



Completion Report

Project Number: 38492-013
Loan Number: 2152
July 2017

India: Power Grid Transmission (Sector) Project

This document is being disclosed to the public in accordance with ADB's Public Communications Policy 2011.

Asian Development Bank

CURRENCY EQUIVALENTS

Currency Unit – Indian rupee/s (₹)

		At Appraisal (1 November 2005)	At Project Completion (5 October 2012)
₹1.00	=	\$0.0222	\$0.01829
\$1.00	=	₹45.04	₹54.65

ABBREVIATIONS

ADB	–	Asian Development Bank
APA	–	advance procurement action
CEA	–	Central Electricity Authority
CERC	–	Central Electricity Regulatory Commission
EIRR	–	economic internal rate of return
EMMP	–	environmental management and monitoring plan
EMP	–	environmental management plan
FSC	–	fixed series compensation
FIRR	–	financial internal rate of return
HVDC	–	high-voltage direct current
IEE	–	initial environmental examination
KN	–	kilonewton
LIBOR	–	London interbank offered rate
LILO	–	loop in loop out
NTDP	–	National Transmission Development Plan
NTPP	–	Neyveli Thermal Power Plant
O&M	–	operation and maintenance
PCB	–	polychlorinated biphenyl
PMU	–	project management unit
POWERGRID	–	Power Grid Corporation of India Limited
ROW	–	right-of-way
RRP	–	report and recommendation of the President
SEB	–	State Electricity Board
T&D	–	transmission and distribution
WACC	–	weighted average cost of capital
WTP	–	willingness to pay

WEIGHTS AND MEASURES

cct-km	–	circuit-kilometer
GW (gigawatt)	–	1,000 megawatt
km	–	kilometer
kV (kilovolt)	–	1,000 volts
kW	–	kilowatt
kWh (kilowatt-hour)	–	1,000 watt-hours
MVA (megavolt-ampere)	–	1,000,000 volt-amperes
MVAR	–	mega volt ampere reactor
MW (megawatt)	–	1,000 kilowatts
V	–	volt
VA	–	volt-ampere
W	–	watt

NOTES

- (i) The fiscal year (FY) of POWERGRID ends on 31 March. FY before a calendar year denotes the year in which the fiscal year ends, e.g., FY2017 ends on 31 March 2017.
- (ii) In this report, "\$" refers to United States dollars.

Vice-President	W. Zhang, Operations 1
Director General	H. Kim, South Asia Department (SARD)
Country Director	K. Yokoyama, India Resident Mission, SARD
Team leader	V. Rao Karbar, Project Officer (Energy), SARD
Team members	G. Mahajan, Senior Environment Officer, SARD
	R. Naduvinamani, Project Analyst, SARD

In preparing any country program or strategy, financing any project, or by making any designation of or reference to a particular territory or geographic area in this document, the Asian Development Bank does not intend to make any judgments as to the legal or other status of any territory or area.

CONTENTS

BASIC DATA	i
I. PROJECT DESCRIPTION	1
II. EVALUATION OF DESIGN AND IMPLEMENTATION	1
A. Relevance of Design and Formulation	1
B. Project Outputs	3
C. Project Costs	6
D. Disbursements	6
E. Project Schedule	6
F. Implementation Arrangements	8
G. Conditions and Covenants	9
H. Consultant Recruitment and Procurement	9
I. Performance of Contractors and Suppliers	9
J. Performance of the Borrower and the Executing Agency	9
K. Performance of the Asian Development Bank	10
III. EVALUATION OF PERFORMANCE	10
A. Relevance	10
B. Effectiveness in Achieving Outcome	11
C. Efficiency in Achieving Outcome and Outputs	11
D. Preliminary Assessment of Sustainability	12
E. Impact	12
IV. OVERALL ASSESSMENT AND RECOMMENDATIONS	14
A. Overall Assessment	14
B. Lessons	15
C. Recommendations	15
APPENDIXES	
1. Design and Monitoring Framework	16
2. Chronology of Main Events	19
3. Comparison of Estimated and Actual Project Costs	20
4. Summary of Contracts	21
5. Annual Average Exchange Rates	23
6. Project Financing Plan	24
7. Actual Disbursements of Loan Proceeds	25
8. Project Implementation Schedule	26
9. Powergrid Organization Chart	27
10. Status of Compliance with Loan Covenants	28
11. Financial and Economic Reevaluation	36

BASIC DATA

A. Loan Identification

1.	Country	India
2.	Loan Number	2152
3.	Project Title	Power Grid Transmission (Sector) Project
4.	Borrower	Power Grid Corporation of India Limited
5.	Executing Agency	Power Grid Corporation of India Limited
6.	Amount of Loan	\$400,000,000
7.	Project Completion Report Number	1634

B. Loan Data

1.	Appraisal	
	– Date Started	10 October 2004
	– Date Completed	13 October 2004
2.	Loan Negotiations	
	– Date Started	24 November 2004
	– Date Completed	25 November 2004
3.	Date of Board Approval	21 December 2004
4.	Date of Loan Agreement	03 November 2005
5.	Date of Loan Effectiveness	
	– In Loan Agreement	01 February 2006
	– Actual	10 January 2006
	– Number of Extensions	0
6.	Closing Date	
	– In Loan Agreement	31 December 2009
	– Actual	5 October 2012
	– Number of Extensions	2
7.	Terms of Loan	
	– Interest Rate	London interbank offered rate (LIBOR) + 0.60%
	– Maturity	20 years
	– Grace Period	5 years
9.	Disbursements	

a. Dates

Initial Disbursement	Final Disbursement	Time Interval
2 June 2006	5 October 2012	76.13 months
Effective Date	Original Closing Date	Time Interval
10 January 2006	31 December 2009	47.71 months

b. Amount (\$ million)

Category or Subloan	Original Allocation	Last Revised Allocation	Amount Canceled	Net Amount Available	Amount Disbursed	Undisbursed Balance
01 Equipment	400.0	400.0	0.0	400.0	400.0	0.0
Total	400.0	400.0	0.0	400.0	400.0	0.0

C. Project Data

1. Project Cost (\$ million)

Cost	Appraisal Estimate	Revised Estimate ^a	Actual
Foreign Exchange Cost	465.2	539.6	400.0
Local Currency Cost	102.8	113.6	202.2
Total	568.0	653.2	602.2

^a Revised estimate as on September 2007. The revised estimate includes the candidate subprojects that were finally financed under the Asian Development Bank loan.

2. Financing Plan (\$ million)

Cost	Appraisal Estimate	Revised Estimate ^b	Actual
Implementation Costs			
Borrower Financed	168.0	253.2	202.2
ADB Financed	400.0	400.0	400.0
Total	568.0	653.2	602.2
IDC Costs			
Borrower Financed	14.9	39.3	30.1
ADB Financed	0.0	0.0	0.0
Total	14.9	39.3	30.1

ADB = Asian Development Bank, IDC = interest during construction.

^b Revised estimate as on September 2007. The revised estimate includes the candidate subprojects that were finally financed under the ADB loan.

3. Cost Breakdown by Project Component (\$ million)

Subprojects	Appraisal Estimate			Revised Estimate ^a			Actual		
	Foreign Exchange	Local Currency	Total	Foreign Exchange	Local Currency	Total	Foreign Exchange	Local Currency	Total
A. Project Expenditure									
1 Grid Strengthening for Tamil Nadu-I	72.3	8.6	80.9	43.0	3.6	46.6 ^b	34.5	24.9	59.4 ^c
2 Grid Strengthening for Tamil Nadu-II									
Grid Strengthening for Tamil Nadu, Andhra Pradesh and Union Territory of Pondicherry	65.5	20.1	85.6	65.5	20.1	85.6	71.6	23.6	95.2
3 Grid Strengthening for Kerala-I									
Grid Strengthening for Kerala-II	228.0	50.0	278.0	156.3	32.4	188.7	138.6	93.1	231.7 ^d
4 Northern Region System Strengthening -V	59.0	13.0	72.0	104.9	13.6	118.5	100.3	28.6	128.9
5 Enhancement of Transmission Capacity in East-West Corridor of Northern Region	0.0	0.0	0.0	19.0	8.1	27.1	14.4	1.1	15.5
6 Western Region Strengthening Scheme-VII	0.0	0.0	0.0	5.1	3.9	9.0	1.7	0.8	2.5
7 Procurement of Bulk Conductors to Strengthen and Develop the National Grid	0.0	0.0	0.0	18.0	0.0	18.0	15.1	0.0	15.1
8 Procurement of Additional Bulk Conductors to Strengthen and Develop the National Grid	0.0	0.0	0.0	23.8	3.1	26.9	23.8	0.0	23.8
Subtotal (A)	424.8	91.7	516.5	435.6	84.8	520.4	400.0	172.1	572.1
B. Contingencies									
Physical Contingency	13.8	2.9	16.7	37.0	6.9	43.9	0.0	0.0	0.0
Price Contingency	16.4	3.6	20.0	41.5	8.1	49.6	0.0	0.0	0.0
Subtotal (B)	30.2	6.5	36.7	78.5	15.0	93.5	0.0	0.0	0.0
C. Interest during Construction (C)	10.2	4.8	15.0	25.5	13.8	39.3	0.0	30.1	30.1
Total (A+B+C)	465.2	103.0	568.2	539.6	113.6	653.2	400.0	202.2	602.2

^a Revised estimate as on September 2007. The revised estimate includes the candidate subprojects that were finally financed under the Asian Development Bank loan.

^b The revised figure is as per the contract award value.

^c This includes contingencies such as price variations.

^d Including the contract award value of balance works related to the Edamon-Muvattupuzha 400 kilovolt transmission line, which was awarded on 1 March 2017.

Sources: Power Grid Corporation of India Limited and Asian Development Bank's loan financial information system.

4. Project Schedule

Subprojects	Appraisal Estimate		Actual	
	Start	End	Start	End
I. Grid Strengthening for Tamil Nadu-I Tendering and Award of Contract Supply, Erection, and Commissioning	Nov 2004 May 2005	Mar 2005 Dec 2007	Apr 2005 Apr 2006	Mar 2006 Oct 2009
II. Grid Strengthening for Tamil Nadu-II Tendering and Award of Contract Supply, Erection, and Commissioning	Dec 2004 Feb 2006	Jul 2005 Dec 2007	May 2005 Apr 2006	Feb 2006 Jul 2010
III. Grid Strengthening for Tamil Nadu, Andhra Pradesh, and Union Territory of Pondicherry Tendering and Award of Contract Supply, Erection, and Commissioning	Nov 2004 Sep 2005	Aug 2005 Dec 2007	May 2005 Apr 2006	Mar 2006 Sep 2010
IV. Grid Strengthening for Kerala-I Tendering and Award of Contract Supply, Erection, and Commissioning	Sep 2005 Apr 2006	Feb 2006 Nov 2008	Sep 2005 Nov 2006	Mar 2008 Mar 2018 ^d
V. Grid Strengthening for Kerala-II Tendering and Award of Contract Supply, Erection, and Commissioning	Sep 2005 Apr 2006	Feb 2006 Nov 2008	Sep 2005 May 2006	Mar 2008 Nov 2011
VI. Northern Region System Strengthening-V Tendering and Award of Contract Supply, Erection, and Commissioning	Mar 2006 Nov 2006	Oct 2006 Jun 2009	May 2006 Mar 2007	Jan 2007 Mar 2010
VII. Enhancement of Transmission Capacity in East-West Corridor of Northern Region Tendering and Award of Contract Supply, Erection, and Commissioning	Jul 2006 Apr 2007	Feb 2007 Jul 2009	Oct 2006 Sep 2007	Jul 2007 Mar 2010
VIII. Western Region Strengthening Scheme-VIII Tendering and Award of Contract Supply, Erection, and Commissioning	Jul 2007 Jan 2008	Dec 2007 Nov 2010	Aug 2007 May 2008	Mar 2008 Oct 2010
IX. Procurement of Bulk Conductors to Strengthen and Develop National Grid Tendering and Award of Contract Supply, Erection, and Commissioning	Sep 2007 Mar 2008	Feb 2008 Aug 2008	Nov 2007 Oct 2008	Sep 2008 Mar 2009
X. Procurement of Additional Bulk Conductors to Strengthen and Develop National Grid Tendering and Award of Contract Supply, Erection, and Commissioning	Nov 2008 May 2009	Apr 2009 Oct 2009	Jan 2009 Jul 2009	May 2009 Mar 2010

^d Expected to complete by March 2018, as informed by POWERGRID during project completion review mission.
Source: Power Grid Corporation of India Limited.

5. Project Performance Report Ratings

Implementation Period	Ratings	
	Development Objectives	Implementation Progress
From 2006 to 2011	Satisfactory	Satisfactory
From 2011 to 2012	On track	On track

D. Data on Asian Development Bank Missions

Name of Mission	Date	No. of Persons	No. of Person-Days	Specialization of Members
Reconnaissance	3–16 Jun 2004	7	98	a, b, c, d, e, f, g, h
Fact-Finding	29 Jul–18 Aug 2004	11	231	a, b, c, d, e, f, g, h, i, j, k
Appraisal	10–13 Oct 2004	7	28	a, b, c, e, f, g, i, m
Inception Mission	24 Jan–1 Feb 2006	2	14	l, n
Special Loan Administration	7–17 Mar 2006	2	20	l, o
Project Review 1	18–21 Sept 2006	2	8	
Project Review 2	16–19 Jul 2007	1	4	m
Project Review 3	20–24 Oct 2008	1	4	m
Project Review 4	5–13 Oct 2009	2		
Project Review 5	19–22 Oct 2009	4	40	p, f, g, q
Project Review 6	6–11 Dec 2010			
Project Review 7	18–22 July 2011	2	10	p, r
Project Review 8	29 Feb–3 Mar 2012; 5 Mar 2012	2	1	p, r
Project Completion Review	6–17 February 2017	3	36	e, s, t

a = senior energy specialist; b = principal infrastructure specialist; c = senior energy specialist (finance); d = senior energy specialist (economist); e = project implementation officer; f = environment specialist; g = social and resettlement specialist; h = senior advisor; i = assistant general counsel; j = principal procurement specialist; k = senior counsel; l = mission leader; m = project administration unit head; n = principal energy specialist; o = project officer; p = senior project implementation officer; q = assistant project analyst; r = senior project assistant; s = project analyst; t = consultant.

I. PROJECT DESCRIPTION

1. As electricity is one of the key drivers of economic growth and poverty reduction, the Government of India set the target of installing an additional 100,000 megawatts (MW) of generation capacity at the time of loan appraisal to provide electricity access to all households by 2012. India had been facing a growing electricity deficit, and the quality of the power supply has been a major concern. With increased generation capacity, transmission bottlenecks were expected to worsen unless the national transmission grid was strengthened and developed. In addition, open transmission access and the development of a national market for power trading, as provided under the Electricity Act, 2003, were significant policy developments that required a robust and reliable transmission grid to ensure smooth power flow in the whole power system. Toward this outcome, the Power Grid Corporation of India Limited (POWERGRID) developed the National Transmission Development Plan (NTDP) with investment requirements of \$12.6 billion up to 2012. The Asian Development Bank (ADB), through the sector loan, met part of the substantial funding requirements of the NTDP.

