Deployment of Rooftop Solar Photovoltaic (SPV) Systems for Sustainable Energy Integration and Enhancing Resilience

Narayanganj city, Bangladesh

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Introduction

Situated on the converging banks of rivers Sitalakhya and Dhaleswari at the eastern-central Bangladesh, Narayanganj is a fast-urbanizing city. Concerns of rising GHG emissions goes with the city's significant contribution to the economy and employment. Narayanganj city (23°37′12″N 90°30′00″E) is situated about 30 km southeast from the national capital of Dhaka. The river port of Narayanganj is one of the oldest in the country. It is a business and industrial hub well-known for its jute and textile mills. Narayanganj attained the status of being the 7th city corporation of Bangladesh in 2011, after merging of three municipalities, Narayanganj, Shiddhirganj and Kadamrasul.

Narayanganj's GHG emissions in year 2018-19 amounted to 1,061,409 tonnes of CO_2e, resulting primarily from the consumption of electricity from the grid that contributes to 63% of the city's emissions and accounts for 35.5% of total energy use. The buildings sector is a key driver of power demand and GHG emissions, with electricity use in residential buildings rising at nearly 5% per year from 2014-15 to 2018-19 and that in commercial and institutional buildings & facilities rising by 6.8% annually over the same period.

Projections indicate a steep rise in energy demand due to the country's dense population, and a booming economy, ranked 5th globally with a GDP growth rate of 8.2% in 2019. Considering the rising energy demand, the Government of Bangladesh has duly considered tapping into renewable energy. Policy initiatives such as the Renewable Energy Policy, 2008, the Sustainable and Renewable Energy Development Authority (SREDA) Act, 2012, the Bangladesh Energy Regulatory Commission Regulations, 2016 for issuing license and Tariff for Roof Top Solar PV Electricity, and the Net-metering policy (revised), 2019 are directed towards enhanced coordination and uptake of renewable energy and energy efficiency programs in the country. Under the Urban-LEDS II project, rooftop Solar PV systems were deployed for sustainable energy integration and enhancing resilience.

Project Objectives

The main objective of the project is to successfully demonstrate the use of rooftop Solar PV system and to showcase its feasibility and implementation potential in meeting the city's electricity demand.

The secondary objectives include;

- To realize significant energy and power bill savings that can be redirected towards other developmental activities
- To build resilience and streamline services provided by health care centres affected by power cuts in Narayanganj

Summary

Total geographical area: **72.43 km²**
Population size: **709,366 (Census 2011)**
Population density: **9794 persons/km²**

Snapshot of the Case Study

Narayanganj City Corporation has successfully installed rooftop Solar PV systems on two public buildings, with the support of ICLEI South Asia (ICLEI SA) through the Urban-LEDS II project.

Thirty percent of the GHG emissions in Narayanganj city in the year 2018-19 were attributed to electricity consumption in the buildings sector (residential, commercial and institutional).

The rooftop Solar PV project helps meet the city's growing electricity demand through a clean energy source and reduce GHG emissions. It contributes to the Government of Bangladesh's efforts on increasing the use of renewable energy, specifically Solar PV systems, as underlined in the Nationally Determined Contribution (NDC), create public awareness, and demonstrate the feasibility of adopting a low carbon solution. To demonstrate the applicability of Solar PV systems solutions (grid tied and hybrid with battery system) two public buildings namely the Ali Ahammad Chunka Nagar Public Library and the Urban Public Healthcare Centre at Bandar, were identified for the pilot installations. A 11.76 kWp grid-connected Solar PV system with net-metering facility was implemented at the Public Library and a hybrid net-metered rooftop Solar PV system of 11.76 kWp with Lithium-ion batteries (to provide back-up to key loads) was established to improve the resilience of the Healthcare Centre at Bandar.

Rationale of Intervention

Narayanganj's GHG emissions rose to 1,061,409 tonnes of CO_2e as compared to 826,950 tonnes of CO_2e in 2014-15 with an annual rate of increase of 5.8% on an average between 2014-15 and 2018-2019. Narayanganj has been dependent on grid electricity as the primary energy source. Residential, commercial and institutional buildings accounted for nearly 75% of Narayanganj's electricity consumption and resultant GHG emissions in 2018-19. The implementation of rooftop Solar PV systems under the Urban-LEDS II program has enabled to demonstrate the benefits of renewable energy sources, and raise public awareness about creating a healthy, low-carbon, and climate-resilient Narayanganj.

