TECHNICAL JUSTIFICATION OF THE PROJECT

A. Electricity Supply in Madhya Pradesh

1. Electricity supply to Madhya Pradesh is principally from two sources: electricity generated in power plants located within Madhya Pradesh and purchase of electricity produced in power plants located outside Madhya Pradesh. Power plants within Madhya Pradesh are owned by three different entities: (i) Madhya Pradesh Genco,[1] (ii) National Thermal Power Corporation (NTPC), and (iii) Independent Power Producers (IPPs). Electricity purchased from outside Madhya Pradesh is produced by NTPC, IPPs and power plants owned by other state-owned generating companies.[2] Each power plant, whether located inside Madhya Pradesh or outside, has a portion of its capacity "allocated" to Madhya Pradesh, the quantity allocated being based on the power purchase agreement between the Seller (the power plant) and the Buyer (the distribution companies of Madhya Pradesh). In FY 2013, Madhya Pradesh expects that the power supply to Madhya Pradesh would be structured as shown in Table 1. In addition to such allocated capacities of power plants, the distribution companies may also purchase power on short-term contracts or use unscheduled interchanges.

Table 1: Power Generation in Madhya Pradesh and Purchases Planned for FY 2013

	Number of Power Plants	Installed Capacity (MW)	Allocation to MP (MW)
Central Stations	11	11,193	2,576
MP Genco Thermal	5	2,870	2,770
Hydro interstate	4	591	324
Hydro Fully allocated to MP	7	605	605
Hydro bilateral and other	5	2,985	2,362
Others	2	55	55
Total	**34**	**18,299**	**8,692**

MP = Madhya Pradesh, MW = megawatt
Source: Aggregate Revenue Requirement and Retail Tariff Order for 2013-14, MPERC, 23 March 2013

2. Electricity purchased from central stations is delivered to Madhya Pradesh through transmission lines of National Grid Corporation (NGC) operating at 765 kV and 400 kV. Electricity purchased from other states may also flow through the same lines, or across state boundaries through 220 kV or 132 kV lines. Similarly, power generated in power plants within the state, but not allocated to Madhya Pradesh, flow outside the state along the same lines. For this purpose, there is a network of transmission lines in Madhya Pradesh operating at 765 kV, 400 kV, 220 kV and 132 kV. All the 765 kV lines and some of the 400 kV lines, and their substations are owned by NGC. Some 400 kV lines, and all the 220 kV lines and 132 kV lines, and their substations are owned by MP Transco[3] (Table 2).

3. Deliveries to distribution companies are at 33 kV. These deliveries occur mostly at 132kV/33kV substation. There are a few points of delivery off 220kV/33kV substations as well. Additionally, very large customers such as coal mines and railway traction too are delivered power at one of the higher voltages; 400kV, 220 kV or 132 kV. Distribution companies that receive power at 33 kV have 33kV lines to carry power to (i) primary substations, where the supply is stepped down to 11 kV, and (ii) large customers who receive power at 33 kV. Power from 33 kV/11 kV substations flows through 11 kV lines to urban areas and rural areas, and transformed to 400 V for distribution to retail customers such as households and small

[1] Madhya Pradesh Power Generation Company.
[2] Currently, purchases from generating companies in other states are small or zero.
[3] Madhya Pradesh Power Transmission Company.

businesses. The supply to retail customers is either at 230 V (single phase) or 400 V (three phase).

Table 2: Transmission Assets of Madhya Pradesh

Voltage level	Length of lines (circuit km)	EHV Substations Numbers	EHV Substations Capacity (MVA)
400 kV	2,448	7	5,460
220 kV	11,337	56	15,750
132 kV	13,988	193	16,881
66 kV	61	1	20
Total	27,834	257	38,111

Status: end May 2013.
Source: MP Transco.

B. Planning of the Transmission and Distribution Network

4. The transmission and distribution network requires to serve the present generation and demand for electricity, at various locations of Madhya Pradesh, and be able to serve the future generation and demand over several years. An increase in demand for electricity is caused by the addition of new customers and through increase in the usage of electricity among existing customers. When the demand increases, the currents flowing in the transmission and distribution network increases. If the lines (or transformers) cannot carry the current required to serve the customer demand, initially the voltage at the receiving end will be lower than the stipulated voltage. This is because excessive currents cause voltage drops along the lines. Additionally, currents in excess of the design current flow in any wire causes higher losses through overheating. As the customer demand gradually increases through the years, at some point, the current exceeds the "thermal" rating of the wire (or associated transformers), and the protection system will trip the wire (or transformer) out of the circuit, causing a power outage. In case the protection system malfunctions, excessive currents may cause burnouts of lines or transformers.

5. The common practice among transmission and distribution utilities is to reduce currents on the line, before it reaches dangerous levels to cause a tripping event, or a catastrophic failure. This is done through selective load shedding, by removing a group of customers served from a line (or a transformer) such that the current is maintained at a safe level. Such load shedding is not owing to shortage of generating capacity, but owing to deficiencies of the transmission and distribution networks. Cautious planning of networks to cater to future growth and implementation of such plans would eliminate such load shedding requirements, while providing an electricity supply of higher quality, at the correct voltage.

6. Madhya Pradesh transmission network is planned and operated based on the planning criteria, operation and monitoring procedures described in the grid code.[4] The grid code specifies, among a large number of operating parameters, the limits of voltage variation allowed at each voltage level of the transmission network (Table 3). Accordingly, MP Transco reviews the adequacy of the transmission network to provide generation connections and to meet the

[4] A grid code is a document prepared by a transmission entity, and approved by the regulator. The grid code is the reference document for planning, operations and metering of the transmission network, and provides both standards and guidelines for the performance and reliability of the transmission network. All "users" of the grid, including generators and distribution utilities, and "operators" should adhere to the grid code. In MP, the grid code was first approved by MPERC in 2005, and amended in 2008.

forecast demand at substations, over a period of 10 years. Load flow studies and short-circuit analyses are then conducted to establish the adequacy of the existing transmission network to meet the future demand, and then to examine the operation of proposed improvements to meet the demand growth. These improvements and their investment requirements are documented in the 10-year rolling plan, and a more detailed 5-year plan. Improvements consist of construction of new transmission lines and substations, expanding the capacity of existing substations, and installation of reactive compensation equipment to improve network performance.

