Technical Considerations for Rooftop Solar PV

C40 Cities Finance Facility

Funding partners:

Federal Ministry for Economic Cooperation and Development
CHILDREN'S INVESTMENT FUND FOUNDATION
UK Government
USAID FROM THE AMERICAN PEOPLE

Implementing agencies:

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
C40 CITIES

The C40 Cities Finance Facility (CFF) is a collaboration of the C40 Cities Climate Leadership Group and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. The CFF supports cities in developing and emerging economies to develop finance-ready projects to reduce emissions to limit global temperature rise to 1.5°C and strengthen resilience against the impacts of a warming climate. The CFF is funded by the German Federal Ministry for Economic Development and Cooperation (BMZ), the Children's Investment Fund Foundation (CIFF), the Government of the United Kingdom and the United States Agency for International Development (USAID).

Published by:
C40 Cities Finance Facility

Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

Registered offices
Bonn and Eschborn, Germany

Potsdamer Platz 10
10785 Berlin, Germany

E contact@c40cff.org
W c40cff.org

Author:
Agafer Creative Research and Development Services
27 Sgt. J. Catolos St., Brgy. Pinagkaisahan, Quezon City
E acrdsconsultancy@gmail.com

Content Editors:
Ferdinand Larona, CFF
Lyan Baybay Villacorta, CFF

Contributors:
Aris Moro, CFF
Milag San Jose-Ballesteros, C40 Cities
Jacqueline Lam, C40 Cities

Design & layout:
Opalyn A, Agulay

Key Insights

- The Philippines, through its National Renewable Energy Plan, aspires to attain 1,528 megawatts (MW) of total additional capacity for solar energy. Distributed renewable energy (DRE) systems, one example of which is a rooftop solar photovoltaic (PV), offer remarkable opportunities to accelerate the transition to affordable, reliable, clean, and modern energy services. The local government initiative to deploy rooftop solar PVs can contribute to the realisation of this objective.
- Venturing into rooftop solar PV provides sustainable and meaningful impacts to the local government and its constituents. These benefits and advantages can be categorised by sector. For example:

  — Environmental impacts include decreased greenhouse gas emissions, reduced and eliminated dependence on carbon-intensive energy sources, and optimal use of space.

  — Economic impacts include job creation and increased savings for local governments, which can be allocated to other development projects. A local government unit (LGU) would save an average of PHP 8.87/kWh.

  — Social impacts comprise strengthened local capability to manage and scale-up renewable energy projects, reduced health risks associated with conventional sources of energy, increased knowledge and awareness of the community with regards to renewable energy, and widened energy consumer choices.
- Starting and implementing a rooftop solar PV project presents technical challenges due to the existing institutional environment in the country. One notable existing condition is the bureaucracy of the net-metering process. The process currently involves securing

electrical and/or building permits and certification of a final electrical inspection. However, LGUs are in a position to streamline processes like this, to help projects like rooftop solar PVs come to fruition.

- For the local renewable energy landscape to flourish, one of the initiatives that the local government unit must pursue is to develop its internal capacity in planning and implementing projects related to the cause. Technical competence and institutional development can be attained by the LGU investing in the knowledge and capacity of its personnel. Sharpened knowledge and skills on developing renewable energy projects can help staff effectively and sustainably plan and implement rooftop solar PV projects.

- Local government units find information and education campaigns crucial in increasing the use of renewable energy technologies, especially in deploying rooftop solar PVs. Tailor-made initiatives will widen knowledge about and deepen the appreciation of local stakeholders. In return, this will increase acceptance of and support to rooftop solar PV.

About this Knowledge Product

The C40 Cities Finance Facility (CFF) and Agafer Creative Research and Development Services have prepared two reader-friendly knowledge products (Part 1 on Institutional and Financial Considerations and Part 2 on Technical Considerations) to contribute to the empowerment of local governments to plan and implement their own rooftop solar PV projects.

A wide array of stakeholders from the national and local level were engaged to collect primary information and ensure inclusiveness in the resulting product. Select cities were further engaged to gather views and contextualise their local renewable energy conditions. The knowledge product also benefits from a review of existing initiatives, policies, laws, and literature related to distributed renewable energy in the Philippines.

The knowledge products can be accessed at www.c40cff.org

Objectives

Upon completing this knowledge product, readers will be familiar with:

- Common forms and implementation of distributed renewable energy.
- Feasibility of rooftop solar PV in the Philippines.
- Sectoral benefits (environmental, economic, and social) of a rooftop solar PV.
- Challenges, limitations, and possible ways forward in the implementation of a rooftop solar PV.

Overview

This knowledge product provides key technical information that stakeholders, specifically LGUs, will find useful and appropriate for the development of a rooftop solar PV. It will also provide the technical prerequisites and enabling environment needed for taking up the renewable energy technology. The knowledge product is divided into three sections. The first section provides an overview of DRE, particularly the rooftop solar PV. This section also gives a brief explanation of the sectoral benefits that can be gained from the implementation of DRE initiatives. The second section touches on the key technical challenges and limitations that are currently being experienced by the stakeholders. This section also presents an overview of the net-metering process – a mechanism established to allow consumers to generate their own electricity using a renewable energy source. The last section outlines a few potential ways forward that LGUs can implement to increase the uptake of rooftop solar PVs.