Specifications of Solar PV systems implemented

Table 1 details the specifications of Solar PV systems implemented in the two locations.

Table 1 Specifications of the Solar PV sytems

System Specifications	**Ahamad Chunka City Library and Auditorium** Bangabandhu Sarak, Narayanganj-1400 Latitude & Longitude: 23.614644, 90.501551	**Urban Public Healthcare Center, Bandar** 4; Nagar Matrisadan Shahi Masjid Road, Bandar Bus Stand, Bandar-1400 Latitude & Longitude: 23.612991, 90.519403
Building details • Number of floors • Roof top area • Usable area	 G+ 6 floor 332 sq.m 100-120 sq. m.	 G+ 6 floor 250 sq. m 100-120 sq. m.
Average Energy Consumption /month	4000+ kWh	1750 kWh
Sanctioned Load (kW)	320	143
Operating hours per week	40	54
SPV Power Plant Capacity	11.76 kWp	11.76 kWp
Module	GCL-M3/72 H, Output power 415 W with 20.9% efficiency at Standard Test Conditions (STC)	GCL-M3/72 H, Output power 415 W with 20.9% efficiency at STC
Number of modules	28	28
Power Conditioning Unit	Goodwe – GW10KN-DT, 3 phase inverter with Net Metering capability and remote data monitoring facility	3 numbers of Single phase- Victron Quattro, 48/5000., Blue Solar charge controller, a Hybrid Inverter with Net-Metering capability and remote data monitoring
Battery	Direct grid connection/ no battery	2 sets of Lithium-ion, 10 kWh, 48V- 2
Output Voltage	50/60Hz; 400Vac	50/60Hz; 400Vac
Annual GHG emission reduction	9,735 tCO_2e	9,735 tCO_2e

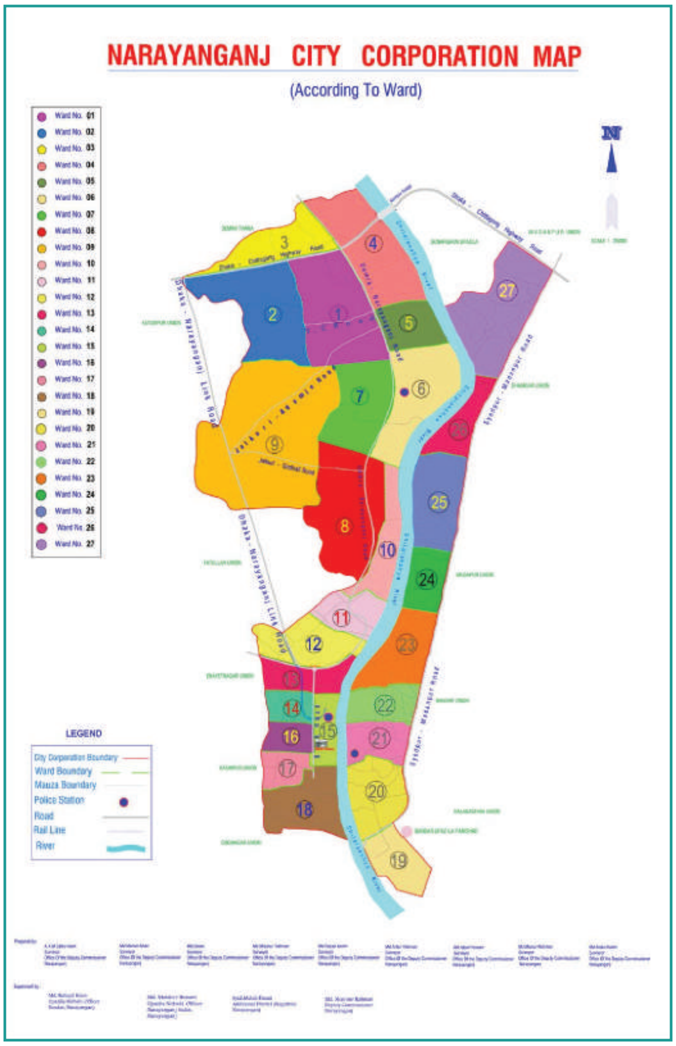

Figure 1: Narayanganj City Corporation map

Organisations, Stakeholders, Location, period of implementation

A project pre-feasibility assessment was carried out by the Narayanganj City Corporation (NCC) and ICLEI South Asia. Five potential public buildings were identified initially including four Health Centres at different locations and one Public Library and Auditorium at Bangabandhu Road, Narayanganj.

