Estimating Climate Impacts:
Case Study - Installing Solar PV Panels on Quezon City’s Schools
**Project Description**

Solar photovoltaic (PV) technologies provide cost-effective renewable electricity and are well suited to many locations in the Philippines due to the large amount of annual solar radiation the region receives. Grid connected distributed PV systems generate power during the day, part of which will be directly consumed by the end-users in the building, and part of which is surplus generation that can be either stored in a battery storage device or fed back into the electricity grid for offsite utilisation. The C40 Cities Finance Facility (CFF) has supported the preparation of an ambitious project to install grid-connected PV systems on the rooftops of 50 schools throughout Quezon City.

In the Quezon City project, as each school involved in the project has a different electricity consumption profile and daily energy requirements, some schools will be limited by the quantity of electricity they consume while others will be limited by the 100 kWp net-metering cap required by the Philippine Department of Energy and the Energy Regulatory Commission. The systems will not include battery storage and therefore all the surplus electricity produced will be fed into the grid.

**Objectives of the project**

Through this project, Quezon City aims to reduce greenhouse gas emissions and provide a platform for raising environmental awareness, especially among urban youth attending the participating schools. The locally produced renewable energy will reduce the demand from the electricity grid, which is mainly produced by fossil fuel power plants in the Philippines.

The distributed renewable energy generation will also bring economic savings to the schools, by reducing their energy bill, as PV systems typically offset their relatively high initial cost in a few years of operation.

Additionally, once the initial project is implemented it will help catalyst additional investment in PV systems in more schools and other Quezon City owned buildings.

**Data & Methods**

**General methodological considerations**

The emission mitigation potential for a project is determined by comparing the difference in GHG emissions generated in the baseline scenario versus the project scenario. The baseline scenario is calculated using parameters that describe the context conditions assuming the planned intervention (the photovoltaic systems in this case) is not implemented. The project scenario reflects any changes in conditions that the planned intervention will create.

In the case of a photovoltaic system replacing grid-connected electricity consumption, the baseline scenario emissions for a given year are determined by calculating the quantity of electricity that the photovoltaic system can generate. The generation level is a function of system size, slope, efficiency, degradation factors and the solar insolation rate of the location. This calculation estimates the amount of useful electricity generated by the photovoltaic system in that year. To derive the baseline scenario emissions, the amount of electricity generated is multiplied by the emission factor for grid electricity (specific to the year). The project scenario emissions for a photovoltaic project are set to zero.

More detailed documentation and discussion of the methods used in the calculation (including equations definition of terms) can be found in the accompanying document ‘Estimating Climate Impacts - A Methodology for Estimating GHG Emission Mitigation Potentials of Infrastructure Projects’.

**Baseline scenario data**

For the Quezon City photovoltaic project, the baseline scenario assumes that the 50 schools would continue to consume electricity from the Luzon-Visayas regional power grid. The baseline emissions are equal to the electricity generation potential of the PV systems multiplied by the grid electricity emission factor.

Following Clean Development Mechanism (CDM) guidelines, for energy producing projects that displace energy produced by grid connected power plants, the emission factor is calculated as the combined margin (CM), consisting of the combination of 75% operating margin (OM) and 25% build margin (BM).

The operating margin is the emission factor that refers to the group of existing power plants whose current electricity generation would be affected by the proposed CDM project activity. The build margin is the emission factor that refers to the group of prospective power plants whose construction and future operation would be affected by the proposed CDM project activity.

Both the operating and the build margin approaches are based on historical production and installation data and the resulting baseline grid emission factor is then kept constant throughout the crediting period. The large proportion of coal and other fossil fuel generation plants that exist in the Luzon-Visayas regional electricity grid, result in a relatively high combined emission factor of 0.683625 kg CO2e/kWh (in 2017, the most recent data available).

**Project scenario data**

As defined above, the project includes the installation of photovoltaic systems on 50 schools in Quezon City. The CFF technical assistance team collected detailed data on the proposed peak capacity for each school and the size, orientation and tilt angle of roofs available for installation. Using the information on capacity requirements, panel default performance factors and site-specific roof characteristics and solar insolation data, the required solar panel area to be installed was estimated and how much electricity would be generated annually for each school. Due to the degradation of photovoltaic panels the energy generation potential of each system is anticipated to decline by 2% by the end of the first year and then by 0.8% during each subsequent year.
Results and emission reductions

This sub-section provides an overview of the GHG emissions impacts of the project. The calculations are completed for each year of operation from 2021 (the assumed initiation year) to 2050 (the final horizon year for the analysis). Table 1 describes the estimated emission mitigation values for the Quezon City solar PV project and Figure 1 shows the evolution of the aggregated baseline and project emissions. The cumulative mitigation impact for 2021 to 2050 is 50,730 tCO₂e, which demonstrates the projects total potential to reduce GHG emissions and contribute to global climate protection efforts.

Challenges and lessons learned

This section describes the process used to generate the GHG mitigation estimate highlighting the challenges encountered and the solutions adopted which could be utilised by other practitioners.

Preliminary estimates

A preliminary estimate of GHG emission reductions was required at an early stage of project preparation. The details of the project had not been refined, which made providing an accurate estimation more challenging:

- The 50 schools that were to be targeted by the project had not been chosen yet;
- Location data and electricity consumption data was only available for 8 potential school sites (8 out of 100 candidate sites).

Two additional considerations related to the project were used:

- The maximum PV area installed was limited to 100 kWp/school;
- The net-metering system and policies meant that the schools would not be able to sell back to the grid electricity produced exceeding their annual electricity consumption.

The magnitude of the mitigation impact is influenced by the project’s implementation assumptions, technical specifications, and context conditions. For the Quezon City photovoltaic project, the mitigation potential is primarily dependent on the total surface area of the photovoltaic panels, their orientation/slope, the load factor for grid-connected systems in the city and the grid electricity emission factor. Additional (and more minor in their influence on the results) factors include the type of panel used and the equipment degradation rate. It is assumed that the 50 installations will have a combined generation capacity of 2,180 kWp and be capable of generating an average of 2,473 MWh per year of renewable electricity.

Based on those assumptions, the cumulative emission reductions for the 2021-2050 period was estimated at 79,600 tCO₂e. Table 2 outlines the preliminary yearly emission reductions estimated for the project.

Final estimates

The assumptions used in the preliminary estimate were refined after the technical assistance has advanced. The 50 schools were selected and for each one data on all potential roofs, and total electricity consumption were collected. Additionally, the technical assistance identified the capacity of PV panel that will be installed on each school. The average capacity calculated was 42.75 kWp per school which is considerably lower than the initial value used.

The average irradiance was calculated using the data on available roof area per school, optimising the quantity of solar radiation absorbed by the PV panels. The average yearly solar irradiance was estimated at 1,792 kWh/m² per year.

Total emission reduction for the 2021-2050 period was estimated at 50,730 tCO₂e.

Discussion on the change in emission reductions between estimates

Total emission reductions for the project life was overestimated by 57% in the preliminary estimate. This was caused by an overestimation of the average surface that could be installed per school. This was driven by two factors:

- The project design chose to undersize the installed capacity relative to each school’s electricity consumption. This was a project decision that was not known at the time of the preliminary estimate.

Acknowledgements

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Table 1: Final GHG mitigation impacts of the solar PV project.

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Table 2: Preliminary GHG mitigation impacts of the solar PV project.

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