2. In December 2004, ADB approved the Power Grid Transmission (Sector) Project loan of \$400 million to POWERGRID, with India as guarantor, to meet part of its investment needs.¹ The loan became effective on 10 January 2006 and closed on 5 October 2012. The expected impact of the project was to provide adequate and reliable power supply to meet the demand for electricity in India by strengthening and developing India's national transmission grid. The project aimed to help POWERGRID to strengthen and develop India's national transmission grid, comprising 765 kilovolt (kV) and 400 kV transmission lines and associated substations, to improve system reliability, facilitate interstate and interregional power transfers by removing transmission bottlenecks, reduce transmission losses, facilitate the efficient use of existing and planned power plants, facilitate the development of a national power trading market, and hence promote increased private sector participation through open access to the national transmission grid. The expected outcome was the national transmission grid strengthened and expanded, with transmission bottlenecks removed and losses reduced.

3. The original project outputs included three subprojects:² (i) grid strengthening for Tamil Nadu I; (ii) grid strengthening for Tamil Nadu II; and (iii) grid strengthening for Tamil Nadu, Andhra Pradesh, and Union Territory of Pondicherry. Based on detailed appraisal reports submitted by POWERGRID during project implementation, seven additional subprojects³ were approved from 2005 to 2007: (i) grid strengthening for Kerala I, (ii) grid strengthening for Kerala II, (iii) northern region system strengthening scheme V, (iv) enhancement of transmission capacity in the east–west corridor of the northern region, (v) western region strengthening scheme VII, (vi) procurement of bulk conductors and insulators, and (vii) procurement of additional bulk conductors to strengthen and develop the national grid.

II. EVALUATION OF DESIGN AND IMPLEMENTATION

A. Relevance of Design and Formulation

4. The project design was *relevant* at appraisal and completion. At the time of appraisal, the project was consistent with ADB's country strategy and program for India as well as its energy

¹ ADB. 2004. *Report and Recommendation of the President to the Board of Directors: Proposed Loan to India for the Power Grid Transmission (Sector) Project*. Manila.

² These subprojects were appraised and approved at the time of loan processing. Subsequent approvals were obtained to include additional subprojects to the scope of the project during implementation.

³ Approved based on the subproject selection criteria agreed during the loan processing (para. 29 of RRP).

sector strategy,⁴ which supported (i) reforming the power sector; (ii) expanding and optimizing transmission and distribution (T&D) systems; (iii) providing institutional strengthening to implement reforms required by the Electricity Act, 2003; (iv) promoting private sector participation; and (v) encouraging energy conservation, and ensuring environmental and social sustainability. The project was built on earlier ADB interventions to POWERGRID, which supported the country's national grid expansion, and reforms in the energy sector.⁵ The project supported the NTDP, which aimed at strengthening and expansion of transmission lines and associated substations. The sector project modality was used to enable POWERGRID to develop and implement projects as required. This modality also provided POWERGRID with flexibility to adjust the scope of subsequent subprojects based on the most urgent requirements, thereby maximizing the outcomes to be realized from the available budget and ADB loan, the amounts of which were specified in the loan agreement. The sector loan modality was appropriate given the funding requirements of the NTDP. In accordance with ADB's sector lending modality, the original subprojects (core subprojects)⁶ were identified in the southern regional grid at the time of loan processing. ADB's formulation of the loan included core and candidate subprojects, with POWERGRID being responsible for the design and implementation of subprojects. The project was designed to help strengthen POWERGRID's institutional framework and to enhance the economy and efficiency of intra and inter-regional high-capacity transmission development, including operation and maintenance (O&M) services, without causing major environmental and social problems. No major changes were made to the scope during project implementation. The project was formulated in close coordination with POWERGRID, the Central Electricity Authority (CEA), the Ministry of Power, and the Department of Economic Affairs.

5. At appraisal, the government's objective was to improve efficiency in the power sector by removing transmission bottlenecks to facilitate better utilization of existing and planned generating stations, the entry of independent power producers, and the development of a robust and reliable national transmission grid to ensure smooth power flow within the whole power system in the country. ADB's country strategy was to fund infrastructure projects in key sectors that contributed to economic growth. Its sector strategy focused on (i) expanding the availability of and access to energy by reducing losses, (ii) strengthening infrastructure, (iii) promoting clean energy, and (iv) increasing energy efficiency.⁷ At project completion, ADB's strategy and policy (Strategy 2020 and Energy Policy 2009)⁸ for the power sector in India were in synergy with the government's 11th five-year plan objectives, 2007–2012⁹ to develop infrastructure for economic growth and poverty reduction. ADB's current strategy (India country partnership strategy, 2013–2017) for assistance to India's power sector also includes investments in central sector transmission systems.

⁴ ADB. 2003. *Country Strategy and Program: India, 2003–2006*. Manila; and ADB. 2004. *Country Strategy and Program Update: India, 2005–2007*. Manila.

⁵ Since 1995, ADB has provided POWERGRID with eight sovereign loans and two non-sovereign loans to strengthen its transmission system nationally.

⁶ Core subprojects are subprojects that are appraised and approved at the time of processing for funding under a sector loan.

⁷ Investments were targeted (i) transmission at the state and central levels; (ii) distribution networks at the state level, including remote metering, feeder separation, and high-voltage distribution systems; (iii) renewable energy development, particularly solar; (iv) demand-side energy efficiency; and (v) new technologies such as smart grids.

⁸ ADB. 2008. *Strategy 2020: The Long-Term Strategic Framework of the Asian Development Bank, 2008–2020*. Manila. ADB. 2009. *Energy Policy*. Manila.

⁹ Government of India, Planning Commission. 2006. *Towards Faster and More Inclusive Growth: An Approach to the 11th Five Year Plan*. Delhi.

B. Project Outputs

6. The project supported (i) the grid strengthening plan in the southern regional grid covering Andhra Pradesh, Karnataka, Kerala, Tamil Nadu, and Union Territory of Pondicherry; and (ii) some transmission capacity enhancement schemes in the northern and western regional grids. The project delivered most of the expected outputs as envisaged.¹⁰ The updated design and monitoring framework is in Appendix 1. The main events in project implementation are presented chronologically in Appendix 2. A brief review of the status of completion of project outputs follows.

1. Grid Strengthening for Tamil Nadu I

7. The subproject comprised the (i) construction of 266.5 kilometers (km) of 400 kV double circuit (D/C) transmission line from Tirunelveli to Udumalpet; (ii) augmentation of existing 400/220 kV substations at Udumalpet and Trivandrum, each with a 315 mega volt-ampere (MVA) transformer; and (iii) construction of 110 km of loop in loop out (LILO) of 400 kV D/C transmission line from Madurai to Trivandrum, and new 400/220 kV substation with 2x315 MVA transformation capacity at Tirunelveli—this component was subsequently dropped from the project scope and cost estimates for the subproject were revised accordingly during the inception mission; it was financed by POWERGRID from its own resources.¹¹ The subproject, completed in October 2009, enabled the states of Tamil Nadu and Kerala to draw their share of power of about 270 MW and 250 MW, respectively, from the central sector generation projects (Kudankulam Nuclear Power Plant, Tamil Nadu). POWERGRID also informed that this subproject has reduced overloading in the state transmission networks of Tamil Nadu and Kerala, and has improved the voltage profile at 400 kV substations, which has enhanced the reliability and stability of the 400 kV network in these two states.

2. Grid Strengthening for Tamil Nadu II

8. The subproject comprised the (i) construction of 124 km of 400 kV D/C transmission line from Pugalur to Madurai and 67 km of 400 D/C kV transmission line from Udumalpet to Arasur, (ii) construction of new 400/220 kV substations with 2x315 MVA transformation capacity each at Pugalur and Arasur, and (iii) augmentation of 400/220 kV substation bays at Madurai and Udumalpet. The subproject, completed in July 2010, enabled Tamil Nadu to draw its share of power to 800 MW from the central sector generating plant, Neyveli Thermal Power Plant (NTPP) at Neyveli, Tamil Nadu. In addition, POWERGRID informed that this subproject is facilitating Tamil Nadu to wheel about 200–300 MW of wind power generated under the private sector in the state to the load centers at Madurai and Karaikudi.

3. Grid Strengthening for Tamil Nadu, Andhra Pradesh, and Union Territory of Pondicherry

9. The subproject, completed in September 2010, comprised the construction of (i) a 400/220 kV 2x315 MVA substation each at Pondicherry and Warangal, (ii) 13 km LILO of the Neyveli–Sriperumbudur 400 kV single circuit (SC) transmission line, and (iii) 14 km LILO of the Ramagundam–Khammam 400 kV SC transmission line.

¹⁰ The contribution of the project to the ADB Results Framework is 1,258.2 km of transmission lines installed against the original target of 667 km.

¹¹ Because of the urgent need to complete the 400 kV D/C transmission line from Madurai to Trivandrum, and new 400/220 kV substation with 2x315 MVA transformation capacity at Tirunelveli, POWERGRID initiated procurement following its own guidelines; this component was dropped at the request of POWERGRID.

10. The new 400 kV substation at Pondicherry and LILO of the Neyveli–Sriperumbudur line has facilitated the Union Territory of Pondicherry to draw its share of power from the NTPP through the POWERGRID transmission network. Before the new POWERGRID substation at Pondicherry, its transmission network was connected to the Tamil Nadu grid only and was completely dependent on this transmission network. The subproject enabled Union Territory of Pondicherry to meet increased load demand of 683 MW compared with 347 MW peak demand before the substation was commissioned. It also contributed to the achievement of 100% electrification in Union Territory of Pondicherry.

11. The new 400 kV substation at Warangal and LILO of the Ramagundam–Khammam line have (i) provided a reliable system to tap about 150–200 MW of power from Unit 7 of Ramagundam Thermal Power Plant of the National Thermal Power Corporation of India, to cater to the needs of the Warangal and nearby districts in Telangana state; and (ii) about 500–600 MW of power from the Kakatiya Thermal Power Station at Bhopalpally and the National Lignite Power Corporation of India Expansion II Project is also being pooled at Warangal substation for further dispersal to the Telangana and Andhra Pradesh load centers.

4. Grid Strengthening for Kerala I and II

12. The grid strengthening for Kerala I subproject comprised the construction of (i) the 400 kV 81.2 km Tirunelveli–Edamon multi-circuit line, and (ii) the 400 kV 150 km Edamon–Muvattupuzha line.¹² The grid strengthening for Kerala II subproject comprised (i) construction of the 400 kV 80 km Muvattupuzha–North Trichur line, (ii) construction of a new 400/220 kV substation at Muvattupuzha, and (iii) extension of the bays at the existing 400/220 kV substation in North Trichur. The Kerala I (except the 400 kV 150 km Edamon–Muvattupuzha line) and Kerala II subprojects were completed in November 2011. These subprojects were designed to (i) facilitate the drawl of the Kerala share of power from central sector generating plants like the NTPP and the Kudankulam Nuclear Power Plant; and (ii) provide an interconnection with the POWERGRID network in the southern region to enhance the state grid stability and reliability—through the interconnection of the state grid with the southern regional grid at multiple locations instead of the existing radial connection through the 400 kV line between North Trissur (Kerala) and Udumalpet (Tamil Nadu). As a result of the grid strengthening achieved through these subprojects, Kerala was able to draw about (i) 550 MW of power from the central sector power plants, and (ii) 140–150 MW of wind power generated by the private sector in southern parts of Tamil Nadu.

5. Northern Region System Strengthening Scheme V

13. The subproject comprised the construction of (i) LILO of the 400 kV Hissar–Jaipur transmission line at Bhiwadi of 78 km; (ii) the 400 kV D/C Agra–Bhiwadi transmission line of 204 km; (iii) the 400 kV D/C Bhiwadi–Moga transmission line of 351 km; and (v) associated 400 kV bays at (a) Agra, (b) Moga, and (c) Bhiwadi substations. The subproject, completed in March 2010, was part of the interregional transmission capacity expansion scheme undertaken by POWERGRID to import 2,500 MW from the eastern region to the northern region—subproject components are helping northern region beneficiary states like Haryana, Rajasthan, Uttar Pradesh, and Punjab to pool their share of power at their respective substations to meet local demand.

¹² The Edamon–Muvattupuzha line is yet to be completed. The work stalled because of a right-of-way (ROW) issue, but POWERGRID confirmed during the PCR mission that the issue has been resolved. The related contract was awarded in March 2017 and completion is scheduled by March 2018.

6. Enhancement of Transmission Capacity in East–West Corridor of Northern Region

14. The subproject involved the installation of series compensation in existing POWERGRID substations to enhance power transfer capacity between the eastern and western parts of the northern region.¹³ The subproject comprised the establishment of (i) 30% fixed series compensation (FSC) on the Bareilly–Mandaula 400 kV D/C line at Bareilly, (ii) 45% FSC on the Unnao–Bareilly 400 kV D/C at Unnao, and (iii) 30% FSC on the Gorakhpur–Lucknow 400 kV D/C line at Lucknow. Completed in March 2010, implementation of the subproject has led to enhancement of the transfer capability between the eastern and western parts of the northern region. The subproject has contributed in balancing the load among the parallel transmission corridors and has optimized the loading of the network. It has improved the loading capacity of the lines by 30%–45% (about 500 MW). Overloading of the parallel transmission lines in the east–west corridor of the northern region has been reduced, and the subproject helped to meet an additional 500 MW of energy demand without having to construct an additional transmission line in the northern region.

7. Western Region Strengthening Scheme VII

15. The subproject comprised the installation of 125 mega volt ampere reactive (MVAR) bus reactors along with the extension of associated bays at the 400/220 kV Khandwa and Dehgam substations. Commissioned in October 2010, the bus reactors installed at these two substations helped voltage control in the western region, which had been experiencing persistent high voltage condition during the off-peak period in some of the 400 kV substations for which transmission lines needed to be opened to contain overvoltage conditions. The subproject has contained voltage within stipulated limits and thereby enhanced the safety and security of the grid, resulting in efficient and more reliable delivery of services to consumers.

8. Procurement of Bulk Conductors and Insulators

16. Under this component, POWERGRID procured (i) 2,349 km of aluminum conductor steel reinforced (ACSR) moose conductor, (ii) 87,161 120 kilonewton (KN) insulators, and (iii) 134,761 160 KN insulators, used in the national grid development transmission line project ± 800 kV high-voltage direct current (HVDC) northeastern region to north-west interconnection line. Procurement under these contracts was completed in March 2009.

9. Procurement of Additional Bulk Conductors to Strengthen and Develop the National Grid

17. Under this component, POWERGRID procured 3,150 km of ACSR LAPWING conductor used in the national grid development transmission line project ± 800 kV HVDC northeastern region to north-west interconnection line. Procurement under this contract was completed in March 2010.

¹³ In the northern region, many thermal generation stations are in the southeast while loads are concentrated in the west. As such, the transmission lines were critically loaded before this.