Table 3: Specified Limits of Voltage Variation in the Madhya Pradesh System

System	Limits of Voltage Variation		
Nominal (kV)	**% Limit of variation**	**Maximum (kV)**	**Minimum (kV)**
400	+5%/-10%	420	360
220	+/-10%	245	200
132	+/-10%	145	120

Source: MP Grid Code, MPERC, 2005

7. According to the distribution code[5] approved by MPERC, each DISCOM is required to prepare a five-year plan for distribution development, which in turn is based on the 5-year demand forecast for the DISCOMs network prepared using the guidelines given in the distribution code. The growth in new household connections, increasing demand among already connected households, commercial, and industrial customers, are considered in preparing the demand forecast. The target is to meet the service voltages stipulated in the distribution code, at the lowest investment and operating costs, including lowest losses.

C. Power Flows in the Transmission Network and Future Growth

8. Power flows in the transmission network are examined in two ways: (i) as the generating capacity and locations, and the centers of customer demand (i.e. substations) and their locations are know, power flows in the transmission network can be calculated using a modeling software package, (ii) current, voltage and power measurements are recorded regularly at all nodes/line/transformers in the transmission network. MP Transco has filed the following information (Table 4) with MPERC, about the reliability it the transmission system. MP Transco has been able to exceed the availability targets established by MPERC through improved management and expansion of the transmission network to meet the growing demand.

Table 4: Transmission Availability

	Transmission availability				
	2008-09	**2009-10**	**2010-11**	**2011-12**	**2012-13**
400 kV	96.56%	98.96%	99.26%	98.40%	99.37%
220 kV	98.70%	98.55%	99.09%	99.45%	99.43%
132 kV	98.87%	99.00%	99.13%	99.29%	99.46%
Overall system	**98.16%**	**98.82%**	**99.13%**	**99.23%**	**99.44%**
Target established by MPERC	**97.00%**	**98.00%**	**98.00%**	**98.00%**	**98.00%**

Source: MP Transco.

9. There have been significant improvements in the Madhya Pradesh power sector over past few years. Electricity sales have grown at a compound average growth rate of 8.3% for the eight-year period from FY 2003 to FY 2012. Growth in the recent past has been even higher:

[5] A distribution code is similar to the grid code, but for the distribution network. MPERC approved the distribution code for MP in 2006. All “users” including transmission utilities and customers and “operators” of the distribution network should adhere to the requirements stated in the distribution code.

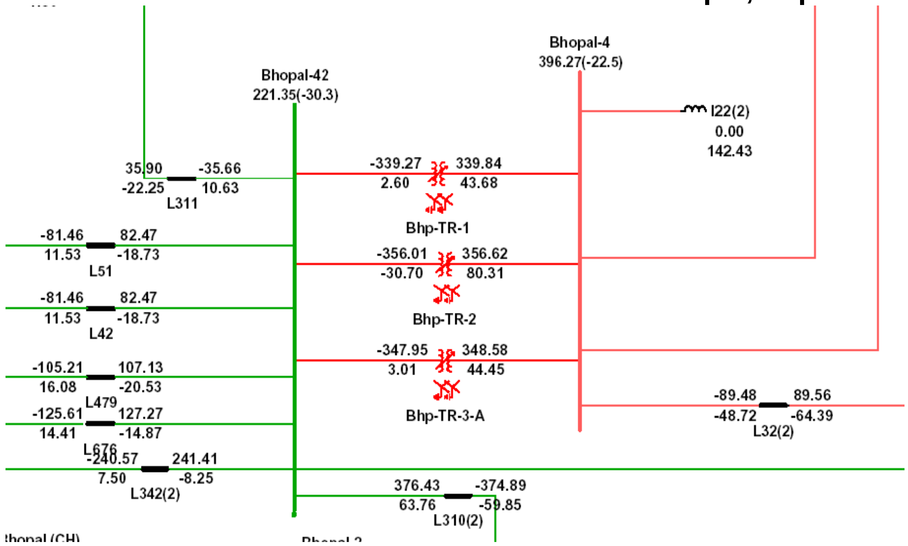
the average growth in sales over three years from FY2009 to FY2011 has been at 13.4%. The officials demand forecast indicates a sales growth rate of at least 11% to prevail over the next five years, as a result of the policy initiatives by the state government such as providing uninterrupted power to the rural households and increasing the agriculture connections. There are various Central Government schemes like Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) program for rural electrification, the Restructured Accelerated Power Development Reforms Program (R-APDRP) to improve electricity distribution infrastructure in urban areas. All such programs would contribute to sustain the accelerated sales growth over the next few years. Further, the overall per capita electricity consumption is likely to improve as a result of overall economic development in the state. For example, the GDP of Madhya Pradesh has grown at around 10% during the last year as compared with the national GDP growth of around 4%.

10. Although the sales grew at 13.4% over FY 2009 to 2011, the generation and peak demand did not require to grow at such rates, owing to the progressive reduction in losses in transmission and distribution. The energy supplied grew only by 5.9%. The balance sales requirement was effectively recovered from losses and converted to sales. While further reductions in transmission and distribution loses are expected, such growth cannot be served with recovered losses alone: to meet the forecast sales growth of 11% over the next five years, the growth in energy supplied requires to be 8.7%. This additional amount of power requires to flow through the transmission network. Therefore, the demand to be served off each substation will also increase at rates typically between 8.7% to 11% over the next five years. Substations serving rural areas are expected to experience higher growth rates, as well as significant reduction in losses.

