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September 27, 2017

PROJECT DOCUMENT

OF

THE ASIAN INFRASTRUCTURE INVESTMENT BANK

Republic of India
Transmission System Strengthening Project

CURRENCY EQUIVALENTS
(as of September 4, 2017)

Currency unit	=	Rupee (Rs.)
US$ 1.00	=	Rs. 63.9804

FISCAL YEAR

April 1 – March 31

ABBREVIATIONS

AC	Alternating current
ADB	Asian Development Bank
AIIB (or Bank)	Asian Infrastructure Investment Bank
CAG	Comptroller and Auditor General
CEA	Central Electricity Authority
CERC	Central Electricity Regulatory Commission
CPTD	Compensation Plan for Temporary Damages
CVT	capacitor voltage transformer
DC	direct current
D/C	double-circuit
EIRR	economic rate of return
EMP	Environmental Management Plan
ESPP	Environmental and Social Policy and Procedures
ESS	Environmental and Social Standard
FIRR	financial rate of return
GoI	Government of India
GW	gigawatt
HVDC	High-voltage direct current
IA	Implementation Agency
ICAI	Institute of Chartered Accountants of India
IEC	International Electrotechnical Commission
IEE	Initial Environmental Examination
ISO	International Organization for Standardization
km	kilometer
kV	kilovolt
kWh	kilowatt-hour
MDB	multilateral development bank
MW	megawatt
MVA	megavolt-ampere
O&M	operation and maintenance
OPGW	optical fiber composite ground wire
PIU	project implementation unit

PLCC	power line carrier communication
POWERGRID	Power Grid Corporation of India Ltd.
RoW	right of way
SERF	shadow exchange rate factor
SPS	Safeguard Policy Statement
WACC	Weighted average cost of capital

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1. Project Summary Sheet

India: Transmission System Strengthening Project (the Project)

Project No.	000006
Guarantor Borrower(s) Implementation Agency	Republic of India Power Grid Corporation of India Limited (POWERGRID) POWERGRID
Sector / Subsector	Energy / Electricity
Project Objectives/Brief Project Description	The objective of the Project is to enhance the capacity of electricity supply in the Southern Region of India. The Project covers construction and installation of five transmission lines.
Project Implementation Period	Start Date: August 1, 2017 End Date: February 29, 2020
Expected Loan Closing Date	September 30, 2020
Project cost and Financing Plan	Total project cost: US$303.47 million. Financing plan: Bank: US$100.00 million (33.0%) ADB: US$50.00 million (16.5%) Borrower: US$153.47 million (50.6%)
AIIB Loan (Size and Terms)	US$100 million, with a 11-year term, including a grace period of 3 years, at the Bank's standard interest rate for sovereign-backed loans with the corresponding weighted average maturity period of less than 8 years. Borrower will pay the Front-end Fee from its own resources within 60 days after loan effectiveness.
Co-financier	ADB, US$50 million, with a 20-year term, including a grace period of 5 years, at annual rate determined in accordance with ADB's pricing policy.
Environmental and Social Category	Category B
Project Risk	Low
Conditions for Effective-ness and Disbursement	
Key Covenants	The Borrower shall ensure that the implementation of all Project activities comply with ADB's Safeguards Policy Statement (including the Initial Environmental Examination, Environmental Management Plan and Compensation Plan for Temporary Damages), AIIB's Prohibited Practices Policy, and ADB's Procurement Guidelines.
Policy Assurance	

President	Jin Liqun
Vice-President	D.J. Pandian
Director General	Supee Teravaninthorn
Manager	Ke Fang
Team leader	Hongliang Yang, Senior Investment Operation Specialist

Team members	Bin Wang, Senior Policy Officer Haiyan Wang, Senior Finance Specialist Ian Nightingale, Procurement Advisor Jessana A Yanuario, Finance Officer Kishlaya Misra, Operations Support Specialist Kishor Uprety, Senior Legal Counsel Somnath Basu, Senior Social Development Specialist Thomas Walenta, Investment Officer Wanjun Zhang, Financial Management Consultant Xuemei Yang, Project Assistant Yan Li, Economic and Financial Consultant

2. Strategic Context

A. Country Context

1. With a gross domestic product (GDP) of US$2,051 billion, India is one of the world's largest economies. India has made significant progress on many fronts in the past decade, positioning itself to be a high potential economy in the foreseeable future. It performed relatively well in the recent global economic slowdown – its GDP growth was 7.2% in fiscal year 2014/15 (FY2014/15) and 8.0% in in FY2015/16, and is projected at 7.1% in FY2016/17. Due to the reduced external vulnerabilities and improved growth prospects, India has attracted large foreign direct investment inflows in recent years. In 2016 India's international reserves reached US$360.2 billion (around 8.6 months of import cover), and its external debt-to-GDP ratio remained largely stable at 23.5%. As per the International Monetary Fund (IMF), there could be disruptive impact arising from global financial market volatility stemming from unexpected developments in the course of US monetary policy or China's growth slowdown. Domestic risks include a continued weakening of bank and corporate balance sheets as well as setbacks in the structural reform processes.[1] Looking ahead, India's medium-term economic outlook is expected to be sustainable, characterized by continued high GDP growth rate (see Annex 4).

2. India is now at a unique historical juncture. With a population of around 1.31 billion and per capita GDP of around US$1,581 in 2015, India is still a lower middle income country. Although its steady economic growth in the past decade has lifted many people out of poverty, as per IMF and World Bank's statistics, around 21% of the population still lives below the national poverty lines.[2] To benefit from its demographic dividend, India has to find its own path for economic development. The current consensus among economists and practitioners is that India should invest heavily in infrastructure, including electricity. As of June 30, 2017, India had about 330.3 gigawatt (GW) of installed capacity, which is one of the largest in the world in terms of absolute numbers.[3] However, there are still 280 million people in the country without connection to the power grid, and many who are connected continue to face frequent supply disruptions.[4]

3. The Government of India (GoI) prioritizes electricity sector development in its 12th Five Year Plan (2012-2017).[5] Per the International Energy Agency's World Energy Outlook 2015, India will contribute more than any other country to the projected rise in global energy demand during the period of 2015-2040. The GoI plans to increase the share of renewable energy in the country's electricity generation, and announced at the 2015 Paris Climate Conference (also known as COP21) that it aims to increase to 40% the share of installed generating capacity from non-fossil fuel-based energy resources by 2030. This includes plans to quadruple the country's (non-hydro) renewable energy capacity to 175 GW by 2022, which will require substantial investments in generation, as well as substantial complementary investments in strengthening the transmission network to absorb the intermittent renewable

[1] International Monetary Fund (IMF), 2017. Country Report No. 17/54: 2017 Article IV Consultation-Press Release; Staff Report; and Statement by the Executive Director for India.
[2] World Bank, 2016, World Development Indicators.
[3] Central Electricity Authority (CEA), 2017. All India Installed Capacity of Power Stations (as of June 30, 2017). New Delhi, India.
[4] World Bank, 2016, World Development Indicators: Energy and Mining.
[5] Government of India, Planning Commission. 2013. Twelfth Five Year Plan (2012-2017). New Delhi, India.

energy.[6] Tamil Nadu is the leading state in India with the highest installed generating capacity of renewable energy and is expected to contribute about 8,884 megawatt (MW) of solar power and 11,900 MW of wind power towards the national target. However, due to inadequate transmission infrastructure, Tamil Nadu faces challenges in evacuating electricity from renewables, such as wind, and exploiting its large renewable energy potential. The proposed Project is designed to ease the electricity supply constraint in the Southern Region by enhancing electricity transmission capacity in Tamil Nadu and by facilitating evacuation of electricity from renewables to the grid.

B. Sectoral and Institutional Context

4. India's electricity system needs to grow rapidly to fuel the country's economic growth and provide electricity to its growing population. As per the International Energy Agency, India, home to 18% of the world's population, uses only 6% of the world's primary energy. In 2014 its electricity consumption per capita was only about 750 kWh, much lower than China's 3,900 kWh and Malaysia's 4,500 kWh in the same year. Even compared to the world average of 3,026 kWh in 2013, India falls well behind.[7] Further, the country is now experiencing massive urbanization and may aggravate the already serious electricity supply shortage. Recognizing the importance of power supply for the sustained growth of the country, various initiatives have been undertaken by the GoI to scale up investments in electricity generation, transmission and distribution.

5. While the GoI has made efforts to maximize generation from cleaner sources other than coal, coal-based generation has been the main source of electricity generation in India to date. As of June 30, 2017, India had a generation mix including coal 59%, gas and diesel 8%, renewable 31%, and nuclear 2%.[8] India's electricity system is divided into five regions, i.e. Northern, Western, Eastern, Southern, and North-Eastern Regions. Almost all regions in India experienced peak power shortage of varying magnitude in 2016, from 0.2% in the Western Region to 5.2% in the North-Eastern Region.[9] The electricity supply shortage in the Southern Region is also serious, mainly due to: (i) delay in anticipated power generation projects, and (ii) insufficient fuel supply for existing gas fired power plants. Some estimates indicate that as of today, the maximum power demand of the Southern Region is about 41 GW, but by the end of the 13th Five-Year Plan (2018 – 2022), it will double to about 82.2 GW. Hence, the supply deficit in the Southern Region is expected to be extremely severe if nothing is done to address it in near future.

6. India's electricity transmission network comprises regional and intrastate grids. Regional grids consist of 400 kilovolt (kV), 765 kV, and 800 kV transmission lines, and transmit electricity over long distances across states and/or regions. Intrastate grids exist within respective Indian states, formed by 400kV and lower voltage transmission lines. As of May 31, 2016, the length of transmission lines at 220 kV and higher voltage levels was 376,217 circuit-km, and transformation capacity of substations at 220 kV and above was about 770,815

[6] Government of India, MNRE. 2015. Tentative State-wise break-up of Renewable Power target to be achieved by Year 2022. New Delhi.
[7] International Energy Agency, 2015. Key World Energy Statistics 2015. Paris, France.
[8] Central Electricity Authority (CEA), 2017. All India Installed Capacity of Power Stations (as of June 30, 2017). New Delhi, India.
[9] Central Electricity Authority, Government of India, 2016. Loan Generation Balanced Report 2016-17.

megavolt ampere (MVA) in the country.[10] India's aggregate transmission and distribution losses is currently around 25%, which translates to a loss of over 200 billion units of electricity annually,[11] whereas the total loss in the United States was only 9.4% in 2013. Part of the loss is technical, due to inadequate investments over the years for system improvement, which has led to unplanned extensions of distribution lines, overloading of system elements, such as transformers and conductors, and lack of adequate reactive power support. There is an urgent need to upgrade the voltage level of electricity transmission and reduce the technical losses of the grid.

7. Inadequate investment in transmission infrastructure also inhibits utilization of renewable energy. About 60% of India's renewable energy capacity is in six states, including Andhra Pradesh, Gujarat, Karnataka, Maharashtra, Rajasthan, and Tamil Nadu. Tamil Nadu has been a frontier in renewable energy development owing to various policy measures and institutional arrangements. In the recent past, renewable energy plants in Tamil Nadu have experienced difficulties in fully evacuating power, leading to loss of revenues. It was estimated that around 1,000 MW of excess wind power could not be transmitted to other states due to the outdated transmission network. Also, Tamil Nadu has approximately 33,800 MW wind power potential, of which only 22.5% had been realized by March 2016. A study in 2012 showed that to facilitate the transfer of electricity from renewable energy-rich states to others, as well as manage electricity absorption and address renewable energy intermittency and timing differences, US$7 billion of investments should be undertaken, including: (i) intrastate transmission investments of about US$3.6 billion within renewable energy-rich states; and (ii) interstate investments of more than US$3.4 billion to enable electricity flows across states over long distances.[12] The proposed Project is in line with these initiatives.

8. The Ministry of Power is the country's apex central government body administering the electricity sector. It was created on July 2, 1992, and is primarily responsible for sector planning, policy formulation, investment decision, training and manpower development, and administration and enactment of legislation related to sector development regarding thermal and hydro power generation, transmission and distribution. It is also responsible for the execution of India's Electricity Act (2003) and Energy Conservation Act (2001), and for proposing amendments to these Acts when necessary, in conformity with the GoI's policy objectives. The Ministry of New and Renewable Energy is mainly responsible for new and renewable energy development. Its mandate covers research and development, intellectual property protection, and international cooperation and promotion in renewable energy resources such as wind, small hydro, biogas, and solar. In India's governance system, both the central government and the state governments are involved in establishing policies and laws for the electricity sector. This motivates the central and state governments to help expedite projects and conduct sector reforms. Among the electricity sector entities, the Power Grid Corporation of India Limited (POWERGRID), the implementation agency (IA) for the Project, plays a pivotal role in transmission system construction and evacuation of renewable energy.

9. POWERGRID, the central transmission utility incorporated in 1989, is responsible for planning the regional and inter-state transmission system, while the state transmission utilities are responsible for the development of intrastate transmission. The Power System Operation

[10] Ministry of Power, 2017. Transmission Overview. Access at: http://powermin.nic.in/content/overview-0.
[11] India Energy Security Scenarios, "User Guide for India's 2047 Energy Calculator T&D Losses and Smart Grids". Access at: http://indiaenergy.gov.in/docs/TD%20Documentation.pdf.
[12] POWERGRID. 2012. Report on Green Energy Corridors–Transmission Plan for Envisaged Renewable Capacity. Gurgaon, New Delhi.

Corporation Limited manages the national and regional grids from a national load dispatch center and five regional load dispatch centers through unified load dispatch and communication facilities. The transmission lines are operated in accordance with regulations and standards of the Central Electricity Authority (CEA) and Central Electricity Regulatory Commission (CERC), as well as the State Electricity Regulatory Commissions. POWERGRID transmits about 50% of the total electricity generated in India on its transmission network.

10. POWERGRID is listed on both the Bombay Stock Exchange and the National Stock Exchange of India, with 57.9% holding by the GoI and the remaining 42.1% by institutional investors and the public. As of June 30, 2017, it owned and operated around 140,723 circuit-km of alternating-current (AC) and direct-current (DC) transmission lines at voltage levels ranging from 800/765 kV to 132 kV; and 222 AC and DC substations with transformation capacity of more than 293,670 MVA.[13] POWERGRID consistently maintains its transmission network through deployment of state-of-the-art operation and maintenance (O&M) techniques at par with global standards, normally at 99% of availability. In addition, POWERGRID has been playing an active role in formation of a strong cross-country grid in the South Asia for effective utilization of resources, and offers consultancy services to various national and international clients from South Asia, the Middle East, and Africa. It is also active in facilitating grid interconnection of renewable generation across the country through implementation of the GoI's Green Energy Corridors Initiative.

11. During the 12th Five Year Plan (2012-2017), POWERGRID made a capital investment of more than Rs. 1,200 billion (US$17.88 billion) to develop inter-state transmission systems, including about 45,900 circuit-km of transmission lines and 164,000 MVA of transformation capacity. It is now providing back-bone connectivity to all metros, major cities and towns in the country, as well as to the grid in the North-Eastern Region. POWERGRID has a well-established integrated management system and has been certified to the standards of the International Organization for Standardization (ISO), such as ISO 9001 for Quality Management Systems, ISO 14001 for Environmental Management Systems, and OHSAS 18001 for Occupational Health and Safety Management Systems. POWERGRID has also been certified to the SA-8000 by Social Accountability International. Finally, POWERGRID's Corporate Office was certified to ISO 50001 for energy management.

12. ***Private sector participation***. Renewable energy is still more expensive than conventional coal-fired power generation in India. Intermittency of renewable energy also adds to the cost burden. Through the Electricity Act (2003), the National Action Plan on Climate Change, and the Jawaharlal Nehru National Solar Mission, the GoI has created the necessary legal and regulatory frameworks to support renewable energy development, including projects financed by private sector. For example, in Tamil Nadu various incentives were given to attract private sector investment into renewable energy, including fiscal concessions, custom and excise duty exemptions, tax holidays and feed-in tariffs. However, transmission networks, as a natural monopoly, are in most cases still under the control of the public sector, which is responsible for the investments in the grid that will allow increased private sector participation in renewable energy generation that can be reliably distributed.

[13] POWERGRID's corporate website. Access on December 17, 2016 at http://www.powergridindia.com.