C. Project Costs

18. The project cost at appraisal was \$568.0 million, comprising \$465.2 million in foreign currency (81.9%) and the equivalent of \$102.8 million (18.1%) in local currency.¹⁴ After the approval of the candidate subprojects, cost estimates were revised to \$653.2 million, which comprised \$539.6 million in foreign currency and \$113.6 million in local currency. The actual completion cost of the project is \$602.2 million—\$400.0 million from the ADB loan and \$202.2 million from POWERGRID's own resources. Savings amounted to \$51.1 million. Appendix 3 compares the estimated and actual project costs. The summary of contracts is in Appendix 4. Appendix 5 provides the average exchange rates used to convert local currency to the United States dollar equivalent. Appendix 6 contains the project financing plan.

19. The cost savings of \$51.1 million can be attributed to (i) lower-than-estimated procurement costs, primarily because POWERGRID received competitive prices from international competitive bidding for the procurement of four subprojects—enhancement of transmission capacity in the east–west corridor of the northern region, the western region strengthening scheme VII, procurement of bulk conductors, and procurement of additional bulk conductors (\$24.0 million); (ii) savings in contingencies (\$17.8 million); and (iii) savings in interest during construction (IDC) (\$9.2 million).

D. Disbursements

20. Disbursements totaled \$400 million out of the loan amount. A reimbursement procedure approved by ADB was used. POWERGRID expressed its satisfaction regarding ADB's disbursement procedures, and informed the project completion review (PCR) mission that it had not encountered any problems in processing reimbursement claims under various contracts. The projected (at the beginning of each calendar year) and actual disbursements are in Appendix 7.

E. Project Schedule

21. The planned implementation steps of the subprojects are compared with the actual sequence of events in Appendix 8. It was estimated at appraisal that all subprojects would be completed before the loan closing date of 31 December 2009. The project was extended twice to March 2012 (the first extension was approved until December 2010) at the request of the borrower. Factually, (i) two subprojects were completed within the original loan closing date of December 2009¹⁵; (ii) six subprojects were completed within the first revised loan closing date of December 2010¹⁶; (iii) one subproject was completed within the second extended loan closing date of March 2012¹⁷; and (iv) one of the components (150 km 400 kV D/C Edamon–Muvattupuzha transmission line) of the grid strengthening for Kerala I subproject is under implementation, scheduled for completion by March 2018. This line could not be completed as of the PCR mission (February 2017) because the right-of-way (ROW) issues were not resolved until

¹⁴ For comparison purposes, the revised estimated cost of the project, i.e., the appraisal estimates of subprojects that were finally financed under the ADB loan, was considered.

¹⁵ These subprojects are (i) grid strengthening for Tamil Nadu I, and (ii) procurement of bulk conductors to strengthen and develop the national grid.

¹⁶ These subprojects are (i) grid strengthening for Tamil Nadu II; (ii) grid strengthening for Tamil Nadu, Andhra Pradesh, and Union Territory of Pondicherry; (iii) north region system strengthening V; (iv) enhancement of transmission capacity in the east–west corridor of the northern region; (v) western region strengthening scheme VIII; and (vi) procurement of additional bulk conductors to strengthen and develop the national grid.

¹⁷ This subproject is grid strengthening for Kerala II.

August 2016 and the contract for the line works was awarded in March 2017. The major milestones in the implementation of the subprojects are described below.

1. Grid Strengthening for Tamil Nadu I

22. Advance procurement action (APA) was taken for this subproject with the prior approval of ADB, and all six contract packages were awarded by March 2006 compared with the appraisal schedule of March 2005. The subproject was completed in October 2009 against the scheduled completion date of December 2007. The delay of 22 months in the completion of this subproject is primarily attributable to the delays in the implementation of associated central sector generation projects. The 12-month delay in contract award and 10-month delay in physical implementation have not impacted the expected outcomes of the subproject.

2. Grid Strengthening for Tamil Nadu II

23. APA was taken for this subproject with the prior approval of ADB, and all eight packages were awarded by February 2006 against the appraisal schedule of July 2005. The subproject was completed in July 2010 compared with original completion schedule of December 2007. The delay of 30 months in the completion of the subproject is primarily attributable to the delays in the implementation of associated central sector generation projects in the region. POWERGRID revised the implementation schedule to match with the generation projects, and the delay has not impacted on the expected outcomes of the subproject.

3. Grid Strengthening for Tamil Nadu, Andhra Pradesh, and Union Territory of Pondicherry

24. APA was taken for this subproject with the prior approval of ADB, and all five contract packages were awarded by March 2006 compared with the appraisal schedule of August 2005. The subproject was completed in July 2010 compared with the original completion schedule of December 2007. The delay of 30 months was mainly due to delays in the execution of the associated generation project. To match with the generation project schedule, POWERGRID revised the implementation schedule of the subproject. The subproject was completed in July 2010 without any impacts on the expected outcomes of the subproject.

4. Grid Strengthening for Kerala I and II

25. Procurement of all 16 contract packages under grid strengthening for Kerala I and II was completed in March 2008 against the appraisal schedule of February 2006. The grid strengthening for Kerala I subproject comprised the construction of (i) 80 km of the 400 kV Tirunelveli–Edamon transmission line—completed in March 2010 against the appraisal schedule of November 2008, since physical implementation followed the schedule of the associated central sector generation projects although the contract was awarded as envisaged at appraisal in March 2006; and (ii) 150 km of the 400 kV D/C Edamon–Muvattupuzha transmission line—the contract was awarded in March 2008 against the schedule of February 2006 because the tower packages (A1, A2, and A3) were rebid. Since the award of contract for Edamon–Muvattupuzha line, only 18 km of the 150 km line have been completed. Severe ROW issues delayed implementation of the transmission line, as project-affected persons did not accept the compensation offered. However, these issues were resolved through a special compensation package provided to affected persons, based on state government orders in July 2015 and August 2016; and a fresh contract for balance works was awarded in March 2017, with completion scheduled for March 2018.

POWERGRID is implementing the remaining 132 km of the transmission line, scheduled for completion in March 2018, using its own funds.

26. The grid strengthening for Kerala II subproject was completed in November 2011 against the original completion schedule of November 2008. The delay of 36 months was mainly due to (i) rebidding of tower packages A1, A2, and A3; and a stay order from the High Court of Kerala on the opening of bids for these packages because of ROW issues—POWERGRID awarded the tower packages in March 2008 against the schedule of February 2006; and (ii) matching the implementation schedule with associated central sector generation projects.

5. Northern Region System Strengthening Scheme V

27. Nine contract packages for the works under this subproject were awarded in January 2007 compared with the appraisal schedule of October 2006. The subproject was completed in March 2010 against the scheduled completion date of June 2009. The delay of 9 months was due to (i) a 3-month delay in the award of contract, and (ii) a 6-month delay in physical implementation.

6. Enhancement of Transmission Capacity in East–West Corridor of Northern Region

28. One contract package was awarded for various works under this subproject in July 2007. The subproject was completed in March 2010 against scheduled completion in July 2009. This subproject involves FSC installation, requiring shutdown of running substations, which entails coordination with various state transmission agencies and load dispatch centers. This resulted in a slower pace of work and a delay in subproject completion.

7. Western Region Strengthening Scheme VII

29. In March 2008, one contract was awarded for the procurement of 125 MVAR bus reactors alongside the extension of bays at 400/220 kV substations in Khandwa and Dehgam. The subproject was completed in October 2010 ahead of the original schedule of November 2010.

8. Procurement of Bulk Conductors and Insulators

30. Two contracts were awarded by September 2008 for the procurement of bulk conductors and insulators, compared with the original schedule of February 2008. The subproject was completed in March 2009 against the original schedule of August 2008. The delay was mainly due to a lag in completing the procurement process and award of contract.

9. Procurement of Additional Bulk Conductors

31. In May 2009, one contract for a conductor package was awarded for the procurement of bulk conductors. Supplies were completed in March 2010 against the original schedule of October 2009.

F. Implementation Arrangements

32. POWERGRID was the executing agency for the project. The implementation arrangements remained as envisaged at appraisal, and ADB found them adequate. Overall responsibility for project implementation was with the director (projects) of POWERGRID, who was assisted by the corporate monitoring group. Construction supervision for each subproject was under the executive directors of the respective regions, assisted by the planning, engineering,

finance, and personnel departments at regional headquarters. Engineering and contracting activities for all contract packages funded under the ADB loan component were carried out from the corporate headquarters of POWERGRID in Gurgaon, Haryana. The company's executive director (corporate planning) was in charge of overall coordination with ADB. POWERGRID's computerized integrated project management system enabled (i) a master network schedule for each project; (ii) separate work schedules for each contract package with contractors to meet the master network schedule; and (iii) regular progress review and monitoring at field, regional, and corporate levels. The regional executive directors monitored subproject progress through weekly and monthly review meetings. POWERGRID's top management reviewed the implementation progress of each subproject at quarterly project review meetings. Forest clearances, land acquisition for substations, and rehabilitation of project-affected persons were planned and executed to avoid delays. The organization chart of POWERGRID is in Appendix 9.

G. Conditions and Covenants

33. No special or additional conditions other than legal opinions were required for loan effectiveness. No covenant was modified, suspended, or waived during implementation. All the covenants were reasonable and relevant for the sector, and for the borrower's operations. The status of compliance with covenants is in Appendix 10. POWERGRID was generally in compliance with all loan covenants.

H. Consultant Recruitment and Procurement

1. Consultant Recruitment

34. As originally envisaged, the project was implemented without the services of consultants.

2. Procurement

35. POWERGRID made use of the advance procurement facility, as agreed by ADB. POWERGRID awarded all major contracts for the first set of subprojects immediately after the loan became effective. ADB cooperated with POWERGRID to achieve the important milestones in project implementation by proving timely approvals of the procurement documents. In general, POWERGRID carried out all procurement activities for ADB-financed contract packages in accordance with the *Guidelines for Procurement under Asian Development Bank Loans* (February 1999, as amended from time to time).

I. Performance of Contractors and Suppliers

36. POWERGRID reported that the performance of all contractors was generally satisfactory. All goods and services procured for the project complied with the specifications and other operational performance standards.

J. Performance of the Borrower and the Executing Agency

37. POWERGRID was both the borrower and the executing agency of the project. The overall performance of POWERGRID in both roles was *satisfactory*. The entire scope of the project has been completed except for the 400 kV D/C Edamon–Muvattupuzha transmission line of 150 km under the grid strengthening for Kerala I subproject, whose construction was delayed because of ROW issues (para. 25). POWERGRID was able to operate and maintain all the subprojects at high levels of efficiency. At appraisal, the overall annual availability of POWERGRID's

transmission system was 99.00%. At completion, the availability of the national transmission grid was maintained at 99.55% and above, which compares well with the best transmission utilities in the world. Overall, POWERGRID has demonstrated its capacity to formulate and appraise, arrange finance for, and carry out engineering, procurement, and construction of a variety of projects across the country, conforming to approved specifications and standards and to the satisfaction of ADB.

K. Performance of the Asian Development Bank

38. ADB monitored project progress closely and regularly through review missions and quarterly progress reports, and provided useful advice in several areas, including procurement and project management. ADB accorded timely approvals that enabled project milestones to be achieved, which contributed to smooth project execution. Administration of the project was delegated to the resident mission on 1 January 2010. ADB, POWERGRID, and officials from the Department of Economic Affairs held many tripartite portfolio review meetings, which helped in the successful implementation of the project. The resident mission also took timely corrective measures, which were proposed on several occasions. Thus, ADB's overall performance was rated *satisfactory*.

III. EVALUATION OF PERFORMANCE

A. Relevance

39. The project is rated *relevant*. The project was aligned with the energy sector objectives of the government and to ADB's sector strategy and country strategy for India both at appraisal and completion.

40. The project design focused on critical investments needed to strengthen and expand India's transmission system in the power sector. At the same time, it addressed the urgent need to promote higher efficiencies and accessibility to energy, reliability and quality of power supply. It provided benefits in terms of the reduction in generation capacity requirement due to numerous factors like time diversity and the spinning reserves requirement. These investments were critical for the long-term development of a strong power sector. The project's design and monitoring framework made logical linkages from inputs to outputs, outcome, and impact; and risk analysis was sound. The Project was implemented as planned, without changes in scope.

41. At completion, the project remains consistent with the India country partnership strategy, 2013–2017, which supports (i) clean and renewable energy expansion; (ii) enhancing energy efficiency; (iii) promotion of advanced high-voltage transmission technology, including HVDC transmission lines to increase transmission efficiency, and facilitate interregional power exchanges; and (iv) grid integration of renewable energy.¹⁸ The government in 2015 set an ambitious plan for establishing 175 gigawatts (GW) of renewable generation capacity by 2022 (100 GW of solar energy, 60 GW of wind energy, and 15 GW of other renewable sources). The project components are expected to support the transmission of the energy from these resources to the load centers. Thus, the project was and still is consistent with the government's objectives and with ADB's strategy for the Indian energy sector at appraisal and at completion.¹⁹

42. India's central and state governments are pursuing capacity expansion, reforms, provision of a transmission infrastructure that uses existing installed capacities optimally, the setting of bulk

¹⁸ ADB. 2013. *Country Partnership Strategy: India, 2013–2017*. Manila.

¹⁹ Contribution to ADB Results Framework: 1,428.7 km of transmission lines.

and retail tariffs on commercial terms by independent regulators, and private sector participation. To achieve these objectives, the government enacted a comprehensive Electricity Act in 2003. The project will continue to be relevant in the future because of the need for rapid expansion of the power sector,²⁰ including the need for bulk transmission of power and greater interregional power exchanges (including the transmission of 175 GW of renewable energy being developed under new government initiatives). The project will also continue to facilitate the future implementation of the open access policy under the Electricity Act.

B. Effectiveness in Achieving Outcome

43. The project is rated *effective*. It achieved its outcome of supporting POWERGRID in strengthening and developing India's national transmission grid to improve system reliability, facilitate interstate and interregional power transfers by removing transmission bottlenecks, and facilitate the efficient use of existing and planned power plants through (i) expanding the 400 kV transmission network and enhancing the transmission capacity of existing transmission lines, and (ii) constructing new substations and augmenting existing ones in identified regions. POWERGRID operated all the project components at very high levels of efficiency. The project achieved the physical targets established at appraisal.

44. The project substantially strengthened the power transmission capacity in the region by improving existing grid interconnections. The southern transmission system subprojects fulfilled the high capacity transmission requirements of the region. At appraisal, the project had the following targets: (i) availability of the national transmission grid at 99.00% or greater, and (ii) T&D losses reduced from about 30.00% in 2004 to 20.00% in 2012. At completion, achievement was as follows: (i) availability of the national transmission grid was maintained at 99.55% or greater, and (ii) T&D losses were reduced to 28.55% by 2012. Although the outcome target for T&D losses was not achieved within the original closing date because of delays during implementation, the indicator is likely to be achieved by 2019 according to government plans. Almost all outputs were delivered. The subprojects will support the integration of the regional grids and the overall reliability of the system. The Project intervention has not resulted in environment degradation. Safeguard monitoring was timely and adequate. The Project outcomes have positively impacted project communities and women in general (refer to para. 34–49).