11. The preparation of the plan done by MP Transco using the software model “Cyme PSAF” to analyze the present flow of power in the network, and the expected power flows in any year in the future. As the additions to the transmission networks occur gradually, the industry norm is to conduct load flow and other studies on the transmission network for five-year intervals. Accordingly, MP Transco has conducted a load flow analysis for year FY2011 and for FY2016. All changes previously planned and being implemented that occur in the transmission network between FY2011 and FY2016 are included in the network model, and then the adequacy of network assets (transmission lines, transformers, specialized equipment) are checked for their adequacy.

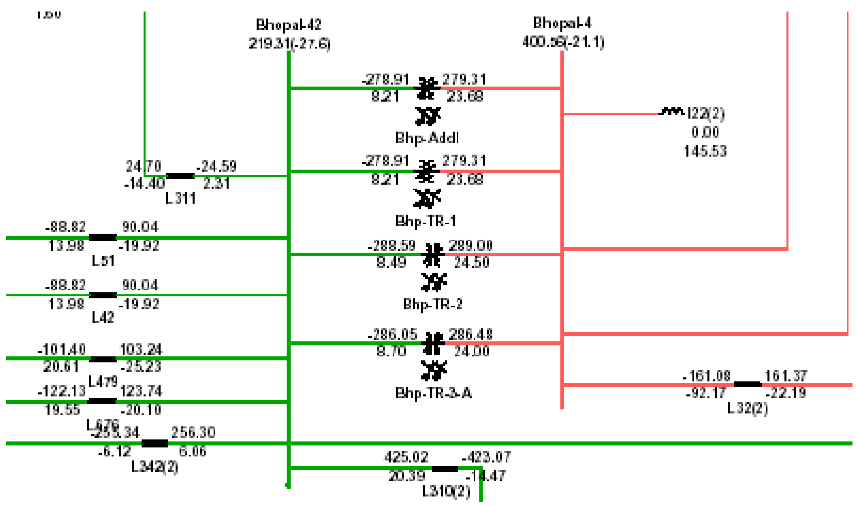
12. For example, the Bhopal 400 kV substation is a receiving station, at which the power flow is from the 400 kV network to the 220 kV network. The power flow is into Bhopal, because there is no generation in Bhopal. There are three transformers at Bhopal through which power flows from 400 kV to 220 kV. Load flow studies for year 2015-16 indicates that two out of the three existing transformers at Bhopal 400 kV substation will be overloaded by FY2016 (Figure 1). The existing transformers are each rated at 315 MVA, but they are estimated to be loaded to 329 kVA, 356 kVA and 347 kVA by year 2015-16. Accordingly, MP Transco has proposed that a fourth transformer be added to this location, thus relieving the overload situation up to FY2015 (Figure 2).

Figure 1: Power Flow from 400 kV Network to 220 kV at Bhopal, Expected in FY2015



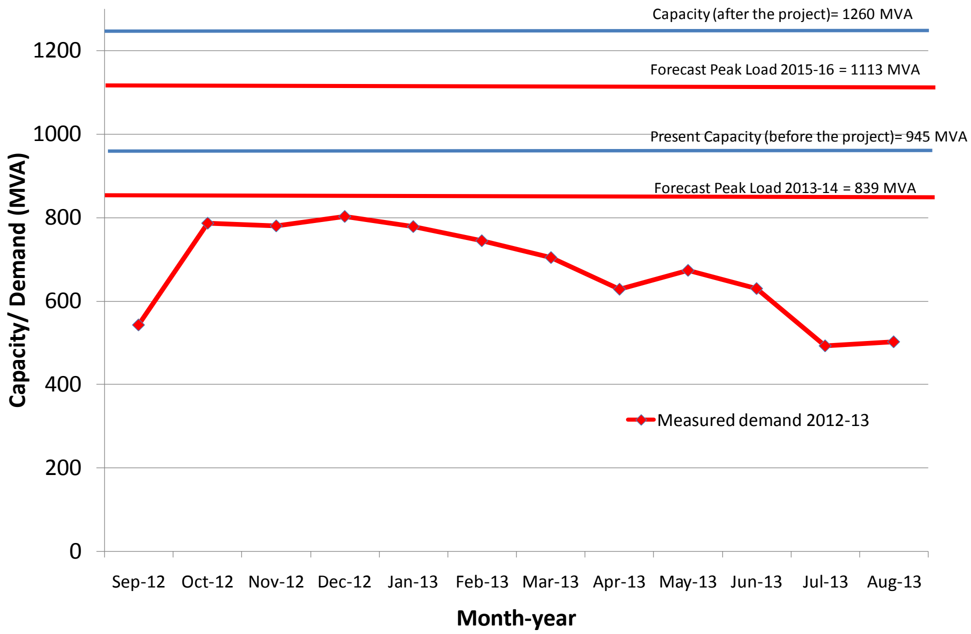
Note the marked power flows across the three transformers TR-1, TR-2 and TR-3A show that they will exceed their capacity of 315 MVA by FY2015. Network point Bhopal-4 operates at 400 kV, Bhopal-42 operates at 220 kV.

