



Technical Assistance Report

Project Number: 42054
April 2008

India: Developing the Power System Master Plan for Bihar

CURRENCY EQUIVALENTS

(as of 1 April 2008)

Currency Unit	–	Indian rupee/s (Re/Rs)
Re1.00	=	\$0.0249
\$1.00	=	Rs40.11

ABBREVIATIONS

ADB	–	Asian Development Bank
BSEB	–	Bihar State Electricity Board
BSG	–	Bihar state government
kV	–	kilovolt
TA	–	technical assistance

TECHNICAL ASSISTANCE CLASSIFICATION

Targeting Classification	–	General intervention
Sector	–	Energy
Subsector	–	Energy sector development
Themes	–	Sustainable economic growth, capacity development
Subtheme	–	Institutional development

NOTES

- (i) The fiscal year (FY) of the Government of India ends on 31 March.
- (ii) In this report, "\$" refers to US dollars.

Vice President	L. Jin, Operations 1
Director General	K. Senga, South Asia Department (SARD)
Director	T. Kandiah, Energy Division, SARD
Team leader	N. T. Anvaripour, Senior Finance Specialist (Energy), SARD

I. INTRODUCTION

1. During discussions for the country operations business plan 2008–2010¹ the Government of India requested technical assistance (TA) from the Asian Development Bank (ADB) to enhance the capacity of power sector entities in the state of Bihar. ADB conducted a fact-finding mission from 3 to 14 December 2007 and reached an understanding with the Bihar state government (BSG) on the TA's objective, scope, cost estimates, financing plan, implementing arrangements, and consultants' terms of reference. The design and monitoring framework is in Appendix 1.²

II. ISSUES

2. Demand for electricity in Bihar is expected to grow rapidly as the generation network is rehabilitated and as suppressed demand is released. Years of neglect and lack of generation sources has driven many electricity consumers out of the state or to alternative energy sources including captive generation. Most of these consumers are likely to reappear once BSG can demonstrate that electricity is reliable and affordable. Rural electrification is also expected to significantly increase electricity consumption, and existing customers of Bihar State Electricity Board (BSEB) will naturally increase their electricity drawn from the grid by simple virtue of the increase in the number of hours for which they receive supply from the grid. This demand growth will increase load density in some areas meaning that new supply solutions will need to be investigated. It will also result in a wider geographic supply base with very low load density in some areas, which requires a different set of supply solutions to those currently adopted.

3. Uncertainty surrounds future sources of electricity for Bihar. The state has significant hydropower potential, but the risk inherent in hydropower development and the long lead times suggest that hydropower may not be a significant power generating source for Bihar within the next 10–15 years. In the meantime, new in-state thermal plants and electricity purchased from outside Bihar will be the main power sources. The need to develop a planning framework within which various generation scenarios can be developed is essential if the transmission grid is to be capable of efficiently supplying all in-state and out-of-state consumers with an appropriately reliable supply.

4. Despite the clear need, no coherent plan is in place for development of the power system in Bihar, and BSEB does not have long-term planning capability. No meaningful regional long-term demand forecasting is evident, and the concept of staged development of the power system to meet horizon year demand is not understood. In the absence of a planning framework, capacity additions are made in an ad hoc manner in response to the availability of funding.

5. Considering the wide range of possible supply and demand scenarios that may develop in Bihar, the preparation of a comprehensive power system master plan is essential. The master plan would be linked to a sector policy and include a clear planning framework, planning criteria, and a detailed and disaggregated demand forecast at the power substation (33/11 kilovolt) level. It would provide a series of staged, least-cost, 10–15 year network expansion programs matched to demand growth and various generation scenarios. A rolling 5-year capital works plan linked to the master plan also needs to be developed and regularly updated with detailed project reports prepared for projects covered in the first 1–2 years of the capital works plan. The

¹ ADB. (2007). *India: Country Operations Business Plan 2008-2010*. Manila

² The TA first appeared in *ADB Business Opportunities* on 24 January 2008.

master plan will include a loss reduction framework and a staged capital works program designed to reduce technical and nontechnical losses.

6. ADB's TA will assist BSG in developing the power system master plan, which will address long existing planning issues of Bihar's power sector.