C. Efficiency in Achieving Outcome and Outputs

45. The project is rated *efficient* in achieving outcome and output. It was implemented within budget and within the approved extended time frame. The loan extension was required in part because of the delay in procurement activities, ROW issues, as well as to match the implementation of project with associated central sector generation projects. The delays were justifiable, and the resulting changes enhanced the outcome of the project. The subprojects have been operating continuously with an availability factor of 99.55% and above. At completion, the economic internal rate of return (EIRR) for the project was calculated at 19.7%,²¹ greater than hurdle rate of 12.0%.²² The EIRR was calculated based on the project's primary benefits, which stemmed from (i) removal of existing bottlenecks to meet the growing energy needs through the introduction of economic dispatch between neighboring regions; (ii) improving efficiency, reliability, and system security; (iii) energy trade from surplus to deficit regions; and (iv) loss

²⁰ Power demand in India is projected to more than double from 300 GW to over 700 GW by 2030 according to International Energy Agency. 2015. *India Energy Outlook*. Paris.

²¹ At appraisal, the EIRR was estimated at 30.5% for the proposed investments under the NTDP, amounting to \$12.6 billion up to 2012, while at completion, the EIRR was calculated for the ADB-financed project components.

²² ADB. 2016. *Guidelines for the Evaluation of Public Sector Operations*. Manila.

reduction. The physical output, interstate transmission of electricity, added to existing supply (incremental benefit) and substituted (non-incremental) for the alternative form of energy supply. The incremental benefits were calculated for each category of customers, using customers' willingness to pay (WTP) for electricity. Sensitivity analysis of the main parameter (reduction in energy sales) indicates that the impact of the risk would only reduce the EIRR to 15.9%, underscoring the robust nature of the project's economic performance. Major assumptions used in the economic evaluation, and detailed calculations of the EIRR, are in Appendix 11.

D. Preliminary Assessment of Sustainability

46. The project is rated *likely sustainable*. The design of all the subprojects and the technology adopted are robust and appropriate, given the technical parameters, the requirements of India's power sector, and the project's long-term sustainability. Future funding for the required O&M is expected to be adequate. Transmission tariffs are determined based on cost-plus methodology, which ensures the recovery of costs incurred at normative availability of the transmission system at 99.5% and a return on equity of 15.5% per annum. The financial internal rate of return (FIRR) of 5.6% exceeds the weighted average capital cost of 3.1%, indicating that the project is financially viable and its returns will contribute to POWERGRID's overall financial health. The project is expected to remain financially sustainable because POWERGRID (i) has executed commercial contracts with all the project beneficiaries to provide a transmission network, and (ii) holds a letter of credit for more than 100.0% of the monthly billing of the beneficiaries. According to government forecasts, demand will be adequate for the evacuation of power from existing stations and for the transfer of power from regions with a surplus to regions with a deficit, ensuring the optimum use of the transmission systems established under the project.²³ The technical standards and quality systems adopted, and the material and equipment procured and installed, are of latest technology. POWERGRID also has in-house capacity to operate and maintain the subprojects effectively and efficiently. Hence, all the components are expected to be used optimally throughout the project. The project benefits and development impacts are likely sustainable. Major assumptions used in the financial evaluation and detailed calculations of the FIRR are in Appendix 11.

E. Impact

1. Environmental Impacts

47. The environment category of the project designed in the sector loan modality was B, according to ADB's Environment Policy (2002). POWERGRID prepared the initial environmental examination (IEE) reports for the core subprojects in 2004. A summary IEE report, including the environmental management and monitoring plan (EMMP) and the environmental assessment and review framework, was prepared as supplementary appendix to the report and recommendation of the President (RRP, footnote 1). Subsequently, POWERGRID prepared IEE reports for the non-core subprojects. During the appraisal of the non-core subprojects, project-affected persons and nongovernment organizations participated in public consultations in relation to IEE preparation. ADB reviewed the IEEs before approval and all IEE reports were disclosed on its website. POWERGRID took special care in selecting the routes of the transmission lines to avoid, as much as possible, the alignments passing through ecologically sensitive areas; unstable areas; human settlements; developed areas; and places of archeological, historical, and cultural

²³ Power demand in India is projected to more than double from 300 GW to over 700 GW by 2030 according to International Energy Agency. 2015. *India Energy Outlook*. Paris. In accordance with system requirements, POWERGRID has increased interregional transmission capacity from 28 GW in March 2012 to 46.5 GW in December 2014 and 70 GW in February 2017, indicating very strong requirements for strengthening the national grid in India.

importance. Where this was not possible, the alignments were finalized in consultation with forest and other authorities, as applicable, to minimize the ecological damage and disturbance to local communities. Thanks to this careful route selection process, none of the subprojects were located within, close to, or passing through any ecologically sensitive areas (such as national parks, sanctuaries, and biosphere reserves) or protected monuments; and only 20.57 km of transmission lines traversed through the forest (0.015% of the total length). It also confirmed that no changes were made to substation site locations or transmission line alignments during implementation. POWERGRID confirmed that all requisite statutory environmental approvals (e.g., forest clearances and permission for cutting trees) were obtained before the commencement of works. It also paid the forest department for compensatory afforestation toward the loss of vegetation caused by the use of about 94.53 hectares of forestland for ROW under the transmission lines. The EMMPs were included in the contract documents. Contractors' contracts included EMMP provisions for proper and timely implementation such as safety related risks, noise, and environmental pollution. Transformers and other equipment used in the project were free from polychlorinated biphenyl. POWERGRID encouraged the use of personal protective equipment by laborers and site staff, and organized periodic training programs for site staff on safety. In one of the subprojects, POWERGRID introduced multi-circuit towers and the extension of towers to reduce the ROW requirement. It introduced rainwater harvesting and the reuse of treated wastewater in substations for conserving and recharging groundwater. It also encouraged the use of solar energy in substations. These measures resulted in a reduced requirement of forestland and vegetation loss, increased availability of land for gainful use, improved conservation of resources, and a reduced risk of exposure to electromagnetic fields. POWERGRID reported that the replacement trees were planted.²⁴ The overall implementation of the EMMP provisions was observed to be generally adequate. Independent experts monitored each subproject externally and submitted semiannual monitoring reports. ADB monitored the environmental aspects of the subprojects sufficiently, and ensured that POWERGRID and the contractors implemented the EMMPs. POWERGRID confirmed that no complaints were received from local residents regarding environmental issues during implementation.

2. Social Impacts

48. The project was gender-neutral regarding beneficiaries, as all categories of electricity consumers—domestic, agricultural, industrial, and commercial—would derive benefits from the project. These benefits include increased power availability, fewer supply interruptions, and less load shedding. The project increased the availability and reliability of the power supply in the project areas. Other benefits are increased industrial productivity and job creation in the manufacturing sector through additional, reliable power supply. The project is expected to have a positive impact on poverty reduction by enabling increased investments in the beneficiary states of the southern, northern, and western regions; and creating long-term, stable, direct, and indirect employment opportunities for skilled and unskilled workers during the operation of the subprojects established under the project.

49. POWERGRID has taken satisfactory measures to address the concerns of the project-affected persons and provide rehabilitation assistance to them. These included (i) special care in selecting the routes of transmission lines to avoid human rehabilitation, threats to the survival of vulnerable communities, and common property resources; (ii) adequate compensation for damage to crops, trees, and buildings or structures; (iii) adequate compensation and rehabilitation

²⁴ Ministry of Environment, Forest and Climate Change. Compensatory Afforestation Fund Management and Planning Authority (CAMPA). <http://envfor.nic.in/major-initiatives/compensatory-afforestation-fund-management-and-planning-authority-campa>.

assistance for project-affected persons; (iv) robust institutional arrangements for monitoring of rehabilitation measures; (vi) employment of project-affected persons and local people by contractors during construction; and (viii) employment of project-affected persons and local residents through contractors after project completion. The resettlement plan for the core subprojects and the resettlement framework for the project as a whole were prepared as supplementary appendixes to the RRP. Subsequently, POWERGRID prepared resettlement plans for the non-core subprojects. POWERGRID disclosed all resettlement plans on its website. In accordance with the indigenous peoples planning framework of the RRP, no indigenous peoples were impacted so no indigenous peoples' development plan was prepared.

50. The project involved the construction of five new substations, for which 68.83 ha of land were acquired—6.88 ha of state government land and 61.94 ha acquired from private owners. POWERGRID issued the necessary prior notification during the land acquisition process, and conducted consultations with the project-affected persons. During the land acquisition process, 200 affected persons were compensated in accordance with the entitlement matrix.²⁵ Rehabilitation assistance was also provided to all eligible project-affected households following the provisions in the entitlement matrix.²⁶ The impact of the project on agricultural land along the transmission line route was restricted to the construction phase. POWERGRID compensated private landowners for temporary damage to crops and trees caused by the project. To minimize crop loss, construction activities were carried out during the off-season when possible. The affected persons were compensated according to officials from the revenue, horticulture, and forest departments. A total of ₹605.5 million has been paid to 17,553 affected persons for crops and trees damaged en-route these transmission lines.²⁷ POWERGRID confirmed that most of the complaints received from local residents during implementation regarding the payment of compensation were successfully resolved through the local grievance redress committees established for each subproject. POWERGRID undertook regular consultations with local residents to (i) understand the challenges they faced, (ii) facilitate the resolution of concerns, and (iii) expedite the compensation process. POWERGRID constructed roads, health facilities, community centers, water tanks, school buildings, furniture and computers for primary schools, and masts and street lighting, as part of its community development works, at a cost of ₹15.7 million. The provision of facilities was determined through consultations with the affected communities.

IV. OVERALL ASSESSMENT AND RECOMMENDATIONS

A. Overall Assessment

51. Overall, the project is rated *successful*, based on the ratings of *relevant*, *effective*, *efficient*, and *likely sustainable*. The project was successful in achieving all the outcome targets and outputs. Project formulation and design were consistent with ADB's country and sector strategies

²⁵ POWERGRID reported that 22 land acquisition cases were subjudice at Arasur, Pugalur, and Pondicherry on account of land ownership disputes. POWERGRID has deposited the assessed value of these lands in the court, and it will be disbursed once rightful ownership is established. At Muvattupuzha, six landowners have approached the revenue department for revision of the land cost in accordance with the latest state government circular. The revenue department has issued revised demand letters for ₹3.3 million, which POWERGRID is processing for the release of the enhanced compensation amount.

²⁶ POWERGRID engaged an external agency to monitor the implementation of the rapid action plan (RAP) provisions. The agency's report established that most recipients of the compensation and rehabilitation assistance have gainfully invested the proceeds in additional livelihood generation activities and improved the livelihoods of project-affected persons.

²⁷ Some affected persons have approached the court for enhanced compensation for damaged trees and crops. POWERGRID will pay the enhanced compensation, if applicable, in accordance with court orders.

and with POWERGRID's plan to develop a national grid. The performance of the executing agency and the borrower, and the contractors, was *satisfactory*. All the subprojects were implemented as conceived at appraisal. All but one of the subprojects achieved a high level of performance within a few months of being commissioned. The exception was the 400 kV D/C Edamon–Muvattupuzha transmission line of 150 km under the grid strengthening for Kerala I subproject, which was delayed primarily because of ROW issues. POWERGRID has the capability to operate and maintain the subprojects to derive maximum benefits from them.

B. Lessons

52. POWERGRID took advance action to acquire land and obtain statutory clearances, which helped in project implementation, though one transmission line is yet to be completed because of substantial delays in resolving ROW issues. One of the major reasons for delays in the implementation of transmission lines in India is ROW issues. It is advisable that the processing team assess the severity of ROW issues and associated risks in project implementation through adequate site visits and consultations with stakeholders along the planned stretch of the transmission lines. Based on this, the processing team should account for possible delays in implementation while designing the project.

C. Recommendations

1. Project Related

53. **Future monitoring.** Except for a small portion of one subproject, all other subprojects have been implemented successfully and are operating without problems. ADB will continue to monitor the completion of the Edamon–Muvattupuzha transmission line, including the submission of the safeguards monitoring reports, in accordance with the loan agreement; and disclose the safeguards monitoring reports following the Public Communication Policy 2011. As POWERGRID has a long and successful record of not only operating and maintaining the transmission system but also operating the regional grids on a real-time basis, no future project monitoring by ADB is required for the other subprojects.

54. **Further action or follow-up.** ADB will continue to monitor the completion of the grid strengthening for Kerala I subproject, which is scheduled for completion by March 2018. After this, the project will not require any specific follow-up action by ADB. POWERGRID, the beneficiary states of the project, and the CEA are closely monitoring the reliability and future performance of the project components.

55. **Timing of project performance evaluation report.** A project performance evaluation report mission may be fielded in 2019.

2. General

56. The interregional links and the grid-strengthening projects implemented under the ADB loan are expected to enhance the open access to the state level utilities. With continuing support from ADB and the World Bank, POWERGRID should be able to establish a robust national grid in India by 2020, facilitating the transfer of power across the regional grids, and thus help India make optimal use of its already installed and planned generating capacities. This will also help India in the optimal utilization of its energy resources. Therefore, the PCR mission opines that ADB may continue supporting POWERGRID in strengthening India's power grid.

DESIGN AND MONITORING FRAMEWORK

Design Summary	Targets	Achievement	Remarks
Impact Adequate and reliable supply to meet demands for electricity in India	100,000 megawatts (MW) of additional generation capacity by 2012 Electrification of rural households increased from 31% in 2004 to 100% in 2012	97,027 MW of generation capacity has been added from 2004 to 2012 ¹ About 67% of rural households have access to electricity in 2012 ²	As of 2017, 79.43% ³ of rural households have access to electricity. The government is targeting 100% access by 2018.
Outcome National transmission grid strengthened and expanded with transmission bottlenecks removed and losses reduced	Availability of national transmission grid at 99% or greater Transmission and distribution losses reduced from about 30% in 2004 to 20% in 2012	Availability of national transmission grid at 99.55% ⁴ Transmission and distribution (T&D) losses reduced from 30.00% in 2004 to 28.55% in 2012 ⁵	T&D losses have been reduced to 28.55% in 2012 and 22.00% in 2017. ⁶ The government is targeting to reduce T&D losses to 15.00% by 2019.
Outputs <ul style="list-style-type: none"> Tamil Nadu I Grid Strengthened Tamil Nadu II Grid Strengthened Tamil Nadu, Andhra Pradesh, and Union Territory of Pondicherry Grid Strengthened 	820 circuit-kilometer (cct-km) of 400 kilovolt (kV) transmission lines, and 1,260 megavolt-amperes (MVA) of 400/220kV substation capacity added ⁷ 436 cct-km of 400 kV transmission lines and 1,260 MVA of 400/220 kV substation capacity added 98 cct-km of 400 kV transmission lines and 1,260 MVA of 400/220 kV substation capacity added	400 kV double circuit (D/C) Tirunelveli–Udumalpet line of 267.5 km (535 cct-km); 315 MVA at Udumalpet and Trivandrum substations (630 MVA) 400 kV D/C Pugalur–Madurai line – 124 km (248 cct-km) 400 kV D/C Udumalpet–Arasur line – 67 km (134 cct-km) 2x315 MVA substations each (new) at Pugalur and Arasur (1,260 MVA)	Completed in October 2009 Completed in July 2010

¹ Central Electricity Authority (CEA) and Ministry of Power annual reports. New Delhi.