Based on the pre-feasibility assessment, Ali Ahammad Chunka Nagar Library (a public library and community centre) and the Urban Public Healthcare Centre at Bandar were selected for implementing the pilot project. For the Public library building, a grid-tied rooftop Solar PV system of 11.76 kilowatt (kWp) size was installed along with net-metering capabilities. The Healthcare Centre located at Bandar faces frequent power cuts and previously relied solely on a diesel generator to serve as power backup. Thereby a hybrid rooftop Solar PV system with Lithium-ion batteries was established to improve the Healthcare Centre's resilience. This Solar PV system of 11.76 kWp

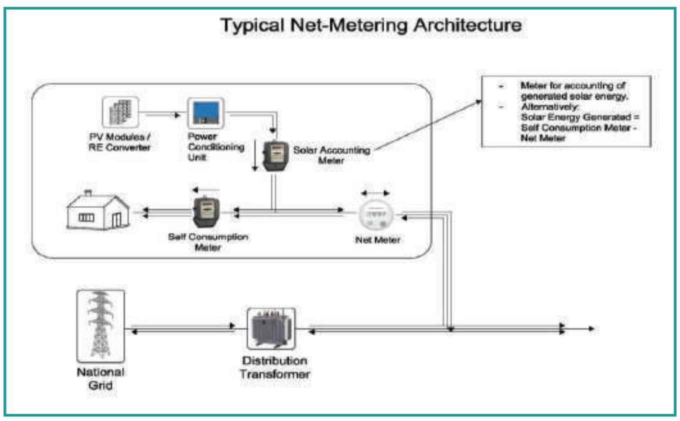

Figure 2: Electrical Design of typical Net Metering Solar PV installation

with Lithium-ion batteries and net-metering provides back-up to key loads and helps replace and minimize use of the on-site diesel generator.

A third-party contractor, Rahimafrooz Renewable Energy Ltd. undertook the pilot implementation at both locations.

Project Activities

Inputs

Site visits and feasibility studies were conducted for the identified buildings based on information pertaining to building use, rooftop area and condition, energy consumption, and energy bills. The analysis of information collected enabled estimation of Solar PV potential and designing of the Solar PV system. Based on the site visits and analysis, a grid-tied rooftop Solar PV system of 11.76-kilowatt (kWp) capacity was proposed with net-metering on the Ali Ahammad Chunka Nagar public library building and a hybrid roof top Solar PV system of 11.76 kWp with Lithium-ion batteries and net-metering was proposed at the health care centre in Bandar.

Outputs

The project has contributed towards boosting the uptake of clean energy technologies for energy generation, reduced dependency on fossil fuel-based energy consumption and contributed to the renewable energy target of Sustainable & Renewable Energy Development Authority (SREDA) . It has demonstrative impacts since the pilot was deployed on two public buildings (Public library and health centre) used by wider community. It has also supported towards increasing awareness among people through project information boards installed at appropriate locations in the buildings to showcase the system details and benefits. The project is estimated to deliver annual energy savings of 15,023 kWh each for the public library and the health care centre building, with annual monetary savings of around Bangladeshi Taka (BDT) 150,000 potentially realized in the power bills of each building.

Outcome

The project has aided city officials in replacing fossil fuel with renewable energy sources. The pilot has enabled demonstrating awareness on the utility of clean, low carbon, climate resilient, and environment-friendly energy options for Narayanganj city. It also supports health facilities to be resilient amidst power supply irregularities and enhances the provision of health care services.