Figure 2: Overloading of Transformers at Bhopal Relieved by Adding a Fourth Transformer by 2015-16



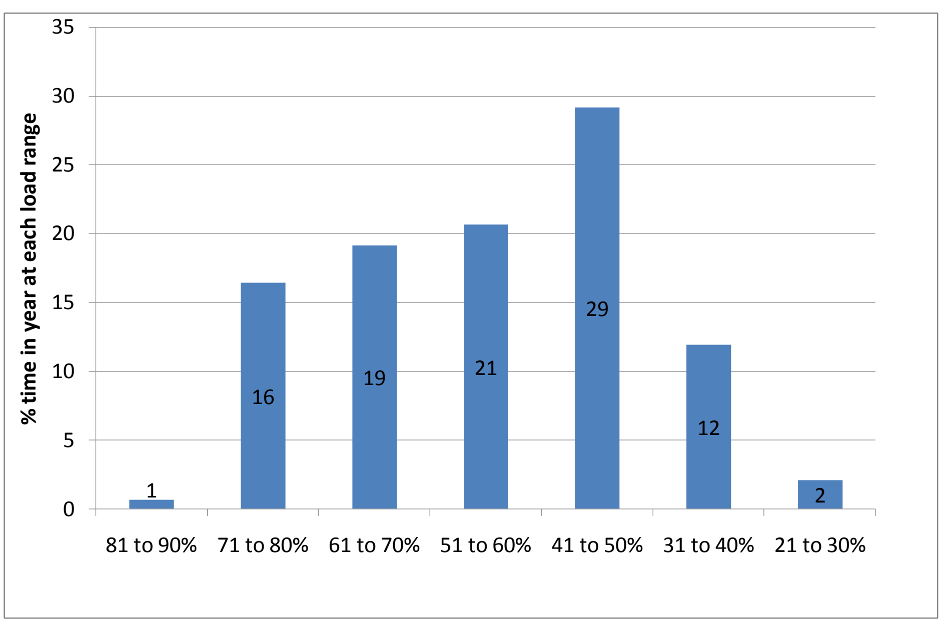
Note the marked power flows across the three transformers TR-1, TR-2 and TR-3A, as well as the newly added transformer Bhp-Addl are all below 315 MVA in 2015-16. Bhopal-4 operates at 400 kV, Bhopal-42 operates at 220 kV

Figure 3: Capacity and Loading Levels of Bhopal 400 kV/220 kV Substation



13. The summarized load profile of Bhopal 400/220kV substation for last 12 months is given in Figure 3. This figure shows that in December 2012, a maximum demand of 802 MVA was delivered by the Bhopal substation. The calculated maximum demand from load flow studies for FY2013 is 839 MVA. Considering the load growth at and around Bhopal area, the load on these transformers is expected to grow up to 1,113 MVA by year 2015-16 which can be served with the 4x315MVA (= 1260 MVA) transformer capacity already planned under the project.

Figure 4: Hourly Loading Pattern of Bhopal 400 kV/220 kV Substation



14. Furthermore, the daily loading pattern (summarized in Figure 4) indicates that the Bhopal 400 kV/220 kV transformers are presently loaded to their maximum (90%) only for about 1% of the time in a year. This loading pattern is expected to continue. MP Transco is developing a new 400/220kV substation at Ashta with 2x315MVA transformers which will relieve the loading of Bhopal 400kV substation in the future. With Ashta substation available, installation of a 5th transformer of 315MVA at the Bhopal 400kV substation is unlikely to be economically feasible in the present scenario.

15. Bhopal 400 kV substation will be loaded by 2016, even with the 4th transformer installed by the project. It is not possible to install another (the 5th one) transformer in Bhopal, due to short-circuit level considerations. A new 400 kV substation may be planned in the future in different location. For now, the following will address the potential overloading of Bhopal 400 kV substation:(i) A new 400 kV line from Bhopal to Ashta and a substation of 2x315 MVA has been planned and contracts were recently awarded under the PPP route, as a separate project; (ii) in an emergency (a failure of one transformer at Bhopal), the loads can be transferred to the new substation at Ashta; (iii) additionally, MP Transco has proposed a new 400kV substation at Sagar which will be connected with Vidisha through 220kV double circuit link that will further provide support to Bhopal substation.

16. The planning of the transmission system is a continuous process and the transmission plan of MP Transco is reviewed annually. Central Electricity Authority (CEA) has recently revised the "Manual on Transmission Planning Criteria" (January 2013) and as indicated in clause 15.4 of the manual, the allowable transformation capacity of the 400kV substations has been increased from 1260 MVA to 2000 MVA. In view of this, if the necessity arises, an additional transformer of adequate capacity can be installed at Bhopal 400kV substation in future. However, owing to short-circuit level considerations, MP Transco may not plan to raise the capacity at Bhopal 400 kV/220 kV substation in the near future, purely by increasing the number of transformers. The strategy would be build new substations and relieve the load on the Bhopal substation.

D. Transmission Plan

17. Through a similar procedure of identifying network additions, MP Transco has prepared the Transmission Investment Plan up to FY 2016. This plan has also been approved by MPERC. For the formulation of this Madhya Pradesh transmission plan, MP Transco has conducted extensive system studies with the help of technical consultants and has regularly updated the same on annual basis to incorporate the changes in the generation plans and distribution requirements. When network elements are proposed to be added, the planning department considers technical and economic merits, as well as practical considerations and constraints. The studies have been conducted in contingency conditions for transient analysis, temporary over voltages etc, and based on the results, the network requirements of the following types have been identified in the transmission plan:

- (i) New lines required at various voltage levels: 400 kV, 220 kV and 132 kV
- (ii) Building the second circuit of existing single circuit lines
- (iii) Line-in line-out requirements for interconnection to 400 kV or 220 kV substations
- (iv) Additional transformer requirements of existing substations

18. Accordingly, MP Transco has proposed 53 specific project activities to be financed under the ensuing loan. Tables 5, 6, 7, 8 and 9 provide details of transmission projects submitted for funding. Each table is followed by the technical justification of the new substations proposed to be built under the category. Table 10 provides a summary of these project activities proposed by voltage level. The PPTA consultants and ADB staff reviewed the load flow analyses

conducted by MP Transco's planning and design department, to examine the adequacy, impacts and technical prudence of the proposed project components and found that the proposed projects are technically sound.