² Government of India, Planning Commission. 2006. *Towards Faster and More Inclusive Growth: An Approach to the 11th Five Year Plan*. New Delhi.

³ Government of India. Data on rural households electrification. New Delhi.

⁴ Power Grid Corporation of India Limited. Gurugram.

⁵ CEA annual reports. New Delhi.

⁶ CEA annual reports. New Delhi.

⁷ Construction of 220 cct-km of line in line out (LILO) of 400 kV transmission line from Madurai to Trivandrum, and new 400/220 kV substation with 2x315 MVA transformation capacity at Tirunelveli were subsequently dropped from the project scope during the inception mission (January 2006).

Design Summary	Targets	Achievement	Remarks
Candidate subprojects			
Grid Strengthening for Kerala-I	Construction of 620 cct-km of new 400 kV transmission lines from Tirunelveli to Muvattupuzha (East Kochi) via Edamon;	13 km line in line out (LILO) of Neyveli–Sriperumbudur 400 kV D/C line at Puducherry; 14 km LILO of Ramagundam–Khammam 400 kV S/C line at Warangal Substation; 2x315 MVA substations each (new) at Pondicherry and Warangal (1,260 MVA)	Completed in July 2010
Grid Strengthening for Kerala-II	Construction of 160 cct-km of new 400 kV transmission lines from Muvattupuzha (East Kochi) to North Trichur, construction of a new 400/220 kV substation with 2x315 MVA transformation capacity at Muvattupuzha (East Cochi), and extension of 400/220 kV substation bays at North Trichur;	400 kV D/C Tirunelveli–Edamon line – 81.2 km (2x162.4 cct-km); 400 kV D/C Edamon–Muvattupuzha line – being completed – 150 km (300 cct-km)	Completed in March 2010 To be completed in March 2018
Northern Region System Strengthening	Construction of 1,172 cct-km of new 400 kV transmission lines from Agra to Bhiwadi and Bhiwadi to Moga, 160 cct-km of new loop in loop out of 400 kV transmission line from Hissar to Jaipur at Bhiwadi, and extension of 400/220 kV substation bay at Bhiwadi, Moga and Agra.	400 kV D/C Muvattupuzha–North Trichur line – 80 km (160 cct-km); 2x315 MVA substations (new) at Muvattupuzha; Bay extension at North Trichur substation	Completed in November 2011
Enhancement of Transmission Capacity in East-West Corridor of Northern region	Two number 30% fixed series compensation (FSC) on 400 kV Gorakhpur–Lucknow line at Lucknow substation and on 400 kV Bareilly–Mandaula line at Bareilly substation; Two number 45% FSC on 400 kV Unnao–Bareilly line D/C at Unnao substation.	LILO of 400 kV S/C Hissar–Jaipur line – 39 km (78 cct-km) at Bhiwadi; 400 kV D/C Agra–Bhiwadi line – 204 km (408 cct-km); 400 kV D/C Bhiwadi–Moga line – 351 km (702 cct-km) Extension of bays at Agra, Bhiwadi, and Moga substations; 30% FSC on 400 kV Bareilly–Mandaula cct-1 and cct-2 at Bareilly substation; 45% FSC on 400 kV Unnao–Bareilly cct-1 and cct-2 at Unnao substation; 30% FSC on 400 kV Gorakhpur–Lucknow cct-1 and cct-2 at Lucknow substation	Completed in March 2010
Western Region Strengthening Scheme VII	125 MVAR bus-bar reactor at Khandwa and 125 MVAR bus-bar reactor at Dehgam substation	125 MVAR bus-bar reactor each at Khandwa and Dehgam substations, along with associated bays	Completed in October 2010
Procurement of Bulk Conductors and Insulators	ACSR Moose Conductor (2,349 km), 120 KN Insulators (87,161 nos), and 160 KN insulators (134,761 nos).	ACSR moose conductor (2,349 km) 120 KN insulators (87,161)	

Design Summary	Targets	Achievement	Remarks
Procurement of additional Bulk Conductors	Procurement of 3,150 km of ACSR LAPWING conductor	160 KN insulators (134,761) Procured 3,150 km ACSR LAPWING conductor	Completed in March 2009 Completed in March 2010

CHRONOLOGY OF MAIN EVENTS

Year	Date	Main Event
2004	3–16 June	ADB project reconnaissance mission
	29 July–18 August	ADB project fact-finding mission
	10–13 October	ADB appraisal mission
	24–25 November	Loan negotiations
	21 December	ADB Board approval of the loan
2005	3 November	Loan signing
	28 October	ADB approval of appraisal report for grid strengthening of Kerala I and II
2006	9 January	ADB approval of appraisal report for northern region system strengthening V
	10 January	Loan effectiveness
	24 January–1 February	ADB project inception mission
	7–17 March	Special Loan Administration
	28 August	ADB approval of appraisal report for enhancement of transmission capacity in the east–west corridor of the northern region subproject
2007	18–21 September	ADB project review mission (1)
	5 July	ADB approval of appraisal report for western region strengthening scheme VII
	16–19 July	ADB project review mission (2)
	4 October	ADB approval of appraisal report for procurement of bulk conductors and insulators to strengthen and develop the national grid
2008	18 February	Request was made to delegate authority to India Resident Mission
2009	20–24 October	ADB project review mission (3)
	21 September	ADB approved loan closing from 31 December 2009 to 31 December 2010
	5–13 October	ADB project review mission (4)
	9 December	ADB approval of appraisal report for procurement of additional bulk conductors to strengthen and develop the national grid
2010	1 January	Project delegated to India Resident Mission
	19–22 October	ADB project review mission (5)
	6–11 December	ADB project review mission (6)
	21 December	ADB approved a second loan extension from 31 December 2010 to 31 March 2012
2011	18–22 July	ADB project review mission (7)
2012	29 February–3 March and 5 March	ADB project review mission (8)
	31 March	Loan closing date (revised)
	5 October	Loan closure
2017	6–17 February	ADB project completion review mission

Source: Asian Development Bank.

COMPARISON OF ESTIMATED AND ACTUAL PROJECT COSTS
(\$ million)

Subprojects	Appraisal Estimate			Revised Estimate ^a			Actual		
	Foreign Exchange	Local Currency	Total	Foreign Exchange	Local Currency	Total	Foreign Exchange	Local Currency	Total
A. Project Expenditure									
1 Grid Strengthening for TN I	72.3	8.6	80.9	43.0	3.6	46.6 ^b	34.5	24.9	59.4 ^c
2 Grid Strengthening for TN II									
Grid Strengthening for TN and AP and UT of Pondicherry	65.5	20.1	85.6	65.5	20.1	85.6	71.6	23.6	95.2
3 Grid Strengthening for Kerala I									
Grid Strengthening for Kerala II	228.0	50.0	278.0	156.3	32.4	188.7	138.6	93.1	231.7 ^d
4 Northern Region System Strengthening V	59.0	13.0	72.0	104.9	13.6	118.5	100.3	28.6	128.9
5 Enhancement of Transmission Capacity in East–West Corridor of NR	0.0	0.0	0.0	19.0	8.1	27.1	14.4	1.1	15.5
6 Western Region Strengthening Scheme VII	0.0	0.0	0.0	5.1	3.9	9.0	1.7	0.8	2.5
7 Procurement of Bulk Conductors to Strengthen and Develop the National Grid	0.0	0.0	0.0	18.0	0.0	18.0	15.1	0.0	15.1
8 Procurement of Additional Bulk Conductors to Strengthen and Develop the National Grid	0.0	0.0	0.0	23.8	3.1	26.9	23.8	0.0	23.8
Subtotal (A)	424.8	91.7	516.5	435.6	84.8	520.4	400.0	172.1	572.1
B. Contingencies									
Physical Contingency	13.8	2.9	16.7	37.0	6.9	43.9	0.0	0.0	0.0
Price Contingency	16.4	3.6	20.0	41.5	8.1	49.6	0.0	0.0	0.0
Subtotal (B)	30.2	6.5	36.7	78.5	15.0	93.5	0.0	0.0	0.0
C. Interest during Construction (C)	10.2	4.8	15.0	25.5	13.8	39.3	0.0	30.1	30.1
Total (A+B+C)	465.2	103.0	568.2	539.6	113.6	653.2	400.0	202.2	602.2

^a Revised estimate as on September 2007. The revised estimate includes the candidate subprojects that were finally financed under the Asian Development Bank loan.

^b The revised figure is in accordance with the contract award value.

^c Includes contingencies such as price variations.

^d Including the contract award value of balance works related to the Edamon–Muvattupuzha 400 kilovolt transmission line, awarded on 1 March 2017.

Sources: Power Grid Corporation of India Limited and Asian Development Bank's loan financial information system.

SUMMARY OF CONTRACTS

PCSS No.	Category No.	Item Description	Contract Amount (\$)	Contract Disbursed (\$)
0001	01	Supply, erection, and commissioning for tower package (A1) Tirunelveli–Udumalpet	7,895,179	7,895,179
0002	01	Supply, erection, and commissioning for tower package (A2) Tirunelveli–Udumalpet	9,876,314	9,876,314
0003	01	Supply of insulator package (C2) Tirunelveli–Udumalpet	1,005,058	1,005,058
0004	01	Supply of equipment and material of substation package (A1) associated with Pagalur–Madurai; Arasur–Udumalpet (A1)	12,510,616	12,510,616
0005	01	Supply of conductor package (B2) Tirunelveli–Udumalpet	7,344,674	7,344,674
0005	01	Supply of conductor package (B2) Tirunelveli–Udumalpet	1,320	1,320
0006	01	Supply of insulator package (C1) Tirunelveli–Udumalpet	914,390	914,390
0007	01	Supply of conductor package (B1) Tirunelveli–Udumalpet	7,424,395	7,424,395
0007	01	Supply of conductor package (B1) Tirunelveli–Udumalpet	2,637	2,637
0008	01	Supply of insulator package (C1) Madurai–Pagalur	1,055,118	1,055,118
0009	01	Supply, erection, and commissioning for tower package (A1) Madurai–Pagalur	8,320,379	8,320,379
0010	01	Supply of equipment and material of substation package (B1) associated with Pondicherry and Warangal	9,765,056	9,765,056
0011	01	Supply of equipment and material of substation package (B2) associated with Pondicherry and Warangal	9,794,509	9,794,509
0012	01	Supply of conductor package (B1) Tirunelveli–Edamon	9,029,668	9,029,668
0012	01	Supply of conductor package (B1) Tirunelveli–Edamon	1,131	1,131
0013	01	Supply of conductor package (B2) Tirunelveli–Edamon	6,622,453	6,622,453
0014	01	Supply and erection for insulator package (C1) Tirunelveli–Edamon	1,493,199	1,493,199
0015	01	Supply and erection for insulator package (C2) Tirunelveli–Edamon	1,575,727	1,575,727
0016	01	Supply of equipment and material of substation package (A2) associated with Pagalur–Madurai; Arasur–Udumalpet (A1)	10,690,719	10,690,719
0017	01	Supply of conductor package (B2) Udumalpet–Arasur line, Ramagundam Khammam at Warangal and Neyveli Sriperumbudur at Pondicherry	5,345,861	5,345,861
0017	01	Supply of conductor package (B2) Udumalpet–Arasur line, Ramagundam Khammam at Warangal and Neyveli Sriperumbudur at Pondicherry	1,346	1,346
0018	01	Supply of insulator package (C2) Udumalpet–Arasur line, Ramagundam Khammam at Warangal and Neyveli Sriperumbudur at Pondicherry	354,328	354,328
0019	01	Supply, erection, and commissioning for tower package (A2) Udumalpet–Arasur line, Ramagundam Khammam at Warangal and Neyveli Sriperumbudur at Pondicherry	6,435,154	6,435,154
0020	01	Supply of conductor package (B1) Madurai–Pagalur	7,375,315	7,375,315
0021	01	Supply, erection, and commissioning for tower package (A1) Tirunelveli–Edamon	13,344,054	13,344,054
0022	01	Supply, erection, and commissioning for tower package (A2) Tirunelveli–Edamon	13,285,720	13,285,720
0023	01	Substation package associated with grid strengthening for Tamil Nadu I, Kerala I and Kerala II	23,420,037	23,420,037
0024	01	Supply of conductor package (B1) for 400 kV D/C (quad) associated with grid strengthening Edamon–Muvattupuzha–North Trissur	7,986,441	7,986,441
0025	01	Supply of 120 KN and 160 KN disc insulators package (C3) grid strengthening for Edamon–Muvattupuzha–North Trissur	1,822,045	1,822,045
0026	01	Supply of ACSR moose conductor package (B3) associated with Edamon–Muvattupuzha–North Trissur line	8,861,683	8,861,683
0027	01	Supply of insulator package (C2) associated with Edamon–Muvattupuzha–North Trissur	2,304,735	2,304,735

PCSS No.	Category No.	Item Description	Contract Amount (\$)	Contract Disbursed (\$)
0028	01	Supply of 120 KN and 160 KN DISC insulators package (C1) Associated with Edamon–Muvattupuzha–North Trissur	2,553,924	2,553,924
0029	01	Supply of ACSR moose conductor package (B2) Edamon–Muvattupuzha–North Trissur	8,083,340	8,083,340
0030	01	Supply of ACSR moose conductor package (B2) for 400 kV D/C line Agra–Bhiwadi and LILO of Hissar–Jaipur 400 kV S/C at Bhiwadi	17,921,198	17,921,198
0031	01	Supply and erection for tower package (A3) for transmission of 400 kV D/C line Agra–Bhiwadi and LILO of Hissar–Jaipur 400 kV S/C at Bhiwadi	8,172,435	8,172,435
0032	01	Supply and erection for tower package (A4) for transmission of 400 kV D/C line Agra–Bhiwadi and LILO of Hissar–Jaipur 400 kV S/C at Bhiwadi	10,201,175	10,201,175
0033	01	Supply of insulator package (C2) Agra–Bhiwadi, Hissar–Jaipur	2,302,549	2,302,549
0034	01	Supply of equipment and material of substation package associated with extension of Bhiwadi, Agra, and Moga substations	10,945,280	10,945,280
0035	01	Supply, erection, and commissioning for tower package (A1) Moga–Bhiwadi 400 kV D/C line	10,816,987	10,816,987
0036	01	Supply, erection, and commissioning for tower package (A2) Moga–Bhiwadi 400 kV D/C line	11,725,096	11,725,096
0037	01	Supply of conductor package (B1) Moga–Bhiwadi 400 kV D/C Line	25,805,310	25,805,310
0038	01	Supply of insulator package (C1) Moga–Bhiwadi 400 kV D/C line	2,411,015	2,411,015
0039	01	FSC at 400 kV Lucknow, Bareilly, and Unno substations associated with FCS at Lucknow, Bareilly and Unnao	3,449,925	3,449,925
0039	01	FSC at 400 kV Lucknow, Bareilly, and Unno substations associated with FCS at Lucknow, Bareilly, and Unnao	10,970,352	10,970,352
0040	01	Supply portion of tower package A1 for 400 kV D/C (Quad) Edamon–Muvattupuzha line (part 1) associated lines	14,135,566	14,135,566
0041	01	Tower Package A2: 400 kV D/C (quad) Edamon–Muvattupuzha (Part 1) transmission line	14,282,616	14,282,616
0042	01	Tower Package A3: 400 kV D/C (quad) Muvattupuzha North Trichur transmission line	9,805,002	9,805,002
0043	01	420 kV Shunt reactor package at Khandwa and Dehgam substations under western region strengthening	1,665,913	1,665,913
0044	01	Procurement of bulk conductors (conductor package A)	12,993,007	12,993,007
0045	01	Procurement of insulators (package B)	2,084,707	2,084,707
0046	01	Supply and delivery of additional bulk conductor package (C2)	23,815,346	23,815,346

ACSR = aluminum conductor steel reinforced, D/C = double circuit, FSC = fixed series compensation, KN = kilonewton, kV = kilo volt, LILO = line-in-line-out, No. = number, PCSS = procurement contract summary sheet, S/C = single circuit.