3. THE PROJECT

A. Rationale

13. The Project will enhance overall interregional connectivity in India, and is critical not only for bulk power evacuation but also for power system optimization and renewable energy utilization. As part of a larger scheme to wheel 6.0 GW of electricity from Chhattisgarh and Madhya Pradesh to a hub at Pugalur in Tamil Nadu, the Project will help transmit 4.0 GW of electricity into Tamil Nadu and mitigate the electricity shortage in the Southern Region. It will also help optimize the overall electricity system and improve the generation mix, thereby making it easier to utilize unevenly distributed renewable energy resources. The Project is expected to make substantial contributions to a reliable electricity supply in south India.

14. The Project is fully aligned with the Bank's mandate and Energy Sector Strategy in terms of promoting sustainable and green infrastructure, especially in transmission and distribution. By filling the Project's financing gap and refining and improving the Project materials, the Bank helps the Project get off the ground more quickly. The Bank's involvement in the Project will help further develop its institutional capacity and expertise in this area. The Project also provides the Bank access to the strategic transmission sector in India and establishes a platform for future dialogue between the Bank and the GoI on electricity system optimization and renewable energy utilization.

B. Objective

15. The objective of the Project is to enhance capacity of electricity transmission in Southern Region and re-balance the peak and off-peak energy sharing from the surplus areas of Northern and Western Regions to the deficit areas in Southern Region. The overall impact of the Project will be to enhance availability and sustainability of power supply in India.

16. The Project's key performance indicators (see Annex 1) include:

(i) At outcome level:
- capacity of electricity supply added in Southern Region (unit: MW)

(ii) At output level:
- length of 400kV transmission lines installed (unit: km); and
- number of transmission lines constructed (unit: number).

C. Project Description and Components

17. Although in varying degree almost all regions in India continue to experience peak power shortage, there are short-term surpluses depending on the season or time of day.[14] This is because peak power demands in different places do not occur at the same time. Hence, there is room to use this short-term surplus if a more integrated grid is in place to transfer electricity from surplus to deficit areas. In view of the increasing supply deficit and resulting demand for interstate electricity transmission, construction of high-voltage-direct-current (HVDC) transmission links along with 400 kV AC interconnections is essential. The Project is a part of a larger sector development scheme, the "HVDC Bi-pole Link between Western Region

[14] Central Electricity Authority, Government of India, 2016. Loan Generation Balanced Report 2016-17.

(Raigarh, Chhattisgarh) and Southern Region (Pugalur, Tamil Nadu) – North Trichur (Kerala)" (the Scheme), which comprises three smaller schemes to expand the interstate transmission network in western and southern India.

(i) Scheme 1: +800kV HVDC link from Raigarh (Chhattisgarh, Western Region) to Pugalur (Tamil Nadu, Southern Region).
(ii) Scheme 2: 400kV transmission lines from Pugalur to five grid substations in Tamil Nadu.
(iii) Scheme 3: +320kV HVDC link from Pugalur (Tamil Nadu) to Trichur (Kerala).

18. The Scheme (Schemes 1-3 combined) will be able to wheel 6.0 GW of electricity from Chhattisgarh and Madhya Pradesh states to the Pugalur hub substation, and then transmit 4.0 GW of electricity into Tamil Nadu and 2.0 GW of electricity into Kerala. While POWERGRID has already secured financing support for Schemes 1 and 3 (and related substations) from the Asian Development Bank (ADB),[15] investment funding for Scheme 2 is urgently needed to maximize the potential benefit of the whole Scheme. As Scheme 2 is designed to handle two-thirds of the total capacity of the Scheme, the economic and financial viability of Scheme 1 (and arguably Scheme 3) will depend on the successful completion of Scheme 2.

19. The GoI has showed strong support for the implementation of the Scheme on various occasions. The Scheme was discussed and agreed at the 37th and 38th meeting of the Standing Committee on Power System Planning in Southern Region held in July 2014 and March 2015, and at the 26th and 27th meeting of the Southern Region Power Committee (SRPC) held in December 2014 and May 2015. Further, the Scheme was discussed and agreed in the joint meeting of the Standing Committees on Power System Planning of the Southern Region and Western Region held in April 2015. The Ministry of Power approved the implementation of the Scheme by POWERGRID through a regulated tariff mechanism on December 10, 2014.

20. The proposed Project covers the construction of five transmission lines in Tamil Nadu, including:

(i) *Pugalur HVDC substation – Pugalur substation (existing) 400kV double-circuit (quad) line*

The Pugalur (Karur) substation is an existing substation of POWERGRID with 400kV connectivity to Madurai, Karaikudi, Kalivandhapattu and Neyveli substations. The Pugalur substation helps extend the power supply to Erode, an urban area of Tamil Nadu. In addition to meeting the growing electricity demand of the region, the proposed line will help anchor the proposed HVDC system and contribute to the short circuit level required for stable operation of HVDC.

(ii) *Pugalur HVDC substation – Arasur substation 400kV double-circuit (quad) line*

The Arasur substation, located in the Coimbatore area, is integrated with the grid through 400 kV double-circuit lines from Mettur and Udumelpet. The Arasur substation currently has transformation capacity of 630 MVA. To meet the growing power demand in the region, the addition of 1x500 MVA transformer has already been approved and is under implementation. The proposed line will increase electricity transfer capacity to the

[15] ADB, 2015. Proposed Loan for Green Energy Corridor and Grid Strengthening Project (Project Number: 44426-016).

Arasur substation and relieve load pressure on the 400kV line between the Madurai and the Udumelpet substations.

(iii) *Pugalur HVDC substation – Thiruvalam substation 400kV double-circuit (quad) line*

The Thiruvalam substation is an important 765/400 kV substation in Tamil Nadu, through which the major portion of the loads in Tamil Nadu is fed. The Thiruvalam substation is currently connected through eight 400 kV lines and two 765kV lines, and has 765/400 kV transformation capacity of 3,000 MVA. Through linking the Pugalur substation and Thiruvalam substations, two important transmission corridors, such as the 800 kV HVDC link from Raigarh to Pugalur and the 765 kV AC link from Kurnool to Thiruvalam, can be interconnected, thus strengthening the reliability of electricity supply in the Southern Region.

(iv) *Pugalur HVDC substation – Edayarpalayam substation 400kV double-circuit (quad) line*

The Edayarpalayam substation is a new substation currently under implementation by the Tamil Nadu State Electricity Board to cater to the increasing electricity demand in the area. The proposed Pugalur HVDC substation – Edayarpalayam substation 400 kV double-circuit (quad) line will feed the Edayarpalayam substation.

(v) *Edayarpalayam substation – Udumulpet substation 400kV double-circuit (quad) line*

The Udumulpet substation has a transformation capacity of 945 MVA and provides electricity to Udumulpet and surrounding areas. It connects substations at Madurai, Salem, Tirunelveli and Palakkad, and acts as a major gateway of electricity supply to Kerala. Currently, the existing Madurai – Udumulpet 400kV line is heavily loaded. The proposed 400 kV double-circuit (quad) line will act as additional feed, and help reduce the heavy load of the existing Madurai-Udumulpet 400kV line. In addition, the two transmission lines together (Pugalur HVDC – Edayarpalayam – Udumulpet) will enhance the feeding capacity to Kerala through the Udumulpet – Palakkad 400kV double-circuit transmission line.

D. Cost and Financing

21. The Project is estimated to cost US$303.47 million. Table 1 shows the Project cost and financing plan.

22. A loan of US$100.00 million from the Bank is requested by the GoI to finance the Project. The loan will have a 11-year term, including a grace period of 3 years, at the Bank's standard interest rate for sovereign-backed loans with the corresponding weighted average maturity. The Borrower will pay the Front-end Fee from its own resources, within 60 days from the date of loan effectiveness.

23. The GoI has also requested ADB to provide US$50 million to finance the Project. ADB's loan will have a 20-year term, including a grace period of 5 years, at an annual rate

determined in accordance with ADB's pricing policy. The loans from the Bank and ADB will be used together to finance the Project. The balance of the Project cost will be covered by POWERGRID.

Table 1: Project Cost and Financing Plan (US$ million)

Item		Estimated Costs [a]	AIIB		ADB		Domestic	
			Amount	%	Amount	%	Amount	%
A.	**Investment Cost** [a]	264.29	100.00	37.8	50.00	18.9	114.29	43.3
1.	Civil Works	0.15					0.15	100.0
2.	Equipment and Material (incl. goods, works, and services)	206.81	100.00	48.3	50.00	24.2	56.81	27.5
3.	Safeguard Mitigation and Compensation	42.08	-		-		42.08	100.0
4.	Survey & Soil Investigation	0.23	-		-		0.23	100.0
5.	Others [b]	15.02	-		-		15.02	100.0
B.	**Contingencies** [c]	21.14	-		-		21.14	
C.	**Financing Charges During Construction** [d]	18.03	-		-		18.03	100.0
	Total (A+B+C)	**303.47**	**100.00**	**33.0**	**50.00**	**16.5**	**153.47**	**50.5**

Note: [a] In April 2016 prices, excluding customs and excise duty.
[b] Including cost estimates on incidental expenditure, overheads, and special tools & plants for operation.
[c] Including physical and price contingencies.
[d] Including estimates on interest during construction, commitment charge, sovereign guarantee fee, and Front-end Fee.
Sources: Bank and POWERGRID estimates.

E. Implementation Arrangements

24. The Project will be implemented over 31 months between August 1, 2017 and February 29, 2020, and the loan closing date will be September 30, 2020.

(a) Implementation Management

25. POWERGRID has a well-developed corporate structure with clearly defined roles and responsibilities for all Project-related positions. This structure has been proved effective by its successful track record in terms of implementing large transmission projects in the past. The Project's implementation arrangements will make best use of POWERGRID's existing integrated project management and control system. As the IA, POWERGRID will take full responsibility for implementation of the Project, including: (i) overall Project management and monitoring; (ii) annual budget preparation and monitoring of utilization of loan proceeds; (iii) progress reporting, including reports on cost management and Project outputs; and (iv) compliance with loan covenants. The Department of Corporate Planning will be the interface between POWERGRID and the Bank, and the internal coordinator among the functional departments to lead the preparation and implementation of the Project. While environmental and social and procurement requirements will be closely monitored through related departments, the regional offices will be responsible for the construction and commissioning of the proposed transmission lines and bay extensions and will submit monthly implementation progress reports to the Department of Corporate Planning. The implementation arrangements are summarized in Table 2.

Table 2: Implementation Arrangement

Aspects	Arrangements
Implementation period	August 1, 2017 – February 29, 2020
Loan closing date	September 30, 2020
Management	
(i) Oversight body	Coordination Committee, POWERGRID
(ii) Implementation agency (IA)	POWERGRID
(iii) Project Implementation Unit (PIU) / Internal coordinator	Department of Corporate Planning
Procurement: goods and works	All goods, works, and consulting services to be financed will be procured through open competitive bidding, following ADB's Procurement Guidelines (2015, as amended from time to time). Universal procurement will apply to all procurement packages to be financed by ADB and the Bank.
Environmental and Social	An Initial Environmental Examination and Compensation Plan for Temporary Damages have been prepared, as per ADB's Safeguard Policy Statement (2009). The PIU will supervise implementation of the plan, with support from external monitoring consultants if necessary.
Retroactive financing and/or advance contracting	Advance contracting and retroactive financing will be allowed. Retroactive financing will be applicable to the advance contracting packages for up to 20% of the Bank's loan amount (US$20,000,000) for eligible expenditures including goods, works, and consulting services, which may be incurred prior to loan effectiveness but not earlier than 12 months before the signing date of the respective loan agreements.
Disbursement	The loan proceeds will be disbursed in accordance with the Bank's loan disbursement instructions and detailed arrangements agreed upon between POWERGRID and the Bank.

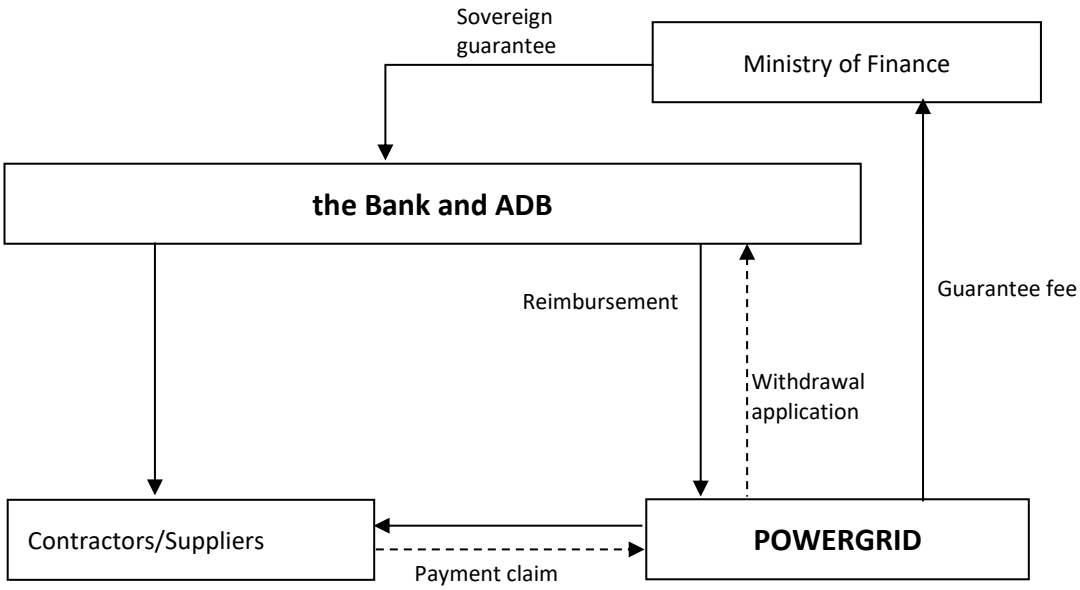
(b) Procurement

26. All procurement of goods, works and services will be undertaken in accordance with ADB's Procurement Guidelines (2015, as amended from time to time). Procurement arrangements will be centralized. Universal procurement will apply to all procurement packages to be financed by ADB and the Bank. POWERGRID will be responsible for all aspects of the procurement process from the planning, design, and tendering stages to contract award and supervision of contract implementation. The tender document preparation and evaluation of tenders/proposals will be carried out by POWERGRID staff. The Bank is satisfied that POWERGRID's procurement arrangements are fit for purpose and will ensure a value for money outcome, and that the procurement risk mitigation measures are appropriate.

(c) Fund Flow Arrangement and Disbursements

27. The loan will be made directly to POWERGRID, with a separate guarantee agreement with the GoI. POWERGRID will ensure that all items of expenditures financed out of the loan proceeds are exclusively for the Project. The GoI will exercise its rights under the Guarantee Agreement in such manner as to protect its interests and those of the Bank and to achieve the purposes of the Loan.

Figure 1: Fund Flow Arrangement



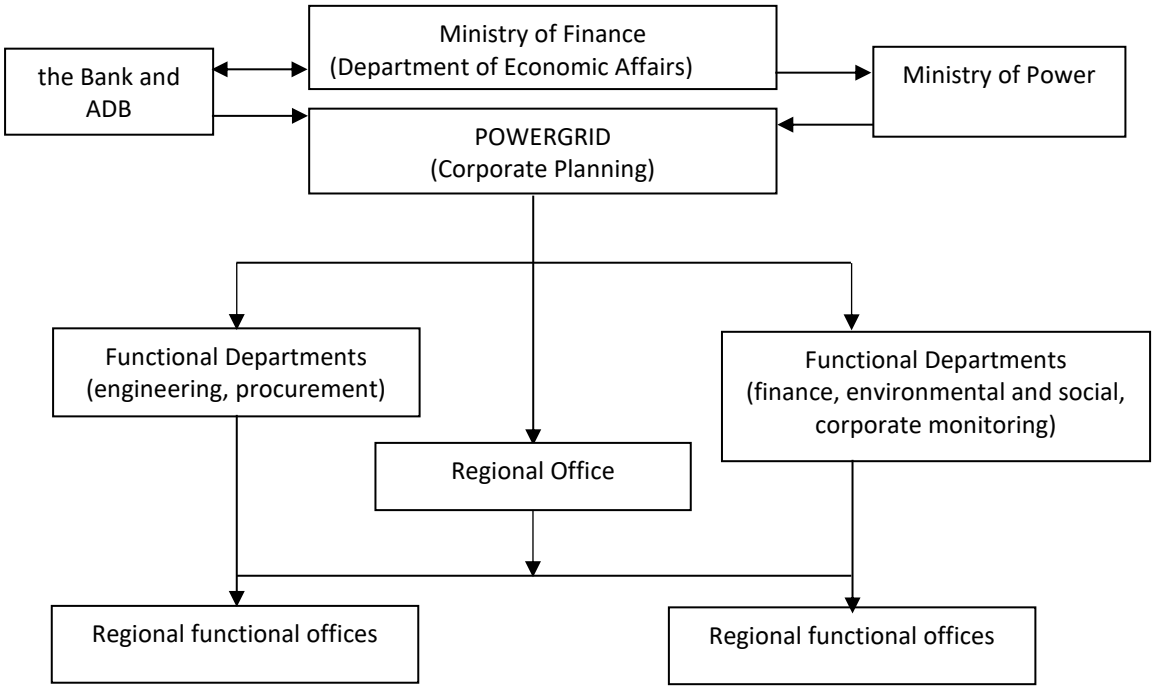
28. The loan proceeds will be disbursed in accordance with the Bank's loan disbursement instructions. For eligible expenditures, withdrawals for retroactive financing will be permitted, and will be subject to the date and limit specified in the legal agreements.