Table 5: Proposed 400 kV Projects

Subproject	Voltage	Transmission Line	Transmission line length (km)	Substation	Bay
A1	400kV	LILO of 400 kV Seoni to Bhilai SC line at Balaghat/Kirnapur DC	5	Balaghat/Kirnapur 400/132kV (2x100+40MVA) + 400kV FB(2)+132kV FB(4)	-
A2	400kV	LILO of both ccts of 400 kV Nagda - Rajgarh line at Badnawar (2xDC)	10	Badnawar 400/220kV (2x315MVA) + 400kV FB(4)+220kV FB(4) + 125MVAR bus reactor	-
A3	400kV	400/220kV Additional Transformer at Bhopal 400kV SS	-	1x315 MVA	-
A4	400kV	400/220kV Additional Transformer at Chegaon 400kV SS	-	1x315 MVA	-
A5	400kV	400kV Bus Reactor at Nagda 400kV SS	-	1x125 MVAR	-

LILO = line-in line-out. A procedure to tap an existing transmission line to serve a substation.
DC = double circuit, FB = feeder bay, SC = single circuit, SS = substation.

19. **400/132kV Substation at Balaghat/Kirnapur (District: Balaghat)**: At present loads of the Balaghat area are being supplied over a 132kV double circuit line from Seoni which is critically loaded. In the event of outage of any circuit of this line, it is difficult to manage the load in this area. Looking to the prospective load growth and critical loadings of existing lines, MP Transco proposes to build a 400/132kV substation at Balaghat/Kirnapur by LILO of 400kV SC line between Bhilai and Seoni.

20. **400/132kV Substation at Badnawar (District: Ujjain)**: At present loads of the Ratlam 220kV and Badnagar 220kV are being supplied from Nagda and Indore 400kV Substation alongwith the loads of other 220kV substations. The existing installed capacity of Nagda 400kV Substation has reached to 945 MVA and the Indore 400kV substation to 1260MVA. The 220kV lines supplying power to Ratlam 220kV substation from Nagda and Badnagar 220kV Substation from Indore are critically loaded. Looking to the prospective load growth and critical loadings of existing lines, MP Transco proposes to build a 400/220kV substation at Badnawar by LILO of both circuit of 400kV Nagda - Rajgarh DCDS[6] line and LILO of both circuits of Badnagar-Ratlam 220kV DC line at Badnawar.

Table 6: Proposed 220 kV projects

Subproject	**Voltage**	**Transmission Line**	**Transmission line length (km)**	**Substation**	**Bay**
B1	220kV	LILO of one circuit of Ashta 400 - Dewas 220kV DC line at Chapda 220kV SC (DC)	35	Upgradation of Chapda 132kV SS to 220kV (1x160MVA) + 220kV FB(2)	

[6] DCDS: double-circuit, double stringing (this means the line towers are designed as to carry two circuits and both circuits have been strung on the towers).

Subproject	Voltage	Transmission Line	Transmission line length (km)	Substation	Bay
B2	220kV	Pithampur (400kV) - Depalpur (220kV) DCSS line	35	Upgradation of Depalpur 132kV SS to 220kV (1x160MVA) + 220kV FB(1)	Pithampur400(1)
B3	220kV	LILO of 1 circuit of Bhopal - Hoshangabad 220kV DC line at Adampur 220kV SS (DC)	5	Adampur 220/33kV 2x50MVA + 220kV FB(2)	
B4	220kV	LILO of Badnagar - Raltam 220kV DC line at Badnawar 400kV S/S (2xDC)	20		
B5	220kV	Julwaniya (400kV)-Kukshi (220kV) line (DC)	80	Kukshi 220/132kV 160 MVA + 220kV FB(2) + 132kV FB(1)	Julwaniya400(2)

LILO = line-in line-out. A procedure to tap an existing transmission line to serve a substation.
DC = double circuit, FB = feeder bay, SC: single circuit, SS = substation.

21. **220/132kV substation at Chapda (District: Dewas)**: At present loads of the Chapda area are being supplied over 132kV line from Dewas 220kV substation which is critically loaded. Further the 80MW wind power project is also connected with Chapda 132kV substation. In the event of outage of single circuit of this line, it is difficult to manage the load in this area. Looking to the prospective load growth and critical loadings of existing line, MP Transco proposes to build a 220/132kV substation at Chapda by LILO of one circuit of Ashta400 – Dewas 220kV DCDS line.

22. **220/132kV substation at Depalpur (District: Indore)**: At present loads of the Depalpur area are being supplied over a 132kV DCDS line from Indore-II Jetpura which is critically loaded. Looking to the proposed Industrial Zone and prospective load growth in and around the North –West Indore city, MP Transco proposes to build a 220/132kV substation at Depalpur by constructing 220kV DCSS[7] line from Pithampur 400kV SS to Depalpur.

23. **220/132kV substation at Adampur (District: Bhopal)**: City of Bhopal being the capital of Madhya Pradesh is expanding very rapidly and many of new townships are being built in and around the Bhopal City. Further an Industrial area is also being developed near Adampur. In order to cater to the additional load demand in and around Bhopal City area, MP Transco proposes to build a 220/132kV substation at Adampur, Bhopal by LILO of one circuit of 220kV DC line between Bhopal 400kV SS and Hoshangabad.

24. **220/132kV substation at Kukshi (District: Badwani)**: At present, loads of the Kukshi area are being supplied over a 132kV single circuit lines from Rajgarh, Nimrani and Julwaniya which are critically loaded. In the event of outage of any of these lines, it is difficult to manage the load in this area. Looking to the prospective load growth and critical loadings of existing lines, MP Transco proposes to build a 220/132kV substation at Kukshi by constructing 220kV DC line from Julwaniya 400kV SS to Kukshi.

[7] DCSS: double-circuit, single stringing (this means the line towers are designed as to carry two circuits but only one circuit has been strung on the towers).