Source: Asian Development Bank loan financial information system.

ANNUAL AVERAGE EXCHANGE RATES

Year	Indian rupees for every United States dollar
2005	44.28
2006	45.33
2007	39.54
2008	48.50
2009	46.56
2010	45.07
2011	52.43
2012	54.65

Source: Reserve Bank of India.

PROJECT FINANCING PLAN
(\$ million)

Source	Appraisal Estimate			Revised Estimate ^a			Actual		
	Foreign Exchange	Local Currency	Total	Foreign Exchange	Local Currency	Total	Foreign Exchange	Local Currency	Total
ADB	400.0	0.0	400.0	400.0	0.0	400.0	400.0	0.0	400.0
POWERGRID/ Borrowing	65.2	102.8	168.0	139.6	113.6	253.2	0.0	202.2	202.2
Total	465.2	102.8	568.0	539.6	113.6	653.2	400.0	202.2	602.2

ADB = Asian Development Bank, POWERGRID = Power Grid Corporation of India Limited.

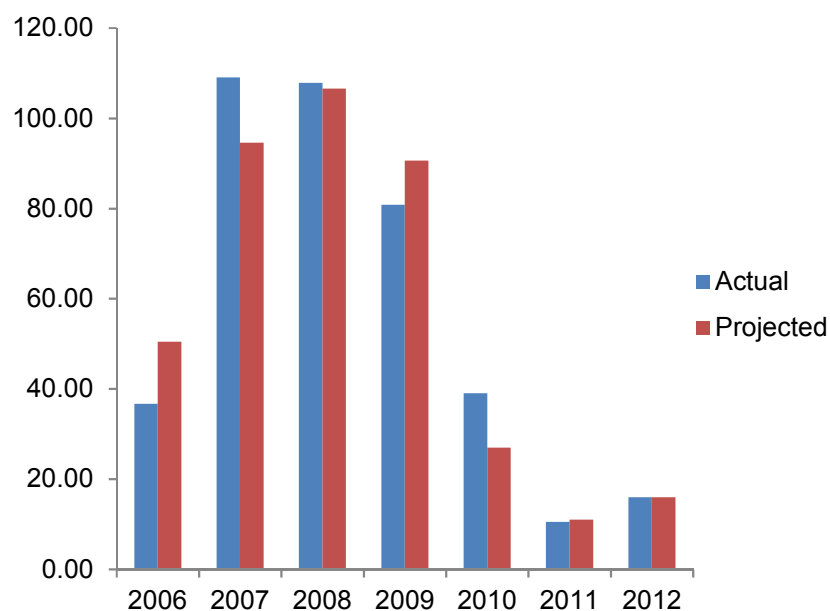
^a Revised estimate as of September 2007.

Source: Power Grid Corporation of India Limited.

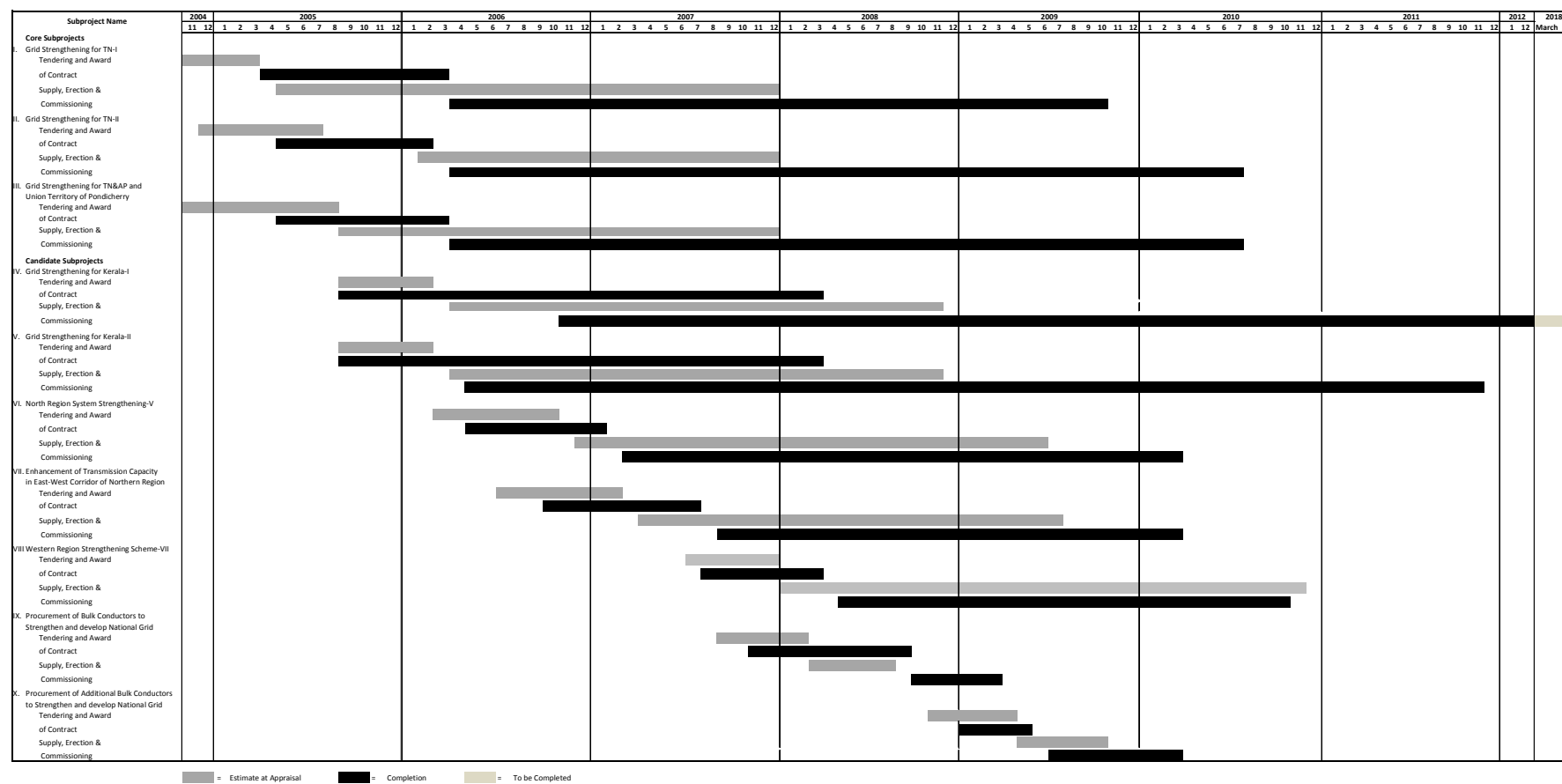
ACTUAL DISBURSEMENTS OF LOAN PROCEEDS
(\$ million)

Year	Projected ^a		Actual	
	For the year	Cumulative	For the year	Cumulative
2006	50.49	50.49	36.71	36.71
2007	94.60	145.09	109.08	145.79
2008	106.60	251.69	107.83	253.62
2009	90.60	342.29	80.79	334.41
2010	27.00	369.29	39.05	373.47
2011	11.00	380.29	10.49	383.96
2012	16.00	396.29	16.04	400.00

^a Projections are made in Asian Development Bank's loan financial information system.
Source: Asian Development Bank loan financial information system.

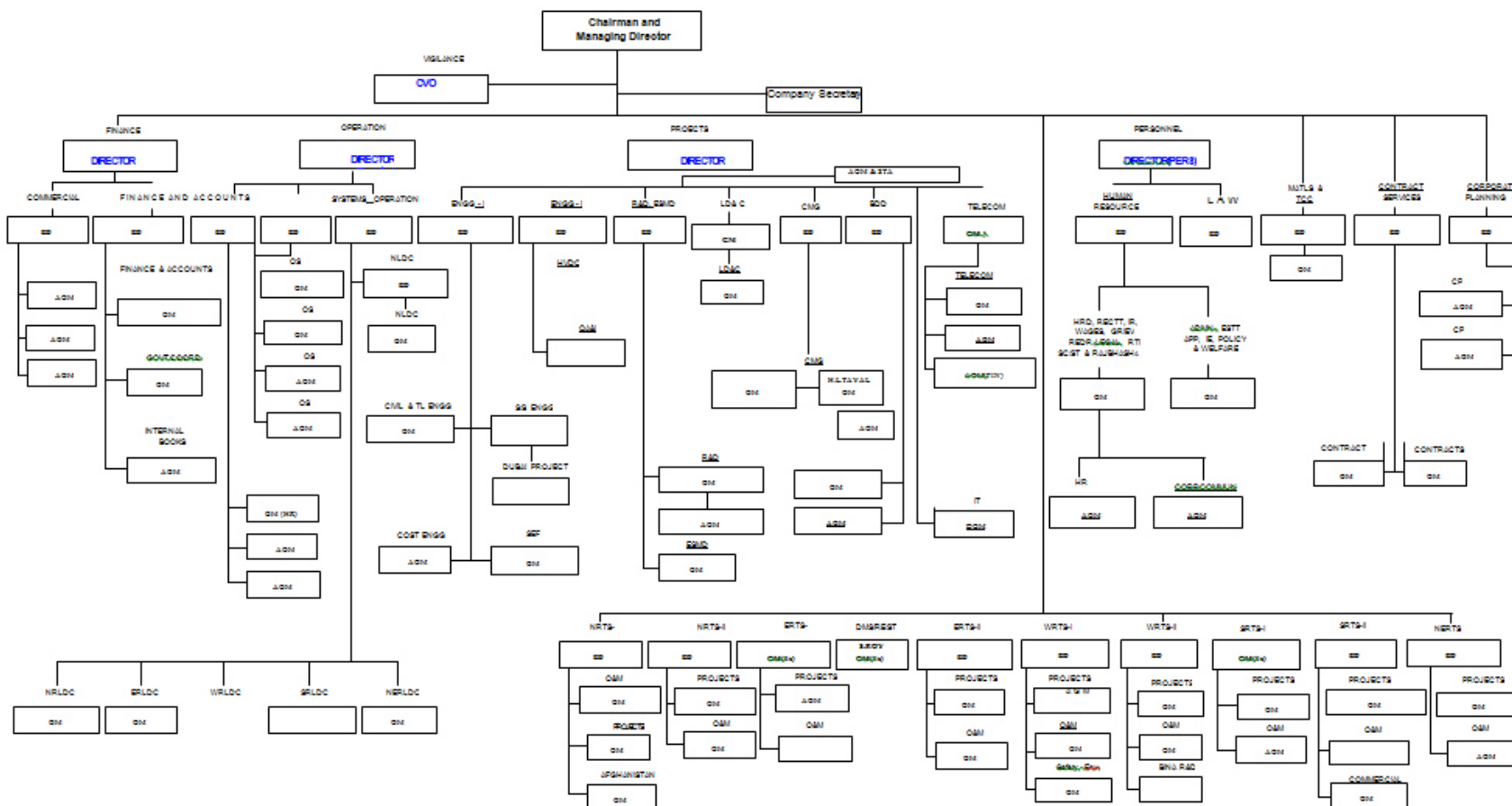


PROJECT IMPLEMENTATION SCHEDULE



Source: Power Grid Corporation of India Limited.

POWERGRID ORGANIZATION CHART



AGM = Assistant General Manager, CVO = Central Vigilance Officer, ED = Executive Director, GM = General Manager, O&M = Operation and Maintenance, Pers = Personnel, Proj = Projects, HR = Human Resources.

STATUS OF COMPLIANCE WITH LOAN COVENANTS

Project Specific Covenants	Reference	Status/Actions to be Taken
Project Implementation POWERGRID shall be responsible for the planning, design and procurement under the Project as well as coordination of the Project.	Loan Agreement (LA), Schedule 4, para. 1 (a)	Complied with.
The Project Management Unit (PMU) through the related functional departments of the Borrower shall be responsible for processing and implementing the subprojects. The concerned regional offices of the Borrower shall be responsible for construction supervision, commissioning, maintenance and operation of the subprojects.	LA, Schedule 4, para. 1 (b)	Complied with.
The Guarantor shall continue to emphasize and support the autonomy of the Borrower, with respect to its commercial, administrative and operational activities.	LA, Schedule 4, para. 2	Complied with.
The Project shall be limited to the grid strengthening and expansion of national grid and will not include subprojects (i) that include transmission lines emanating from power generation stations, or (ii) that fall under category A in accordance with ADB's Environment Policy, 2002.	LA, Schedule 4, para. 3	Complied with.
To be eligible for financing under the Loan (i) the Subproject shall be technically feasible and shall be part of the Borrower's National Transmission Development Plan, and (ii) the SEB or other beneficiary of the Subproject, has a satisfactory payment record with the Borrower (i.e., having Accounts Receivable of 3 months or less)	LA, Schedule 4, para. 4 (a)	Complied with.
For selecting each Subproject, the Borrower shall follow procedures as set out below (i) carry out a technical feasibility study for the Subproject (that shall include a detailed engineering design, cost estimates, contract packages and implementation schedule); (ii) prepare an RP; (iii) conduct an IEE; (iv) prepare an IPDP (if required); and (v) submit for approval to ADB, a Subproject appraisal report in the format as agreed with ADB	LA, Schedule 4, para. 4 (b)	Complied with.
Unless otherwise acceptable to ADB, the Borrower shall submit the Subproject appraisal reports (including all requirements set forth in this paragraph), in the format as acceptable to ADB, not later than 31 December 2005. Any subproject that does not satisfy the requirements of this paragraph will not be eligible for ADB's consideration under the Project	LA, Schedule 4, para. 4 (c)	Complied with.
Environmental POWERGRID shall ensure that the Project is undertaken and all subproject facilities are operated and maintained, in accordance with all applicable laws and ADB's Environment Policy 2002. POWERGRID shall prepare and implement each Subproject, the IEE, and the EMP (with budget).	LA, Schedule 4, para. 5	Complied with. All subprojects have been implemented based on the IEE, EMP (with budget), including the ongoing for the Edamon–Muvattupuzha transmission line. All clearances have been obtained and right-of-way (ROW) issues have been resolved.