I. Introduction

Renewable energy carries multiple benefits, all compatible with the aim of attaining sustainable development. Even with improved circumstances for renewable energy resources, such as reduced cost of capital investment and the passage of enabling laws, the Philippines is still lagging when it comes to the utilisation of this resource, particularly solar energy through rooftop solar photovoltaic systems.

a. Distributed renewable energy for energy access and sustainability

A distributed renewable energy system refers to 'a small-scale generation unit harnessing renewable energy sources, at or near the point of use, where the users are the producers'. In the current Philippine energy set up, this system is relatively new among the cities and municipalities. The system provides a reliable, democratic, and low-emission source of energy, making it one of the, if not the, best solution for attaining energy security and sustainability.

i. Sources of energy

DRE systems make use of replenishable sources. Applicable technologies for DRE system are: solar, small scale biomass/biogas technology, and wind.

ii. *Current system operations and technologies*

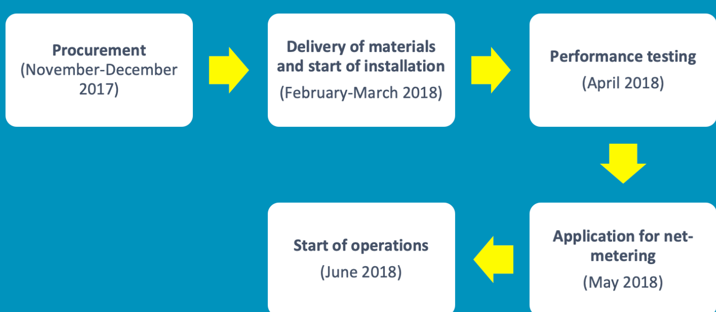
Multiple DRE generation options are currently available in the market. The system and technology correspond to the renewable energy resource that will be harnessed for energy generation. For solar energy, the solar PV system is a common option. A solar PV system is an electrical installation that converts solar energy into electricity.[2] The product is commercially available and the technology is proven to be efficient; it can be used for peak-shaving, which reduces the energy purchased from the distribution utility. It is environment friendly, due to zero carbon emission, and maintenance costs are relatively low compared to other renewable energy facilities.

[i] Under a moderate emissions scenario relative to the 1951 level.
[ii] Based on projections from PAGASA.

In the Philippines, solar energy is recognised as a renewable resource for its huge potential as a critical part of the Philippine energy mix. However, this has yet to be realised through policy implementation and deployment.[3] A rooftop solar PV can be installed and operational within a span of thirty months on average.[4] This is far shorter than other renewable energy projects, which usually take at least three to five years to operationalise.[5]

CLOSER LOOK: ROOFTOP SOLAR PV INSTALLATION IN NAGA CITY, CEBU

The first LGU in Visayas to have a solar PV installation is in Naga City, Cebu, with an installed capacity of 100 kWp. The installation took seven months from procurement to commercial operation, as shown in the illustration.



Source: PNOC, 2019[6]

iii. Rooftop solar photovoltaic (PV) as a feasible DRE initiative in the Philippines

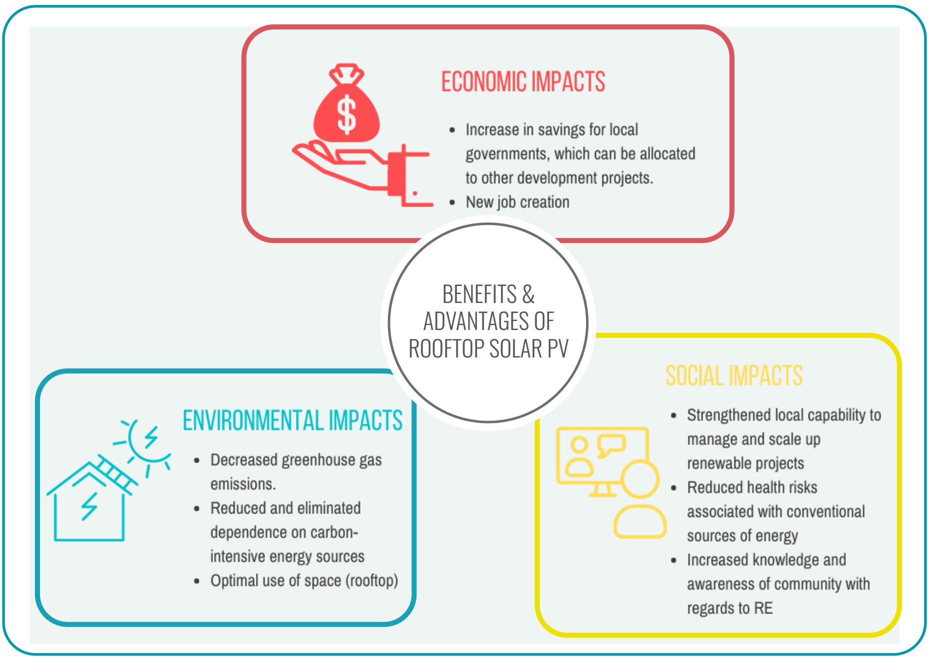
Energy provision has a direct effect on the delivery and performance of other equally important sectors such as health, education, agriculture and food, water, and communication services among

among others. As such, equitable energy access is essential in order to improve quality of life.

