ECONOMIC ANALYSIS: PROJECT 1

A. Economic Rationale

1. The proposed project will help the state of Rajasthan develop its renewable energy potential to meet its own renewable energy purchase obligations and help other Indian states do the same. The Rajasthan Solar Policy 2011 aims to develop the state as a solar hub with the addition of up to 12,000 megawatts (MW) of capacity over a twelve-year period with private sector participation. Renewable energy development is expected to provide lessons benefiting Rajasthan in subsequent stages of its expansion of renewable energy.

2. Solar and wind power are more expensive than energy from conventional sources such as coal and hydro. The environmental benefits of renewable energy such as solar and wind cannot be internalized without government interventions to support private sector investment in solar and wind power. The Electricity Act, 2003; the National Action Plan for Climate Change (NAPCC); and the Jawaharlal Nehru National Solar Mission (JNNSM) created in India the necessary regulatory framework to internalize environmental externalities and ensure private sector participation in renewable energy. In the present program, renewable energy generation is undertaken by the private sector while supporting infrastructure, including for transmission, is provided by the public sector. As transmission lines are natural monopolies, the risk of crowding out private investment with public sector intervention in transmission infrastructure is low. The project conforms to priorities of the India country partnership strategy of the Asian Development Bank (ADB) and leverages additional financing with the Clean Technology Fund.

B. Project Alternatives and Least-Cost Analysis

4. The Program is a constituent of the state's investment plan to achieve 8,000 MW of renewable energy installed capacity by 2018 through an addition of 5,700 MW over 2012-2018. About 4,300 MW of renewable energy is expected to be directly supported over the investment program horizon while investments in system control and power management would be critical for the state to effectively evacuate its installed capacity of renewable energy by 2018. The economic analysis adopted a time slice approach for renewable energy generation and transmission to be developed over the investment program horizon. This approach is required to analyze the economics of transmission lines because of the difficulty of identify and quantify the benefits of a transmission line alone. Project alternatives for consideration reflected what would have taken place in Rajasthan electricity generation without the project. The scenario without the project is, by definition, the least-cost mutually exclusive alternative of producing the same amount of electricity.

5. The availability of solar and wind resources and the comparative advantage of using these renewable energy resources in Rajasthan suggest that significant investment in renewable energy and associated transmission systems can satisfy the renewable procurement obligations of states particularly in North India.[1] In particular, analysis shows that Uttar Pradesh, Haryana, Delhi, and other Indian states are unable to effectively fulfill their renewable procurement obligations because of resource deficits, especially of solar. These states could procure renewable power from projects to be located in Rajasthan. The costs of various feasible alignments for transmission lines were compared, and the proposed line alignments are the least-cost options.

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1 Tariffs offered for wind power or realized through competitive bidding for solar power in Rajasthan are among the lowest in the country.

C. Cost–Benefit Analysis

6. The economic analysis model uses a time slice approach with a view to highlighting the welfare implications of producing and evacuating renewable power in Rajasthan. Costs and benefits were aggregated, without taxes or other distortions. Costs are converted using these conversion factors: 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.[2] A 25-year horizon was considered, and a 12% discount rate was used to calculate net present value.

7. For Project 1 to be completed by 2016, the transmission investments are expected to evacuate about 1,900 MW of renewable capacity addition including 500 MW to be developed in phases in the Bhadla solar park, 750 MW of solar in other renewable energy zones in western Rajasthan, and about 650 MW of wind power.

8. Project costs include additional investment in wind and solar generation by independent power producers, transmission investment and solar park development costs at Bhadla. Benefits were assumed to gradually increase as generation projects came online.

9. Two types of project benefits were considered in the economic analysis: direct consumer benefits and environmental benefits. The conventional benefits of wind and solar power were estimated as the area under the demand curve, i.e., revenue plus consumer surplus. Revenue was estimated using the prevailing average retail tariff. Consumer surplus was estimated using estimated price elasticity for India from the published sources.[3]
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10. In addition to the consumer benefits described above, wind and solar power provide local environmental benefits in the form of prevented costs from local air pollution and prevented local effects from climate change. In the case of prevented local air pollution, the scenario without the project is necessary to estimate incremental reduction in pollutants. In this case, the scenario assumes electricity generated using indigenous coal. The benefit-transfer method was used to estimate local air pollution costs using similar contexts in India. All economic costs and benefits are in 2013 prices.