Project Specific Covenants	Reference	Status/Actions to be Taken
POWERGRID will ensure that adequate funds are budgeted for and duly expended for implementation of environmental mitigation measures set forth in the IEE and EMP for each subproject and ensure that these are incorporated in detailed designs (including any amendments due to detailed designs with prior approval by ADB). POWERGRID shall ensure that these measures are also followed during construction and operation of the subprojects.	LA, Schedule 4, para. 6 (a)	Complied with.
POWERGRID shall obtain all necessary environmental clearances as required, from relevant statutory authorities of the Government, and in particular, shall not undertake works in any stretch of transmission lines passing through reserve forests or other forestland unless the required forest and environmental clearances are obtained from the Ministry of Forest and Environment.	LA, Schedule 4, para. 6 (b)	Complied with.
POWERGRID shall ensure that all Subprojects shall be subject to ADB's classification and any Subproject deemed sensitive shall require justification and documentation including effective mitigation measures for anticipated impacts.	LA, Schedule 4, para. 6 (c)	Complied with.
POWERGRID shall ensure that, to the extent feasible, the Project shall not include Category B sensitive subprojects. However, if included, for Subprojects categorized as Category B sensitive, in accordance with ADB's Environment Policy 2002, the Borrower shall ensure that the summary IEE is made available to the general public and posted on ADB website at least 120 days before Subproject approval by ADB.	LA, Schedule 4, para. 6 (d)	Complied with.
POWERGRID shall use only polychlorinated biphenyls (PCB)-free transformers for all the substations renovated and/or established under the Project.	LA, Schedule 4, para. 7 (a)	Complied with. Suitable clauses incorporated in the bidding and contract documents.
POWERGRID shall install oil separator (oil trap) in all outlets of the sewers of substations. The sludge of oil trapped by the separator will be kept in safe place within the property of the substation and will be sold only to the authorized third parties in accordance with applicable laws and regulations of the Guarantor.	LA, Schedule 4, para. 7 (b)	Complied with. POWERGRID has confirmed the provision of oil traps. It has also confirmed that the sludge is being sold to authorized vendors.
POWERGRID, through Environmental and Social Management Department (ESMD), shall continue to implement its internal environmental and social policies and procedures and shall undertake routine monitoring to check the implementation of the mitigation measures recommended by the IEE and the EMP for each subproject.	LA, Schedule 4, para. 8	Complied with. ESMD has been monitoring implementation of environmental safeguards.
Social		
POWERGRID shall implement subprojects in accordance with requirements of Guarantor's applicable laws, ADB's Involuntary Resettlement Policy, 1995. For each subproject the Borrower shall: make available land and rights-of way required, in a timely manner	LA, Schedule 4, para. 9 (a)	Complied with.

Project Specific Covenants	Reference	Status/Actions to be Taken
implement the provisions of the RP (including any changes on account of detailed designs with prior approval of ADB);	LA, Schedule 4, para. 9 (b)	Complied with. RPs were prepared and approved by ADB for five substations involving private land acquisition. In the case of transmission lines, compensation plan for temporary damages (CPTD) was prepared for temporary damage to crops and trees.
ensure that people affected are consulted and compensated in a timely manner in accordance with the applicable RP, such that their living standards are not adversely affected;	LA, Schedule 4, para. 9 (c)	Complied with. Affected persons were compensated in accordance with approved RP, and some have gone to courts for higher compensation.
ensure that prior to land acquisition and resettlement under each Subproject, the related RP (including its update), is posted on ADB's Involuntary Resettlement Website and through appropriate measures, disclosed to persons affected by the Subproject;	LA, Schedule 4, para. 9 (d)	Complied with.
ensure that (i) all compensation payments shall be made to affected households and persons prior to commencement of civil works, in accordance with the related RP; and (ii) that vulnerable households, such as Scheduled Tribes, Scheduled Castes, female headed households, shall be provided with additional assistance as provided for in the entitlement matrix in the related RP; and	LA, Schedule 4, para. 9 (e)	Complied with. Compensation amount was disbursed to affected persons before commencement of civil works, and additional assistance was provided to vulnerable affected persons.
ensure that essential public infrastructure including but not limited to roads, bridges, telephone and electric poles, lighting, that may be affected under land acquisition and resettlement is replaced as appropriate in an expeditious manner.	LA, Schedule 4, para. 9 (f)	Complied with.
For each subproject, POWERGRID shall ensure timely provision of budget for land acquisition and other activities in order to satisfy ADB's requirements relating to involuntary resettlement.	LA, Schedule 4, para. 10	Complied with. POWERGRID made budget available for land acquisition and resettlement requirements.
POWERGRID shall set up the Social, Resettlement and Environment Implementation Unit under the Environmental and Social Management Dept. (ESMD). These units shall be assisted, as required, by local community-based organizations to be engaged for field implementation.	LA, Schedule 4, para. 11	Complied with.
Within 3 months of Effective Date, POWERGRID shall establish a grievance redress committee under each Core Subproject, in accordance with the related RP. Similarly, POWERGRID shall establish, prior to commencement of civil works, for each subproject other than the Core Subprojects, a grievance redress committee in accordance with the related RP.	LA, Schedule 4, para. 12(a)	Complied with. Grievance redress committees were formed under each subproject. Establishment of the committees was delayed because of administrative reasons, but this has not affected project implementation performance.
By not later than 3 months of Effective Date for the Core Subprojects and at least 2 months prior to commencement of civil works under each Subproject other than Core Subprojects, POWERGRID shall engage an independent individual expert in	LA, Schedule 4, para. 12(b)	Complied with. Independent monitoring agencies were engaged for all subprojects involving land acquisition. They updated and improved the quality of reports.

Project Specific Covenants	Reference	Status/Actions to be Taken
consultation with ADB, for monitoring and verification of the RP implementation under each Subproject.		
POWERGRID shall monitor, audit, and report semi-annually, the implementation of the IEE and EMP for each Subproject to ADB. Likewise the Borrower shall submit progress and completion reports on land acquisition and resettlement under the progress reports for each Subproject.	LA, Schedule 4, para. 12 (c)	Complied with. Semiannual monitoring reports on implementation of EMP and RP were submitted by POWERGRID to ADB.
POWERGRID shall ensure that contracts under the Subprojects incorporate provisions to the effect that contractors (i) shall not use children as labor; (ii) shall follow legally-mandated provisions relating to labor (including equal pay for equal work), health, safety, sanitation and working conditions. The contracts under the Subprojects shall also provide for termination of the contracts by the Borrower in case of breach of any of the stated provisions by the contractors.	LA, Schedule 4, para. 13	Complied with.
Prior to award of civil works contract under each Subproject (other than Core Subprojects), POWERGRID shall have disclosed through appropriate measures, the draft Resettlement Plan to persons affected by the Subproject, and submitted the same to ADB for review and obtained its approval.	LA, Schedule 3, para. 14	Complied with.
Benefit Monitoring and Progress Reports		
Within 3 months of the Effective Date, POWERGRID shall establish the Project Performance Management System (PPMS) for the Project in a form acceptable to ADB. The Borrower shall undertake periodic Project. Reviews to evaluate the scope, implementation arrangements, progress and achievement of outcomes of the Project on the basis of performance indicators stipulated in the Project Framework included in Appendix 5 to the RRP.	LA, Schedule 4, para. 14	Complied with. The transmission projects of POWERGRID are planned, implemented, monitored, and controlled through an integrated project management and control system. Internal review meetings such as project review meetings, executive committee meetings, and Chairman and Managing Director's review meetings are held regularly, i.e., monthly, quarterly, semiannually and annually. These meetings appraise the progress of ongoing and new schemes, commercial issues, budget use, and strategic issues for determining future course of action. Regular review meetings are also undertaken with contractors, vendors and suppliers to evaluate timely implementation of the projects and achievement of various milestones. To evaluate the performance of ongoing projects, the Ministry of Power held quarterly progress reviews and discussed all key parameters. The Planning Commission, Central Electricity Authority, Ministry of Statistics, and program implementation and cabinet secretariat also undertook regular review of POWERGRID's performance against targets.

Project Specific Covenants	Reference	Status/Actions to be Taken
<p>Without limiting the generality of Section 7.04 of the Loan Regulations: Based on monthly, progress reports received from the PMU, POWERGRID shall prepare quarterly progress reports on Subprojects implementation that will include report on progress, made during the period, changes to implementation schedule if any, problems or difficulties encountered and the remedial actions taken, and the work to be carried out in the upcoming quarter. The reports to be submitted to ADB within 45 days of the end of each quarter shall also include a summary financial account for Project (including the Subprojects), expenditures to date, and report on benefit monitoring undertaken pursuant to the previous paragraph.</p>	LA, Schedule 4, para. 15 (a)	Complied with.
<p>ADB will review the implementation and operation of the Project and Subprojects' based on the quarterly progress reports, and meet with the Borrower and the Guarantor, to discuss Project progress and remedial measures to be taken if any, for timely implementation of Subprojects and the Project, and achieving its objectives. A midterm review of the Project shall be undertaken by ADB and the Borrower, 2 years after the Effectivity Date that will focus on the engineering, resettlement, environment, indigenous peoples and other social aspects, and financial status of the Borrower; ADB and the Borrower shall agree on any mid course corrections to ensure Project objectives and its implementation.</p>	LA, Schedule 4, para. 15 (b)	Complied with.
<p>Policy Matters POWERGRID shall continue to function as the central transmission utility under the Guarantor's Electricity Act, 2003, as amended from time to time, provide transmission services, and facilitate private participation in power transmission.</p>	LA, Schedule 4, para. 16	Complied with.
<p>POWERGRID shall share, upon completion, the outcome of the World Bank's detailed reviews relating to the Borrower's (i) corporate governance and financial accountability, (ii) safeguard management (environmental and social), and (iii) procurement management.</p>	LA, Schedule 4, para. 17	Complied with.
<p>In accordance with the Guarantor's current requirements of its Department of Company Affairs, the Guarantor shall restrict government appointed directors to not more than 2, and shall maintain at least 3 non-government directors in the board of directors of the Borrower.</p>	LA, Schedule 4, para. 18	Complied with.
<p>POWERGRID shall promptly exercise its rights including the right to effect reduction in supply under the commercial contracts with SEB/other beneficiaries as well as under the Tripartite Agreements.</p>	LA, Schedule 4, para. 19	Complied with.
<p>The Guarantor shall continue to allow POWERGRID to approve any projects costing less than ₹3 billion, subject to statutory clearances, and applicable policies of the Guarantor.</p>	LA, Schedule 4, para. 20	Complied with.
<p>Financial POWERGRID shall maintain its Accounts Receivables at a level not exceeding an amount equivalent to the income proceeds of</p>	LA, Schedule 4, para. 21	Complied with.

Project Specific Covenants	Reference	Status/Actions to be Taken
its transmission services for the preceding 3 months of billable amount allowed by CERC.		
POWERGRID shall obtain from all SEB's and other beneficiaries, irrevocable letter of credit, in the aggregate amounting to no less than 100% of average monthly billings of previous financial year as allowed by CERC.	LA, Schedule 4, para. 22	Complied with.
POWERGRID shall, commencing from September 2005 and thereafter not later than 30 September each year, prepare and furnish to ADB its 10-year financial projections, including its investment program, financial plan, income statements, cash flow statements and balance sheets for at least succeeding 5 years.	LA, Schedule 4, para. 23 (a)	Complied with.
The Borrower shall share the findings and recommendations of the World Bank review of its corporate governance and financial accountability	LA, Schedule 4, para. 23 (b)	Complied with.
Whenever for the purpose of this paragraph, as well for purposes of paragraph 25 of this schedule, it shall be necessary to value, in terms of the currency of the Guarantor, debt payable in another currency, such valuation shall be made on the basis of the prevailing lawful rate of exchange at which such other currency is, at the time of such valuation, obtainable for the purpose of servicing such debt, or in the absence of such rate on the basis of a rate of exchange acceptable to ADB.	LA, Schedule 4, para. 24	Complied with.
POWERGRID shall not incur any debt, if after such debt may be incurred the ratio of debt to equity would be greater than 80:20.	LA, Schedule 4, para. 25.	Complied with.
POWERGRID shall produce for each of its fiscal year, funds from internal resources equivalent to not less than twenty percent of the annual average of POWERGRID's capital expenditures incurred, or expected to be incurred for the previous, current, and following fiscal year.	LA, Schedule 4, para. 26.	Complied with.
The Borrower shall protect itself against any loss resulting from changes in the rate of exchange between Rupees and the currency or currencies in which the Borrower's outstanding money obligations will have to be met.	LA, Schedule 4, para. 27	Complied with.
Paragraphs 19, 22 (a) and 22 (b) of Schedule 4, and Section 4.12 of Loan Agreement for the Power Transmission Improvement (Sector) Project between the Borrower and ADB (Loan 1764) shall stand amended in accordance with paragraphs 16, 21, 22 and 24 respectively of this Schedule Section 4.14 of Loan Agreement for the Power Transmission Improvement (Sector) Project between the Borrower and ADB (Loan 1764) shall stand deleted. Further, paragraph 9 of Schedule 5 of Loan Agreement for the Power Transmission Improvement (Sector) Project between the Borrower and ADB (Loan 1405) shall stand amended accordance with paragraph 19 of this Schedule.	LA, Schedule 4, para. 28	Complied with.
The Borrower shall carry out the Project with due diligence and efficiency and in conformity with sound administrative, financial, engineering, environmental and public electric utility practices	LA, Article IV, Section 4.01 (a)	Complied with.

Project Specific Covenants	Reference	Status/Actions to be Taken
In the carrying out of the Project and operation of the Project facilities, the Borrower shall perform, or cause to be performed, all obligations set forth in Schedule 4 to the Loan Agreement to the extent that they are applicable to the Borrower	LA, Article IV, Section 4.01 (b)	Complied with.
The Borrower shall make available, promptly as needed, the funds, facilities, services, land and other resources which are required, in addition to the proceeds of the Loan, for the carrying out of the Project and for the operation and maintenance of the Project facilities.	LA, Article IV, Section 4.02	Complied with.
In the carrying out of the Project, the Borrower shall employ competent and qualified contactors acceptable to ADB and to an extent and upon terms and conditions satisfactory to ADB and the Borrower.	LA, Article IV, Section 4.03 (a)	Complied with.
The Borrower shall carry out the Project in accordance with plans, design standards, specifications, work schedules and construction methods acceptable to ADB. The Borrower shall furnish, or cause to be furnished, to ADB, promptly after their preparation, such plans, design standards, specifications and work schedules, and any material modifications subsequently made therein, in such detail as ADB shall reasonably request.	LA, Article IV, Section 4.03 (b)	Complied with.
The Borrower shall take out and maintain with responsible insurers, or make other arrangements satisfactory to ADB for, insurance against such risks and in such amounts as shall be consistent with sound practice.	LA, Article IV, Section 4.04 (a)	Complied with.
Without limiting the generality of the foregoing, the Borrower undertakes to insure, or cause to be insured, the goods to be procured for the Project and to be financed out of the proceeds of the Loan against hazards incident to the acquisition, transportation and delivery thereof to the place of use or installation, and for such insurance any indemnity shall be payable in a currency freely usable to replace or repair such goods.	LA, Article IV, Section 4.04 (b)	Complied with.
The Borrower shall (i) have its accounts and financial statements (balance sheet, statements of income and expenses, and related statements) audited annually, in accordance with appropriate auditing standards consistently applied, by independent auditors whose qualifications, experience and terms of reference are acceptable to ADB; (ii) furnish to ADB, as soon as available but in any event furnish to ADB, not later than 6 months after the end of each related FY, certified copies of such audited accounts and financial statements and the report of the auditors relating thereto (including the auditors' opinion) on the use of the Loan proceeds and compliance with the financial covenants of this Loan Agreement (including actual calculation for all ratios in conformity with the definitions as set forth in this Loan Agreement), all in the English language; and (iii) furnish to ADB such further information concerning such accounts and financial statements, and the audit thereof, as ADB shall from time to time reasonably request.	LA, Article IV, Section 4.05 (a)	Complied with.