To achieve energy security and sustainability, efforts related to DRE should be hastened and given attention. With the country's complementary natural environment, it is projected that the Philippines' solar energy potential could even surpass the aspirational target of 1,528 MW cited in the National Renewable Energy Plan.[7] Solar energy is one of the emerging yet untapped DRE technologies in the Philippines, and LGUs can help reach DRE goals by venturing into this kind of development project – specifically rooftop solar PVs.

b. Benefits and advantages of rooftop solar PV

Figure 1. Sectoral benefits and advantages of rooftop solar PV



i. Environmental

The deployment of a rooftop solar PV is a mitigation measure that cities can implement as it provides numerous environmental benefits. Rooftop solar PV systems use a clean and renewable source of energy, minimising energy dependency on coal and oil powerplants. This presents opportunities in the reduction of greenhouse gas emissions. To illustrate, a typical 100 kilowatt-peak (kWp) rooftop solar PV facility is equivalent to about 80 metric tons of annual CO_2 emissions savings. In addition, the development of a building's rooftop to harness energy diversifies and makes more efficient the use of land.

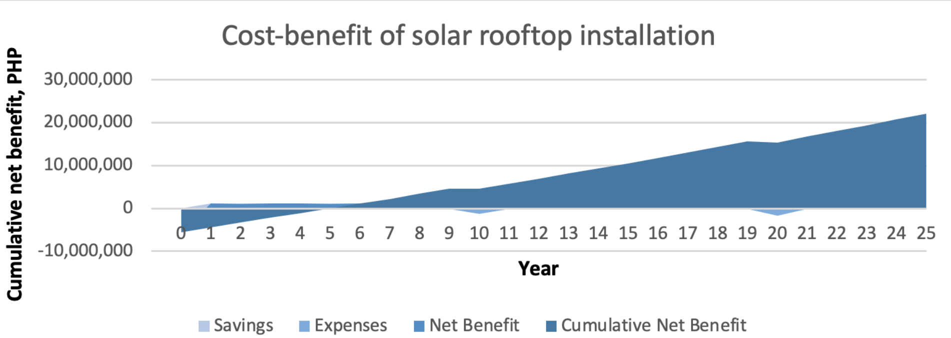
ii. Economic

A local government unit can realise long-term savings through reduced on-grid electricity consumption. A financial return can be expected after five to eight years depending on the capacity of the system (baseline: distribution utility generation rate). A facility can have a lifespan of about 20 to 25 years if properly maintained and operated.

Through the installation of solar PV, the LGU can reduce the electricity to be provided by the distribution utility, which results in avoided cost equivalent to the effective electricity rate of the distribution utility (generation, transmission, systems loss, distribution, subsidies, taxes and other charges) in the long run. If the system is under net-metering, excess generation exported to the distribution utility will also be credited equivalent to the current generation rate of the distribution utility. The earned peso credit will be deducted from the LGU's electricity bill.

An example of cost benefits is provided in Figure 2. Assuming an installed capacity of 100 kWp under net-metering, with an electricity cost of about PHP 9.50 per kWh and operating from Mondays to Fridays, the LGU would be able to save an average of PHP 1.18 million in electricity costs – an average savings rate of PHP 8.87/kWh. Please see Annex 1 for the detailed sample computation of savings.

Figure 2. Cost-benefit of solar rooftop installation



Aside from generating savings due to reduced energy consumption, the promotion and utilisation of renewable energy through rooftop solar PVs can further contribute to inclusive growth by creating new jobs. Through solar energy alone, Germany generated more than 100,000 new jobs over a span of seven years. In the United States of America 93,502 jobs were generated in 2010 with a potential of expanding this to as many as four million jobs by 2020. This can also happen in the Philippines. It is projected that with just solar technology, a 100-MW installation target promises to create at least 5,000 full-time jobs in three years.[8] Various phases of the project such as the planning, design, procurement, and construction can create employment for the residents of the LGU and its nearby localities. Further, as a general rule of thumb of the electronics industry, each direct job in the sector gives rise to seven indirect jobs. This means the industry can provide an estimated 175,000 jobs to people all over the country.[9]

iii. Social

Social benefits are benefits provided to individuals and households to mitigate the effects of social risks.[10] Social benefits are often linked with the sectors of education, health, and housing among others. The deployment of a rooftop solar PV in a city can directly benefit the general welfare of its constituents. Some of the notable social benefits are:

