potential of linking with South East Asia through Myanmar. The western part of the region is still to witness similar developments.

A potential linking of Afghanistan–Pakistan and Indian grids could facilitate development of an interconnected system between Central Asia and South Asia which would benefit the countries in these regions.

The current techno-commercial analysis is focused on the India-Pakistan Cross Border Electricity Trade, but the same could be extended to cover the whole of western region including Afghanistan.

With the development of India-Pakistan interconnection, India can export power to Pakistan in the short-term,since the later is experiencing huge power shortage. In the long-term, Pakistan can become surplus and export to India because of its aggressive power generation addition as well as likely connectivity to the Central Asian system. Either way, the South Asian region is set to benefit from the optimal source of power generation.

The incumbent countries in the western part of South Asian region could form a joint committee to evaluate the electricity trade potential. The nodal agencies from respective countries could be identified and given the responsibility to work out various techno-commercial issues. A detailed feasibility study for the identified interconnections could be taken up immediately to finalise the costs and alignment.

Various technical issues would need to be looked for viz. harmonisation of grid connection code, operating parameters etc. The CASA 1000 Project, which would establish the link between Afghanistan and Pakistan, could establish benchmarks for the integrated operation.

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ABOUT SARI/EI

Over the past decade, USAID's South Asia Regional Initiative/Energy (SARI/E) has been advocating energy cooperation in South Asia via regional energy integration and cross border electricity trade in eight South Asian countries (Afghanistan, Bangladesh, Bhutan, India, Pakistan, Nepal, Sri Lanka and the Maldives). This fourth and the final phase, titled South Asia Regional Initiative for Energy Integration (SARI/EI), was launched in 2012 and is implemented in partnership with Integrated Research and Action for Development (IRADe) through a cooperative agreement with USAID. SARI/EI addresses policy, legal and regulatory issues related to cross border electricity trade in the region, promote transmission interconnections and works toward establishing a regional market exchange for electricity.

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

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