Project Specific Covenants	Reference	Status/Actions to be Taken
The Borrower shall enable ADB, upon ADB's request, to discuss the Borrower's financial statements and its financial affairs from time to time with the Borrower's auditors, and shall authorize and require any representative of such auditors to participate in any such discussions requested by ADB, provided that any such discussion shall be conducted only in presence of an authorized officer of the Borrower unless the Borrower shall otherwise agree.	LA, Article IV, Section 4.05 (b)	Complied with.
The Borrower shall enable ADB's representatives to inspect the Project, the goods financed out of the proceeds of the Loan, all other plants, sites, works, properties and equipment of the Borrower, and any relevant records and documents.	LA, Article IV, Section 4.06	Complied with.
The Borrower shall, promptly as required, take all action within its power to maintain its corporate existence, to carry on its operations and to acquire, maintain and renew all rights, properties, powers, privileges and franchises which are necessary in the carrying out of the Project or in the conduct of its business.	LA, Article IV, Section 4.07 (a)	Complied with.
The Borrower shall at all times conduct its business in accordance with sound administrative, financial, environmental and public electric utility practices, and under the supervision of competent and experienced management and personnel.	LA, Article IV, Section 4.07 (b)	Complied with.
The Borrower shall at all times operation and maintain its plants, equipment and other property, and from time to time, promptly as needed, make all necessary repairs and renewals thereof, all in accordance with sound administrative, financial, engineering, environmental, public electric utility practices, and maintenance and operational practices.	LA, Article IV, Section 4.07 (c)	
Except as ADB may otherwise agree, the Borrower shall not sell, lease or otherwise dispose of any of its assets which shall be required for the efficient carrying on of its operations or the disposal of which may prejudice the ability of the Borrower to perform satisfactorily any of its obligations under this Loan Agreement	LA, Article IV, Section 4.08	Complied with.

ADB = Asian Development Bank, CERC = Central Electricity Regulatory Commission, EMP = environmental management plan, IEE = initial environmental examination, POWERGRID = Power Grid Corporation of India Limited, RP = resettlement plan, SEB = State Electricity Board.

FINANCIAL AND ECONOMIC REEVALUATION

1. The major assumptions used in the financial and economic evaluation of the project are discussed in this appendix.

A. Financial Reevaluation

2. The financial reevaluation of the project was carried out in accordance with the *Financial Management and Analysis of Projects* of the Asian Development Bank (ADB).¹ It was carried out in real terms using the concept of financial cost incurred and benefit streams realized on the entire project. Costs and benefits were evaluated for the project. All costs and revenues in the calculations are expressed in constant May 2017 prices.

3. The capital costs considered for financial reevaluation include all capital expenditure for the project, including interest during construction.

4. The project was financed by foreign debt (the ADB loan) and domestic borrowing/equity. The cost of borrowing from ADB is 1.70%, while the cost of domestic borrowing/equity has been considered at 9.55% in Indian rupee terms (according to the Power Grid Corporation of India Limited [POWERGRID]). The weighted average cost of capital (WACC) is estimated in real terms and shown in Table A11.1.

Table A11.1: Weighted Average Cost of Capital

Source	Amount (\$ million)	Cost (%)	Weighted (%)
ADB loan	400.0	1.70	0.15
Domestic loans/ government equity	202.2	9.55	2.95
Weighted average cost of capital	602.2		3.10

ADB = Asian Development Bank.

Source: Power Grid Corporation of India Limited.

1. Capital Cost

5. All seven subprojects have been completed. Financial and economic analysis has been carried out for all the subprojects, except for the additional bulk transmission subprojects. The subprojects include (i) grid strengthening for Tamil Nadu I; (ii) grid strengthening for Tamil Nadu II; (iii) grid strengthening for Tamil Nadu, Andhra Pradesh, and Union Territory of Pondicherry; (iv) grid strengthening for Kerala I and II; (v) northern region system strengthening scheme V; (vi) enhancement of transmission capacity in the east–west corridor of the northern region; and (vii) western region strengthening scheme VII. Capital costs considered comprise all capital expenditure for the various subprojects, including interest during construction. No salvage value has been assumed at the end of the useful life of the various subprojects.

2. Energy Transfer, Revenue, and Operating Cost

6. Actual energy transfer (million kilowatt-hours per year) and annual revenue are considered for estimating the benefits of the project. The revenue for POWERGRID is mainly derived from transmission charges, which are based on the Central Electricity Regulatory Commission norms for the tariff determination of transmission systems, considering 99.5% of transmission availability

¹ ADB. 2005. *Financial Management and Analysis of Projects*. Manila.

and a 15.5% return on equity. The revenue realized for each subproject is based on transmission charges and booked against these subprojects to the respective beneficiary states.

7. The annual operating cost has been calculated based on the actual operation and maintenance costs of each subproject.

3. Financial Internal Rate of Return

8. At the time of appraisal, the financial internal rate of return (FIRR) was estimated as 7.9%, which was higher than the WACC of 4.5% in real terms.

9. The FIRR of the project at completion is calculated as 5.6%, which is higher than the WACC of 3.1% in real terms. The difference in FIRR value at appraisal and completion is because the FIRR at appraisal was estimated for proposed investments under the National Transmission Development Plan amounting \$12.6 billion up to 2012, while the FIRR at completion was calculated for ADB-financed project components. The detailed FIRR calculation is in Table A11.4.

B. Economic Revaluation

10. The economic analysis of the subprojects was carried out on the basis of the economic benefits of power consumption to the final consumers, represented by their willingness to pay (WTP) as applicable.²

11. **Economic costs.** The economic analysis was carried out using the world price numeraire. The economic costs were derived from the financial costs by deducting the taxes and duties. The costs were separated into foreign exchange, indirect foreign exchange, and local currency costs. Traded inputs and fuel were valued at their border price equivalent values, then adjusted to the domestic price numeraire by multiplying by a shadow exchange rate factor of 1.03. Non-traded inputs were valued at domestic prices. It was assumed that there are no significant distortions in the wage rates for skilled labor. For unskilled labor, as underemployment exists in the economy, a shadow wage rate of 0.75 was adopted. Taxes and financing charges were excluded. Local costs were further separated and a specific conversion factor of 0.75 was used for unskilled labor. The labor cost was assumed to be 10% of the local currency costs, and unskilled labor costs were assumed to be 35% of the labor costs.³

12. **Economic benefits.** The physical infrastructure created under the project through the establishment of transmission lines and related substations has enhanced the availability of power for final consumers. The actual energy transmitted in view of the project for each year was considered for computing the economic benefits. POWERGRID has provided actual energy transmitted through the project assets each year. Incremental energy flows provided by POWERGRID are at the transmission level only; transmission and distribution losses were deducted from these incremental energy flows, while arriving at the actual energy being delivered to the final consumers. Thus, the incremental energy flows considered for each year are net of transmission and distribution losses. The cost toward electricity generation in the regions, according to the Central Electricity Authority, Government of India, and toward distribution of the incremental energy arising from this subproject, were also considered. The incremental benefits

² The average WTP for all consumer types is ₹7.2 per kilowatt-hour (kWh), and the average cost of electricity is ₹4.9/kWh (The Energy and Resources Institute. 2017. Charging Power: Understanding Electricity Pricing and the Willingness to Pay for Electricity in India. *Policy Brief*. February. <http://www.teriin.org/policybrief/index.php?a=41>).

³ The shadow exchange rate factor and the shadow wage rate are based on values used in other recently approved similar projects in India.

were valued for each category of consumers, using the consumers' WTP for electricity. The non-incremental benefits were not quantified since India has been operating with a matching load generation since 2016.

13. **Willingness to pay.** It compared the WTP for electricity services in India with current electricity pricing. The value of each unit of electricity to consumers is measured by comparing current prices against the prices of alternative sources. The cost of kerosene used for 4 hours a day is estimated to consume 1 liter of kerosene as a cost of Rs9.50.

Table A11.2: Willingness to Pay by Consumer Category

Consumer Category	Willingness to Pay (₹/kWh)	Consumption (%)
Domestic	8.5	23.0
Commercial	6.2	8.0
Industrial	6.2	44.0
Agriculture	9.3	18.0
Total/Average	7.2	
Average Cost per kWh	4.9	

kWh = kilowatt-hour.

Sources: Government of India, Ministry of Statistics and Programme Implementation. 2016. Energy Statistics. New Delhi; and The Energy and Resources Institute. 2017. Charging Power: Understanding Electricity Pricing and the Willingness to Pay for Electricity in India. *Policy Brief*. February. <http://www.teriin.org/policybrief/index.php?a=41>.

14. The economic internal rate of return (EIRR) was estimated as 30.5% at appraisal and 19.7% at completion. The difference in EIRR values is because the EIRR at appraisal was estimated for proposed investments under the National Transmission Development Plan amounting \$12.6 billion up to 2012, while the EIRR at completion was calculated for ADB-financed subprojects.

15. **Sensitivity analyses.** The EIRRs calculated for this project were subjected to sensitivity tests that show the project economic viability can withstand changes in the assumptions used in the analysis. The EIRR is recalculated based on a period of 25 years and it is 13.5%–20.0% for all three scenarios. In all cases, the EIRR is more than the 12% hurdle rate.

Table A11.3: Sensitivity Analysis

Scenario	Whole Project	
	EIRR at Appraisal (%)	EIRR at Completion (%)
Base case	30.5	19.7
Transmission and distribution loss variation	*	20.0
Energy sales reduction by 20%	28.1	15.9
Combination of variables	22.1	13.5
hurdle rate	12.0%	12.0%

* data not available

EIRR = economic internal rate of return.

Sources: Asian Development Bank, Manila.

16. The EIRR estimated for the project is in Table A11.5.

Table A11.4: Financial Internal Rate of Return of Project at Completion
(₹ million)

Year	Revenues	Capital Cost	O&M Costs	Total Cost	Net Cash Flow
2005		229		229	(229)
2006		1,835		1,835	(1,835)
2007		6,254	97	6,351	(6,351)
2008		6,183	102	6,285	(6,285)
2009		4,632	113	4,745	(4,745)
2010	486	2,239	377	2,576	(2,089)
2011	1,445	602	477	1,079	366
2012	1,799	920	482	1,401	397
2013	2,276		521	521	1,821
2014	2,287		471	471	1,891
2015	2,304		481	481	1,904
2016	2,326		465	465	1,941
2017	2,346		465	465	1,961
2018	2,366		465	465	1,981
2019	2,387		465	465	2,002
2020	2,387		465	465	2,002
2021	2,387		465	465	2,002
2022	2,387		465	465	2,002
2023	2,387		465	465	2,002
2024	2,387		465	465	2,002
2025	2,387		465	465	2,002
2026	2,387		465	465	2,002
2027	2,387		465	465	2,002
2028	2,387		465	465	2,002
2029	2,387		465	465	2,002
2030	2,387		465	465	2,002
2031	2,387		465	465	2,002
2032	2,387		465	465	2,002
2033	2,387		465	465	2,002
2034	2,387		465	465	2,002
2035	2,387		465	465	2,002
2036	2,387		465	465	2,002
2037	2,387		465	465	2,002
FIRR					5.6%

() = negative, FIRR = financial internal rate of return, O&M = operation and maintenance.

Source: Asian Development Bank, Manila

Table A11.5: Economic Internal Rate of Return
(₹ million)

Year	Transmission Capital Cost	Transmission O&M Costs	Generation Incremental Cost	Distribution Incremental Cost (capital and O&M)	Total Cost	Annual Energy Transfer (kWh million)	Incremental Benefits (willingness to pay)	Net Cash Flow
2005	238		261	166	665			(665)
2006	1,901		2,091	1,711	5,703			(5,703)
2007	6,480	99	7,127	5,832	19,538			(19,538)
2008	6,406	105	7,046	5,765	19,322			(19,322)
2009	4,799	110	5,279	4,319	14,508			(14,508)
2010	2,320	343	2,552	2,088	7,303			(7,303)
2011	623	486	3,174	146	4,429	5,414	12,452	8,023
2012	995	490	5,702	147	7,334	9,953	22,891	15,557
2013		531	5,702	133	6,366	10,886	25,038	18,672
2014		479	5,702	120	6,301	13,785	31,706	25,405
2015		489	5,702	122	6,313	13,123	30,183	23,870
2016		473	5,702	118	6,293	13,123	30,183	23,890
2017		473	5,702	118	6,293	13,123	30,183	23,890
2018		473	5,702	118	6,293	13,123	30,183	23,890
2019		473	5,702	118	6,293	13,123	30,183	23,890
2020		473	5,702	118	6,293	13,123	30,183	23,890
2021		473	5,702	118	6,293	13,123	30,183	23,890
2022		473	5,702	118	6,293	13,123	30,183	23,890
2023		473	5,702	118	6,293	13,123	30,183	23,890
2024		473	5,702	118	6,293	13,123	30,183	23,890
2025		473	5,702	118	6,293	13,123	30,183	23,890
2026		473	5,702	118	6,293	13,123	30,183	23,890
2027		473	5,702	118	6,293	13,123	30,183	23,890
2028		473	5,702	118	6,293	13,123	30,183	23,890
2029		473	5,702	118	6,293	13,123	30,183	23,890
2030		473	5,702	118	6,293	13,123	30,183	23,890
2031		473	5,702	118	6,293	13,123	30,183	23,890
2032		473	5,702	118	6,293	13,123	30,183	23,890
2033		473	5,702	118	6,293	13,123	30,183	23,890
2034		473	5,702	118	6,293	13,123	30,183	23,890
2035		473	5,702	118	6,293	13,123	30,183	23,890
2036		473	5,702	118	6,293	13,123	30,183	23,890
2037		473	5,702	118	6,293	13,123	30,183	23,890
EIRR								19.67%

() = negative, EIRR = economic internal rate of return, kWh = kilowatt-hour.

Source: Asian Development Bank, Manila