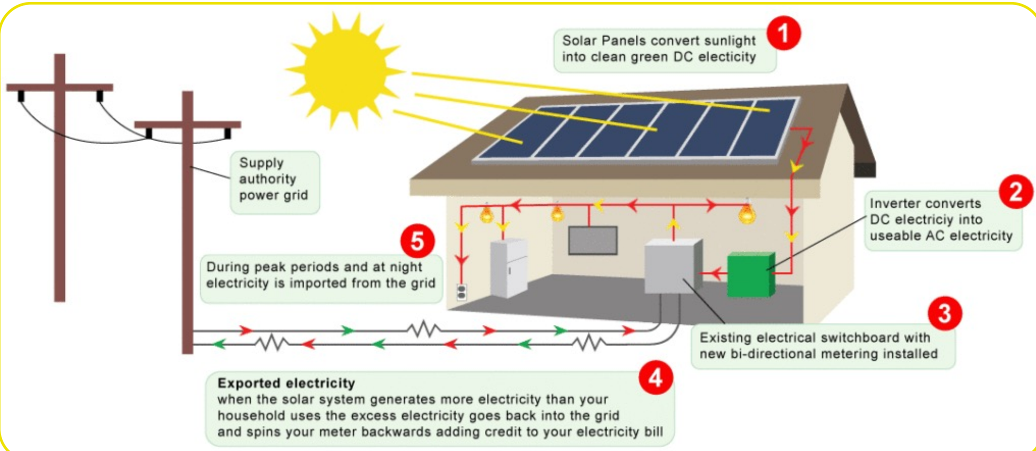
- Reduced health risks associated with conventional sources of energy (i.e. fossil fuel).
- Expansion of consumer choice and readily available alternatives.[11]
- Increased knowledge and awareness about renewable energy.

A rooftop solar PV installation is one of the most suitable DRE projects to be implemented by cities. Aside from the benefits listed above, in an urban setting a local city government can execute this type of project in the many buildings under its jurisdiction. Rooftop solar PVs can be used by energy-intensive users such as hospitals, as shifting to or complementing its energy source with rooftop solar PVs will contribute to the attainment of energy efficiency. Other areas where rooftop solar PV facilities can be installed are government offices, schools, public markets, and other buildings maintained by the LGU.

Installation of rooftop solar PV system

An installed and operational rooftop solar PV system is shown in Figure 3.

Figure 3. Sample of typical solar rooftop installation[12]



II. Key technical challenges and limitations in the implementation of solar PV rooftop projects in the Philippines

Several technical challenges are being experienced by various project proponents in terms of starting and implementing a rooftop solar PV project. Some specific conditions are outlined below alongside pertinent information that may be of use in order to plan ahead.

a. National regulations on net-metering and the electricity market

Net-Metering

Net metering is the first policy mechanism implemented under the *Renewable Energy Act of 2008*. This is an electricity policy for consumers who own renewable energy facilities (such as solar energy) which allows them to produce electricity on site while contributing their excess generation to the grid.

There are only few distribution utilities that are implementing this policy since its full enactment. The first distribution utilities to implement the policy were the Visayas Electric Cooperative followed by Manila Electric Company (MERALCO).

Most of MERALCO's published requirements for net-metering application need a lot of time to prepare, including the need to secure documents from the local village government (barangay) and city hall. One of the problems that proponents experience with these requirements is the cost and timeline for the processing of net-metering – it would take a minimum of seven months to complete all of the requirements. A flowchart of the process is provided in Figure 4.

Some proponents have even found that the application takes up to a year before approval. This delay is caused by the significant amount of time needed to secure the necessary permits and to prepare technical studies prior to the installation of the rooftop solar PV.

This results in foregone savings for the LGU due to the following circumstances: i) energy generated that should be exported to the grid will not be permitted by the system; and ii) the distribution utility may advise the LGU to shut down the system every weekend, limiting the amount of energy exported to the grid to Monday–Friday.

It is necessary to streamline the process between and among the distribution utility, the LGU, and the applicant in order to stay on track with the timeline.

Self-generating facility (own-use system)

An own-use system is a power generating facility owned and constructed by the end-user for their own consumption. This allows end-users to install their own facility higher than the 100 kWp cap for net-metering, provided that there should be no excess energy to be exported to the distribution grid of the distribution utility.

One concrete example of this is the experience of the local government of Quezon City. The city determined in their design analysis that the own-use system is more beneficial for installation in the three city-owned hospitals. The hospitals have no guaranteed minimum billing demand (GMBD) contract, operate non-stop, have a high load demand, and have wide roof space available for installation. These factors present a good opportunity to utilise the abovementioned scheme. Depending on the circumstances, the self-generating facility is a better option than net-metering.

On the contrary, if net-metering is preferred, an institution can request a review of the agreements with the distribution utility and modify the GMBD ratings to lower the capacity billing.

