***Economics of Distributed PV in Bangladesh***

Govinda R. Timilsina, Senior Economist, World Bank, Washington, DC ([gtimilsina@worldbank.org](mailto:gtimilsina@worldbank.org))

Alan D. Lee, Senior Economist, World Bank, Washington, DC ([adlee@worldbank.org](mailto:adlee@worldbank.org))

# Overview: Solar photovoltaics (PV) technologies installed on the premises of consumers who are connected to a distribution grid are referred to as distributed PV or DPV (ESMAP, 2021). DPV owners/operators benefit through net-metering (EnergySage 2021; Qadrdan et al. 2018). DPV is also expected to benefit national electricity utilities through reduction of transmission & distribution (T&D) losses, reduction of CO2 and local air pollutants. The economics of DPV would differ across jurisdictions depending upon several economic and technical characteristics of DPV as well as the electricity grids. The technical characteristics include solar energy profiles, electricity load or demand patterns, electricity generation mix of the grid, transmission and distribution losses of the grid, system losses of the DPV. Economic characteristics include grid electricity tariffs, costs of electricity produced from DPV and valuation of climate change, and other environmental benefits. Economics of DPV is also sensitive to regulatory guidelines, for example, whether the grid accepts electricity supplied by DPV for all hours or only selected hours; what electricity tariffs the utility offers to the DPV owners. Therefore, series of studies analyzing the economics of DPV from different stakeholders' perspectives are necessary for a different jurisdiction. While a few studies, such as Ahmad (2021), Vilaça Gomes et al. (2018) Holdermann et al. (2014), Mitscher and Rüther (2012) are available in the literature, our study aims to enrich the literature through an illustrative analysis considering the case of a developing country, Bangladesh.

# Methodology and Data: We evaluated the economics of DPV from different perspectives: DPV owners’ or investors’, electricity grid’s and national. The analysis was carried out for three sectors: residential, commercial, and industrial. We developed an excel based model for the analysis. The model accounts for the hourly electricity generation profiles of the DPV and the hourly load profiles of the DPV owners and the grid. A DPV owner sells excess generation to the grids at the prices set by the regulators. Electricity tariffs and the net-metering tariffs differ across the hours (i.e., time of the day). The load profiles differ by months and also by weekdays and weekends/holidays. The model has a sub-module for calculating the Levelized costs of DPV as well as various types of electricity generation resources feeding the grid. Besides the T&D losses, the model also accounts for direct subsidies provided by the government to the utilities. The data used include economic and technical characteristics of DPV and other sources of grid electricity generation, hourly load data for the grid, electricity tariff. Several sensitivity analyses were carried out for alternative values for many variables, such as discount rate, capital costs of DPV, the ratio of DPV capacities and their peak loads, prices of fuels used for grid electricity generation, net metering prices.

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**Results:** The analysis finds that DPV systems are economically attractive to consumers or DPV owners or investors in all sectors. The net savings of DPV owners are 25% (residential sector) to 34% (industrial sector) of corresponding electricity bills in the absence of DPV. If the benefits are compared with costs of installation and operation of the DPV, the benefits are about two times as high as the costs in the residential sector and about three times as high as the costs in the industrial sector. The benefits to DPV owners are sensitive to several input variables. For example, the higher the relative size of DPV with respect to their peak load, the larger would be the benefits as the DPV owners will get opportunities to export more electricity to the grid. The same is true if the net metering tariff is higher. The lower costs of DPV electricity through lower CAPEX and lower discount rate increase the benefit to cost ratio. The nation as a whole benefit from the DPV even if environmental benefits are not accounted for. The total national gain depends on the type of generation DPV replaces. If it replaces the average fuel mix of the generation system, the gain would be 2% of the total electricity generation costs in the absence of DPV. On the other hand, if the DPV replaces the marginal generation, the benefit would much higher. The study shows that total benefits including climate change mitigation benefits, with the value of CO2 mitigation US$40/tCO2, would vary from 3.6% to 21.5% of the total generation costs depending upon the type of generation the DPV replaces. Whether the national utility gains or loss again depends on the type of generation the DPV replaces. If the DPV replaces fuel oil or diesel which are marginal fuels during the day, the utility gains. On the other hand, if we assume that the DPV replaces all generations, the utility does not make benefits from the DPV. It suffers a small loss of about 3% of its revenue in the absence of DPV.

# Conclusions: This study uses county-level data to analyze the economics of DPV for stylized grid-connected residential, commercial, and industrial sectors in Bangladesh considering hourly patterns of solar irradiation and electricity exchanges between the DPV owners and the electricity utilities. The economics vary between different stakeholders - DPV owners, utility, and society. The economics of DPV depends on the difference in electricity production costs between the DPV and the electricity utility, transmission and distribution loss, feed-in arrangement and compensation, and imputed value of social benefits.

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