11. Wind and solar power also avoid carbon emissions, enabling global environmental benefits. The Government of India considers augmenting renewable energy capacity as a strategy toward achieving its objectives in mitigating climate change. Therefore, incorporating local air pollution and climate change benefits does not amount to double counting.

12. Estimating the prevented costs of climate change at the project level is constrained by theoretical and data deficiencies. A number of alternative approaches include considering the social costs of carbon emissions, mitigation costs, the feed-in tariff, the clean development mechanism carbon price, carbon prices in cap-and-trade markets, and renewable energy certificate (REC) prices, which are available for estimating the benefit of prevented climate change costs. Of these, REC prices are considered to be a suitable proxy for climate change benefits in this case because of the limitations of market mechanisms, locally derived prices,

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[2] A. Lagman-Martin. 2004. Shadow Exchange Rates for Project Economic Analysis: Towards Improving Practice at the Asian Development Bank. *ERD Technical Note Series.* No.11. Manila: ADB

[3] M. Filippini and S. Pachauri. 2004. Elasticities of Electricity Demand in Urban Indian Households. *Energy Policy* 32:429–436

and the value based on incremental local cost of climate change mitigation. REC prices from compliance market trading on the India Power Exchange (IEX) from the end of February 2011 to the end of February 2013 were used as the climate benefits. The average IEX price in this period was used for non-solar RECs. More limited trading in solar IEX RECs, from the end of May 2012 and to the end of February 2013, was also considered. Sensitivity analysis uses policy guidelines for floor, average, and forbearance prices set by the regulator, the Central Electricity Regulatory Commission, for predicting high solar and non-solar REC prices. The delay of solar RECs coming on the national REC markets has created high demand and therefore the expectation of high prices in the short and medium term.[4] This is factored into the sensitivity analysis.

13. The base case includes consumer benefits, avoided local air pollution costs, and climate change benefits valued at low solar and non-solar REC prices. The base case had an economic internal rate of return of 16.4% and a net present value of Rs32,980 million, indicating economic viability. Local and global environmental benefits, when taken as a proportion of total benefits, dominate the base case benefit stream over the project period. Table 1 shows the cost–benefit stream for the base case.

Table 1: Project 1 Cost–Benefit Stream

Year	**Cost** (Rs million)	**Gross Consumer Benefit** (Rs million)	**Local Environmental Benefit** (Rs million)	**Climate Change Benefit** (Rs million)
2013 (year 1)	0	0	0	0
2014 (year 2)	92936	6,879	6,692	1,745
2015 (year 3)	75386	11,158	13,230	2,753
2016 (year 4)	22655	12,462	15,289	3,049
2017 (year 5)	3187	12,462	15,289	3,049
2018 (year 6)	3387	12,462	15,289	3,049
2019 (year 7)	3599	12,462	15,289	3,049
2032 (year 20)	8231	12,462	15,289	3,049
2033 (year 21)	8799	12,462	15,289	3,049
2034 (year 22)	9412	12,462	15,289	3,049
2035 (year 23)	10073	12,462	15,289	3,049
2036 (year 24)	10787	12,462	15,289	3,049
2037 (year 25)	11558	12,462	15,289	3,049

Source: ADB Estimates

D. Sensitivity Analysis

14. Sensitivity analysis indicates that the base case is viable and remains viable with a cost escalation of 10% and, to a lesser extent, with a one year delay in the receipt of project benefits (Table 2). The importance of including global environmental benefits when calculating viability is highlighted in the results and also accounted for in sensitivity analysis. The program benefits are therefore stable under the circumstances considered in the analysis, and the program is thus economically viable.

[4] Solar REC trading started with 5 MW in May 2012. There has been improvement in the trading volumes since. For calculating the economic internal rate of return, the market price has been conservatively considered vis-à-vis 2013 prices.

Table 2: Results of Program Sensitivity Analysis

Sensitivity Parameter	**EIRR** (%)
Base case	**16.4**
10% cost increase	14.0
Delay in project benefits by 1 year in base case	13.6
Base case modified with high solar REC prices of Rs13.4/kilowatt-hour	29.7
Base case modified with high non-solar REC prices of Rs4.3/kilowatt-hour	25.0

EIRR = economic internal rate of return, REC = renewable energy certificate.
Source: ADB Estimates