F. Monitoring and Reporting

29. POWERGRID will be responsible for monitoring the Project progress through its project monitoring system, and the Department of Corporate Planning will be the internal coordinator. POWERGRID will submit to the Bank consolidated quarterly reports and annual reports on project implementation progress. The contents of the reports will cover all essential aspects of project implementation, including contract awards, disbursements, physical progress as per the defined key performance indicators, environmental and social safeguards, key implementation issues and solutions, and updated implementation and procurement plans for the next 12 months. POWERGRID will also submit a project completion report within six months of physical completion of the Project.

30. Project implementation will be closely monitored by the Bank's project team on a regular basis, including project inception mission, supervision mission, and midterm review mission, if necessary. In case of any non-compliance identified during project implementation, a corrective plan will be developed and implemented. Project accounts and POWERGRID's audited financial statements, together with the associated auditor's report, will be reviewed regularly. POWERGRID is required to maintain detailed records on project implementation for possible verification.

Figure 2: Project Management Structure



4. PROJECT ASSESSMENT

A. Technical

31. The Project design is technically sound in terms of transferring electricity to the respective destinations with reliability and security. Technical due diligence was conducted based on: (i) project proposal and feasibility study; (ii) studies on present and future load requirements of the Southern Region; (iii) discussions with planning and designing engineers of POWERGRID; and (iv) findings from project site visits. POWERGRID has a proven record in financing and implementing large and difficult transmission projects, including those financed by development partners.[16] It has been using sophisticated techniques and state-of-the-art technology in the O&M of its assets, which are normally above 99% availability level. Its systems and procedures are revised periodically to keep abreast with the development of technology and international standards.

32. The Project faces no significant technical risk. This is because, first, the interventions supported under the Project are well-established in India and other countries. Second, POWERGRID has strong in-house technical capacity and computer-aided facilities for planning, design, and O&M of the transmission network. Third, the project design has balanced considerations of the present and future load requirements and system redundancy required in the Southern Region.[17] Fourth, prior to designing the Project, various system studies, such as

[16] Two projects are listed here as examples. Asian Development Bank, 2015. Green Energy Corridor and Grid Strengthening Project. Manila, Philippines; World Bank, 2009. Fifth Power System Development Project. Washington DC, US.

[17] In engineering, redundancy is the duplication of critical components or functions of a system with the intention of increasing reliability of the system, usually in the form of a backup or fail-safe.

load flow, steady state stability, switching schemes, protection & control, line configuration, and towers & foundations, had been undertaken for selection of major system and equipment parameters. Fifth, selection of equipment and materials has taken into consideration the present trend in technology development and the need to minimize transmission losses. A detailed project description is in Annex 2.

B. Economic and Financial

(a) *Economic Analysis*

33. *Least-Cost Analysis*. An alternative to the proposed transmission lines is to construct new power plants within the Southern Region. The incremental levelized cost of supply from the alternative is estimated at around Rs. 1.4 per kWh whereas that from the proposed solution is around Rs 0.8 per kWh. POWERGRID has also confirmed that the proposed solution is both lower-cost and technically superior.

34. Two cost-and-benefit analyses were carried out, one for the overall Scheme (Schemes 1, 2 and 3) and the other for Scheme 2 alone while treating it as a marginal addition to the existing HVDC investments in Schemes 1 and 3.[18] Both analyses were carried out over a project lifetime of 25 years exclusive of the construction period. A social discount rate of 12.0% was used.

35. *Economic Costs*. All project costs are expressed in domestic currency and in constant 2016 prices, excluding financial charges, transfer payments and price contingencies, adjusted for various degrees of market distortions. The economic costs include: (i) investment costs; (ii) O&M costs and (iii) the cost of power supply, based on coal-fired generation from the north.

36. *Economic Benefits*. Without the investment in the overall Scheme (1, 2 and 3), unserved demand in the Southern Region would increase to an estimated 10 GW and 5,300 GWh by 2021, the expected year of commissioning of the Project. It has been assumed that, without the Project, a small proportion of this demand would be served by alternative energy sources, such as kerosene for domestic lighting assumed at 1% of the domestic demand (16 GWh in 2021, increasing to 46 GWh by 2024) and diesel for non-residential standby generation assumed at 10% of non-domestic demand (369 GWh in 2021, increasing to 1,047 GWh by 2024). The costs of kerosene and diesel fuels were based on the World Bank's projections for international crude oil prices, converted to their border price-equivalent values with appropriate shadow exchange rate factor (SERF). Thus, the levelized cost was estimated at Rs. 41.2 per kWh for kerosene lighting, and Rs. 21.3 per kWh for diesel-based standby power generation. With the investment in the Scheme, these alternative power sources will be displaced by grid-based power supply. Moreover, the investment will also enable additional power supply to meet unserved demand of 4,908 GWh in 2021 to 13,944 GWh by 2024. To be conservative, the willingness-to-pay for the incremental demand served is assumed at the weighted average cost of supply to the southern system at Rs. 5.0 per kWh plus a 10% wheeling charge. Besides the above-mentioned benefits, the proposed Project will also have positive, however less tangible, effects on the generation mix, system dynamic and transient stability, operational flexibility and local income generation, none of which is quantified in this analysis. Scheme 2 on the margin will enable two-thirds of the abovementioned incremental and non-incremental benefits of the overall Scheme.

[18] The Scheme-wide analysis was carried out by ADB for the appraisal of HVDC investment, including Schemes 1 and 3.

37. *Outcome of the economic analysis*. The economic internal rate of return (EIRR) of the overall Scheme (1, 2 and 3) is estimated at 14.4% over a project lifetime of 25 years, exceeding the economic opportunity cost of capital of 12.0%. Therefore, the investment in the overall Scheme is economically justified (Table 3).

Table 3: EIRR of the Overall Scheme (1, 2 & 3)

Year	**Costs** (Rs million)			**Benefits** (Rs million)		**Net benefit**
	Investment	**Supply**	**O&M**	**Incremental**	**Non-incremental**	
2016	7,375					(7,375)
2017	22,628					(22,628)
2018	44,779					(44,779)
2019	71,490					(71,490)
2020	25,232					(25,232)
2021	28	20,002	2,573	24,540	8,515	10,452
2022		31,400	2,573	38,524	14,527	19,078
2030		56,826	2,573	69,718	30,014	40,333
2040		56,826	2,573	69,718	30,014	40,333
					EIRR	**14.4%**

38. Moreover, when evaluated on the margin, the project investment, i.e., Scheme 2 alone has an estimated EIRR of 47.2% well exceeding the economic opportunity cost of capital of 12.0%, indicating a robust economic return more than adequate to justify the investment.

Table 4: EIRR of Scheme 2 as a Marginal Addition to Schemes 1&3

Year	**Costs** (Rs million)			**Benefits** (Rs million)		**Net benefit**
	Investment	**Supply**	**O&M**	**Incremental**	**Non-incremental**	
2017	1,922					(1,922)
2018	9,608					(9,608)
2019	6,533					(6,533)
2020	1,125					(1,125)
2021	28	13,335	288	16,360	5,677	8,386
2022		20,933	288	25,683	9,685	14,146
2030		37,884	288	46,479	20,009	28,316
2040		37,884	288	46,479	20,009	28,316
					EIRR	**47.2%**

39. *Conclusion*. The economic analysis confirms that the overall Scheme, of which the Project investment is a part, is both the least cost solution and economically viable. Sensitivity analysis indicates that under a worst-case scenario, assuming a capital and O&M cost increase of 15% and one-year delay in implementation, the EIRR remains above 12% (Annex 3). The economic justification for the Project investment in Scheme 2 is highly robust.

(b) ***Financial Analysis***

40. The proposed Project has a total estimated financial cost of US$303.47 million.

41. *Weighted Average Cost of Capital (WACC)*. The Project's financing mix comprises: (i) a US$100 million loan from the Bank at a fixed swap rate plus the Bank's effective lending spread; (ii) a US$50 million loan from ADB also at a USD fixed swap rate[19] plus ADB's

[19] The fixed swap rate for a US dollar-denominated loan with a 20-year tenure currently stands at 2.7% per annum. Source: https://www.adb.org/sites/default/files/institutional-document/33777/adb-indicative-rates-20170407.pdf.

effective lending spread; (iii) a commercial loan of approximately US$62 million at the prevalent lending rate set by the Central Bank of India at 10.5%; and (iv) about US$91 million or 30% of the total investment to be financed by equity from POWERGRID at 15.5% per annum per the norms defined by CERC. Domestic inflation is estimated around 5.0%[20] while US dollar inflation is estimated at around 2.0%.[21] Thus, the WACC is estimated at 7.4% in nominal terms and 3.7% in real terms (see Annex 3).

42. *Tariff-based Revenue*. Per CERC's regulation, wheeling charge is determined based on cost-plus. POWERGRID owns a portfolio of regulated transmission assets, where depreciation is calculated over 30 years, at a rate of 5.25% for transmission lines and substations and 6.33% for communication equipment in the first 12 years, and a 10% salvage value at the end of the 30th year. Per CERC's regulation, O&M charges stands at Rs. 121,000 per km for double-circuit transmission lines and Rs. 6.871 million per bay for 400kV transmission bays.

43. *Outcome of the financial analysis*. Based on the above assumptions, the financial internal rate of return (FIRR) of the Project investment is estimated at 9.6%, exceeding the WACC of 7.4% in nominal terms. Sensitivity analysis on the FIRR indicates that under an adverse scenario, assuming capital cost increase by 20% and implementation delay by one year, the Project's FIRR of 8% still remains above the nominal WACC.

44. *Conclusion*. The financial viability of the Project investment is robust enough to withstand considerable upswings in costs and implementation delays.

(c) ***Corporate-Level Financial Assessment***

45. POWERGRID operates 90% of India's high-voltage interstate and interregional power transmission network. A listed Company, POWERGRID is 57.9% owned by the GoI and the balance by institutional investors and the public. It has maintained an international long-term issue credit rating of BBB– (Outlook: Stable) from both Standard & Poor's and Fitch, and enjoys the highest domestic credit rating of AAA.[22]

46. POWERGRID's total revenues increased at an annual growth rate of more than 16% from Rs. 157 billion in 2014 to Rs. 213 billion in 2016, while total assets increased at a rate of 13% from Rs. 1,396 billion to Rs. 1,784 billion over the same period. With a corporate debt-to-equity ratio of approximately 2.4 times, and an interest coverage ratio of 1.8 times (3-year average), POWERGRID's ability to satisfy its long-term financial obligations remains strong.

47. POWERGRID is implementing several large projects, and total revenues will increase as projects are completed. Since POWERGRID receives both full recovery of project costs and a defined return on equity, its operating profit margin has been about 60%, and the net profit margin has remained above 28% in each of the past three financial years.

48. Based on the cost-plus nature of the tariff-setting process coupled with its operating efficiency, POWERGRID has increased total revenues and net income consistently, maintaining a robust financial position with stable cash flows to cover its costs, capital expenditures, and

[20] Source: http://www.oecd.org/economy/india-economic-forecast-summary.htm
[21] Source: https://data.oecd.org/price/inflation-forecast.htm
[22] Since 2001, POWERGRID's domestic bonds have been rated AAA by the Credit Rating Information Services of India Limited and AAA by the Investment Information and Credit Rating Agency of India Limited. Since 2008, the Credit Analysis and Research has also given these bonds an AAA rating.

debt service. Although POWERGRID has an aggressive investment plan and a large need for additional borrowings, its corporate financial data show it has a sound financial position.

49. *Conclusion*. POWERGRID has a sound financial position to implement the Project investment, and to operate and maintain the constructed assets while fulfilling the associated debt service obligations.

C. Fiduciary and Governance

50. POWERGRID is managed by a board of directors that is comprised of five full-time directors, two part-time directors from the Ministry of Power, and seven independent directors. Its management team has extensive functional and managerial experience. POWERGRID has an advanced computerized accounting system, and well-established procedures to control its business activities. Therefore, the fiduciary and governance risks are low (see Annex 5).

(a) *Finance*

51. The financial management capacity of POWERGRID is strong and satisfactory with systems for funds-flow arrangements, governance, staffing, budgeting, accounting and financial reporting, along with internal control procedures and external auditing arrangements. POWERGRID is audited regularly by the Comptroller and Auditor General of India (CAG), in addition to audit by one or more independent chartered accountant firms appointed by the CAG. Also, as a publicly listed company, POWERGRID is subject to strict governance measures imposed by India's Securities and Exchange Board, which ensure transparency and predictability of its financial governance through information disclosure to shareholders and the public. Moreover, POWERGRID has extensive experience working with international development partners, such as the ADB and the World Bank. [23] Under the Project, POWERGRID will, thus, ensure that proper accounts and records of use of the loan proceeds are maintained and audited in a timely manner.

(b) *Internal Control and Audit*

52. POWERGRID has a comprehensive internal control mechanism in place to verify its accounting and financial management system, adequacy of controls, material checks, and compliance implementation mechanism. Regular internal audits are carried out semi-annually by experienced Chartered Accountant firms in close coordination with POWERGRID's Internal Audit Department to ensure that all checks and balances are in place and all internal controls/systems are in order. The Internal Audit Department also conducts system audits and management audits to confirm the effectiveness of the internal control mechanism. In addition, POWERGRID's Board has an audit committee comprising independent and part-time directors, which meets at least four times a year, and oversees the company's financial management in its entirety.

(c) *Vigilance and Anti-corruption*

53. POWERGRID has an internal Vigilance Department, headed by a Chief Vigilance Officer appointed by the Central Vigilance Commission of India.[24] The Vigilance Department

[23] ADB, 2015. Power System Expansion and Efficiency Improvement Investment Program (Tranche 3).

[24] Pursuant to its Resolution on "Public Interest Disclosure and Protection of Informer" dated April 2004, the Government of India has authorized the Central Vigilance Commission as the "Designated Agency" to receive

provides continuing in-house monitoring and oversight of operations, and has the authority to receive written complaints for disclosure on any allegation of corruption or misuse of office and recommend appropriate action. POWERGRID's internal control and vigilance mechanism will help ensure that any alleged corrupt, fraudulent, collusive, or coercive practices relating to the Project will be redressed appropriately in a timely manner and consistent with the Bank's Policy on Prohibited Practices (2016). In addition, adequate supplementary measures on anti-corruption have been included in the Loan Agreement. The Project tender documents will do the same in the implementation of the Project.

D. Environmental and Social

54. The Bank has decided to use ADB's Safeguard Policy Statement (SPS, 2009), since: (i) it is materially consistent with the Bank's Environmental and Social Policy (ESP) and relevant Environmental and Social Standards (ESS); and (ii) the monitoring procedures that ADB has in place to ascertain compliance are appropriate for the Project. In accordance with ADB's SPS (2009), the Project is classified Category B for Environmental and Involuntary Resettlement, and Category C for Indigenous Peoples.

55. An Initial Environmental Examination (IEE) has been prepared for the Project to assess environmental and social risks and impacts. The IEE includes an Environmental Management Plan (EMP) which addresses environmental and social mitigation and monitoring measures for the Project. The IEE is complemented by a Compensation Plan for Temporary Damages (CPTD). The environmental and social risks and impacts for the Project are moderate, concentrated in the construction phase and can be managed through implementation of the EMP and CPTD.

56. A preliminary survey was carried out for the transmission lines to select the best feasible route from three alternative alignments. Thus, the route has been selected to avoid wildlife sanctuaries, protected and environmentally sensitive areas, human settlements and structures. No physical displacement or land acquisition is required for the transmission lines and towers or construction-phase access roads. An innovative tower design implemented by POWERGRID will reduce the required width of the right of way (RoW) for the 400-kV double-circuit lines from 52 meters to 46 meters. An estimated 20-30 hectares of land designated as forest by the GoI may be affected, for which Borrower shall obtain necessary clearance as per regulations before start of work in forest area along with appropriate mitigation measures.