UNDERSTANDING POWER BILLS

Power tariffs are generally classified as either residential service (usually single meter family dwellings) or commercial/industrial. Most local government facilities will likely fall under the commercial/industrial class. If we take the example of MERALCO, the biggest electric utility in the country, the commercial/industrial customers are categorised as follows::

1. General Service (GS) – commercial and industrial customers with a connected load of less than 40kW for general power, heating, and/or lighting.
    - General Service A (GS-A) – any business premise whose contracted capacity does not exceed 5kW (e.g. bakery, salon, car wash, etc.)
    - General Service A (GS-A) – any business premise whose contracted capacity does not exceed 5kW (e.g. bakery, salon, car wash, etc.)
    - General Service B (GS-B) – any business premise whose contracted capacity is between 5kW and 39kW (e.g. restaurant, small commercial spaces, convenience stores, etc.)

2. General Power (GP) – commercial and industrial customers with a connected load above 40kW
3. Government hospitals, metered streetlights and charitable institutions (GHMSCI)

In general, GS-A and GHMSCI customers are not assigned with a guaranteed minimum billing demand (GMBD). GMBD based on the 70% of contracted capacity (in kW), which in turn is the projected load demand of a facility/building when it applied for energisation. Meralco imposes the GMBD in order to recover the cost of constructing and maintaining the distribution infrastructure needed to energise a building, and to pass on the generation cost it contracted from its suppliers to ensure continuous supply of electricity to the facilities. MERALCO is open to the review and modification of the GMBD should a consumer request it.

Before venturing into a renewable energy project, it is important for the implementor to find out if there is a GMBD in its contract, as it will impact the economics of the project. If there is GMBD, at the very least one has to study whether the peak demand of electricity coincides with the availability of the renewable energy generation. The renewable energy production can potentially reduce the coincident peak demand for electricity. This should be the basis for designing the system for facilities with a GMBD contract.

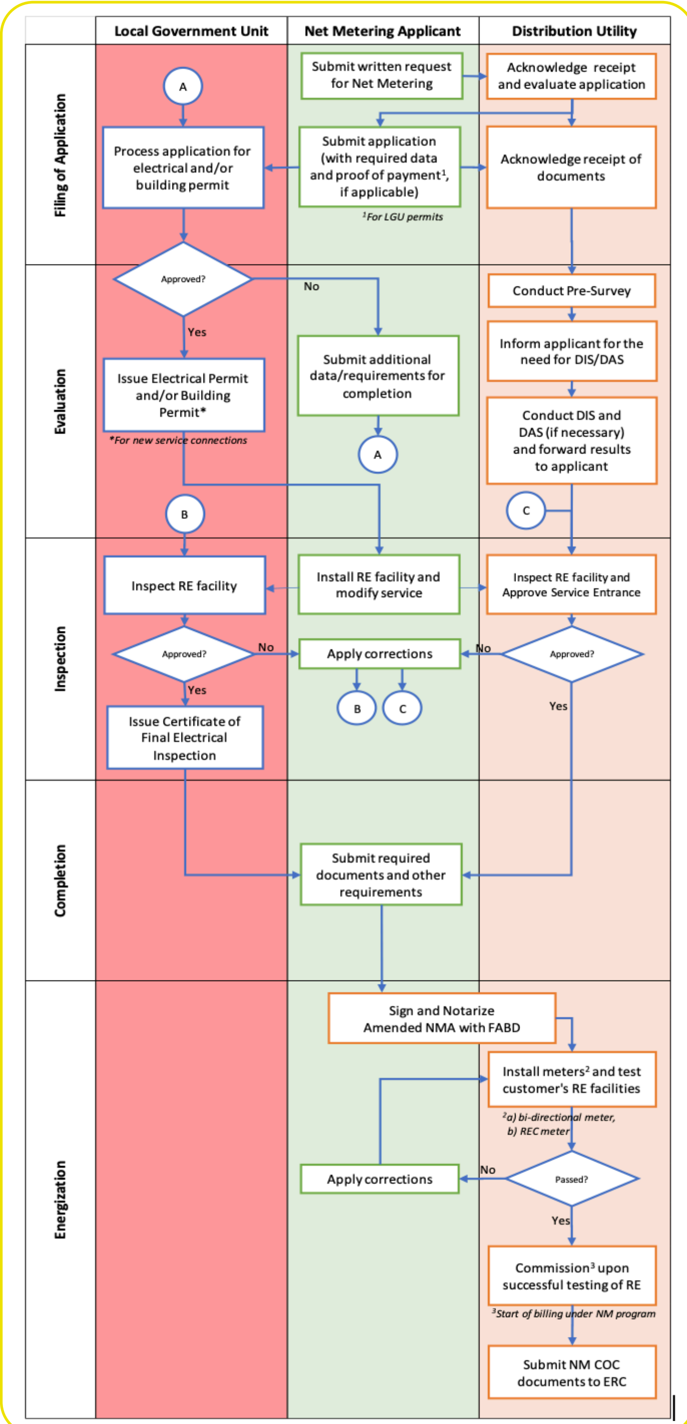
b. Readiness of distribution utilities

Although the distribution utilities are required by law to accommodate requests for net-metering, this is currently being impeded by the level of capacity of most of the distribution utilities.