III. THE TECHNICAL ASSISTANCE

A. Impact and Outcome

7. The outcome of the TA will be a comprehensive power system master plan to provide the blueprint for development of the power system in Bihar. The master plan will coordinate generation, transmission, and distribution expansion to ensure with confidence that all proposed capital investments are not ad hoc and are instead part of a long-term, structured plan. It will ensure that network expansion is economically efficient and will provide a realistic framework for loss reduction.

B. Methodology and Key Activities

8. The expected outputs of the TA include

- (i) a detailed long-term (10-year) demand forecast for Bihar at the power substation level, with demand disaggregated between main consumer groups;
- (ii) a series of realistic long-term generation capacity expansion scenarios, with consideration given to prospects for in-state generation development as well as generation sourced from outside of Bihar;
- (iii) a series of least-cost transmission expansion plans, matched to the generation expansion scenarios developed;
- (iv) an assessment of the amount and timing of generation and transmission investments for each system development scenario;
- (v) an estimate of distribution investment costs to meet demand growth;
- (vi) a program of distribution loss reduction initiatives;
- (vii) a targeted loss reduction program, with an assessment of returns expected from investments in terms of technical and nontechnical loss reduction;
- (viii) institutional reform recommendations for BSEB to develop capacity to implement and revise the power system master plan as necessary;
- (ix) a power system analysis software program and equipment (computers); and
- (x) a detailed 5-year program of capital works, and detailed project reports for projects to be covered in the first 2 years.

9. By using the least-cost analysis to compare various options for generation, transmission, and distribution in line with ADB's *Guidelines for the Economic Analysis of Projects* (1997), key activities under the TA will include

- (i) assess existing electricity demand and prepare a demand forecast, using both bottom-up (location-specific) data and top-down (macroeconomic) parameters;
- (ii) develop demand-side management options;
- (iii) assess potential energy sources for generation development in Bihar, and compare the likely development costs of in-state generation versus the expected costs of interstate purchase of electricity over the long term;

- (iv) develop a series of staged generation expansion plans including in-state options, out-of-state options, and combinations of the two;
- (v) undertake computer modeling of Bihar's current existing power system down to the power substation (33/11 kilovolt) level, and analyze constraints;
- (vi) develop and conduct computer modeling of network expansion options to match the various generation expansion plans, and forecast demand growth;
- (vii) calculate annual investment requirements and investment net present values under each of the expansion plans and for a reasonable set of input cost assumptions;
- (viii) assess annual distribution investment costs for the plan period, based on expectations regarding load density, age and condition of existing equipment, and a realistic program of rural electrification;
- (ix) identify, analyze, and prepare cost estimates for options and opportunities for loss reduction, including projects forming part of the overall master plan and stand-alone projects;
- (x) prepare a detailed transmission and distribution capital works program for the first 5 years of the master plan, including loss reduction subprojects;
- (xi) procure power system analysis software and equipment (computers);and
- (xii) prepare detailed project reports for projects included in the first 2 years of the capital works program.

9. The TA consultants will conduct on-the-job and classroom-based training for BSG and BSEB staff in modern power system planning techniques and tools, and regular workshops to update stakeholders on progress with master plan preparation and to discuss and debate assumptions and scenarios. The power system analysis software to be purchased will include a training component for BSEB users.

10. To provide fulltime assistance to the TA consultant and to ensure BSG ownership of the power system master plan, BSG will establish a power system master plan task force.

C. Cost and Financing

11. The total cost of the TA is estimated at \$850,000 equivalent. ADB will finance \$600,000 on a grant basis from ADB's TA funding program.³ BSG will finance the remaining \$250,000 equivalent in kind through the provision of administrative setup, including office space and equipment, and local transportation. The detailed cost estimates are presented in Appendix 2.

D. Implementation Arrangements

12. A task force will be established, headed by the energy secretary with members from the Reform Management Unit, and BSEB's director of expenditure and four executive engineers with transmission and distribution backgrounds. It will meet monthly and oversee TA activities.

13. BSEB will be the Executing Agency for the TA. It will appoint a senior staff member as project director and establish a project management office within BSEB. The project management office will be responsible for day-to-day TA management, coordinate with all

³ Advisory TA for Capacity Development of Bihar State Power Sector Agencies is included in ADB.(2007). *India: Country Operations Business Plan 2008-2010*. Manila for \$800,000. SAEN will use \$600,000 for the TA to develop the Bihar power system master plan.

government and nongovernment TA stakeholders, oversee consultants' activities, and facilitate all TA administration.

14. BSEB will provide (i) office accommodation and facilities, internet access, and secretarial support; and (ii) land transportation within Bihar for consultants. BSEB and agencies concerned will provide the consultants with existing data, preliminary analysis, and reports; and guide consultants in data collection and in liaising with other government ministries and agencies. BSEB, other relevant agencies, and consultants will jointly organize dissemination workshops for counterpart staff and other stakeholders. BSEB will ensure close coordination with consultants of other ongoing ADB TA projects. The consultants will incorporate lessons from past ADB TA projects in the power sector. The consultants will organize workshops, seminars, and consultation meetings to brief stakeholders and receive their feedback on the policy update collaboration with ADB. The consultants will be accountable to ADB and BSEB.

15. The TA will finance the services of international consultants for a total of 11 person-months and national consultants for a total of 9 person-months. ADB will engage a consulting firm or consortium of firms in accordance with its *Guidelines on the Use of Consultants* (2007, as amended from time to time). Recruitment of consultants will be under the quality- and cost-based selection process, and simplified technical proposals will be requested. A standard quality-cost ratio of 80:20 will be used. The international consulting team will comprise a (i) power system planning expert, (ii) hydropower specialist, (iii) distribution specialist, and (iv) power sector economist. The national consulting team will include a (i) thermal generation specialist, (ii) transmission expert, (iii) distribution specialist, and (iv) power sector economist. The outline terms of reference for the consultants are in Appendix 3.

16. The consultants will procure equipment (computers, etc.) and the power system analysis software following ADB's *Procurement Guidelines* (2007, as amended from time to time). Equipment and software purchased under the TA will be turned over to the Government after TA completion.

17. The consultants will submit an inception report detailing initial findings and the consultants' proposed action plan. The inception report will be submitted 2 weeks after the commencement of consultant services. An interim report will be submitted in July 2008 and a draft final report in January 2009. The first tripartite meeting between BSG, ADB, and consultants will review the inception report in Patna (Bihar) within 3 weeks of receiving it. The interim report will describe TA progress, person-months utilized, problems encountered, and proposed revision of the work plan. It will incorporate detailed reports on completion of the current policy analysis. The draft final report will detail consultants' findings and recommendations. The second tripartite meeting will review the interim report; the third tripartite meeting will review the draft final report. The final report will be submitted with 4 weeks after the tripartite review of the draft final report. The consultants will prepare monthly status reports for their specific scope of work, highlighting any issue that could become critical for timely implementation and completion of the TA.

18. The TA will commence in April 2008 and be completed by the end of January 2009.

IV. THE PRESIDENT'S DECISION

19. The President, acting under the authority delegated by the Board, has approved the provision of technical assistance not exceeding the equivalent of \$600,000 on a grant basis to the Government of India for Developing the Power System Master Plan for Bihar, and hereby reports this action to the Board.

DESIGN AND MONITORING FRAMEWORK

Design Summary	Performance Targets/Indicators	Data Sources / Reporting Mechanisms	Assumptions and Risks
<p>Impact Economic development in Bihar</p>	<p>Per capita gross state product increased by at least 6% per annum by 2015</p>	<p>Annual budget reports ADB estimates</p>	<p>Assumptions BSG gives high priority to power sector development. Funding is available for power system expansion and augmentation. Sufficient investment is made in other infrastructure.</p>
<p>Outcome Provide a platform for optimal development of Bihar's electricity generation, transmission, and distribution networks</p>	<p>Fully articulated, least-cost power system master plan for Bihar by 2009</p>	<p>Power system master plan steering committee periodic reports Bihar Electricity Regulatory Commission annual reports</p>	<p>Assumption Powergrid and BSEB cooperate to provide grid connection inputs and data to least-cost planning process.</p>
<p>Outputs A comprehensive and well-articulated master plan for development of Bihar's power system, including</p> <p>(i) assessment of existing electricity demand and preparation of a demand forecast, using bottom-up (location-specific) data and top-down (macroeconomic) parameters;</p> <p>(ii) demand-side management options;</p> <p>(iii) assessment of potential energy sources for generation development in Bihar, and comparison of likely development costs of in-state generation versus expected costs of interstate purchase of electricity in the long term;</p> <p>(iv) development of a series of staged generation expansion plans including in-state options, out-of-state options, and combinations of the two;</p> <p>(v) computer modeling of Bihar's current power system to the power substation (33/11 kilovolt) level, and analysis of constraints;</p> <p>(vi) development and computer modeling of network expansion options to match the various generation expansion plans and forecasted demand growth;</p> <p>(vii) calculation of annual investment requirements</p>	<p>TA final report in the form of a power system master plan by January 2009</p>	<p>Power system master plan steering committee periodic reports TA final report</p>	<p>Assumptions Access to data is unencumbered. Suitable counterpart staff is available.</p>

Design Summary	Performance Targets/Indicators	Data Sources / Reporting Mechanisms	Assumptions and Risks
<p>and investment net present values under each of the expansion plans and for a reasonable set of input cost assumptions;</p> <p>(viii) assessment of annual distribution investment costs for the plan period, based on expectations regarding load density, age, and condition of existing equipment; and a realistic program of rural electrification;</p> <p>(ix) identification, analysis, and cost estimates of options and opportunities for loss reduction, including projects forming part of the overall master plan and stand-alone projects;</p> <p>(x) preparation of a detailed transmission and distribution capital works program for the first 5 years of the master plan, including loss reduction subprojects;</p> <p>(xi) procurement of power system analysis software and equipment (computers); and</p> <p>(xii) preparation of detailed project reports for projects included in the first 2 years of the capital works program.</p>			
<p>Activities with Milestones</p> <p>1. Power system master plan</p> <p>1.1 Assess existing electricity demand and prepare a demand forecast by May 2008.</p> <p>1.2 Prepare a long-term, least-cost generation development plan by July 2008.</p> <p>1.3 Prepare a long-term, least-cost transmission development plan by August 2008.</p> <p>2. Distribution system planning and loss reduction</p> <p>2.1 Estimate annual distribution investment costs for the medium term by September 2008.</p> <p>2.2 Identify cost options and opportunities for loss reduction by October 2008.</p> <p>3. Project formulation</p> <p>3.1 Prepare a detailed transmission and distribution capital works program for the first 5 years of the master plan by November 2008.</p> <p>3.2 Prepare detailed project reports for projects included in the first 2 years of the capital works program by December 2008.</p> <p>4. Reporting</p> <p>4.1 Produce an interim report by July 2008.</p> <p>4.2 Produce a TA final report by January 2009.</p> <p>5. Training</p> <p>5.1 Provide on-the-job training for counterpart staff throughout the TA.</p> <p>5.2 Regularly update stakeholders through formal and informal workshops.</p>			<p>Inputs</p> <p>Consulting services</p> <p>ADB: \$600,000</p> <p>Government: \$250,000</p>

ADB = Asian Development Bank, BSEB = Bihar State Electricity Board, BSG = Bihar state government, TA = technical assistance

COST ESTIMATES AND FINANCING PLAN
(\$'000)

Item	Total Cost
A. Asian Development Bank Financing^a	
1. Consultants	
a. Remuneration and Per Diem	
i. International Consultants	250.00
ii. National Consultants	90.00
b. International and Local Travel	40.00
c. Reports and Communications	10.00
2. Power System Analysis Software	100.00
3. Equipment ^b	10.00
4. Training, Seminars, and Conferences	25.00
5. Surveys	0.00
6. Miscellaneous Administration and Support Costs	10.00
7. Representative for Contract Negotiations	0.00
8. Contingencies	65.00
Subtotal (A)	600.00
B. Government Financing^c	
1. Office Accommodation and Transport	150.00
2. Remuneration and Per Diem of Counterpart Staff	100.00
Subtotal (B)	250.00
Total	850.00

^a Financed by the Asian Development Bank's technical assistance (TA) funding program.

^b Equipment and software purchased under the TA will be turned over to the Government after TA completion.

^c The Bihar state government will contribute office space, transportation, and counterpart staff.

Source: Asian Development Bank estimates.

OUTLINE TERMS OF REFERENCE FOR CONSULTANTS

1. The outcome of the technical assistance (TA) will be a comprehensive power system master plan that will provide the blueprint for development of the power system in Bihar. The master plan will coordinate generation, transmission, and distribution expansion to ensure with confidence that all proposed capital investments are not ad hoc and are instead part of a long-term structured plan. Consultants will be engaged to develop the master plan in close consultation with the Bihar State Electricity Board (BSEB), Electricity Department of the Bihar state government (BSG), and power system master plan steering committee.
2. The international power planning expert will be designated the team leader, responsible for overall management of the study. The team leader will coordinate the TA among all government agencies concerned and the Asian Development Bank (ADB) to ensure smooth implementation and no duplication of work, and will ultimately be responsible for all deliverables of the TA study. Other consultants will help with the team leader's tasks. The team leader will also closely coordinate with the consulting teams of other relevant ADB studies.
3. The consulting firm or a consortium of firms to be engaged under the TA will provide experts with relevant experience in technical and economic aspects of power system development including generation, transmission, and distribution; and have experience in and knowledge of the Indian power sector including central and state approaches to sector planning and development.
4. Information dissemination and skill and technology transfer will be an important part of the TA. The consultants will conduct regular workshops in addition to those identified explicitly in the terms of reference, to ensure that stakeholders are fully informed and have an opportunity to participate in the planning process. The consultants will provide hands-on experience to selected BSEB staff in the use of power systems planning software and techniques that the consultants use to prepare the power system master plan.
5. The least-cost analysis to compare various options for generation, transmission, and distribution will be in line with ADB's *Guidelines for the Economic Analysis of Projects* (1997).
6. **Power System Planning Expert and Team Leader** (international, 5 person-months). The consultant will undertake the following:
 - (i) Review the present approach to power system (generation, transmission, and distribution) planning in Bihar; and identify and analyze the linkages between state, regional, and national planning.
 - (ii) Assess potential energy sources for generation development in Bihar in the short term (5 years) and medium term (10 years), taking into account committed, expected, and possible development of generating plants by independent power producers. Prepare a series of generation expansion scenarios including a 100% import strategy. Comment on generation development beyond the horizon year.
 - (iii) Estimate investment and operating costs under each expansion scenario for a reasonable range of assumptions regarding base prices, and identify a preferred generation development strategy.

- (iv) Conduct a workshop to discuss generation development scenarios and seek agreement on a development strategy to use as the basis for developing the power system master plan.
- (v) Procure suitable power system analysis software as well as appropriate equipment (computers, etc.), and coordinate appropriate training related to the software for relevant stakeholders.
- (vi) In conjunction with the transmission and distribution expert, prepare a staged transmission network development program, down to the 33/11 kilovolt (kV) substation level, to deliver forecast power demand to load centers in Bihar.
- (vii) In conjunction with all TA team members, prepare the inception, interim, and final reports in the form of an overall power system master plan for Bihar.

7. **Hydropower Expert** (international, 1 person-month). The consultant will have the following responsibilities:

- (i) Review existing plans, reports, and policy regarding hydropower development in Bihar. Coordinate with the ADB Hydrological River Basin Study TA.
- (ii) Produce a realistic, staged, least-cost, long-term hydropower development program; and estimate its annual capital and operating costs.
- (iii) Support the power system planning expert in producing a series of generation development scenarios for the short and long term.

8. **Distribution Expert** (international, 3 person-months). The consultant will undertake the following:

- (i) Model and analyze the performance of the existing 33 kV network down to the 11 kV component of 33/11 kV substations under a range of realistic operating scenarios.
- (ii) Identify, analyze, and produce cost estimates for a series of loss-reduction options and opportunities in the short, medium, and long term, including projects forming part of the general capital investment program. Include replacement of old equipment, as well as stand-alone projects such as power factor correction and line upgrading. Estimate the distribution loss reduction path that these works and the overall distribution investment program would be expected to deliver.
- (iii) Prepare a distribution capital works plan for the first 5 years of the power system master plan. Include reasonable cost detail, and present it in a form that can be regularly updated and submitted to the Bihar Electricity Regulatory Commission.
- (iv) Prepare detailed project reports in a suitable format for submission to and approval by the Ministry of Power for projects included in the first 2 years of the distribution capital works plan.
- (v) Assist the power system planning specialist (team leader) in procuring suitable power system analysis software.

- (vi) Conduct on-the-job and classroom-based training of BSG and BSEB staff in modern power system planning techniques and tools; and conduct regular workshops to update stakeholders on progress with preparation of the master plan, and to discuss and debate assumptions and scenarios.
- (vii) Coordinate the training program to be conducted for BSG and BSEB staff as part of the software package.

9. **Power Economist** (international, 2 person-months). The consultant will have the following responsibilities:

- (i) Prepare a 10-year demand forecast for Bihar at the distribution circle level, disaggregated by major consumer groups (domestic, industrial, commercial, agricultural, and government), and incorporating bottom-up (location-specific) and top-down (macroeconomic) drivers of demand growth. Prepare demand forecasts for average and maximum load growth scenarios, and clearly articulate the economic rationale of each.
- (ii) On the basis of the generation, transmission, and distribution development plans, estimate the discounted average cost of supply, average incremental cost of supply, and average cost of supply for 33 kV and 11 kV facilities. Comment on the implications of these costs for future tariffs, assuming a move to full cost recovery over time.

10. **Thermal Generation Expert** (national, 2 person-months). The consultant will have the following responsibilities:

- (i) Review existing plans and reports regarding thermal power development in Bihar, including rehabilitation and modernization of existing plant. Produce a realistic, staged, long-term thermal development program, and estimate the annual capital and operating costs of the program.
- (ii) Support the power system planning expert in producing a series of generation development scenarios for the short and long term.

11. **Transmission Expert** (national, 2 person-months). The consultant will undertake the following:

- (i) Model and analyze the performance of the current transmission network under a range of realistic operating scenarios.
- (ii) Assess the suitability of BSEB's transmission planning framework and reliability criteria and, if necessary, propose changes to it.
- (iii) On the basis of the proposed planning framework and criteria, estimate transmission network investment costs for the each realistic generation expansion scenario through to the horizon year.
- (iv) Produce a detailed, staged, least-cost plan for development of the transmission network for the base generation expansion plan to meet forecast demand growth. Estimate the annual capital and operating costs of the program. Model and analyze

the performance of the proposed transmission network under a range of realistic operating scenarios.

- (v) Prepare a transmission capital works plan for the first 5 years of the power system master plan. Include reasonable cost detail and present it in a form that can be regularly updated and submitted to the Bihar Electricity Regulatory Commission for information and approval.
- (vi) Prepare detailed project reports, in a suitable format for submission to and approval by the Ministry of Power, for projects included in the first 2 years of the transmission capital works plan.

12. **Distribution Expert** (national, 3 person-months). The consultant will undertake the following:

- (i) Work together with the international distribution expert and assist the power system planning specialist in developing the distribution component of the power system master plan.
- (ii) Assist in modeling and analyzing the performance of the existing 33 kV network down to the 11 kV side of 33/11 kV substations under a range of realistic operating scenarios.
- (iii) On the basis of demand forecasts at the distribution circle level, assist in preparing staged, least-cost, 33 kV network and 33/11 kV substation expansion plans for the medium term (10 years). Model and analyze the performance of the proposed 33 kV network and 33/11 kV substations under a reasonable range of operating scenarios.
- (iv) On the basis of demand forecasts and taking into account the present condition, age, and adequacy of the 11 kV and low voltage distribution networks, estimate distribution network capital investment requirements for the medium term (10 years).
- (v) Assist in identifying, analyzing, and producing cost estimates for a series of loss-reduction options and opportunities in the short, medium, and long term, including projects forming part of the general capital investment program such as replacement of old equipment and stand-alone projects such as power factor correction and line upgrading. Estimate the distribution loss reduction path that these works and the overall distribution investment program would be expected to deliver.

13. **Power Economist** (national, 2 person-months). The consultant will undertake the following:

- (i) Work with the international power economist.
- (ii) Assist in preparing a 10-year demand forecast for Bihar at the distribution circle level, disaggregated by major consumer groups (domestic, industrial, commercial, agricultural, and government), and incorporating bottom-up (location-specific) and top-down (macroeconomic) drivers of demand growth. Prepare demand forecasts under average and maximum load growth scenarios, and clearly articulate the economic rationale of each.