57. The environmental and social impacts are related to the footings for the transmission towers; RoW areas for stringing the transmission lines; clearing of crops and vegetation, including trees; construction of access roads and borrow pits; and maintenance of the RoW. The EMP and CPTD were prepared to address these issues. The CPTD is based on the general findings of a desk review, preliminary field assessments, and consultations with various stakeholders. It contains guidelines for payment of compensation for damages regarding these impacts. The CPTD will be updated during construction of lines and monitoring reports on compensation plan shall be submitted to the Bank semi-annually by the Borrower.

58. Public participation and community consultations were a part of the Project's environmental and social assessment process. There were three public consultations and several

written complaints for disclosure on any allegation of corruption or misuse of office and recommend appropriate action.

informal group meetings held in the Project area between December 2015 and June 2016, during the preliminary surveys for the transmission line routes. Various types of consultations will continue to be conducted during implementation and operation of the Project. The IEE and CPTD have been disclosed and posted on the POWERGRID's website[25] and the Bank's website.[26] A summary of the CPTD and Entitlement Matrix in English and Tamil will be available in the project area. A Project-level grievance redress mechanism will be put in place, per POWERGRID's Environmental and Social Policy and Procedures (ESPP), relevant national regulations and the provisions of ADB's SPS (2009).

59. Schemes 1 and 3 funded by ADB have been the subject of environmental and social studies consistent with POWERGRID's ESPP and ADB's SPS (2009). These studies did not identify any significant environmental or social risks and impacts and have environmental and social provisions that are like those being used for the Project. The studies also have been subject to public consultation and have been disclosed by POWERGRID and ADB.[27]

E. Risks and Mitigation Measures

60. The Project is classified as low risk, since: (i) the Project area is not located in a disputed territory or international waterway; (ii) POWERGRID's technical and financial management capacity is strong; (iii) there is a sound record of POWERGRID's historical performance in terms of implementing projects financed by various development partners; (iv) due diligence did not identify any major risks; and (v) its environmental and involuntary resettlement category is "B" (and "C" for Indigenous Peoples). Potential implementation risks foreseen are manageable, and appropriate mitigation measures have been considered and incorporated in the Project design. Implementation risks and proposed mitigation measures are summarized in Table 5.

Table 5: Summary of Risks and Risk Management Plan

Risk Description	Assessment	Risk Management Plan / Mitigation Measures
Shortfall in revenue	Low	Due to its business profile, regulated nature of capital expenditure, predictable tariff-based revenues, and full cost recovery in a supportive regulatory environment, the revenue risk is low. Tariff regulations allow cost recovery of regulator-approved cost overruns. The transmission service agreement which covers the payments for transmission charges already exists.
Regulatory changes	Low	The regulatory risk is low. The Project, as a subset of a larger Scheme, has been extensively discussed and well received by various governmental organs and public. Also, related regulatory decisions have been made through a public and transparent process. The possibility of having a sudden and significantly adverse regulatory change in the sector is low.

[25] http://www.powergridindia.com/disclosure
[26] https://www.aiib.org/en/projects/proposed/2016/india-transmission-system.html
[27] https://www.adb.org/projects/44426-016/main#project-documents

Risk Description	Assessment	Risk Management Plan / Mitigation Measures
Environmental and social impact	Low	The environmental and social risks are low. Along certain transmission line segments some trees may be felled below the conductor to facilitate stringing; however, this can be minimized by careful route selection. The field based route surveys that have been conducted, have allowed the proposed routing to avoid protected areas, reserved forests, and human settlements.
Foreign exchange	Low	The foreign exchange risk is low. Above all, most of POWERGRID's long-term debt is denominated in Indian rupees. Also, POWERGRID is permitted to pass through foreign exchange-related costs or losses in the tariff, without further regulatory approval.

ANNEX 1: RESULTS FRAMEWORK AND MONITORING

Project Objective Indicators	Unit	Baseline 2016	Target Values				Data Collection and Reporting		
			2017	2018	2019	2020	Frequency	Data Collection Instruments	Responsibility for Data Collection
Capacity of electricity supply added in Southern Region	megawatt	0	0	0	1,500	4,000	quarterly	Project implementation report	POWERGRID
Project Output Indicators									
Length of 400 kV transmission lines installed	kilometers	0	0	0	500	619	quarterly	Project implementation report	POWERGRID
Number of transmission lines constructed	number of bays	0	0	0	4	5	quarterly	Project implementation report	POWERGRID

ANNEX 2: DETAILED PROJECT DESCRIPTION

A. Background and Rationale

1. India's electricity demand will keep increasing in the coming decades. Although all regions continuously experienced peak power shortages of varying magnitude on an overall basis – from 0.2% in the Western Region to 5.2% in the North-Eastern Region during FY2015/16, there were short-term surpluses depending on the season or time of day. [1] Because peak power demands in different places do not occur at the same time, a more integrated electricity grid will be able to facilitate electricity transfer from surplus to deficit areas, encouraging power trading across regions. It also helps optimize the whole electricity system and improve the generation mix, thereby making it possible to utilize unevenly distributed renewable energy resources. The Southern Region in India has been facing a serious power supply shortage, mainly due to: (i) delay in anticipated generation projects, and (ii) insufficiency of fuel supply for existing gas fired power plants. Some estimates indicate that as of today, the maximum power demand of the Southern Region is about 39 GW. By the end of XIII Plan (2017/18 – 2021/22), power demand in the Southern Region will be about 82.2 GW. Hence, the supply deficit in the Southern region is expected to be extremely severe if nothing is done to address it in the near future.

2. In view of the increasing supply deficit and need for power transfer to meet future requirements, construction of high-voltage direct-current (HVDC) transmission links along with 400 kV AC interconnections is essential and has been initiated. The proposed Project is a subset of a larger sector development scheme, the "HVDC Bi-pole Link between Western Region (Raigarh, Chhattisgarh) and Southern Region (Pugalur, Tamil Nadu) – North Trichur (Kerala)" (the Scheme), which comprises three related smaller schemes to expand the interstate transmission network in western and southern India.

- Scheme 1: a ±800 kV HVDC link from Raigarh (Chhattisgarh, Western Region) to Pugalur (Tamil Nadu, Southern Region).
- Scheme 2: 400 kV transmission segments from Pugalur to five other grid substations in Tamil Nadu.
- Scheme 3: ±320 kV HVDC link from Pugalur (Tamil Nadu) to Trichur (Kerala).

3. The Scheme (Schemes 1-3 combined) will be able to wheel 6.0 GW of electricity from Chhattisgarh and Madhya Pradesh states to the Pugalur Hub substation, and then transmit 4.0 GW of electricity into Tamil Nadu and 2.0 GW of electricity into Kerala. While POWERGRID has already secured financing support for Schemes 1 and 3 (and related substations) from ADB,[2] investment funding for Scheme 2 is urgently needed to maximize the potential benefit of the whole Scheme. As Scheme 2 is designed to handle two-thirds of the total capacity of the Scheme, the economic and financial viability of Scheme 1 (and arguably Scheme 3) will depend on the successful completion of Scheme 2. Therefore, Bank financing is essential and critical to the success of the Scheme.

B. Government Support

[1] Central Electricity Authority, Government of India, 2016. Loan Generation Balanced Report 2016-17.
[2] ADB, 2015. Proposed Loan for Green Energy Corridor and Grid Strengthening Project (Project Number: 44426-016).

4. Governmental institutions showed their strong supports for the implementation of the Scheme on various occasions. The Scheme was discussed and agreed in the 37th and 38th meeting of the Standing Committee on Power System Planning in Southern Region held on July 31, 2014 and March 7, 2015, and in the 26th and 27th meeting of Southern Region Power Committee (SRPC) held on December 20, 2014 and May 12, 2015. Further, the Scheme was discussed and agreed in the Joint meeting of the Standing Committees on Power System Planning of Southern Region and Western Region held on April 20, 2015. The Ministry of Power already approved the Scheme to be implemented by POWERGRID under compressed time schedule through regulated tariff mechanism on December 10, 2014. Being a Navratna Company, POWERGRID Board can approve its project under the delegated powers.[3]

C. Project Description

61. The proposed Project covers the construction of five transmission lines in Tamil Nadu, including:

(i) Pugalur HVDC substation – Pugalur substation (existing) 400kV double-circuit (quad) line

The Pugalur (Karur) substation is an existing substation of POWERGRID with 400kV connectivity to Madurai, Karaikudi, Kalivandhapattu and Neyveli substations. The Pugalur substation helps extend the power supply to Erode, an urban area of Tamil Nadu. In addition to meeting the growing electricity demand of the region, the proposed line will help anchor the proposed HVDC system and contribute to the short circuit level required for stable operation of HVDC.

(ii) Pugalur HVDC substation – Arasur substation 400kV double-circuit (quad) line

The Arasur substation, located in the Coimbatore area, is integrated with the grid through 400kV double-circuit lines from Mettur and Udumelpet. The Arasur substation currently has transformation capacity of 630 MVA. To meet the growing power demand in the region, the addition of 1x500 MVA transformer has already been approved and is under implementation. The proposed line will increase electricity transfer capacity to the Arasur substation and relieve load pressure on the 400kV line between the Madurai and the Udumelpet substations.

(iii) Pugalur HVDC substation – Thiruvalam substation 400kV double-circuit (quad) line

The Thiruvalam substation is an important 765/400kV substation in Tamil Nadu, through which the major portion of the loads in Tamil Nadu is fed. The Thiruvalam substation is currently connected through eight 400kV lines and two 765kV lines, and has 765/400kV transformation capacity of 3,000 MVA. Through linking the Pugalur substation and Thiruvalam substations, two important transmission corridors, such as the 800kV HVDC link from Raigarh to Pugalur and the 765 kV AC link from Kurnool to Thiruvalam, can be interconnected, thus strengthening the reliability of electricity supply in the Southern Region.

[3] Navratna-status public sector undertakings may invest up to less than (i) Rs10 billion or (ii) 15% of net worth on a single project or 30% of net worth in a single year, without having to seek the government's permission.

(iv) Pugalur HVDC substation – Edayarpalayam substation 400kV double-circuit (quad) line

The Edayarpalayam substation is a new substation currently under implementation by the Tamil Nadu State Electricity Board to cater to the increasing electricity demand in the area. The proposed Pugalur HVDC substation – Edayarpalayam substation 400kV double-circuit (quad) line will feed the Edayarpalayam substation.

(v) Edayarpalayam substation – Udumulpet substation 400kV double-circuit (quad) line

The Udumulpet substation has a transformation capacity of 945 MVA and provides electricity to Udumulpet and surrounding areas. It connects substations at Madurai, Salem, Tirunelveli and Palakkad, and acts as a major gateway of electricity supply to Kerala. Currently, the existing Madurai – Udumulpet 400kV line is heavily loaded. The proposed 400kV double-circuit (quad) line will act as additional feed, and help reduce the heavy load of the existing Madurai-Udumulpet 400kV line. In addition, the two transmission lines together (Pugalur HVDC – Edayarpalayam – Udumulpet) will enhance the feeding capacity to Kerala through the Udumulpet – Palakkad 400kV double-circuit transmission line.

D. System Design and Equipment Selection

5. POWERGRID has developed in-house technical capabilities and computer aided facilities for planning, design, and O&M of transmission systems. Before planning a transmission line, various system studies, such as load flow, system stability and short-circuit, are undertaken with considerations of the existing system, present and future load flow requirements, and minimum redundancy required. Also, design studies are undertaken for selection of major system and equipment parameters for transmission systems, keeping in view the current trend in technology development. The conductors are selected based on a balanced consideration of internal resistance and external effects. The bus bar materials, clamps and connectors are chosen in terms of stringent international standards to keep the transmission loss at the lowest level. The reactors and switchgears are also selected to minimize future operational losses.

6. A walk-over survey has been conducted for the proposed transmission lines by POWERGRID. Types of terrain, forest stretches, and crossings of power lines, road and rivers to be encountered by the proposed transmission lines have been taken into consideration when estimating the quantities of equipment and materials and the required length of transmission lines.

E. TECHNOLOGY ISSUES

(i) Salient features of 400 KV Substation Equipment and facilities

7. The design and specification of substation equipment will be based on the following factors:

a. Insulation Coordination

8. Insulation Coordination is a series of steps used to select the dielectric strength of equipment in relation to the operating voltages and transient overvoltages which can appear on the system for which the equipment is intended. Under the Project, the 400 kV system will be designed to limit the switching overvoltage to 2.5 per unit (p.u.) and is expected to decay to 1.5 p.u. in 5 to 6 cycles. To control the steady state, transient and dynamic overvoltage to specified levels, compensation equipment will be provided.

b. Steady State Stability

9. Steady state stability is the ability of a system to return/remain in a state of equilibrium when subjected to small or gradual changes of disturbances. The steady state stability limit is the maximum power that can flow through some lines in the system when the entire or part of the system is subjected to a small disturbance without loss of its stability. Steady state stability is usually quantified by measuring the relative angular displacement (also called as swing curve) between the two buses (nodes) in a network when a small disturbance occurs somewhere in the system.

10. In an integrated power system consisting of large number of generators, load and line etc., a maximum relative angular separation of about 30 degrees between the two buses may be assumed to be acceptable (safest) limit for maintaining the steady state stability of the system. Angular separation for different alternatives has been studied and found to be in order.

c. Switching Schemes

11. The following switching schemes have been considered in various substations:

Substation	**400kV side**
400 kV SS PUGALUR SS-Extension	One & Half breaker
400 kV SS ARASUR SS-Extension	One & Half breaker
400 kV SS THIRUVALAM SS-Extension	One & Half breaker
400 kV SS UDUMULPET SS-Extension	One & Half breaker
400 kV SS EDAYARPALAYAM SS-Extension	One & Half breaker
400 kV SS PUGALUR HVDC SS	One & Half breaker

d. 400 kV Substation Equipment

12. *Circuit breakers*. Circuit breakers will in general comply with IEC 62271-100 & IEC-60694 and will be of SF6 Type. The rated break time will not exceed 40 millisecond (ms) for 400kV circuit breakers. Circuit breakers will be provided with single phase and three phase auto reclosing. The circuit breakers controlling 400 kV lines wherever required will be provided with pre-insertion closing resistor of about 400 ohms with 8 ms insertion time for 400kV. The short line fault capacity will be the same as the rated capacity and this is proposed to be achieved without use of opening resistors.

13. *Isolators*. The isolators shall comply to IEC 62271-102 in general. Isolators shall be horizontal/ double/vertical break/ pantograph type keeping in view the bus switching schemes proposed. Isolators shall be motor operated. Earth switches are provided at various locations to facilitate maintenance. Main blades and earth blades shall be interlocked and interlock shall be fail safe type. All earth switches shall be motor operated type.

14. *Current transformers*. Current transformers shall comply with IEC 60044-1 in general. All ratios shall be obtained by secondary taps. They shall have six secondaries for 400 KV and 765 kV. The burden and knee point voltage shall be in accordance with the requirements of the system, including possible feeds for telemetry.

15. *Capacitor voltage transformers (CVT)*. Voltage transformers shall comply with IEC 60044-2 in general. These shall have three secondaries, out of which two shall be used for protection and one for metering. The voltage transformers on lines shall be suitable for Carrier Coupling. The capacitance of CVT shall be 4400/6600/8800 pF depending on the requirements of power line carrier communication (PLCC).

16. *Surge arresters*. Station class current limiting, heavy duty gapless type surge arresters conforming to IEC 60099-4 in general shall be provided. The rated voltage of Surge arrester and other characteristics are chosen in accordance with system requirements. Surge arresters shall be provided near line entrances, to achieve proper insulation coordination. These shall be fitted with pressure relief devices and diverting ports suitable for preventing shattering of insulator housing providing path for the flow of rated currents in the event of arrestors failure. The switchgear shall be designed and specified to withstand operating conditions and duty requirements.

17. *Shunt reactors*. Shunt Reactors, wherever provided, shall comply to IEC:289/IS:5553 in general. 400 kV shunt reactors shall have linear characteristics up to 1.5 p.u. voltage. These should be Oil-Natural-Air-Natural Cooled. The neutral of line reactors shall be grounded through adequately rated neutral grounding reactors to facilitate single phase recloser against trapped charges. The neutral of 400 kV class shunt reactors shall be insulated to 550 kV peak for lightning impulse and shall be protected by means of 145 kV Class surge arresters.

e. Substation Support facilities

18. Certain facilities required for O&M of substations as described below shall be provided in new substation and in existing substation they have already been provided and they would be extended, wherever required.