In terms of infrastructure (system and facilities), most of the distribution utilities have yet to upgrade their systems for this scheme. With the distribution utilities' systems receiving excess energy from distributed renewable energy producers, disturbances in the distribution line may occur as the current system cannot control the exported generation from the solar PV facility. This may degrade the quality of service of the distribution utility (i.e. voltage and potential systems losses).

Another challenge that is currently being encountered is that other distribution utilities need to improve their capacities in preparing distribution impact studies. This type of study is one of the technical requirements in net-metering. This study will determine the possible impact of a rooftop facility to the system of the distribution utility once the solar PV exports excess generation. Further, this will determine the protective device that needs to be installed to protect the interconnection line of the distribution utility during operation of the facility.

Figure 4 shows the net-metering process from MERALCO following the Energy Regulatory Commission Resolution No. 06, series of 2019 'A Resolution Adopting the Amendment to the Rules Enabling the Net-Metering Program for Renewable Energy'. The net-metering application is further divided into five stages: filing of application, evaluation, inspection, completion, and energisation. The first three stages involve all parties including the applicant, the LGU, and the distribution utility. Fewer parties are involved for the last two stages – solely the applicant for the fourth stage, while the culmination of the process entails the participation of the applicant and the distribution utility.



No validation on the process timeline. Number of days per step is on a case-to-case basis depending on several variables such as the profile of the customer, the capacity of net-metering facility, the location of the customer, and the permitting process per LGU, among others.

Figure 4. Flowchart of net-metering process[13]

The said resolution provides for the distribution utilities to complete the whole interconnection process within twenty (20) working days from the receipt of the letter of interest, provided all necessary permits and licenses from various concerned agencies are secured and completed.

c. Difficulty in measuring and communicating environmental and social benefits

Multiple methodologies for measuring the abovementioned environmental and social benefits of renewable energy are already available. Unfortunately, there is a lack of technical knowledge and in-house capacity for calculating these benefits among LGUs. Compounded by the lack of capacity is the difficulty in formulating and conveying the tailored information to stakeholders.

The situation can be improved by building LGU capacity for measuring and communicating the environmental and social benefits of rooftop solar PVs. The benefits of solar energy can be enhanced by tailored messaging and framing. Better knowledge and appreciation of the benefits of rooftop solar PV will make individuals more likely to invest and shift to this clean energy source.

III. Ways Forward

Despite the mentioned challenges to and limitations of implementing rooftop solar PV, LGUs are in a unique and advantageous position to improve the local renewable energy landscape. As LGUs have local autonomy to attain their fullest potential and development, officials can shape local conditions through tailored programmes and initiatives based on the assessed needs of the city.

Initial efforts that can be enforced and that are within the capacity and purview of LGUs include institutional development through capacity building, technical support, and information and education campaigns. Capability building and technical support on rooftop solar PV, with key LGU departments as the main beneficiaries, will strengthen staff competence for the immediate and seamless initiation and management of local renewable energy projects at the city or municipal level. Theoretical and practical capacities that must be honed within the city can be identified in line with the various phases of implementing and managing rooftop solar PVs.

For the pre-development stage, LGUs must have skills, tools, and software in place for the preparation of a study to determine the technical and financial viability of the project. Study topics at this stage include assessment of the structural and electrical integrity of prospective buildings, review of as-built plans, acquisition of building and applicable national/local legal and regulatory frameworks and policies, permit and licensing, and financing options. The second stage is the system design and procurement stage. Relevant in-house knowledge and capacities at this stage include development of system design, selection of suitable components for the system, configuration of the array, estimation of system performance, and the conduct of due diligence. The third stage is the implementation stage, which covers activities associated with the financial closing and procurement, installation, final testing, and commissioning of the rooftop solar PV system. The LGU must develop the knowledge and capacities of its personnel towards equipment acquisition, ensuring safety, installing the system, testing and commissioning. The last and longest stage is the operations and maintenance. This involves monitoring the performance and upkeep of the rooftop solar PV. Relevant knowledge and capacities at this stage are performance monitoring, cleaning, diagnostic testing, and preventive maintenance.

Adequacy of resources is critical in the realisation and level of success of a project. Funding of a renewable energy project can come from the LGU's own resources, if available, or the LGU can look for assistance from various development organisations such as CFF, the Public-Private Partnership (PPP) Centre, and others. With such resources secured, the LGU can identify and prioritise the activities that will enhance its institutional mechanism and technical competence throughout the stages cited above. If the LGU has enough resources and renewable energy is one of its top priorities, the whole spectrum of stages and activities can be tackled by one ambitious capacity-building programme. Otherwise, if resources are scarce and priority is lower, the study topics can focus on those of the pre-development stage. In return, this will aid the LGU in determining the feasibility and worthiness of planning and implementing renewable energy projects, specifically rooftop solar PVs.

Aside from developing the internal capacity of the LGU to plan, promote, and implement rooftop solar PVs, the local government must also set the pace for solar adoption and expansion within its locality. Complementary initiatives for this purpose include putting in place effective public policy alongside ensuring proper implementation. Effective policy translated into concrete actions and realised environmental, economic, and social benefits will encourage various sectors of society to use this clean energy. Apart from leading by example through solar installations on public and government-owned buildings, the following measures can be taken by the LGU to be solar-friendly:

- Publicise local financing options.
- Encourage and support community solar projects.
- Build a relationship with the servicing distribution utility.
- Eliminate red tape by streamlining processes (i.e. one-stop permitting that will cover building and electrical inspections and other project requirements), setting limitations on fees charged, and standardisation of requirements and processing time.

- Encourage new homes and/or buildings to be designed in anticipation of installing rooftop soe future.[15]

Information and education campaigns are also crucial as these will widen the knowledge of and deepen the appreciation for renewable energy among local stakeholders and constituents. Important information that is effectively relayed can be turned into an advantage through increased acceptance and take-up of rooftop solar PVs.

For wider and more successful adoption of renewable energy technology, local governments must spearhead campaigns customised to the information needs and level of comprehension of various stakeholders. Immediate availability of clear and objective information on rooftop solar PVs, particularly on the institutional processes, financing options, and installation, will entice consumers to invest and embark on this renewable energy technology. Learning sessions and media production can be carried out by the local government unit through its technical department.

All endeavours mentioned above coincide with and should complement the institutional and financial aspect of developing a rooftop solar PV system. It is imperative for LGUs to devise a well-rounded initiation and implementation plan for the efforts and impacts of rooftop solar PV to be maximised and sustained.

Annex 1. Sample computation of potential savings from a rooftop solar PV

To appreciate the monetary benefit of solar PV installation, a sample computation of potential annual savings for LGUs is provided below.

Installed capacity	100 kWp
Distribution utility rate	9.50/kWhr
Estimated annual energy generation	133,000kWh
Net-metering rate	5/kwh
Degradation factor	0.7%
Installation cost	5.5 M
Escalation rate	1%

Table 1. Parameters used for the computation of savings

DEFINITION OF TERMS

- Installed capacity – the total solar PV capacity that can be installed in the rooftop. This can be determined based on the demand load of the building and the available rooftop area of the building.
- Distribution utility rate – blended generation cost and all other charges of the distribution utility.
- Estimated annual energy generation – annual potential energy generation

  Annual energy generation = capacity x net capacity factor* x 8760
  = 100 kWp x (4.85 hrs / 24 hrs x 0.75) x 876
  = 132,769 kWh, use 133,000 kWh

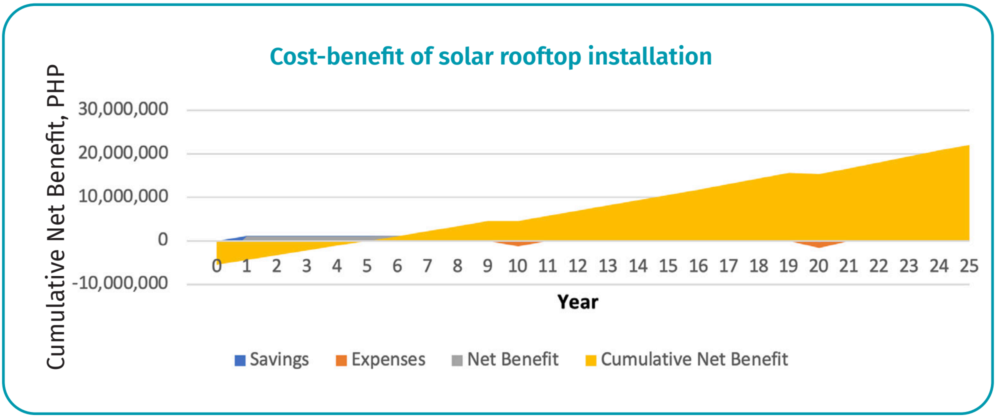
- *Net capacity factor – available sun-hours divided by 24 hours multiplied by the performance ratio of the system (coefficient of losses ranging from 0.5 to 0.9, default value is at 0.75)
- Net-metering rate – assumed rate based on the average annual energy generation of the distribution utility; this may vary on a monthly basis. LGU may check the effective monthly rate published in the website of the distribution utility.
- Degradation factor – this is the annual decrease of the panels' efficiency; hence it also reduces the expected annual generation of the facility.
- Installation Cost – total cost of the facility this includes the cost of panel, inverter, electrical equipment and other components, labor cost. The cost may also vary depending on the type of structure where the facility will be installed, whether it is a slab of GI sheet.
- Escalation rate – we will assume a 1% escalation rate for the electricity cost.
- Expenses – this includes capital and operating expense of the facility including the overall charges of the distribution utilities.

NOTE:

There will be an increase in expenses every 10 years for the inverter replacement, thus, the annual revenue on the 10th and 20th year is relatively low compared to other years of operation.

Table 2. Cost-benefit of solar rooftop installation based on the first 10 years of its Operation

	1	2	3	4
Net electrical output	133,000	132,907	132,814	132,721
Own use	113,206	113,126	113,047	112,968
Export	19,794	19,781	19,767	19,753
Rate	9.50	9.50	9.60	9.53
Export rate	5.29	4.77	4.82	4.96
Savings	1,180,257	1,169,011	1,179,874	1,174,735
Expenses	(69,834)	(69,595)	(69,279)	(68,881)
Net benefit	1,110,423	1,099,416	1,110,596	1,105,853
Cumulative net benefit	(4,389,577)	(3,290,161)	(2,179,566)	(1,073,712)
Cumulative net benefit in USD	(87,792)	(65,803)	(43,591)	(21,474)



	5	6	7	8	9	10
	132,628	132,535	132,442	132,350	132,257	132,164
	112,889	112,810	112,731	112,652	112,573	112,494
	19,739	19,725	19,711	19,698	19,684	19,670
	9.63	9.72	9.82	9.92	10.02	10.12
	5.01	5.06	5.11	5.16	5.21	5.26
	1,185,651	1,196,670	1,207,790	1,219,014	1,230,343	1,241,776
	(132,157)	(67,822)	(67,151)	(66,379)	(65,500)	(1,247,154)
	1,053,494	1,128,847	1,140,639	1,152,635	1,164,843	(5,378)
	(20,218)	1,108,629	2,249,268	3,401,904	4,566,747	4,561,369
	(404)	22,173	44,985	68,038	91,335	91,227

Environmental savings of a typical 100 kWp solar rooftop facility

Not only does the burning of fossil-fuel energy resources contribute to local air pollution, it also increases the atmospheric greenhouse gases responsible for global climate change. International efforts to prevent abrupt climate change have been set out in the Kyoto Protocol International Agreement. Through the installation of solar rooftop facilities, the LGU would be able to contribute to the environmental benefits listed in Table 3.

Table 3. Sample environmental savings parameters

Parameter	Amount
CO2 savings annually	80 metric tons
CO2 reduction annually	159,158 pounds
Gallons of gasoline	8,377
Acres of forest	60
Cars taken off the road (1 year)	15
Trees grown (10-year period)	1,862
Homes powered (1 year)	10
Light bulbs powered – 60W (1 year)	606

References

[1] Vezzoli, C. et al., 2018. 'Designing Sustainable Energy for All. Sustainable Product-Service System Design Applied to Distributed Renewable Energy', in Designing Sustainable Energy for All, 1st ed., Switzerland: Springer Nature.

[2] ARUP. n.d. Five-minute guide to Rooftop Solar PV. Retrieved from: www.arup.com/perspectives/publications/promotional-materials/section/five-minute-guide-to-rooftop-solar-pv

[3] GIZ. 2013. It's More Sun in the Philippines: Facts and Figures on Solar Energy in the Philippines Project Development Programme (PDP) Southeast-Asia. Retrieved from: www.doe.gov.ph/sites/default/files/pdf/netmeter/policy-brief-its-more-sun-in-the-philippines-V3.pdf

[4] ADB. 2014. Handbook for Rooftop Solar Development in Asia. Retrieved from: www.adb.org/sites/default/files/publication/153201/rooftop-solar-development-handbook.pdf

[5] Ibid.

[6] PNOC Renewables Corporation. 2019. Inauguration of 100kWp Solar PV Rooftop Project in Naga Cebu. Retrieved from: www.pnoc-rc.com.ph/index.php/news-and-events/49-inauguration-of-100kwp-solar-pv-rooftop-project-in-naga-cebu

[7] Ibid.

[8] GIZ. 2013. It's More Sun in the Philippines: Facts and Figures on Solar Energy in the Philippines Project Development Programme (PDP) Southeast-Asia. Retrieved from: www.doe.gov.ph/sites/default/files/pdf/netmeter/policy-brief-its-more-sun-in-the-philippines-V3.pdf

[9] GIZ. 2013. It's More Sun in the Philippines: Facts and Figures on Solar Energy in the Philippines Project Development Programme (PDP) Southeast-Asia. Retrieved from: www.doe.gov.ph/sites/default/files/pdf/netmeter/policy-brief-its-more-sun-in-the-philippines-V3.pdf

[10] IPSASB. 2015. Recognition and Measurement of Social Benefits. IFAC. New York. Retrieved from: www.ifac.org/system/files/publications/files/IPSASB-Consultation-Paper-Social-Benefits_0.pdf

[11] Kumar, M. 2020. 'Social, Economic, and Environmental Impacts of Renewable Energy Sources'. DOI:10.5772/intechopen.89494

[12] Retrieved from: www.uniquepulse.in/solar-roof-top-system/

[13] Provided by MERALCO, 2021.

[14] Endrejat, P.C., Güntner, A.V., Ehrenholz, S., and Kauffeld, S. 2020. 'Tailored communication increases the perceived benefits of solar energy', Energy Policy. https://doi.org/10.1016/j.enpol.2020.111714.

[15] Retrieved from: https://environmentamerica.org/feature/ame/ten-ways-your-city-can-go-solar