ECONOMIC ANALYSIS

A. Introduction

1. The economic analysis of the Samarkand Solar Power Project was conducted in accordance with the Asian Development Bank (ADB) Guidelines for Economic Analysis of Projects (1997).[1] The analytical framework was carried out from the country viewpoint. The economic viability assessed the costs and benefits of the project by comparing with-project and without-project scenarios. A sensitivity analysis examined the robustness of the project against cost increases as well as benefit reduction.

2. The project constructs a 100 megawatt photovoltaic solar power plant. The plant is located in Samarkand and is connected to Uzbekistan's national power grid. The power plant is expected to be commissioned in 2016, and operated and maintained by the turnkey contractor for the first 3 years, after which operation and maintenance (O&M) will be handed over to the project executing agency.

B. Sector Overview

3. Over 89% of Uzbekistan's 12.6 gigawatts (GW) of installed capacity are conventional thermal power plants fueled by natural gas (76%), fuel oil (7%), and coal (6%). Half of this fossil-based energy is generated in power plants built before 1982, with only 10% generated in power plants built after 1997. The inefficient power generation is exacerbated by total grid losses of around 20%, due in part to long distance transmission and distribution. While Uzbekistan is almost 100% electrified, the demand-supply gap leaves many provinces, including Samarkand, with intermittent power supply.

4. With a vision to increase the renewable energy share in the generation mix from the current 11% up to 21% by 2031, Uzbekistan has an ambitious plan to install at least 4 GW of solar capacity. This project is the first of its kind and scale to mark the government's commitment to solar energy and to pave the way for other solar energy projects to follow as well as to nurture the domestic industry for solar energy development.

5. The Uzbekistan power sector is managed by the State Joint-Stock Company Uzbekenergo, a vertically integrated 100% state-owned utility. The power generated from the power plant will feed into the national grid and will be sold to the customers as a part of the generation mix. The end-user tariff has been steadily increased since 2004, at a rate above the inflation rate, in order to ensure cost recovery and the financial sustainability of the power sector.

C. Method and Approach

1. Least Cost

6. Among various proven and commercially available solar energy technologies, crystalline photovoltaic technology with fixed tilt structure was selected for the project based on the least cost approach. Presently, photovoltaic is more cost effective than concentrated solar power both in terms of investment costs and O&M costs. The levelized energy cost is generally lower for

[1] This section was prepared during the project fact-finding mission in June 2013, based on supports provided by ADB. 2011. *Technical Assistance to Uzbekistan for Solar Energy Development*. Manila.

photovoltaic ($0.16/kilowatt-hour (kWh) to $0.27/kWh) than for concentrating solar power ($0.16/kWh to $0.33/kWh).[2] Within the commercially available photovoltaic technologies, crystalline silicon technologies are generally more efficient (13%–19%) than thin-film technologies (4%–12%) and require less land area, which improves the cost advantage of crystalline silicon technologies. While the tracking system with a single axis device may be more efficient, it requires a higher investment cost, a larger land area, and more sophisticated operational know-how than the fixed-tilt support structure; thus, it is not considered a technology appropriate for the project. The project site is selected to minimize the construction cost of the transmission line connection to the nearest 220 kilovolt power grid. Solar power is one of many renewable energy technologies the government would like to promote as an essential part of its energy diversification policy, and this project is expected to pave the way for many solar projects to be developed.

2. Economic Costs

7. The analysis numeraire is border price in 2013 constant prices. The project financial investment costs are converted into economic costs by applying the standard conversion factor of 0.9 to the non-traded costs components and a conversion factor of 0.75 to the unskilled labor portion of the local component (assumed to be 20% of the local civil work cost).[3] The major difference between economic and financial costs results from the exclusion of taxes and duties from economic cost. O&M costs are also converted into economic costs by applying the conversion factor to the financial costs.

8. The capital outlay of the project extends over 5 years (2014–2019). The economic internal rate of return (EIRR) analysis includes the cost of the solar photovoltaic power plant turnkey contract, transmission line equipment supply and installation works, supporting infrastructure (e.g., access road, fences, telecommunication, water supply), costs of environmental and social mitigation measures, consulting services, land acquisition, recurrent cost, and physical contingencies, but excludes taxes and duties, price contingencies, and financial costs such as interest during construction and commitment charges. The economic cost of land acquisition is estimated by the replacement value of productive land and crops.

9. The O&M costs during the operation period (2016–2040) comprise labor, spare parts, insurance, and other operational expenses (communications, water, office supplies). The first 3-year operation of the power plant will be managed by the solar photovoltaic turnkey contractor who will ensure the plant generates the output they guaranteed according to the contract, and will also provide on-the-job training to the Uzbekenergo staff for the smooth transfer and operation of the power plant. The O&M costs are estimated to be $1.7 million during the first 3 years of operation, and $1.3 million thereafter. The transmission and distribution costs of delivering the electricity produced at the power plant to the end-users are also included in the O&M costs.

3. Economic Benefits

10. The economic benefits will be incremental. The electricity consumption will increase in the Samarkand region because the electricity demand is currently suppressed because of

[2] International Energy Agency Energy Technology System Analysis Program. http://www.iea-etsap.org/

[3] Standard conversion factor is estimated as the ratio of the official exchange rate to the shadow exchange rate. Shadow wage rate factor of 0.75 was derived by estimating the difference between project and market wage rates of unskilled/semiskilled labor.

supply constraint. The power generated from the power plant will allow the growing power demand in the area to be met. The power generated from the plant is expected to be 159 GWh in the first year and will be reduced by 0.5% per annum because of a technical feature of photovoltaic technology. The consumed electricity is estimated by taking into account the technical losses.[4] The population and small and medium enterprises will be the primary beneficiaries who enjoy reliable electricity supply from an affordable source. The project output is valued using the willingness to pay for the electricity.