19. *AC & DC power supplies*. For catering to the requirements of three-phase and single-phase AC supply and DC supply for various substation equipment, the following arrangement is envisaged:

i) At each new substation, one 800 kVA 33/0.415 kV LT transformer shall relate to SEB supply and one with tertiary of 400/132/33kV transformer.

ii) 2 Nos. batteries of 220 V for control & protection and 2 Nos. 48 V batteries for PLCC would be provided at each new substation. Each battery would have a boost and trickle charger.

iii) Suitable AC & DC distribution boards and associated LT switchgear would be provided at each new substation.

20. *Firefighting system*. Firefighting system in general conforms to fire insurance regulations of India. The firefighting system is proposed with both AC motor & diesel engine driven pumps. Automatic heat actuated emulsifying system is proposed for transformers & reactors. In addition, for alarm system based on heat/smoke detectors are proposed to be installed at sensitive points in a substation, e.g. Cable Vault, Main Control Room, MCC Room etc. Further, adequate water hydrants and portable fire extinguishers shall be provided in the substations.

21. *Oil evacuating, filtering, testing & filling apparatus.* To monitor the quality of oil for satisfactory performance of transformers, shunt reactors and for periodical maintenance necessary oil evacuating, filtering, testing and filling apparatus would be provided at new substations. Oil tanks of adequate capacities for storage of pure and impure transformer oil would be provided.

22. *Lighting and communication*. Adequate normal and emergency AC & DC lighting shall be provided in the control room of the substation. The switchyards shall also be provided with adequate lighting. A telephone exchange of 24 lines shall be provided at new substations as a means of effective communication between various buildings of the substation.

23. *Control room*. A substation control room would be provided to house station level control along with its peripheral telemetry equipment and recording equipment, AC & DC distribution boards, DC batteries, etc. Air conditioning will be provided in the building as functional requirements.

f. Protection & Control

24. The substations shall be provided with control, relaying & monitoring functions along with substation automation system based on IEC 61850 protocol using fiber optic network. The communication with adjacent connected substations shall be through PLCC and digital protection through optical fiber composite ground wire (OPGW).

25. The state-of-art protection system based on numerical technology has been provided to minimize the damage to equipment in the event of fault for Transformers, Reactors, Transmission lines and Bus bars. These protective relays have self-diagnostic feature and conform to the latest IEC 61850 for communicating the detailed list of events recoded by these relays in the event of fault or any abnormal conditions. Normally all these relays are equipped with in-built fault recorder which can record the analogue as well as digital information for analysis of fault.

26. *Transmission lines*. 400kV lines shall have MAIN-I protection and shall also have numerical distance protection scheme carrier as three-zone distance type with carrier aided inter-tripping feature. All lines shall also have MAIN-II protection which shall have numerical distance protection scheme like Main-I but from a different make than that of MAIN-I.

27. They will also be provided with two stages of over voltage protection. Further, all lines shall be provided with single- and three-phase auto-reclosing facility to allow reclosing of circuit breakers in case of transient faults.

28. These lines will also be provided with distance to fault locators to identify the location of fault on transmission lines.

29. *Auto transformers and reactors*. Auto transformers and reactors shall be provided with the following protections: (i) differential protection, (ii) restricted earth fault protection, and (iii) back-up impedance protection. Besides, these reactors shall also be provided with Bucholz relay, protection against oil and winding temperatures and pressure relief device.

30. *Protective relaying system*. The protective relaying system proposed to be provided for transmission lines, auto-transformers and bus bars to minimize the damage to the equipment in the events of faults and abnormal conditions, is addressed in this section.

31. *Bus bar protection*. The high-speed bus bar differential protection which is essential to minimize the damage and maintain system stability at the time of bus bar faults shall be provided for 400/220 kV buses. The bus bar protection scheme shall be such that it operates selectively for each bus and incorporate necessary features required for ensuring security. The scheme shall have the provision for future expansion.

32. *Local breaker back-up protection*. This shall be provided for each of 400/220 kV breakers and will be connected to de-energize the affected stuck breaker from both sides.

33. *Time synchronization equipment*. Time synchronization equipment complete in all respect including antenna, cable, processing equipment required to receive time signal through global position system or from National Physical Laboratory through Indian National Satellite shall be provided.

34. *Substation automation system*. For all the new substations, state-of-art substation automation system conforming to IEC-61850 shall be provided. The distributed architecture has been used for Substation Automation system where the controls are provided through bay control unit and bay control units are provided bay wise for voltage level 400 kV and above. All bay control units as well as protection units are normally connected through an optical fiber high speed network. The control and monitoring of substation elements such as circuit breaker, disconnector, resetting of relays etc. are being done through Human Machine Interface from the control room. The substation automation system is equipped with the facility of remote operation. By providing remote Human Machine Interface and suitable communication link, the substation can be controlled from a remote location. The functions of control, annunciation, disturbance recording, event logging and measurement of electrical parameters shall be integrated in Substation Automation System. The substation automation system shall be provided with the facility of communication and control for remote end operation.

g. Power Line Carrier Communication (PLCC)

35. PLCC equipment for speech transmission, line protections, and data channels shall be provided on each transmission line. The protections for transmission line and the line compensating equipment shall have full back up communication channels. The PLCC equipment shall include the following:

(i) Coupling device, line traps, digital/analog carrier terminals, protection couplers, high frequency cables, trunk selectors, automatic exchange, and maintenance and testing instruments. Coupling devices shall be suitable for 4400/6600/8800 pF for 420 kV CVTs for phase to phase coupling. The pass band of coupling devices shall have sufficient margin for adding communication channel in future if required. Necessary protection devices for the safety of personnel and low voltage part against power

frequency voltages and transient over voltage shall also be provided. The line traps shall be broad band tuned suitable for blocking the complete range of carrier frequencies.

(ii) The line trap shall have the necessary protective devices such as lightning arresters for protection of the tuning device and shall be equipped with corona rings. A decoupling network consisting of line traps and coupling capacitors may also be required at certain substations in case of extreme frequency congestion.

h. Control Concept

36. All the high-voltage breakers in substation/switching stations shall be controlled and synchronized from the switchyard control room / remote control centre. Each breaker would have two sets of trip circuits which would be connected to separately fused DC supplies for greater reliability. All the isolators shall have remote/local control whereas the earth switches shall have local control only.

(ii) Salient Features of Transmission Lines

37. The primary consideration for design and estimation of the transmission line is a walk over survey, which is based upon topographical map/forest map of India. Type of terrain, forest stretches, crossings etc. to be encountered by the transmission line have been taken into consideration while estimating the quantities.

38. *Wind zone*. The weight of tower will vary in an ascending order from wind zone 1 to wind zone 6 as the transverse load on the tower considered owing to the wind pressure increases in the same pattern. The identification of wind zone is based on the wind zone map given in IS: 875 (part-I) 1987 and the experience in the region. The transmission lines fall under wind zone 2 (39 m/s) as per IS: 875 and it shall be designed accordingly.

39. *Design criteria*. The design parameters proposed to be adopted for the transmission line are generally based on the report of the standardization committee of CEA and stipulations of relevant Indian Standards. Quad bundle conductors have been considered for the design of transmission lines as per requirements of the identified system.

40. *Line configuration*. The 400 kV double-circuit lines shall have vertical configuration of Towers.

41. *Towers and Foundations*. Self-supporting latticed bolted steel towers, fabricated from structural steel angle section shall be used. Tower components and bolts & nuts shall be hot-dip galvanized.

42. Normally, the following four types of double circuit tower shall be used in these lines.

- DA type suspension towers for up to 2 degree angle of deviation.
- DB type tension towers for up to 15 degree angle of deviation.
- DC type tension towers for up to 30 degree angle of deviation.
- DD type tension towers for up to 60 degree angle of deviation and suitable for dead end condition. These may also be used for terminal locations.

43. The standard extension normally used for various types of towers are as follows:

- DA & DD : 3m, 6m, 9m, 18m, 25m

- DB & DC : 3m, 6m, 9m

44. In addition to the above, special towers, for major river crossing, power line crossing and the places where the terrain is particularly different, such as approach to the sub-station, forest stretches etc. shall also be used. All towers shall be designed in accordance with latest edition of IS-802 and considering necessary improvements and reinforcements evolved as per suggestions/recommendations of CEA's expert committee based on the experience of previous tower failures in the country.

45. Structural steel sections used in towers shall be of High Tensile steel & Mild Steel of requisite quality as per IS-2062 or equivalent International Standards.

46. Tower foundations are generally pad & chimney type and typically classified as Dry, Wet, Partially Submerged, Fully Submerged, Wet Black Cotton, Sandy, Dry Fissured Rock, Wet Fissured Rock, Submerged Fissured Rock, Hard Rock etc., depending upon type of soil encountered and designed accordingly based on relevant Indian standards and guidelines. For river crossing locations and soils having poor bearing capacity, wherever required, pile/well type foundations are used.

47. Types of soil encountered by the transmission lines are generally mixed dry, wet, wet black cotton type in the plain terrain and dry fissured rock, wet fissured rock and hard rock in the hilly terrain. The requirements of the foundations are considered in accordance with the type of soil.

48. *Revetment and benching*. For hilly and undulating stretch, wherever the line is passing through, revetment and benching shall be provided as per site conditions.

49. *Conductors*. Conventional Aluminum- Conductor Steel-Reinforced (ACSR) type conductors have been considered based on system requirements as these are most common type of conductors with proven technology having low cost & easy availability.

50. For 400 kV DC lines (quad), aluminium-conductor-steel-reinforced 'MOOSE' conductors (54/3.53 Aluminium and 7/3.53 mm steel) of overall diameter 31.77 mm will be used per phase. The sub-conductor spacing will be 457 mm.

51. *Earth wire/OPGW*. One 7/3.66 mm galvanised steel earth wire shall be used on the line so that it can withstand two successive lightning stroke of 150 kA. Shielding angles of 20 degrees is considered for the transmission line. OPGW will be used to meet the requirements of Power System Communication. Optical fiber technology provides an efficient telecommunication network to support various applications requiring higher speed and bandwidth.

52. *Grounding*. The tower footing resistance shall be kept below 10 ohms. Pipe type or counterpoise earthing shall be used to bring the tower footing resistance down to acceptable level.

53. *Insulator and hardware fittings*. High strength glazed electro porcelain / toughened glass disc insulators shall be used. Suitable hardware fittings shall be used for attachment of the insulators with the tower at one end and for supporting the conductors at the other end. Corona control rings or grading rings will be used for improving corona and radio influence voltage performance as well as to improve the voltage distribution across the insulators discs.

The voltage across any disc shall not exceed 9 % in case of suspension type and 10 % in case of tension type of the line to earth voltage. This will reduce aging and minimize radio interference.

(iii) Line Accessories

54. *Mid span compression joint for conductor/earth wire*. Mid span compression joint suitable for conductor/ earth wire shall be used for joining two lengths of conductor / earth wire. The minimum slipping strength of the joint after compression shall not be less than 95 % of the ultimate tensile strength of conductor / earth wire.

55. *Repair sleeve for conductor*. Repair sleeve shall be used only for repairing not more than two strands broken in the outer layer of conductor. It shall be of compression type in two parts with provision of seat sliding of keeper piece.

56. *Flexible copper bond for earth wire*. Flexible copper bonds shall be used for good electrical continuity between the earth wire and the tower. Two bonds per suspension tower and four bonds (two for each earth wire) per tension tower shall be used.

57. *Vibration damper for earth wire*. Stockbridge vibration dampers shall be used to reduce the maximum dynamic strain caused by aeolian vibrations to a value of 150 micro-strain.

58. *Spacers and spacer damper*. Quad bundle spacers shall be used for the Twin bundle lines respectively to reduce vibrations and maintain sub-conductor spacing under all working conditions. Quad bundle rigid spacer for jumpers shall be used at all tension towers.

59. *Suspension and tension clamps for earth wire*. Suitable suspension/tension clamps shall be used for attachment of earth wire at suspension/tension towers.

60. *T-connectors*. Compression type T-connectors shall be used for conductor jumpering at transposition towers wherever required.

61. *River crossings*. Special towers shall be used for major river crossings where the span is more than 600 meters with anchor towers on either end of river crossing span.

62. *Power line, railway line, road and telegraph line crossing*. The transmission lines will be crossing power lines, railway, roads, and telegraph lines for which suitable extensions of towers will be used.

63. The standard extension normally used for various types of towers are as follows:

- A/DA & D/DD : 3m, 6m, 9m, 18m, 25m
- B/DB & C/DC :3m, 6m,9m

64. In addition to the above body extension, suitable leg/chimney extensions will also be provided in the hilly terrain, wherever required, to reduce benching.

F. Project Management

65. The Project will be planned, implemented, monitored and controlled through the Integrated Project Management and Control System. This system uses program evaluation and

review technique and critical path method as the basic management tool. For effective project planning and review, a three-tier level of planning and review has been adopted.

a. Level I

66. Planning is done by the Corporate Monitoring Group, a central planning cell, which is in the form of an overall project schedule called the Master Network which forms the basis for all subsequent planning and monitoring of the activities. This covers broadly all the project packages and indicates activities of engineering, contracts, manufacturing, erection and commissioning. The Master Network is prepared using computerized techniques which subsequently helps in comparing the actual progress of the Project with the scheduled progress. This gives an indication of likely critical areas and helps in preventing the same, thereby resulting in smoother implementation. The Master Network also acts as a source for the planning to be done at Level-II and Level-III.

b. Level II

67. Planning is done package-wise and is finalised with the respective contractor/vendor during the pre-award stage. Level II networks are made within the milestones identified in the project Master Network (L-I).

c. Level III

68. Plans have elaborate schedules and weekly/monthly rolling plans which are prepared for engineering, supply and field activities. These form the basis of monitoring by the various functions.

69. The system envisages monthly review of the level II programs with contractors and at field level on a weekly basis. A site monthly progress report is sent to the head office having four sections, i.e.

(i) Project completion trend
(ii) Salient achievements for the month
(iii) Program for next month
(iv) Areas needing attention of top management

G. Project Implementation Review

70. POWERGRID has a team of dedicated experts in the field of substation and transmission line engineering, equipped with state-of-the-art technology, software capabilities and computer aided facilities for planning, design, and O&M of transmission systems. It has a well-established system of continuous feedback from the field and upgrades the system accordingly.

71. POWERGRID has developed a project monitoring system matching the organization structure, complexity/intricacies involved in project implementation and management information system. The system calls for increasingly detailed planning in all facets of functioning, such as engineering, contracts, sites and corresponding levels of monitoring and control, to generate a management summary report to the top management. This management summary report highlights project completion trends, and actions being taken/to be taken for the attention of the top management on an exceptional basis for critical areas.

72. Further, the monitoring system envisages a regular total project review called project review meeting. This review meeting is headed by the regional in-charge with representation from all functions, viz. Contracts, Engineering, Field, Personnel, Finance, Corporate Monitoring Group, etc. The participants discuss project critical, project interface problems and project completion trends, etc.

73. The project review meeting emanates a status report and an exception report provided to the Chief Executive and Directors, which highlights extremely critical areas needing immediate attention and assistance required. Once in three months the project review meeting is held at the Corporate Centre. These discussions help in identifying the critical areas and seeking decisions for speedy project implementation.