Table 7: Proposed 132 kV Projects

Subproject	Voltage	Transmission Line	Transmission line length (km)	Substation	Bay
C1	132kV	Pithampur (220kV) - Pithampur-III (132kV) DCDS Line	15	Pithampur-III 132/33kV 63MVA + 132kV FB(2)	Pithampur220(2)
C2	132kV	Dewas (220kV) - Agrod)(132kV) DCSS Line	30	Agrod 132/33kV 40MVA + 132kV FB(1)	Dewas220 (1)
C3	132kV	Badnagar220 - Chhayan 132kV DCSS Line	35	Chhayan 132/33kV 40MVA + 132kV FB(1)	Badnagar220(1)
C4	132kV	Second Circuit of Kukshi - Alirajpur 132kV line	42		Alirajpur (1)
C5	132kV	LILO of 132kV Badod-Garoth line at Shyamgarh (D/C)	25	Shyamgarh 132/33kV 40MVA + 132kV FB(2)	
C6	132kV	Dhar220 - Teesgaon 132kV DCSS Line	20	Teesgaon 132/33kV 40MVA + 132kV FB(1)	Dhar220(1)
C7	132kV	Chhegaon220 - Pandhana 132kV DCDS line	30	Pandhana 132/33kV 63MVA + 132kV FB(2)	Chhegaon220 (2)
C8	132kV	LILO Manawar - Kukshi DCSS line at Singhana (DC)	20	Singhana 132/33kV 40MVA + 132kV FB(2)	
C9	132kV	Julwania400 - Talakpura 132kV DCSS line	30	Talakpura 132/33kV 40MVA + 132kV FB(1)	Julwania400 (1)
C10	132kV	LILO of Ratlam - Meghnagar 132kV SC line at Petlawad DCDS (DC)	20		Petlawad (2)
C11	132kV	Dabra - Chinaur 132kV DCSS Line	35	Chinaur 132/33kV 40MVA + 132kV FB(1)	Dabra (1)
C12	132kV	Sabalgarh220 - Kelaras 132kV DCSS Line	25	Kelaras 132/33kV 63MVA + 132kV FB(1)	Sabalgarh220(1)
C13	132kV	LILO of Mungaoli Traction Feeder to Mungaoli (DC)	10	Mungaoli 132/33kV 63MVA + 132kV FB(2)	
C14	132kV	Stringing of 3rd conductor from Bina220 to Mungaoli (35km)	35		
C15	132kV	Malanpur220 - Gohad 132kV DCDS Line	22	Gohad 132/33kV 63MVA +	Malanpur220(2)

Subproject	Voltage	Transmission Line	Transmission line length (km)	Substation	Bay
				132kV FB(2)	
C16	132kV	LILO one circuit of Mandideep-Hoshangabad 132kV line at Tamot	10	Tamot 132/33kV 40MVA + 132kV FB(2)	
C17	132kV	Shujalpur-Narsinggarh 220kV DCSS line (Initially charged on 132kV)	58	Narsinghgarh 132/33kV 40MVA + 132kV FB(1)	Shujalpur220(1)
C18	132kV	Vidisha220 - Salamatpur 132kV DCSS line	25	Salamatpur 132/33kV 40MVA + 132kV FB(1)	Vidisha220 (1)
C19	132kV	Beragarh220 - Intkhedi 132kV DCDS line	18	Intkhedi 132/33kV 63MVA + 132kV FB(2)	Beragarh220 (2)
C20	132kV	Udaipura - Silvani 132kV DCSS line	25	Silwani 132/33kV 40MVA + 132kV FB(1)	Udaipura (1)
C21	132kV	Ashoknagar 220 kV - Kothiya 132kV DCSS line	35	Kothiya 132/33kV 40MVA + 132kV FB(1)	Ashoknagar220 (1)
C22	132kV	Second circuit of Gairatganj - Vidisha220 132kV line	56		Vidisha220 (1) Gairatganj (1)
C23	132kV	Second circuit of Betul220 - Gudgaon 132kV line	57		Betul220 (1) Gudgaon (1)
C24	132kV	Second circuit of Bairagarh - Shyampur	20		Bairagarh220(1) Shyampur (1)
C25	132kV	Chichli220 - Udaipura 132kV DCDS line (220kV line charged at 132kV)	58	Udaipura 132/33kV 40MVA + 132kV FB(2)	Chichli220 (2)
C26	132kV	Datiya220 - Bhander 132kV DCSS Line	35	Bhander 132/33kV 63MVA + 132kV FB(1)	Datiya220(1)
C27	132kV	Budhera - Bada Malehra 132kV DCSS Line	40	Bada Malehra 132/33kV 40MVA + 132kV FB(1)	Budhera(1)
C28	132kV	2nd ckt of Tikamgarh-Budhera 132kV DCSS Line	45		Tikamgarh(1) Budhera(1)
C29	132kV	LILO of 132kV Balaghat-Seoni/Katangi line at Waraseoni 132kV SS (2xD/C)	20	Waraseoni 132/33kV 40MVA + 132kV FB(2)	
C30	132kV	Narsinghpur220-Devnagar 132kV DCSS Line	30	Deonagar 132/33kV 40MVA + 132kV FB(1)	Narsinghpur220(1)
C31	132kV	Karakbel - Belkheda 132kV DCSS line	20	Belkheda 132/33kV	Karakbel(1)

Subproject	Voltage	Transmission Line	Transmission line length (km)	Substation	Bay
				40MVA + 132kV FB(1)	
C32	132kV	Khurai - Khimlasa 132kV DCSS line	20	Khimlasa 132/33kV 40MVA + 132kV FB(1)	Khurai (1)
C33	132kV	Narsinghpur220kV - Karakbel 132kV DCDS line	50	Karakbel 132/33kV 40MVA + 132kV FB(2)	Narsinghpur220(2)
C34	132kV	LILO of both ckt of 132kV Balaghat-Bhanegaon Line at Balaghat/Kirnapur 4000kV S/s (2xD/C)	18		
C35	132kV	Second circuit of 132kV Tap Line from Balaghat - Katangi	40		Katangi (1)
C36	132kV	Second circuit of Chhatarpur - Khajuraho 132kV line	34		Chhatarpur(1) Khajuraho(1)
C37	132kV	Panagar 220 - Patan 132kV DCSS line.	40		Panagar220(1) Patan(1)

LILO: Line-in line-out. A procedure to tap an existing transmission line to serve a substation.
DC: double circuit, SC: single circuit FB: feeder bay SS: substation.
DCSS: Built for double circuits, but only a single circuit is strung.

Table 8: 132/33 kV Substations

Location	**Justification**
Bistan (District: Khargone)	To cater to the additional demand and to improve voltage profile of Bistan area, MP Transco proposes to build a 132kV substation of 40MVA capacity at Bistan by constructing a 132kV DCSS line between Khargone and Bistan.
Agrod (District: Dewas)	To cater to the additional demand and to improve voltage profile of Agrod area, MP Transco proposes to build a 132kV substation of 40MVA capacity at Agrod by constructing a 132kV DCSS line between Dewas 220kV and Agrod.
Chhayan (District: Dhar)	To cater to the additional demand and to improve voltage profile of Chhayan area, MP Transco proposes to build a 132kV substation of 40MVA capacity at Chhayan by constructing a 132kV DCSS line between Badnagar and Chhayan.
Shyamgarh (District: Mandsaur)	To cater to the additional demand and to improve voltage profile of Shyamgarh area, MP Transco proposes to build a 132kV substation of 40MVA capacity at Shyamgarh by LILO of one circuit of 132kV DC line between Badod 220kV and Gandhi Sagar hydropower station.
Teesgaon (District: Dhar)	To cater to the additional demand and to improve voltage profile of Teesgaon area, MP Transco proposes to build a 132kV substation of 40MVA capacity at Teesgaon by constructing a 132kV DCSS line between Dhar 220kV and Teesgaon.
Pandhana (District: Khandwa):	To cater to the additional demand and to improve voltage profile of Pandhana area, MP Transco to build a 132kV substation of 63MVA capacity at Pandhana by constructing a 132kV DCDS line between Chhegaon 220kV and Pandhana.
Singhana (District: Dhar)	To cater to the additional demand and to improve voltage profile of Singhana area, MP Transco proposes to build a 132kV substation of 63MVA capacity at Singhana by LILO of 132kV DCSS line between Manawar and Kukshi.
Talakpura (District: Khargone)	To cater to the additional demand and to improve voltage profile of Talakpura area, MP Transco propses to build a 132kV substation of 40MVA capacity at Talakpura by constructing a 132kV DCSS line between Julwaniya 400kV and Talakpura.
Pratappura (District: Bhind)	To cater to the additional demand and to improve voltage profile of Pratappura area, MP Transco proposes to build a 132kV substation of 40MVA capacity at Pratappura by constructing a 132kV DCSS line between Mehgaon 220kV and Pratappura.
Chinour (District: Gwalior)	To cater to the additional demand and to improve the voltage profile of Chinour area, MP Transco proposes to build a 132kV substation of 40MVA capacity at Chinour by constructing a 132kV DCSS line between Gwalior-II 220kV and Chinour.

Kelaras (District: Morena)	To cater to the additional demand and to improve the voltage profile of Kelaras area, MP Transco proposes to build a 132kV substation of 63MVA capacity at Kelaras by constructing a 132kV DCSS line between Sabalgarh 220kV and Kelaras.
Mungaoli (District: Ashoknagar)	To cater to the additional demand and to improve the voltage profile of Mungaoli area, MP Transco proposes to build a 132kV substation of 63MVA capacity at Mungaoli by LILO of both circuits of 132kV DCDS line between Bina 220kV and Mungaoli Railway Traction SS.
Gohad (District: Bhind)	To cater to the additional demand and to improve the voltage profile of Gohad area, MP Transco proposes to build a 132kV substation of 63MVA capacity at Gohad by constructing a 132kV DCDS line between Malanpur 220kV and Gohad.
Narsinggarh (District: Rajgarh)	To cater to the additional demand and to improve the voltage profile of Narsinggarh area, MP Transco proposes to build a 132kV substation of 40MVA capacity at Narsinggarh by constructing a 220kV DCSS line initially charged on 132kV between Shujalpur 220kV and Narsinggarh.
Salamatpur (District: Raisen)	To cater to the additional demand and to improve the voltage profile of Salamatpur area, MP Transco proposes to build a 132kV substation of 40MVA capacity at Salamatpur by constructing a 132kV DCSS line between Vidisha 220kV and Salamatpur.
Intkhedi (District: Bhopal)	To cater to the additional demand and to improve the voltage profile of Intkhedi area, MP Transco proposes to build a 132kV substation of 63MVA capacity at Intkhedi by constructing a 132kV DCDS line between Beragarh 220kV and Intkhedi.
Silwani (District: Raisen):	To cater to the additional demand and to improve the voltage profile of Silwani area, MP Transco proposes to build a 132kV substation of 40MVA capacity at Silwani by constructing a 132kV DCSS line between Udaipura and Silwani.
Kothiya (District: Guna):	To cater to the additional demand and to improve the voltage profile of Kothiya area, MP Transco proposes to build a 132kV substation of 40MVA capacity at Kothiya by constructing a 132kV DCSS line between Ashoknagar 220kV and Kothiya.
Udaipura (District: Raisen):	To cater to the additional demand and to improve the voltage profile of Udaipura area, MP Transco proposes to build a 132kV substation of 40MVA capacity at Udaipura by constructing a 132kV DCDS line between Chichli 220kV and Udaipura.
Bhander (District: Datiya):	To cater to the additional demand and to improve the voltage profile of Bhander area, MP Transco proposes to build a 132kV substation of 63MVA capacity at Bhander by constructing a 132kV DCSS line between Datiya 220kV and Bhander.
BadaMalehra (District: Chhatarpur):	To cater to the additional demand and to improve the voltage profile of BadaMalehra area, MP Transco proposes to build a 132kV substation of 40MVA capacity at BadaMalehra by constructing a 132kV DCSS line between Budhera and BadaMalehra.