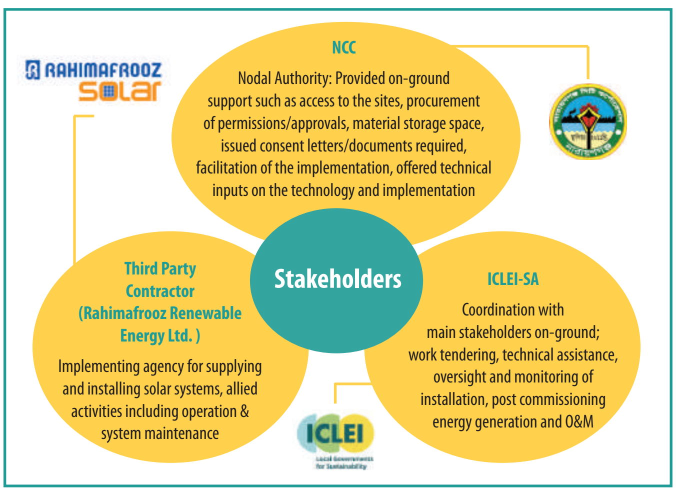

Figure 3: Stakeholders

Planning process

ICLEI SA team visited the identified buildings for carrying out a feasibility study for installation of rooftop Solar PV systems. To begin with, basic information from these buildings was collected such as structure type, building operations, rooftop area[1], average energy consumption and energy bills. This information was used to shortlist and select the buildings where further detailed technical assessments for installation of the pilot Solar PV systems could be undertaken. Thereafter, technical analysis were carried out to evaluate potential energy generation from the Solar PV system and identify preliminary design based on space availability, shadow prone areas on the roof, and building's energy demand. Google sketch-up was used to undertake shadow analysis for the buildings, using respective time zone and sun path for that particular location. This analysis is significant in the designing and estimation of the Solar PV system performance e.g. for parameters such as site location[2]. ICLEI SA and NCC undertook technical feasibility and analysis (pre-feasibility level) and identified broad specifications, size and design. Based on this a Tender document was prepared and published to seek proposals from third-party contractors.

Bidders who were shortlisted were also invited to visit the site and submit financial and technical system design proposals. The technical evaluations ensured a shortlist of qualified bids and the selection of a appropriate designs for the site conditions. Since the design was proposed by the third-party contractor, accountability for execution and performance were ascertained.

Methodology

Various departments and agencies like NCC's Town planning department, Electrical department, Property tax department, etc. were consulted by the project team to collect the necessary information. Meetings with Dhaka Power Distribution Board (DPDC) were helpful to understand the process and permissions required for installing Solar PV system and to adopt Net Metering based system. Based on the site visits and analysis, Public Library and Bandar Health Care Centre were identified to have higher potential for installation of Solar PV system. Other health centres located at Lakkhankhola, Godnail and Deobhogh experienced lesser footfall and offer services such as first-aid and vaccination, which were not energy intensive and had low energy demand. The Bandar Health Centre provided a wider range of healthcare services and thereby had higher energy consumption in comparison. Details of the methodology are depicted in Figure 4.

Understanding the opportunities

The foremost opportunity of the pilot project was to increase the access to energy and support the Government in its commitment towards implementing renewable energy for reducing GHG emissions. The pilot implementation on public buildings also served as an opportunity for increasing public awareness on solar energy and to demonstrate the

1 Space available on rooftop helps in estimating size of the system and potential yield from panels for every square meter of the area available, which is crucial. As a rule of thumb for system design, 1 kWp of solar systems can be installed on 10 sq. m. of area and can generate 3.5 kWh of energy on average per day (ICLEI, 2020).

2 Solar panels are placed facing southern direction for the regions in northern hemisphere of the earth as sun's path is in southern direction.