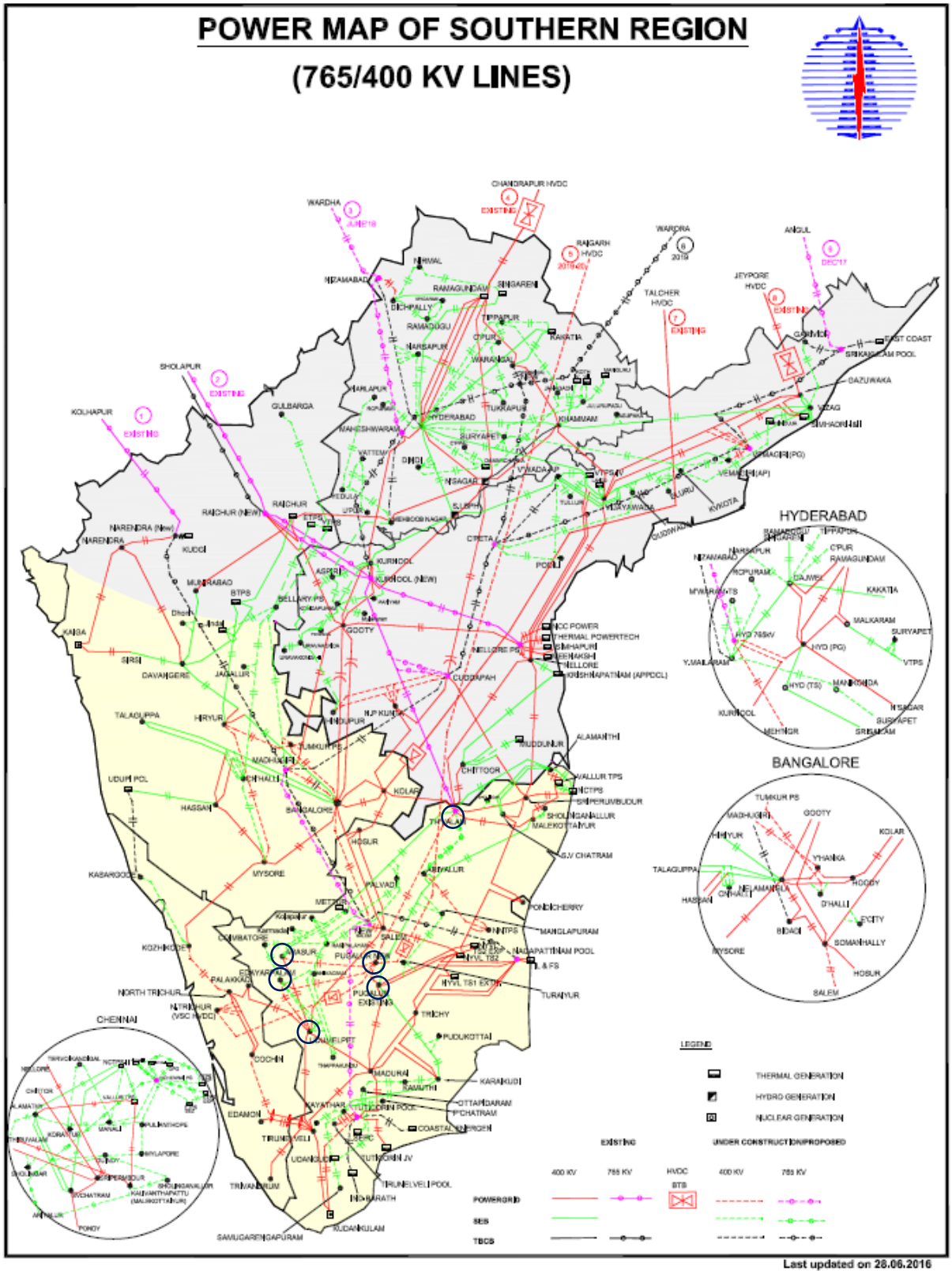
H. Technical Due Diligence Findings

74. Construction of the transmission lines will not only strengthen the regional grid but also facilitate electricity transfer to Kerala. A map showing transmission lines in the Southern Region is included in Appendix below. The six substations to be connected by the proposed transmission lines are encircled on the map.

75. The Project is adequate to transfer electricity to the respective destinations with reliability and security. Technical due diligence was conducted based on: (i) project proposal and feasibility study; (ii) studies on present and future load requirement of the Southern Region; (iii) discussions with planning and design engineers of POWERGRID; and (iv) findings from site visits. POWERGRID has a proven record in financing and implementing large and difficult transmission projects in the past, including those financed by development partners.[4] It has been using sophisticated techniques and state-of-the-art technology in the O&M of its assets, which are normally above 99% availability level. Its systems and procedures are revised periodically to keep abreast with the development of technology and international standards.

76. The Project faces no significant technical risk. This is because, first, the interventions supported under the Project are well established in India and other countries. Second, POWERGRID has strong in-house technical capacity and computer-aided facilities for planning, design, and O&M of the transmission systems. Third, the project design has balanced considerations of the present and future load requirements and bare minimum redundancy required in the Southern Region. Fourth, before project design, various system studies, such as load flow, insulation coordination, steady state stability, switching schemes, protection and control, line configuration, and towers and foundations, had been undertaken for selection of major system and equipment parameters. Fifth, selection of equipment and materials has considered the present trend in technology development and the need to minimize the transmission losses.

[4] Two projects are listed here as examples. Asian Development Bank, 2015. Green Energy Corridor and Grid Strengthening Project. Manila, Philippines; World Bank, 2009. Fifth Power System Development Project. Washington DC, US.



Note: The encircled substations are those to be connected by the Project.

ANNEX 3: ECONOMIC AND FINANCIAL ANALYSIS

1. This annex comprises three parts: (i) the economic analysis of the Project investments; (ii) the financial analysis of the Project investments; and (iii) the financial assessment of the implementing agency.

I. Economic analysis

2. **Sector overview.** India's power sector is facing dual challenges of sustaining the country's rapid economic growth of at least 7% per annum while maintaining affordable power supply to the people. In 2013, India's per capita electricity consumption stood at 783 kWh, about a quarter of the global average.[1] Home to 18% of the world's population, the country consumes only 6 percent of the world's primary energy. With rising per capita consumption, demand for electricity is bound to grow rapidly. In the meantime, access remains an issue with 280 million people yet to be connected to the grid, and those connected facing frequent disruptions.[2] Still a lower middle income country, India is undergoing unprecedented urbanization further aggravating the already serious electricity supply shortage. Recognizing these challenges, the GoI is undertaking a suite of initiatives scaling up investments in power generation, transmission and distribution while investing in efficiency improvements and system loss reduction.[3]

3. India's national grid consists of five regional systems. Although all five regional systems experience varying degrees of shortages during peak hours of demand, time of occurrence of regional deficits varies across the systems – while one system is in deficits, another could be experiencing a temporal surplus.[4] Synchronous interconnectivity has been limited across regions, especially to the south. A more integrated power grid will help direct power flow from surplus areas in the west to shortage areas in the south while promoting intra- and inter- regional power trades. A better integrated grid will also have positive effects on overall system optimization, resource utilization and generation mix.

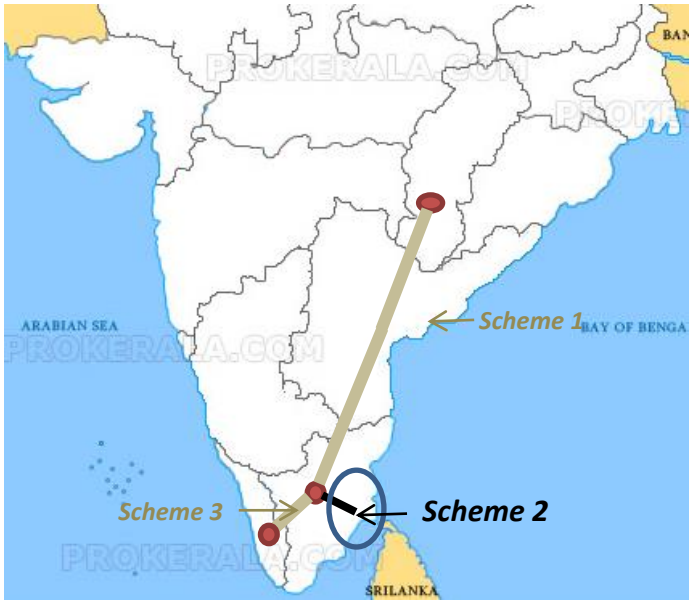
4. The "HVDC Bi-pole Link between Western Region (Raigarh, Chhattisgarh) and Southern Region (Pugalur, Tamil Nadu) – North Trichur (Kerala)" Scheme is designed to expand the interstate transmission capacity in the Southern Region. It comprises three parts:

- *Scheme 1*: a ±800 kV HVDC link from Raigarh (Chhattisgarh, Western Region) to Pugalur (Tamil Nadu, Southern Region)
- *Scheme 2*: 400 kV transmission segments from Pugalur to five other grid substations in Tamil Nadu; and
- Sc*heme 3*: ±320 kV HVDC link from Pugalur (Tamil Nadu) to Trichur (Kerala).

[1] 3,026 KWh per year according to International Energy Agency, 2015. Key World Energy Statistics 2015. Paris, France.
[2] World Bank, 2016, World Development Indicators: Energy and Mining.
[3] Government of India, Planning Commission. 2013. Twelfth Five Year Plan (2012-2017). New Delhi, India.
[4] Central Electricity Authority, Government of India, 2016. Loan Generation Balanced Report 2016-17.

Figure A3.1

The "HVDC Bi-pole Link between Western Region (Raigarh, Chhattisgarh) and Southern Region (Pugalur, Tamil Nadu) – North Trichur (Kerala)" Scheme



5. The overall Scheme will be capable of wheeling 6.0 GW from Chhattisgarh and Madhya Pradesh to the Pugalur hub through *Scheme 1*, and then 4.0 GW from Pugalur to Tamil Nadu through *Scheme 2*, and 2.0 GW to Kerala through *Scheme 3* to alleviate the power shortage situation in the Southern Region.

6. **The proposed Transmission System Strengthening Project** will finance the 400 kV transmission segments under *Scheme 2* while POWERGRID has secured financing for the segments under *Schemes 1* and *3* from ADB. As *Scheme 2* will serve two-thirds of the total load of the entire Scheme, the economic viability of the linked *Scheme 1*, and to a certain extent, that of the parallel *Scheme 3*, will thus depend on the completion of *Scheme 2*. Bank financing is thus essential and critical in the success of the overall Scheme.

7. **Demand analysis.** The Southern Region has been facing severe power supply shortages primarily due to (i) delay in anticipated power generation projects, such as the Krishnapattam Ultra-Mega Power Plant (4,000 MW), Cheyyur Ultra-Mega Power Plant (4,000 MW), and independent power plant projects in Nagapatanam and Cuddalore area (3,000 to 4,000 MW); and (ii) insufficiency of fuel supply for existing gas fired power plants. Peak demand in the region stands around 41 GW, and is projected to double by the end of the XIII Plan (2017/18 – 2021/22), exacerbating the regional supply deficit situation in the coming years. The demand projection is based on the 18th Electric Power Survey carried out by the Central Electricity Authority along with actual system information in 2015/16. Demand is assumed to grow at a declining rate till 2020, and stay constant thereafter.

8. **Least-cost analysis**. An alternative to the proposed transmission lines is to construct new power plants within the Southern Region. Given the country's predominantly coal-weighted generation mix, the alternative plants are assumed to be coal-fired. An analysis of comparable coal-fired plants in the region suggests that the incremental levelized cost of supply

from new coal-fired plants is around Rs 1.4 per kWh whereas that from the proposed solution is around Rs 0.8 per kWh. Moreover, due to resources constraints, constructing new coal-fired plants in the region may not be technically feasible. POWERGRID has also confirmed that the proposed solution is both lower-cost and technically superior.

9. **Cost-benefit analysis and key assumptions.** Two cost and benefit analyses were carried out, one for the overall Scheme (*1*, *2* and *3*), and another for *Scheme 2* alone while treating it as a marginal addition to the existing HVDC investments on *Scheme 1* and *3*.[5] Both analyses were carried out over a project lifetime of 25 years exclusive of the construction period. A social discount rate of 12.0% was used.

10. **Economic costs**. All project costs are expressed in domestic currency and in constant 2016 prices, excluding financial charges, transfer payments and price contingencies, adjusted for various degrees of market distortions: (i) traded goods valued at the border prices in domestic currency with a shadow exchange rate factor (SERF) of 1.03; (ii) non-traded goods valued at their domestic prices; (iii) skilled labor valued at actual wage; and (iv) unskilled labor with a shadow wage rate of 0.75 of market wage to adjust for market oversupply and extensive underemployment in India.[6] The O&M cost is assumed at 1.5% of the capital investment, in line with international experience and the CERC's typical benchmarks. Moreover, the cost of power supply will be based on coal-fired generation from the north.

11. **Economic benefits.** Without the investment in the o*verall Scheme* (*1*, *2* and *3*), unserved demand in the Southern Region would increase to an estimated 10 GW and 5,300 GWh by 2021, the expected year of commissioning of the Project. It has been assumed that, without the Project, a small proportion of this demand would be served by alternative energy sources, such as kerosene for domestic lighting assumed at 1% of the domestic demand (16 GWh in 2021, increasing to 46 GWh by 2024) and diesel for non-residential standby generation assumed at 10% of non-domestic demand (369 GWh in 2021, increasing to 1,047 GWh by 2024). The costs of kerosene and diesel fuels were based on the World Bank's projections for international crude oil prices, converted to their border price-equivalent values with appropriate SERF adjustments. Thus, the levelized cost was estimated at Rs 41.2 per kWh for kerosene lighting, and Rs 21.3 per kWh for diesel-based standby power generation. With the investment in the Scheme, these alternative power sources will be displaced by grid-based power supply. Moreover, the investment will also enable additional power supply to meet unserved demand of 4,908 GWh in 2021 to 13,944 GWh by 2024. To be conservative, the willingness-to-pay for the incremental demand served is assumed at the weighted average cost of supply to the southern system at Rs 5.0 per kWh plus a 10% wheeling charge. Besides the above-mentioned benefits, the proposed Project will also have positive, however less tangible, effects on the generation mix, system dynamic and transient stability, operational flexibility and local income generation, none of which is quantified in this analysis.

12. *Scheme 2* on the margin will enable two-thirds of the abovementioned incremental and non-incremental benefits of the *Overall Scheme*.

13. **Outcome of the economic analysis**. The economic internal rate of return (EIRR) of the overall Scheme (*1*, *2* and *3*) is estimated at 14.4% over a project lifetime of 25 years,

[5] The analysis on the whole Scheme was carried out by ADB for the appraisal of HVDC investment, including Schemes 1 and 3.
[6] Values of SERF and the shadow wage rate are cited from other recently approved projects in India.

exceeding the economic opportunity cost of capital of 12.0%. Therefore, the investment in the overall scheme is economically justified.

Table A3.1: EIRR of the Overall Scheme (1, 2 & 3)

Year	**Costs** (Rs million)			**Benefits** (Rs million)		Net benefit
	Investment	Supply	O&M	Incremental	Non-incremental	
2016	7,375					(7,375)
2017	22,628					(22,628)
2018	44,779					(44,779)
2019	71,490					(71,490)
2020	25,232					(25,232)
2021	28	20,002	2,573	24,540	8,515	10,452
2022		31,400	2,573	38,524	14,527	19,078
2030		56,826	2,573	69,718	30,014	40,333
2040		56,826	2,573	69,718	30,014	40,333
					EIRR	**14.4%**

14. Moreover, when evaluated on the margin, the project investment, i.e., *Scheme 2* alone has an estimated EIRR of 47.2% well exceeding the economic opportunity cost of capital of 12.0%. Therefore, the Project investment is economically justified.

Table A3.2: EIRR of Scheme 2 as a Marginal Addition to Schemes 1&3

Year	**Costs** (Rs million)			**Benefits** (Rs million)		Net benefit
	Investment	Supply	O&M	Incremental	Non-incremental	
2017	1,922					(1,922)
2018	9,608					(9,608)
2019	6,533					(6,533)
2020	1,125					(1,125)
2021	28	13,335	288	16,360	5,677	8,386
2022		20,933	288	25,683	9,685	14,146
2030		37,884	288	46,479	20,009	28,316
2040		37,884	288	46,479	20,009	28,316
					EIRR	**47.2%**

15. *Sensitivity analysis*. Sensitivity analyses were carried out to examine the robustness of the overall Scheme's economic viability under the following adverse scenarios (i) 15% increase in capital costs; (ii) 15% increase in O&M costs; (iii) 1 year delay in commissioning; and (iv) all three adverse scenarios combined. In all cases, the resulting EIRRs are larger than the economic opportunity cost of capital of 12%, indicating the robustness of the economic viability of the investment in the overall Scheme.

Table A3.3: Sensitivity Analysis

Sensitivity parameter	Variation (%)	EIRRs
Base case		14.4%
1. Capital costs increase	+15%	12.9%
2. O&M increase	+15%	14.3%
3. Implementation delay	+ 1 year	14.0%
4. All combined		12.4%

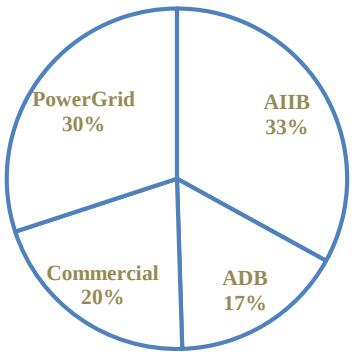
16. **Conclusion**. The economic analysis confirms that the overall Scheme of which the Project investment is a part is both the least cost solution and economically viable. Sensitivity analysis suggests that the conclusion is robust. When evaluated on the margin, the economic justification for the Project investment in Scheme 2 is highly robust.