11. Willingness to pay is defined as the maximum amount consumers are prepared to pay for electricity or alternative energy sources. Some consumers are able and willing to pay more than others, and in the absence of electricity from the grid will, for example, buy a diesel generator or use candles for lighting. The demographic profile of the region (79.5% of non-poor and 20.5% of poor households)[5] and the cost of its respective alternative options for electricity are taken into consideration to estimate the weighted average value of the willingness to pay for incremental electricity. The willingness to pay can be estimated as the area under the demand curve, which can be calculated as the tariff plus the consumer surplus. For the sake of simplicity, the average sales tariff of $0.06/kWh in 2016 is taken as tariff. The consumer surplus is calculated as 40% of the difference between the maximum of the weighted average willingness to pay $0.591/kWh and the average tariff of $0.06/kWh (with the factor of 0.4 reflecting the concave negative slope in the demand curve). Thus, a willingness to pay for the incremental benefits was estimated at $0.251/kWh. The amount of electricity consumed was estimated by the power generated from the power plant minus technical losses in the grid system.

12. Not all benefits have been taken into account for the analysis. The project improves the power security for the Samarkand region where there is no dedicated power plant and all electricity needs to be transmitted from power plants in other regions. In the long run, Uzbekistan aims to install 4 GW of solar capacity, and this is the very first large-scale solar power project that will pave the way for solar energy development in the country. The project is a cornerstone for solar energy development that will substitute the presently dominant fossil fueled power generation and contribute to fuel savings. Fuel saving is important since the natural gas saved can be exported to increase foreign currency earnings. Further, solar energy development that substitutes fossil fueled power generation contributes to carbon emission reduction. If the carbon emission avoidance is measured by carbon abatement costs, which includes the cost of externalities, the benefit of photovoltaic power generation is estimated to be over $20 per ton of carbon dioxide equivalent,[6] or $1.76 million per year.[7] Moreover, it is expected that the project capacity development component through technology transfer will contribute to fostering the domestic industry for solar energy technologies. However, these benefits are difficult to accurately quantify and monetize so they are considered as unquantifiable benefits that are in addition to and not incorporated in the EIRR analysis.

[4] Technical losses are assumed at 6% at the start of the operation year and to be gradually reduced to 2%. The losses are assumed low because of the project's proximity to the load center and the future improvement in loss reduction.

[5] Based on a survey on 200 households conducted by policy and advisory technical assistance consultants. The poor household was defined as those whose per capita income is less than $1.75 per day.

[6] International Energy Agency Energy Technology System Analysis Program. http://www.iea-etsap.org/

[7] It is estimated that a potential annual reduction of 88,000 tons of carbon dioxide equivalent can be achieved with this project.

D. Economic Internal Rate of Return

13. The project EIRR is 16.1%, which compares favorably with the economic opportunity cost of capital of 12% (Table 1).

Table 1: Economic Internal Rate of Return ($ million)

Item	NPV	2013	2014	2015	2016	2017	2018	2019	2020	2025	2030	2035	2040
Costs													
Capital investment	($144)	0.0	(2.3)	(51.2)	(156.3)	(11.0)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
O&M	($7)	0.0	0.0	0.0	0.0	(1.7)	(1.7)	(1.7)	(1.3)	(1.3)	(1.3)	(1.3)	(1.3)
T&D cost	($16)	0.0	0.0	0.0	(2.5)	(2.9)	(2.9)	(2.9)	(2.9)	(2.9)	(2.9)	(2.9)	(2.9)
Gross cost	($167)	0.0	(2.3)	(51.2)	(158.8)	(15.6)	(4.6)	(4.6)	(4.3)	(4.3)	(4.3)	(4.3)	(4.3)
Benefits													
Incremental benefit	$204	0.0	0.0	0.0	31.3	37.4	37.5	37.7	37.8	37.5	36.5	35.6	34.7
Net Benefits	$37	0.0	(2.3)	(51.2)	(127.5)	21.8	32.9	33.1	33.5	33.2	32.3	31.4	30.5
EIRR	16.1%												
NPV@12%	$37												

EIRR = economic internal rate of return, NPV = net present value, O&M = operational and maintenance, T&D = transmission and distribution. ( ) = negative
Sources: Asian Development Bank and technical assistance consultant estimates.

E. Sensitivity Analysis

14. A sensitivity analysis was carried out to examine the robustness of the project economic viability. Key variables considered were capital costs, O&M costs, and benefits (Table 2).

Table 2: Economic Sensitivity Analysis

	Change	EIRR	NPV
Base Case	100%	16.1%	$37
Investment cost	+10%	14.2%	$22
	+20%	12.7%	$8
O&M cost	+10%	15.9%	$36
	+20%	15.9%	$35
Benefit reduction	-10%	13.8%	$16
	-15%	12.7%	$6
Discount rate	15%	16.0%	$7
	0.6%	16.0%	$516

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

15. The project passes all the sensitivity tests. The project EIRR remains above the 12% benchmark, even when investment cost or O&M cost is increased by 20%. The project withstands well even against a 15% reduction in revenue generated from the project benefits.

F. Conclusion

16. The project is economically viable. The economic benefits are incremental as a result of increased electricity consumption. The EIRR is 16.1%, which is greater than the economic opportunity cost of capital (12%). The sensitivity analysis indicates that the project is economically viable under foreseeable increases in investment costs or O&M costs as well as a reduction in project benefits.