ECONOMIC ANALYSIS

A. Project Rationale

1. Madhya Pradesh has been experiencing rapid escalation in demand as well as supply in recent years. Energy sales are projected to increase from under 30 terrawatt-hours (TWh or billion units) per year in 2012 to close to 50 TWh in 2015 and nearly 78 TWh by 2022. Demand for power is projected to increase to 11% over FY2012–FY2016. Generation capacity has also improved significantly and is expected to continue to consolidate going forward, with 14,554 megawatts (MW) of new capacity installed by 2020. The state power system is projected to have a 20% peak period generation surplus according to the Load Generation Balance Report for 2013-14.[1] This is a remarkable improvement in supply capability, considering that 5–6 years ago Madhya Pradesh faced a 13%–14% energy deficit. To transmit and distribute this expanded power generation efficiently to meet growing demand, parallel expansion of the transmission and distribution (T&D) infrastructure is critically important.

2. The proposed investment covers a major expansion of the T&D network, including among other things 1,800 circuit kilometers of high voltage lines (primarily 132 kilovolts [kV] but also 220/400 kV expansion) and 3,125 circuit kilometers of new distribution lines. These new lines will add about 5% to the existing high voltage (132 kV and above) lines and 5.2% to the existing 33 kV line network. The proposed investments will cover transmission investments by Madhya Pradesh Power Transmission Company (MP Transco) of Rs17.47 billion mainly at 132 kV level, as well as 220 kV and 400 kV network. In addition, Rs7.53 billion of capital works have been proposed across the state distribution network at 33 kV, 11 kV, and low tension levels—owned and operated by three distribution companies.[2] Given the sharp increase in load being experienced and the trend of high demand growth, it is important that these extensions are put in place in a timely manner to deliver a stronger and resilient network that can cope with the growing demand.

3. The proposed investment under the project fits well with the policy framework developed by the Government of Madhya Pradesh (GOMP) and the central government to provide greater access to electricity and to reduce technical and commercial losses in the T&D system. The proposed investment will enable reaping the full benefits of reforms undertaken by the GOMP, with support from development partners and the Asian Development Bank, to enhance the financial health of power sector companies in the state. These investments will also ensure that the high voltage system can operate with lower losses, without facing major transmission constraints, allowing more power to be supplied and ensuring optimal dispatch of the generation to avoid expensive peaking gas- (or oil-) based generation.

4. The distribution networks are in dire need of reinforcement, expansion, and refurbishment to meet growing demand. The distribution companies (DISCOMs) are yet to achieve positive net revenues, so public sector intervention is essential to enable them to implement the project activities. The lack of a strong enabling business environment and the presence of subsidized power for agricultural usage suggest that it is unlikely that the private sector will have a substantial interest in T&D investments in Madhya Pradesh. Therefore, the proposed investments are unlikely to crowd out private investments.

[1] Central Electricity Authority (CEA). 2013. *Load Generation Balance Report 2013-14*. New Delhi.
[2] Madhya Pradesh Madhya Kshetra Vidyut Vitaran Company (DISCOM-C); Madhya Pradesh Poorva Kshetra Vidyut Vitaran Company (DISCOM-E); and Madhya Pradesh Paschim Kshetra Vidyut Vitaran Company (DISCOM-W).

5. The economic analysis presented in this summary report is conducted in accordance with ADB's *Guidelines for the Economic Analysis of Projects.*[3] The reduction in technical losses is one of the major benefit of this project. Increasing power supply in a system where consumers have faced major power cuts would have a greater economic benefit from increased consumption. T&D projects in some cases may substitute for the need of peaking generation, by allowing existing remote generation capacity to be utilized better. The economic evaluation focuses on (i) establishing the economic costs and benefits of the activities of the proposed project, and (ii) calculating the economic internal rate of return and its sensitivity to changes in input parameters.

B. Demand Analysis

6. Demand for power in Madhya Pradesh grew at a relatively low rate of 5% per year, from 1996 to 2004. However, the total increase in power requirement in recent years has been strong, with energy sales growing as much as 29% over the 3-year period from FY2010 to FY2012. The projected energy demand growth rate during FY2012 FY2016 is estimated at 11% per year, before it tapers off to 8.26% per year for the subsequent 5-year period until FY2021. As the annual per capita electricity consumption in Madhya Pradesh, 618 kilowatt-hours (kWh) per person per year, is well below the national average of 879 kWh per person per year, latent demand in the system is significant. Apart from a significant number of un-electrified villages, the state has faced significant shortages in grid-connected areas, including an energy shortage as high as 22% in January 2013.[4] Given the electricity shortages and people's willingness to pay for improved service, the T&D system faces virtually no risk of idle capacity.

C. Project Alternatives and Least-Cost Analysis

7. Technical alternatives to the proposed T&D projects include (i) alternative higher/lower voltage projects; (ii) alternative timing of the proposed projects; (iii) generation sites closer to the load centres to the extent these are feasible and substitute for transmission projects, including renewable-based generation; and (iv) demand-side management alternatives. Assessment of the least-cost nature of the proposed projects is complicated because they form part of a much larger reform initiative, preceded by other projects and to be followed by others. It is therefore important to note that the least-cost criterion needs to be applied in a more holistic sense, rather than focusing narrowly on each component.

8. The T&D projects selected are in line with the least-cost philosophy to evacuate generation reliably and economically to meet growing demand from existing customers as well as new customers. MP Transco demonstrates that the proposed projects would cause transmission losses to fall by an estimated 408 gigawatt-hours (GWh) per year in the peak period, consistent with what is expected of a least-cost plan. The distribution network expansion and augmentation projects recognize that the existing 33 kV system capacity are inadequate for the growing load in the system, which will lead to higher losses or require power cuts to avoid overloading. As noted, local generation alternatives (as opposed to grid supply), including renewable opportunities such as solar, wind and biomass, are limited or prohibitively expensive to compete with the proposed T&D expansion.

[3] ADB. 1997. *Guidelines for the Economic Analysis of Projects.* Manila.
[4] CEA. 2013. *Load Generation Balance Report 2013-14*. New Delhi. Annexure IV(a).

D. Cost–Benefit Analysis

9. Added consumption of electricity—caused by added T&D capacity and from the part that would have dissipated from the network as system losses without the proposed investment, or resulting from avoided power cuts—is the key component of the economic benefit of the project. The cost–benefit analysis framework used for the proposed T&D projects compares the discounted cost of the projects with the discounted economic benefit of incremental sales and loss reduction and other relevant benefits over a 27-year life. Economic assessment estimated the economic internal rate of return (EIRR) and net present value (NPV) of the project.

10. The project's economic benefits comprise:

(i) The value of the total additional energy served as a result of project interventions, which includes incremental sales caused by capacity expansion and removal of bottlenecks in the T&D system. The benefit of these incremental sales is estimated as the relevant area under the demand curve.[5] This is equal to the revenue of the incremental sales, plus consumer surplus, less the cost of additional generation associated with incremental sales. Saved energy resulting from technical loss reduction was valued at the cost of generation. The consumer surplus is evaluated using the following formula:

$$Consumer\ surplus = 0.5[P_1 (\Delta Q)^2] / [e_d\ Q_1] = 0.5\ [\Delta Q.\ \Delta P]$$

Where, the prevailing electricity price is P_1, and electricity consumption without the project is Q_1. With the project, the electricity consumption increases to Q_2 with ΔQ being the additional consumption from reduced losses. Finally, e_d is the absolute value of the price elasticity of demand.

(ii) Resource cost savings from the loss reductions, valued at the cost of generation

11. **Key assumptions.** All costs and benefits in the analysis are expressed in 2013 prices. A discount rate of 12% was used in the NPV calculations. A period of 27 years was used for economic assessment. Capital costs considered in the economic evaluation include project material and construction costs, physical contingencies, but exclude taxes, price contingencies, and financial charges during construction. Non-tradable commodities were valued through shadow prices using a standard conversion factor of 0.93,[6] and the following specific conversion factors were used to convert other project costs: 1.00 for equipment, 1.50 for steel, 0.76 for cement, 0.82 for timber, 2.00 for skilled labor, and 0.67 for unskilled labor. These conversion factors were taken from previous ADB project preparatory documents or from other published data. Project costs were phased in over a 3-year period for the distributing companies: 20% in FY2014, 50% in FY2015, and 30% in FY2016. The MP Transco project costs are phased over a 4-year period. Project maintenance costs each year were estimated to be 3% of the costs. In addition to the projects' investment costs, cost of generation (for the incremental sales) was also used in estimating the EIRR and NPV.

12. Only the value of incremental sales and a conservative static estimate of technical losses were used as benefits in the economic analysis. However, the project also provides other

[5] This methodology is recommended by ADB's new economic analysis guide: ADB. 2013. *Cost–Benefit Analysis for Development: A Practical Guide*. Manila.

[6] ADB. 2004. ERD Technical Note Series No. 11, Shadow Exchange Rates for Project Economic Analysis: Toward Improving Practice at the Asian Development Bank. Manila.

benefits such as technical loss reduction growing over the years as system load increases. Potential for technical loss reduction included in the analysis is conservative. Without the proposed investment, if the existing system is used to transmit increasing quantities of power, losses can increase significantly. Greater loss reduction would typically be achieved for subsequent years as the system load increases. Sophisticated dynamic modeling is required to quantify increasing losses over time. Therefore, the benefits of increasing technical loss reduction were not included in the analysis. To enable a conservative assessment, other economic benefits such as avoided outage costs and voltage improvement are not included. The benefit–cost analysis for the base case shows that the project is economically viable, with an estimated EIRR of 21.02%. Economic cost and benefit flows are in Table 1.

Table 1: Annual Costs and Benefits – Base Case

(Rs million)

Year	Project Investment	Project maintenance costs	Total project cost	Value of total energy loss saved	Incremental Sales	Less Cost of Generation	Additional Consumer Surplus	Total economic benefit	Net Economic Benefit of the project
1	3,211	0	3,211	0	0	0	0	0	3,211
2	10,647	0	10,647	0	0	0	0	0	10,647
3	7,565	0	7,565	0	0	0	0	0	7,565
4	3,577	226	3,803		0	0	0	0	3,803
5	0	750	750	1,519	1,839	1,329	2,560	4,589	3,839
6	0	750	750	2,278	2,759	1,993	3,839	6,884	6,134
7	0	750	750	3,038	3,679	2,657	5,119	9,178	8,428
8	0	750	750	3,038	3,679	2,657	5,119	9,178	8,428
9	0	750	750	3,038	3,679	2,657	5,119	9,178	8,428
10	0	750	750	3,038	3,679	2,657	5,119	9,178	8,428
11	0	750	750	3,038	3,679	2,657	5,119	9,178	8,428
12	0	750	750	3,038	3,679	2,657	5,119	9,178	8,428
13	0	750	750	3,038	3,679	2,657	5,119	9,178	8,428
14	0	750	750	3,038	3,679	2,657	5,119	9,178	8,428
15	0	750	750	3,038	3,679	2,657	5,119	9,178	8,428
16	0	750	750	3,038	3,679	2,657	5,119	9,178	8,428
17	0	750	750	3,038	3,679	2,657	5,119	9,178	8,428
18	0	750	750	3,038	3,679	2,657	5,119	9,178	8,428
19	0	750	750	3,038	3,679	2,657	5,119	9,178	8,428
20	0	750	750	3,038	3,679	2,657	5,119	9,178	8,428
21	0	750	750	3,038	3,679	2,657	5,119	9,178	8,428
22	0	750	750	3,038	3,679	2,657	5,119	9,178	8,428
23	0	750	750	3,038	3,679	2,657	5,119	9,178	8,428
24	0	750	750	3,038	3,679	2,657	5,119	9,178	8,428
25	0	750	750	3,038	3,679	2,657	5,119	9,178	8,428
26	0	750	750	3,038	3,679	2,657	5,119	9,178	8,428
27	0	750	750	3,038	3,679	2,657	5,119	9,178	8,428
								NPV	**18,420**
								EIRR	**21.02%**

EIRR = economic internal rate of return, NPV = net present value.
Source: Asian Development Bank estimates.

E. Sensitivity and Risk Analysis

13. As part of the sensitivity and risk analysis, the primary objective is to check the exposure of the proposed investments to downside risk as reflected in an increase in cost or a decrease in benefit parameters. It is checked if the project EIRR risks falling below the notional hurdle rate of 12%. Table 2 shows the results of the sensitivity analyses, which confirm that the project economics are adequately robust and will not go below the hurdle rate as a result of variation in project capital and operating costs by 10%. Any underachievement in loss reductions or new connection by 10% or a 1-year delay in the project would still render the project economically viable. However, the delay reduces the EIRR substantially and measures should be incorporated in the project design to minimize project delays.

Table 2: Results of Sensitivity Analyses

	Sensitivity	NPV of Net Benefit (Rs million)	EIRR (%)
1	Project capital cost increase by 10%	16,518	19.58
2	Capital cost and O&M cost increase by 10%	16,136	19.41
3	Total energy savings reduced by 10%	14,294	19.25
4	1-year delay in project completion	13,615	18.18

EIRR = economic internal rate of return. NPV = net present value, O&M = operation and maintenance.
Source: Asian Development Bank estimates.

F. Conclusion

14. The economic analysis of the proposed T&D investments by MP Transco and three DISCOMs concludes that proposed investments are economically viable. The overall portfolio has an EIRR of 21.02% for the base case. Sensitivity analyses that consider downside risks of 10% variation in costs and benefits and 1 year delay in project implementation demonstrate that the base case is robust in these cases.