II. Financial analysis

17. The proposed Project has a total estimated financial cost of US$303.5 million.

18. The Financing mix comprises: (i) a US$100 million loan from the Bank; (ii) a US$50 million loan from ADB; (iii) a commercial loan of approximately US$62 million, leaving (iv) US$91 million or 30% of the total investment to be financed by the equity from POWERGRID.

Figure A3.2 Financing Mix



19. *Cost of financing.* The loans from the Bank and ADB are US dollar-denominated and LIBOR-based plus an effective lending spread. The fixed swap rate for an ADB US dollar-denominated loan with a 20-year tenure currently stands at 2.70% per annum.[7] The AIIB loan has a similar pricing scheme with a slightly higher lending spread. For the domestic loan, a yearly rate of 10.5% is used based on the prevalent lending rate decided by the Central Bank of India. As per the norms defined by CERC, POWERGRID's cost of equity is 15.5%. Domestic inflation is estimated around 5.0%[8] while US dollar inflation is estimated at around 2.0%.[9]

20. *Weighted Average Cost of Capital* (WACC). Based on the above financing mix and the cost of financing, the WACC is estimated at 7.4% in nominal terms and 3.7% in real terms.

Table A3.4: Calculation of WACC

	IFI (Bank & ADB) loans	Commercial loan	Equity
Weighting	50%	20%	30%
Nominal cost	3.0%	10.5%	15.5%
Tax rate	25%	25%	
Tax-adjusted nominal cost	2.25%	7.88%	15.50%
WACC (nominal)		**7.4%**	
Inflation rate	2.0%	5.0%	5.0%
Real cost	0.25%	2.74%	10.00%
Weighted component of WACC	0.1%	0.5%	3.0%
WACC (real)		**3.7%**	

[7] Source: https://www.adb.org/sites/default/files/institutional-document/33777/adb-indicative-rates-20170407.pdf
[8] Source: http://www.oecd.org/economy/india-economic-forecast-summary.htm
[9] Source: https://data.oecd.org/price/inflation-forecast.htm

21. *Tariff-based revenue.* Per CERC regulation, the wheeling charge is determined based on *cost-plus*. POWERGRID owns a portfolio of regulated transmission assets, where depreciation is calculated over 30 years, at a rate of 5.25% for transmission lines and substations and 6.33% for communication equipment in the first 12 years, and a 10% salvage value at the end of the 30th year. Per CERC regulation, O&M charges stands at Rs 121,000 per km for double-circuit transmission lines and Rs 6.871 million per bay for 400 kV transmission bays.

22. **Outcome of the financial analysis**. Based on the above assumptions, the FIRR of the Project investment is estimated at 9.6% exceeding the nominal WACC of 7.4%. Therefore, the investment is financially justified.

23. *Sensitivity analysis*. Sensitivity analyses were carried out to examine the robustness of the financial viability of the Project investment under the following adverse scenarios: (i) 20% increase in capital costs; (ii) 1 year implementation delay; and (iii) both adverse scenarios combined. The effects on IRRs are outlined below in Table A3.5.

Table A3.5: Sensitivity Analysis

Sensitivity parameter	Variation	FIRR
Base case		9.6%
1. Project capital costs	+20%	9.5%
2. Implementation delay	+1 year	9.3%
3. All combined		8.0%

24. **Conclusion**. The financial viability of the Project investment is robust enough to withstand considerable upswings in costs and implementation delays.

III. Corporate-Level Financial Assessment

25. POWERGRID, India's national power transmission company, is the operator of 90% of India high-voltage interstate and interregional power transmission network. A listed Company, POWERGRID is 57.9% owned by the GoI and the balance by institutional investors and the public. It has maintained an international long-term issue credit rating of BBB– (Outlook: Stable) from both Standard & Poor's and Fitch, and enjoys the highest domestic credit rating of AAA.[10]

Table A3.6: POWERGRID's Financial Data Selected

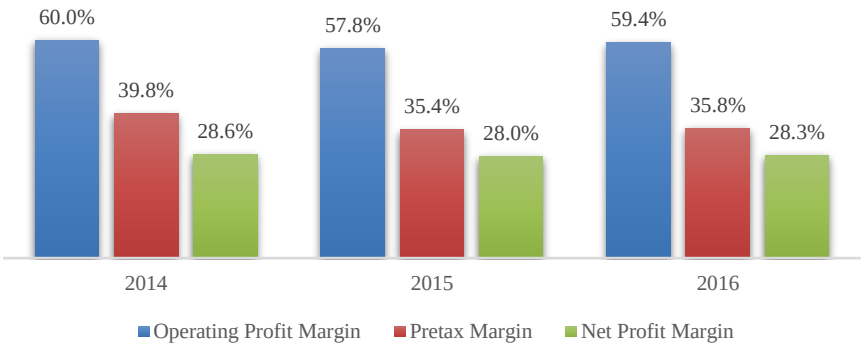
(Rs. billion)	2014	2015	2016
Total Assets	1,395.9	1,583.0	1,784.3
Total Liabilities	1,051.3	1,201.3	1,356.9
Total Equity	344.6	381.7	427.3
Current Assets	90.7	79.3	99.8
Current Liabilities	195.2	218.6	252.5
Total Revenues	157.2	177.8	212.8
Operating Income	94.3	102.7	126.4
Earnings Before Taxes	62.6	62.9	76.2
Net Income	45.0	49.8	60.3

[10] Since 2001, POWERGRID's domestic bonds have been rated AAA by the Credit Rating Information Services of India Limited and AAA by the Investment Information and Credit Rating Agency of India Limited. Since 2008, the Credit Analysis and Research has also given these bonds an AAA rating.

26. POWERGRID's total revenues increased at a compound annual growth rate (CAGR) of more than 16% from Rs. 157 billion in 2014 to Rs. 213 billion in 2016, while total assets increased at a CAGR of 13% from Rs. 1,396 billion to Rs. 1,784 billion over the same period. With a corporate debt-to-equity ratio of approximately 2.4 times and an interest coverage ratio of 1.8 times (3-year average), POWERGRID's ability to satisfy its long-term financial obligations remains strong.

27. POWERGRID is implementing several large projects, and total revenues will increase as projects are completed. Since POWERGRID receives both full recovery of project costs and a defined return on equity, its operating profit margin has been about 60%, and the net profit margin has remained above 28% in each of the past three financial years.

Figure A3.3: Operating and Net Profit Margin



28. For the 12th Five Year Plan, POWERGRID planned a capital investment of more than Rs. 1,200 billion (US$17,882 million) to develop inter-state transmission systems, including about 45,900 circuit km of transmission lines and 164,000 MVA of transformation capacity. To shore up its revenue and create value for its stakeholders and the country, POWERGRID diversified into telecommunication business, leveraging its country wide transmission infrastructure. It is now providing back-bone connectivity to all metros, major cities and towns in the country, as well as the grid in the north-eastern states.

29. Based on the cost-plus nature of the tariff-setting process coupled with its operating efficiency, POWERGRID has increased total revenues and net income consistently, maintaining a robust financial position with stable cash flows to cover its costs, capital expenditures, and debt service. Although POWERGRID has an aggressive investment plan and a large need for additional borrowings, its corporate financial data show it has a sound financial position.

30. Conclusion. POWERGRID has a sound financial position to implement the Project investment, and operate and maintain the constructed assets while fulfilling the associated debt service obligations.

ANNEX 4: SOVEREIGN CREDIT FACT SHEET

A. Recent Economic Development

1. India is a lower-middle-income country, with a population of 1.31 billion. Indian real GDP expanded at an average annual rate of 7.3% between FY2003 and FY2012, however, growth had slowed to 5.6% and 6.5% in FY2012/13 and FY2013/14 because of growing imbalances, binding supply constraints, and subdued sentiment. Since 2014, the Indian economy has been on a gradual cyclical recovery, helped by lower commodity prices bringing about an improvement in the current account. The Indian economy is also supported by structural reforms, such as a new bankruptcy code and the implementation of the pan-India goods and services tax (GST). A range of supply-side measures (including release of surplus grain buffer stocks), an appropriate monetary stance and lower oil price have also contributed to the decline in inflation, from an average of about 9.8% during 2011–13 to 4.9% in FY2015/16. Nevertheless, the demonetization initiative resulted in a slower growth in FY2016/17.[1] The Rupee also weakened with global capital outflow from emerging market assets.

B. Economic Indicators

Table A4.1: Selected Macroeconomic Economic Indicators (2013/14-2017/18)

Economic Indicators	2013/14	2014/15	2015/16	2016/17*	2017/18*
National income and prices (change %)					
Real GDP	6.5	7.2	8.0	7.1	7.2
Inflation (change %, average)	9.4	5.9	4.9	4.9	4.8
Central government operations (% of GDP)					
General government overall balance	-7.6	-7.3	-7.0	-6.8	-6.6
External debt (% of GDP, EOP)	23.9	23.3	23.4	22.9	22.7
Nominal gross public debt (% of GDP)		68.3	69.8	69.6	68.8
Money and credit					
Broad money (% annual change, EOP)	13.4	10.9	10.5	12.0	13.4
Direct investment in India (net, % of GDP)	-1.2	-1.5	-1.7	-1.7	-1.7
Gross reserves (months imports)	6.7	8.5	8.6	8.1	7.9
Current account balance (% of GDP)	-1.7	-1.3	-1.1	-0.9	-1.5
Exchange rate (Rupee/$, end period)	61.0	62.6	66.6	68.4	

Note: * denotes projected figures. Source: IMF Country Report No. 17/54, February 2017; WEO April, July 2017.

C. Economic Outlook and Risks

2. Looking ahead, India's growth is projected to slow to 7.1% in FY2016/17 before rebounding to 7.7% in FY2018/19. This is due to the temporary disruptions, particularly in private consumption, caused by cash shortages accompanying the demonetization. The current account deficit is expected to widen to about 2% of GDP over the medium term on the back of stronger domestic demand and possible increase in commodity prices. External risks include financial market volatility and slower growth in China, EU and US. Internally, India faces some risk arising from potential deterioration of corporate and public bank balance sheets, and setbacks in the reform process including implementation of GST on the domestic side. India's public debt remains sustainable given manageable interest rate costs and robust growth outlook. Assuming gradual fiscal consolidation and implementation of GST, the public debt-to-GDP ratio is forecasted to decline gradually to around 61% of GDP in the medium term from the

[1] Demonetization initiative: On Nov. 8 2016, India's government announced withdrawal of the legal tender of rupees 500 and rupees1000 notes, which accounted for 86% of the value of currency in circulation, and introduction of new rupees 500 and rupees 2000 notes.

current level of almost 70%. Negative growth shocks represent one of the major risks to the debt outlook. India's external debt, currently at 23.5% of GDP, remains sustainable.[2]

[2] International Monetary Fund (IMF), 2017. Country Report No. 17/54– 2017 Article IV Consultation—Press Release; Staff Report; and Statement by the Executive Director for India, February, 2017.

ANNEX 5: FINANCIAL MANAGEMENT ASSESSMENT

SUMMARY

A loan of $150 million from the Asian Infrastructure Investment Bank (the Bank) has been requested by the Power Grid Corporation of India Limited (POWERGRID) to help finance the proposed Transmission System Strengthening (Tamil Nadu) Project (the Project). As an integral part of its fiduciary duty, the Bank seeks to obtain reasonable assurances that its funds are used for their intended purposes, and that the GoI and POWERGRID can perform their obligations under the legal agreements during project implementation.

A financial management assessment was carried out by the Project team to identify POWERGRID's financial management arrangements under the Project that would need to be in place to meet the Bank's fiduciary requirements (see Appendix A5.1). The assessment is carried out based on the Bank's operational policy, discussions with POWERGRID's senior financial management officials, and the lessons learned from recent projects financed by multilateral development banks (MDBs).

In summary, POWERGRID has been implementing projects financed by MDBs for many years. As per assessments of MDBs and the project team, POWERGRID's financial management is strong and appropriate for Project implementation. POWERGRID is required to ensure that proper accounts and records are maintained and audited in a timely manner to adequately identify the use of loan proceeds.

I. Overview of POWERGRID's Financial Management Systems

1. The overall assessment is moderate. POWERGRID has been working with MDBs for many years, and is currently implementing projects financed by MDBs. Its financial management has been assessed, including funds-flow arrangements, staffing, budgeting, accounting and financial reporting systems, internal control procedures, internal and external auditing arrangements, and financial information systems. Based on the assessment results, POWERGRID's organizational structures are generally appropriate for project implementation.

2. POWERGRID's strengths in financial management are summarized as follows.

- Having an integrated computerized accounting and management system.
- A well-defined financial management structure showing clearly the lines of authority, as well as other internal procedural manuals/ guidelines.
- Qualified professional accountants that are currently heading various accounting and finance offices.
- Strict audit and reporting systems and policies, stemming from its status as a listed public company.
- A comprehensive internal control mechanism in place to verify the accounting and financial management system, adequacy of controls, material checks, and compliance implementation mechanism.

- Regularly audited by the Comptroller and Auditor General of India (CAG), in addition to audit by one or more independent chartered accountant firms appointed by the CAG.
- Timely preparation of budgets and budget revisions.
- Familiarity with MDBs' financial management requirements.
- Annual reports disclosed on its website regularly.

II. Assessments of Various Aspects

A. Funds Flow

3. The imprest account was opened at the State Bank of India and managed by the POWERGRID. The Bank loan will be made directly to POWERGRID, with a separate guarantee agreement with the GoI, which will then be paid to contractors respectively. It is envisioned that the GoI will charge POWERGRID a guarantee fee at a rate of 1.2% of the loan amount. POWERGRID has extensive experience working with international development partners, such as ADB and the World Bank.[1]

4. Counterpart funds, comprising domestic borrowings/external commercial borrowings and internal resources of POWERGRID, will also be paid directly to contractors.

B. Cash Management

5. Since offices of POWERGRID are scattered all over India, current bank accounts have been opened at various places to facilitate functioning, which are being operated by various officials. Accounts are reconciled daily and a reconciliation statement is prepared. An adequate, up-to-date cashbook, recording receipts and payments made, is maintained, with controls existing at each collection location. In case of unusual items on the bank reconciliation, careful review is required by a responsible official. All outstanding issues are reviewed and corrected immediately.

C. Personnel

6. POWERGRID has an independent Accounting and Finance Department, headed by two Executive Directors, both of whom report to the Director for Finance. An organization chart of the corporate finance department is in Appendix A5.2. The majority of the relevant accounting and finance staff (i.e. excluding secretarial) have finance and accounting degrees at postgraduate levels and are professionally qualified. Written position descriptions of duties, responsibilities, lines of supervision, and limits of authority for all the officers, managers, and staff exist. Rotation takes place periodically depending on the job requirement. Training programs are conducted by POWERGRID's Human Resource Department regularly in addition to sending staff to outside training programs.

D. Accounting Policies and Procedures

7. POWERGRID's accounts are prepared on an accrual basis in accordance with

[1] ADB, 2015. Power System Expansion and Efficiency Improvement Investment Program (Tranche 3).

applicable Accounting Standards issued by the Institute of Chartered Accountants of India (ICAI) and relevant national regulations. Controls and guidelines are in place regarding the preparation and approval of project financial transactions to ensure that all transactions are correctly made and adequately explained. The authorization and execution of a transaction and its subsequent recording are carried out as per delegation of powers defined and approved by management. General ledger and subsidiary ledgers are reconciled and in balance. All accounting documents are duly signed and authorized by delegated personnel. Strict rules exist regarding the approvals required for various transaction sizes. Accounting and supporting documentation are retained on a permanent basis.

E. Fixed Assets

8. POWERGRID maintains a fixed-assets register and account of physical stocks and inventory. Safeguards systems over inventory exist (e.g. reconciliation of receipts with accounts, established committees to manage inventory, etc.). Reviews of physical inventories and fixed assets and stocks are conducted regularly. Assets are covered under the mega insurance policy or self-insurance scheme of POWERGRID.

F. Budgeting

9. POWERGRID prepares an annual budget which indicates full details of financial and physical targets. It is prepared in consultation with CMG, asset management, finance and other concerned departments, with final approval by POWERGRID's management team. Procedures are in place to plan project activities, collect information from the units in charge of the different components and prepare the budgets, therefore making the budget realistic. Variations in budget are reported to management in advance, and regularized after the fact (situation dependent).