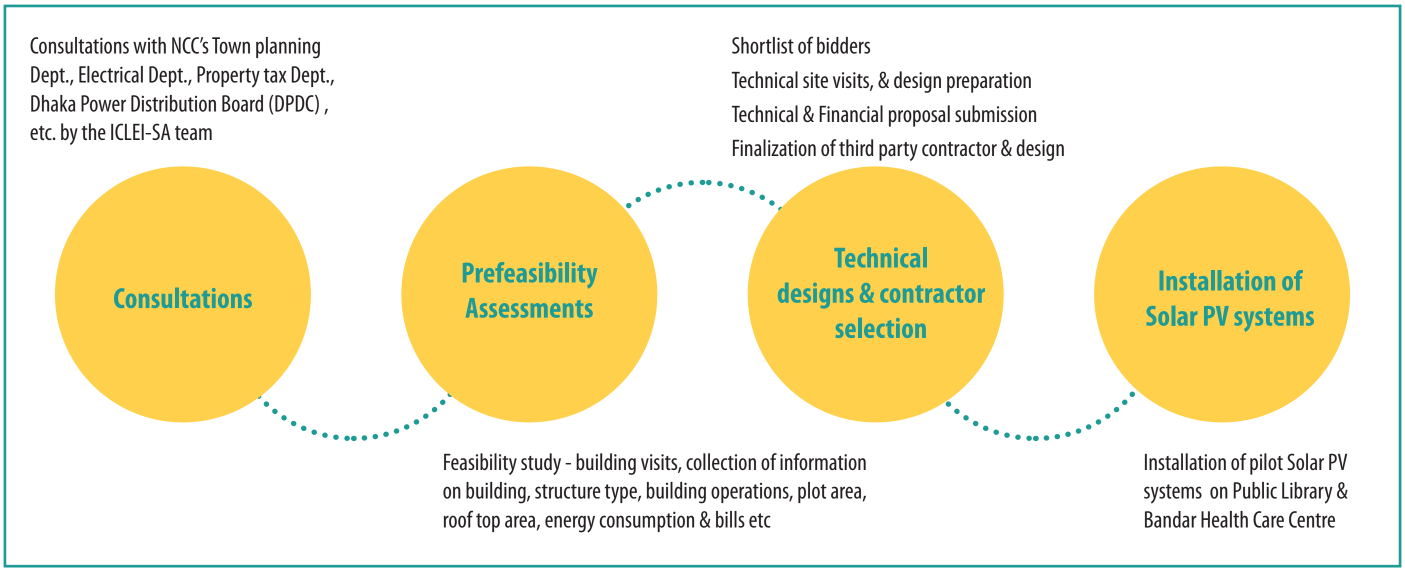

Figure 4: Methodology

feasibility of using rooftop Solar PV systems for meeting energy needs. The locational advantage is in favor of the country in terms of utilization of solar energy, with an average of 4 kWh/m^2 of solar radiation received over 300 days per annum and sunlight available 7 to 8 hours every day. The abundance of Solar energy, offers potential opportunities to transition from traditional fossil fuel-based power consumption to clean energy.

Project Benefits

In addition to the direct **economic benefits** from annual monetary savings, potentially amounting to about BDT 150,000 for each building, the project offers several other economic incentives. Net metering on the public library and the health centre enables both buildings to sell excess energy generated through the solar PV systems to the utility and increase revenue. Other socio-economic benefits may also be considered on account of reduced GHG emissions and air pollution, and enhancement of health sector service delivery.

Beyond the economic benefits, a wide range of **social benefits** include support towards resilient and streamlined services using clean and sustainable energy sources, increasing awareness among the citizens on alternative and renewable energy resources through successful implementation and use of rooftop Solar PV systems on public buildings, promotion of Solar PV systems installation, net-metering based mechanism, in the city's buildings and facilities, and the realization of significant energy and power savings. The resulting monetary savings accrued could be channelized into other development activities.

The **environmental benefits** include reduction in air pollution, GHG emissions, reduced use of scarce resource and lower dependency on fossil fuels.

Challenges

Challenges faced

The maintenance of the system components including the Solar panels, battery and inverter poses challenges, given the limited capacity of concerned city officials and personnel on-site to undertake regular maintenance. Similarly, ensuring uninterrupted and smooth operation of the system may also be challenging, with stakeholders citing from previous experience that electricity generation could be hampered due to accumulation of dust on the panels.

A key concern and challenge highlighted by NCC with respect to the batteries, was the need for regular maintenance of Lead acid type batteries and the need to replace these batteries post their typical lifespan of three years. Lead-acid batteries can stop functioning in the absence of regular maintenance, leading to Solar PV systems with battery backup not adequately serving the energy demand, thereby impacting confidence in the Solar PV technology itself.

Addressing the challenges

The third-party contractor Rahimafrooz Renewable Energy Ltd., has been entrusted with the operation and maintenance of both solar systems for five years. This will ensure their smooth functioning as well as capacity building of the city officials and key persons to manage the Solar PV system in the long-term. The scope of the regular maintenance includes panel cleaning and dust removal practices, which help to address the issue of dust accumulation.

In addition, training of the NCC officials and concerned personnel on the Solar PV systems and their functional modalities has been undertaken.

Similarly, to guarantee adequate operation and maintenance, data loggers and web -based monitoring are provided so that responsible officials can monitor the performance of the Solar PV systems from any location. Such remote monitoring enhances staff productivity while reducing the staff requirement and associated administrative costs.

Selection of appropriate battery technology in the form of Lithium-ion batteries at the health care centre addressed concern of the NCC on system durability and sustainability. Lithium-ion battery is an advanced alternative to lead acid battery, with superior, longer lifespan and lower maintenance requirements, and thereby supports the sustenance of the system.

Lessons Learnt

National leadership and policy environment: Renewable energy plays a vital role in the Government of Bangladesh's energy security. The Renewable Energy Policy of 2008, the Sustainable and Renewable Energy Development Authority (SREDA) Act, 2012, and Renewable Energy Development Authority (SREDA) Act, 2012, and the Net metering guidelines (revised), 2019 facilitate tapping the potential of renewable energy resources. The case study demonstrates the potential of adopting Solar PV systems under the prevailing policy environment to reduce GHG emissions.

Scaling up of benefits: Installations of Solar PV systems on public buildings with the benefits of net metering facility provides several social, economic and environmental benefits and scaling up the same supports the National Agenda. This case study also provides lessons for scaling-up on public sector buildings, realising the growth in markets for solar power, opportunity to benefit from net metering and third-party investments.

Replicability: The two pilot interventions provide lessons for replication of Solar PV installations on other public buildings and other cities across the country to achieve the country's renewable energy targets and the SDG targets of affordable and clean energy and sustainable cities and communities. Narayanganj, being a growing urban area has rising electricity demand. Increasing use of rooftop Solar PV systems offers opportunities for aggregation and connection to the grid, which is hugely beneficial for the buildings sector. The demonstrative project has contended in favour of the installation of rooftop Solar PV systems to meet Narayanganj's (Bangladesh's) growing electricity demands. Adoption of two- fold approach where NCC and ICLEI SA conducted the prefeasibility assessments for preparing the ToR, followed by the development of detailed technical design by the shortlisted third-party contractors ensured that relevant expertise was adequately tapped into and enabled effective implementation of the solution.

Urban-LEDS II project: A Quick Snapshot

The Accelerating climate action through the promotion of Urban Low Emission Development Strategies (Urban-LEDS II) project is a global initiative being implemented in more than 60 cities in eight countries. Urban-LEDS II supports participating local governments on low emission development to reduce greenhouse gas emissions and to simultaneously enhance resilience to adapt to climate change.

The project is funded by the European Commission and implemented jointly by UN-Habitat and ICLEI – Local Governments for Sustainability. It follows on from the first phase (Urban-LEDS I) that took place from 2012 to 2015. ICLEI South Asia is leading implementation of Urban-LEDS II in India and Bangladesh with support from UN-Habitat. The cities were being supported through pilots on climate action and planning (based on the vision, priorities, ideas, and opportunities identified by the cities). Urban-LEDS II and ICLEI SA are supporting these initiatives by way of technical and financial assistance.

- **Project Duration:** 2017-2021
- *Model cities in India:* Nagpur, Thane (deep-dive implementation), Rajkot (knowledge-sharing)
- *Satellite cities in India:* Coimbatore, Gwalior, Panaji, Pimpri-Chinchwad, Shimla (learning cities)
- *Model cities in Bangladesh:* Narayanganj, Rajshahi (deep-dive implementation)
- *Satellite cities in Bangladesh:* Singra, Sirajganj, Faridpur, Mongla (learning cities)

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