Waraseoni (District: Balaghat):	To cater to the additional demand and to improve the voltage profile of Waraseoni area, MP Transco proposes to build a 132kV substation of 40MVA capacity at Waraseoni by constructing a 132kV DCSS line between Balaghat and Waraseoni.
Deonagar (District: Narsinghpur):	To cater to the additional demand and to improve the voltage profile of Deonagar area, MP Transco proposes to build a 132kV substation of 40MVA capacity at Deonagar by constructing a 132kV DCSS line between Narsinghpur 220kV and Deonagar.
Belkheda (District: Jabalpur):	To cater to the additional demand and to improve the voltage profile of Belkheda area, MP Transco proposes to build a 132kV substation of 40MVA capacity at Belkheda by constructing a 132kV DCSS line between Karakbel and Belkheda.
Khimlasa (District: Sagar):	To cater to the additional demand and to improve the voltage profile of Khimlasa area, MP Transco proposes to build a 132kV substation of 40MVA capacity at Khimlasa by constructing a 132kV DCSS line between Bina 220kV and Khimlasa.
Karakbel (District: Narsinghpur):	To cater to the additional demand and to improve the voltage profile of Karakbel area, MP Transco proposes to build a 132kV substation of 40MVA capacity at Karakbel by constructing a 132kV DCDS line between Narsinghpur 220kV and Karakbel.

E. Savings in Transmission Losses

25. Relieving loads (current flows) on existing lines and providing paths of lower resistance for the currents to flow, reduces the energy loss in the transmission network. Load flow analysis models have the capability to provide the energy loss at the time at which the network is modeled. The network is modeled for its status at peak time of the year, which signifies the most critical period. By modeling the network with and without the proposed improvements, the reduction in losses can be estimated, as follows:

<u>220 kV substations and associated lines</u>

Forecast peak demand for MP System in year 2015-16	12,800 MW
Peak-time power losses before implementation of the project	414.8 MW
Peak-time power losses after implementation of the project	382.2 MW
Saving in peak-time power losses	32.6 MW
Annual energy saved at 70% load factor (at a loss-load factor of 53.2%)	151.9 GWh

<u>132kV Substations and associated lines</u>

Reduction in Peak Power Loss	54.03 MW
Annual energy saved at 70% load factor (at a loss-load factor of 53.2%)	251.8 GWh

F. Distribution Plans and Proposed Projects

26. Subprojects selected to be financed under this project were proposed by the planning units of the three DISCOMs, and were reviewed by the PPTA team, to verify that such improvements constitute the lowest cost improvements to ensure adequacy and reliability of the distribution network over the next five years and beyond. The PPTA team found that the lines and substations proposed are part of the five-year plan of each DISCOM, prepared using prudent planning techniques. The proposals considered by the PPTA team were all to

upgrade/build 33 kV and 11 kV lines, and to upgrade/build 33 kV/11 kV substations. The existing 33 kV network is largely overloaded. The reasons are (i) owing to the demand-supply gap, the system is either fully loaded or overloaded during the limited hours of supply available, (ii) owing to congestion in the 33 kV and 11 kV line network, load transfer from an overloaded feeder to another feeders is not possible, leading to further curtailment of load due to overloading.

27. Each DISCOM has specific requirements, which were evaluated, to prepare a list of approved subprojects for implementation. The summary of project components is shown in Tables 9, 10 and 11.

Table 9: Summary of DISCOM-C Project Activities to be Financed under the Loan

	Distribution Project Component	Unit	Items added
1	**Augmentation of capacity in existing primary substations**		
	From 3.15 to 5 MVA	Nos	90
	from 5 MVA to 8 MVA	Nos	45
	Additional 5 MVA transformer	Nos	12
	Total transformer capacity added to existing substations	MVA	366
2	**New primary substations**	Nos	30
	Total new transformer capacity installed	MVA	142
3	**New HV distribution lines**		
	11kV line on PCC pole	km	193
	33 kV line DCSS on H Beam 13 m long	km	363
	33 kV line on PCC pole	km	1,078

DCSS = double circuit line, but with only one circuit strung, PCC = pre-stressed cement concrete.

Table 10: Summary of DISCOM-E Project Activities to be Financed under the Loan

	Distribution Project Component	Unit	Items added
1	**Augmentation of capacity in existing primary substations**		
	From 3.15 to 5 MVA	Nos	103
	from 5 MVA to 8 MVA	Nos	45
	Additional 5 MVA transformer	Nos	12
2	**New primary substations**		
	With 3.15 MVA transformer	Nos	4
	With 5 MVA transformer	Nos	26
	Total transformer capacity in new primary substations	MVA	142.6
3	**New HV distribution lines**		
	33 kV line DCSS on H beam 13 m long	km	363
	33 kV DCSS DP on H beam	Nos	363
	33 kV line on PCC pole	km	1078
	33 kV DP structure on PCC pole	Nos	757
	33 kV bay at EHV SS	Nos	24
	Additional 33 kV bay at 33/11 kV SS	Nos	150
	11kV line on PCC pole	km	193

DCSS = double circuit line, but with only one circuit strung, DP = double pole, EHV = extra high voltage, PCC = pre-stressed cement concrete, SS = substation.

Table 11: Summary of DISCOM-W Project Activities to be Financed under the Loan

	Distribution Project Component	Unit	Items added
1	**Augmentation of capacity in existing primary substations**		
	from 3.15 to 5 MVA	Nos	100
	from 5 MVA to 8 MVA	Nos	11
	Additional 5 MVA transformer	Nos	57
	Total transformer capacity added to existing substations	MVA	703
2	**New primary substations built**	Nos	40
	Total new transformer capacity installed	MVA	200
3	**New HV distribution lines**		
	11 kV lines	km	340
	33 kV lines	km	843
	number of 33 kV feeders installed	Nos	57
4	New distribution transformer capacity installed	MVA	1221