G. Project Level Financial Reporting

10. POWERGRID has written procedures and guidelines that can cater for the financial and operational reporting requirements of the Project. POWERGRID indicated that reports on the project would be conducted monthly to facilitate better decision making by management. Systems and policies are also in place to prevent/mitigate any conflict of interests and any fraud, waste or misuse of project resources and/or property.

H. Internal Control and Audit

11. Appropriate internal controls are in place. POWERGRID has a comprehensive internal control mechanism in place to verify the accounting and financial management system, adequacy of controls, material checks, and compliance implementation mechanism.

12. Regular internal audits are carried out semi-annually by experienced Chartered Accountant firms in close coordination with POWERGRID's Internal Audit Department to ensure that all checks and balances are in place and all internal controls/systems are in order. The Internal Audit Department also conducts System Audits and Management Audits to confirm the effectiveness of the internal control mechanism. In addition, POWERGRID's Board has an audit committee comprising independent and part-time directors, which meets at least four times a year, and oversees the company's financial management in its entirety.

13. Additionally, POWERGRID is audited regularly by the CAG, in addition to audit by

one or more independent chartered accountant firms appointed by the CAG. Also, as a publicly listed company, POWERGRID is subject to many strong governance measures imposed by India's Securities and Exchange Board, which ensure transparency and predictability of its financial governance through information disclosure to shareholders and the public.

I. Payments

14. All invoices are stamped PAID, dated, reviewed and approved, and clearly marked for account code assignment. Controls exist for the preparation of the payroll and changes to the payroll are properly authorized.

J. Vigilance and Anti-Corruption

15. POWERGRID also has an internal Vigilance Department, headed by a Chief Vigilance Officer appointed by the Central Vigilance Commission of India.[2] The Vigilance Department provides continuing in-house monitoring and oversight of operations, and has the authority to receive written complaints for disclosure on any allegation of corruption or misuse of office and recommend appropriate action. POWERGRID's internal control and vigilance mechanism will help ensure that any alleged corrupt, fraudulent, collusive, or coercive practices relating to the Project will be redressed appropriately in a timely manner.

K. Financial Information System

16. POWERGRID has integrated computerized accounting and financial management systems, which can produce the necessary project finance reports in accordance with the Accounting Standards issued by the ICAI. A team of well trained staff can maintain the system. There are sufficient safeguards in place to ensure the confidentiality, integrity and availability of the project data.

III. POWERGRID's Financial Performance

17. POWERGRID is a listed Company, with 57.90% holding of the GoI and balance by institutional investors and the public. POWERGRID is financially strong and has a good credit rating with financial institutions. During FY 2015/16, POWERGRID achieved a turnover of about Rs. 212.81 billion (US$3,224 million) and net profit of Rs. 60.27 billion (US$913 million). Fixed assets of the company have also grown to Rs. 1,500.52 billion (US$22,735 million). For the 12th Five Year Plan, POWERGRID planned a capital investment of more than Rs. 1,100 billion (US$ 16,667 million) to develop inter-state transmission systems, including about 40,000 circuit km of transmission lines and 100,000 MVA of transformation capacity.

18. To shore up its revenue and create value for its stakeholders and the country, POWERGRID has diversified into telecommunication business, leveraging its country wide transmission infrastructure. It is now providing back-bone connectivity to all metros, major cities & towns in the country, as well as the grid in the north-eastern states.

[2] Pursuant to its Resolution on "Public Interest Disclosure and Protection of Informer" dated April 2004, the GoI has authorized the Central Vigilance Commission as the "Designated Agency" to receive written complaints for disclosure on any allegation of corruption or misuse of office and recommend appropriate action.

IV. Conclusions

19. In general, POWERGRID is financially strong and has a good credit rating with financial institutions. It has sufficient capacity and established systems to meet the Bank's financial management requirements. The project team also noted that POWERGRID is experienced in managing MDB-financed projects.

Appendix A5.1:
Financial Management Assessment Questionnaire

	Topic	Response	Remarks
1	**Implementation Agency**		
1.1	What is the entity's legal status/registration?	A public-sector company registered under the Companies Act, 2013 of India	
1.2	Has the entity implemented an externally financed project in the past (if so, please provide details)?	Yes, POWERGRID has implemented various projects financed by MDBs like the World Bank, ADB, etc.	
1.3	What are the statutory reporting requirements for the entity?	Accounts are to be prepared as per provisions of the Companies Act, 2013 of India	
1.4	Is the governing body for the project independent?	Yes	
1.5	Is the organizational structure appropriate for the needs of the project?	Yes	
2	**Funds Flow Arrangements**		
2.1	Describe (proposed) project funds flow arrangements, including a chart and explanation of the flow of funds from the Bank, government and other financiers.	POWERGRID will be the direct borrower	
2.2	Are the (proposed) arrangements to transfer the proceeds of the loan (from the government/ finance ministry) to the entity satisfactory?	Not Applicable	POWERGRID will be the direct borrower
2.3	What have been the major problems in the past in receiving funds by the entity?	No Applicable	
2.4	In which bank will the Imprest Account be opened?	State Bank of India	The Bank shall be informed suitably when required
2.5	Does the (proposed) project implementation unit (PIU) have experience in the management of disbursements from MDBs?	Yes	POWERGRID has availed various loans from MDBs like the World Bank and ADB and is well versed in the management of disbursements under such loans.
2.6	Does the entity have/ need a capacity to manage foreign exchange risks?	Not Applicable	Foreign exchange variation is passed through to the beneficiaries as one of components of transmission tariff.
2.7	How are the counterpart funds accessed?	Through domestic borrowings/ external commercial borrowings and internal resources of POWERGRID.	
2.8	How are payments made from the counterpart funds?	All the loans and internal resources pooled and payments made directly to the contractors.	
2.9	If part of the project is implemented by communities or NGOs, does the PIU have the necessary reporting and monitoring features built into its systems to track the use of project proceeds by such agencies?	Not Applicable	

	Topic	Response	Remarks
2.10	Are the beneficiaries required to contribute to the project costs? If beneficiaries have an option to contribute in kind (in the form of labor), are proper guidelines formulated to record and value the labor contribution?	No	
3	**Staffing**		
3.1	What is the (proposed) organizational structure of the accounting department? Attach an organization chart.	Organisation Chart of Corporate Finance is attached at **Annex-I.**	
3.2	Identify the (proposed) accounting staff, including job title, responsibilities, educational background, and professional experience. Attach job descriptions and CVs of key accounting staff.	The entire staff looking after foreign currency loans and foreign currency payments to contractors is professionally qualified. Majority of the finance and account staff deployed in other areas is also professionally qualified.	
3.3	Is the project finance and accounting function staffed adequately?	Yes	
3.4	Is the finance and accounts staff adequately qualified and experienced?	Yes	
3.5	What is the duration of the contract with the finance and accounting staff?	Not Applicable	
3.6	Indicate key positions not contracted yet, and the estimated date of appointment.	Not Applicable	
3.7	Does the project have written position descriptions that clearly define duties, responsibilities, lines of supervision, and limits of authority for all the officers, managers, and staff?	Yes	
3.8	At what frequency are personnel transferred?	Rotation takes place periodically depending upon the job requirement.	
3.9	What is training policy for the finance and accounting staff?	Training programmes are conducted by Human Resource Department regularly in addition to deputation of staff to outside training programmes.	
4	**Accounting Policies and Procedures**		
4.1	Does the entity have an accounting system that allows for the proper recording of project financial transactions, including the allocation of expenditures in accordance with the respective components, disbursement categories, and sources of funds? Will the project use the entity accounting system?	Yes	
4.2	Are controls in place concerning the preparation and approval of transactions, ensuring that all transactions are correctly made and adequately explained?	Yes	
4.3	Is the chart of accounts adequate to properly account for and report on project activities and disbursement categories?	Yes	
4.4	Are cost allocations to the various funding sources made accurately and in accordance with established agreements?	Yes	

	Topic	Response	Remarks
4.5	Are the General Ledger and subsidiary ledgers reconciled and in balance?	Yes	
4.6	Are all accounting and supporting documents retained on a permanent basis in a defined system that allows authorized users easy access?	Yes	
Segregation of Duties			
4.7	Are the following functional responsibilities performed by different units or persons: (i) authorization to execute a transaction (ii) recording of the transaction; and (iii) custody of assets involved in the transaction?	Yes	
4.8	Are the functions of ordering, receiving, accounting for, and paying for goods and services appropriately segregated?	Yes	
4.9	Are bank reconciliations prepared by someone other than those who make or approve payments?	Yes	
Budgeting System			
4.10	Do budgets include physical and financial targets?	Yes	
4.11	Are budgets prepared for all significant activities in sufficient detail to provide a meaningful tool with which to monitor subsequent performance?	Yes	
4.12	Are actual expenditures compared with the budget with reasonable frequency, and explanations required for significant variations from the budget?	Yes	
4.13	Are approvals for variations from the budget required in advance or after the fact?	Variations in budget are reported to the management in advance, and it is regularized after the fact.	
4.14	Who is responsible for budget preparation and approval?	Budget is prepared by Regions/ projects in consultation with CMG, Asset Management, Finance and other concerned departments, and is got approved from the POWERGRID's management.	
4.15	Are procedures in place to plan project activities, collect information from the units in charge of the different components, and prepare the budgets?	Yes	
4.16	Are the project plans and budgets of project activities realistic, based on valid assumptions, and developed by knowledgeable individuals?	Yes	
4.17	Do invoice-processing procedures provide for: (i) Copies of purchase orders and receiving reports to be obtained directly from issuing departments? (ii) Comparison of invoice quantities, prices and terms, with those indicated on the purchase order and with records of goods actually received? (iii) Comparison of invoice quantities with those indicated on the receiving reports? (iv) Checking the accuracy of calculations?	Yes	
Payments			
4.18	Are all invoices stamped PAID, dated, reviewed and approved, and clearly marked for account code assignment?	Yes	
4.19	Do controls exist for the preparation of the payroll and are changes to the payroll properly authorized?	Yes	
Policies and Procedures			

	Topic	Response	Remarks
4.20	What is the basis of accounting (e.g., cash, accrual)?	Accrual	
4.21	What accounting standards are followed?	All applicable Accounting Standards issued by ICAI.	
4.22	Does the project have an adequate policies and procedures manual to guide activities and ensure staff accountability?	Yes	Finance department has laid down written procedure and guidelines to complete the various tasks. Activities are being carried out as per well-defined delegation of powers which is approved by Board of Directors.
4.23	Is the accounting policy and procedure manual updated for the project activities?	Yes	
4.24	Are there written policies and procedures covering all routine financial management and related administrative activities?	Yes	
4.25	Do policies and procedures clearly define conflict of interest and related party transactions (real and apparent) and provide safeguards to protect the organization from them?	Yes	
4.26	Are manuals distributed to appropriate personnel?	Yes	
Cash and Bank			
4.27	Indicate names and positions of authorized signatories in the bank accounts.	Offices of POWERGRID are scattered all over India. To facilitate functioning, current bank accounts have been opened at various places which are being operated by various officials according to powers delegated by Director (Finance).	
4.28	Does the organization maintain an adequate, up to date cashbook, recording receipts and payments?	Yes	
4.29	Do controls exist for the collection, timely deposit, and recording of receipts at each collection location?	Yes	
4.30	Are bank and cash reconciled on a monthly basis?	Yes	
4.31	Are all unusual items on the bank reconciliation reviewed and approved by a responsible official?	Yes	
4.32	Are all receipts deposited on a timely basis?	Yes	
Safeguard Over Assets			
4.33	Is there a system of adequate safeguards to protect assets from fraud, waste, and abuse?	Yes	
4.34	Are subsidiary records of fixed assets and stocks kept up to date and reconciled with control accounts?	Yes	
4.35	Are there periodic physical inventories of fixed assets and stocks?	Yes	
4.36	Are assets sufficiently covered by insurance policies?	Yes	Assets are covered under the mega insurance policy or self-insurance scheme of POWERGRID. Assets not covered under the above policy are being insured separately.
Other Offices and Implementing Entities			
4.37	Are there any other regional offices or executing entities participating in implementation?	Yes	

	Topic	Response	Remarks
4.38	Has the project established controls and procedures for flow of funds, financial information, accountability, and audits in relation to the other offices or entities?	Yes	
4.39	Does information among the different offices/implementing agencies flow in an accurate and timely fashion?	Yes, computerized accounting system is in use.	
4.40	Are periodic reconciliations performed among the different offices/implementing agencies?	Yes	
Other			
4.41	Has the project advised employees, beneficiaries, and other recipients the reporting procedures to report if they suspect fraud, waste, or misuse of project resources or property?	Yes	
5.	**Internal Audit**		
5.1	Is there an internal audit department in the entity?	Yes	
5.2	What are the qualifications and experience of audit department staff?	All the executives in the Internal Audit Department are professionally qualified. To strengthen the Internal Audit, practicing CA/ CMA firms are also engaged for Internal Audit including Physical Verification of assets of all the Regions and Corporate Centre.	
5.3	To whom does the internal auditor report?	Internal Audit department reports to Director (Finance). The Internal Audit observations are submitted/ discussed with the concerned functional Executive Director and Directors including CMD of the Company. The significant observations of the Internal Audit are also put up to the Audit Committee of Board of Directors.	
5.4	Will the internal audit department include the project in its work program?	Yes	
5.5	Are actions taken on the internal audit findings?	Yes	Measures taken to improve its financial management.
6	**External Audit**		
6.1	Is the entity's financial statement audited regularly by an independent auditor? Who is the auditor?	Yes. Presently four Statutory Auditors appointed by the CAG of India are as follows: i. M/s S.K. Mittal & Co., New Delhi ii. M/s R G N Price & Co., Chennai iii. M/s Kothari & Co., Kolkata iv. M/s Parakh & Co., Mumbai	v.

	Topic	Response	Remarks
6.2	Are there any delays in auditing of the entity? When are the audit reports issued?	No	Audit reports are submitted within a reasonable time, so that AGM could be held within the statutory time limit.
6.3	Is the audit of the entity conducted according to the International Standards on Auditing?	No	Audit is being conducted as per guidelines/standards issued by the ICAI.
6.4	Were there any major accountability issues brought out in the audit report of the past three years?	No	
6.5	Will the entity auditor audit the project accounts or will another auditor be appointed to audit the project financial statements?	Yes	Done by the entity auditor.
6.6	Are there any recommendations made by the auditors in prior audit reports or management letters that have not yet been implemented?	No	
6.7	Is the project subject to any kind of audit from an independent governmental entity (e.g., the supreme audit institution) in addition to the external audit?	Yes	
7	**Reporting and Monitoring**		
7.1	Are financial statements prepared for the entity? In accordance with which accounting standards?	Yes	In accordance with the Accounting Standards issued by the ICAI.
7.2	Are financial statements prepared for the implementing unit?	Yes	
7.3	What is the frequency of preparation of financial statements? Are the reports prepared in a timely fashion so as to be useful to management for decision making?	Financial Statements are prepared annually. Quarterly results are prepared and put up to the Board of Directors for approval and published as per requirements of SEBI.	
7.4	Does the reporting system and budget lines need to be adapted to report on the project components?	No	
7.5	Does the reporting system have the capacity to link the financial information with the project's physical progress? If separate systems are used to gather and compile physical data, what controls are in place to reduce the risk that the physical data may not synchronize with the financial data?	Not Applicable	Separate systems are used for gathering physical data, since there is no linear relation between financial and physical progress considering the nature of the project. Regular budget/ capex review is made vis-à-vis physical progress keeping in view the completion target of the projects.
7.6	Does the project have established financial management reporting responsibilities that specify what reports are to be prepared, what data or information will the reports contain, and how they are to be used?	Yes	
7.7	Are financial management reports used by management?	Yes	
7.8	Do the financial reports compare actual expenditures with budgeted and programmed allocations?	Yes	

	Topic	Response	Remarks
7.9	Are financial reports generated directly by the automated accounting system or are they generated by spreadsheets or some other means?	Yes	Financial reports (Annual Accounts) are prepared directly by the Automated Accounting System in SAP (POWERGRID's enterprise resource planning system).
8	**Information Systems**		
8.1	Is the financial management system computerized?	Yes	
8.2	Can the system produce the necessary project financial reports?	Yes	
8.3	Is the staff adequately trained to utilize and to maintain the system?	Yes	
8.4	Does the management organization and processing system safeguard the confidentiality, integrity, and availability of the data?	Yes	

Appendix A5.2: