The Government of Nepal
Ministry of Energy, Water Resources and Irrigation
Alternative Energy Promotion Centre (AEPC)
Making Renewable Energy Mainstream Supply in Nepal

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

GUIDELINE FOR PROMOTION, PLANNING, AND DEVELOPMENT OF GRID-CONNECTED SOLAR PV SYSTEMS

For Provincial and Local Governments, House Owners and Owners of Commercial and Industrial Establishments

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Preamble

Under the mandate given through the Constitution of Nepal, the Ministry of Water Supply, Irrigation and Energy (MoWSIE), Koshi Province has initiated and supported the development of this guideline in consultation with potential users, AEPC and sector experts. This guideline seeks to assist provincial and local governments, owners of residential buildings, owners of commercial and industrial (C&I) establishments across Nepal in planning and developing grid-connected solar PV systems.

BACKGROUND

Grid-connected solar PV (i.e., solar rooftop systems) are solar power generators interconnected to the electricity grid. Apart from generating electricity to be consumed in-house, they allow excess electricity to be fed in and sold to the grid, subject to permission of the utility. Grid-connected solar systems allow buildings to generate clean energy, reducing energy consumption from the grid thereby reducing electricity bills. Additionally, the export and sale of excess energy are generating additional income while contributing to the nation's supply of clean energy from renewable sources.

With an average solar radiation range of 3.5 to 6.6 kWh per day and approximately 300 days of sunshine, Nepal offers substantial potential for solar power generation. A study[1] conducted in five major cities – Kathmandu, Pokhara, Butwal, Nepalgunj, and Biratnagar – found that the technical potential of solar grid-connected systems of Nepalese households is 5 MWh per year (based on an average roof area of 93 m^2 per household). The decreasing cost of PV components progressively increases the affordability and accessibility of solar energy, while the rising prices of grid electricity make solar power an appealing alternative. With an urban population of about 6 million in 2020, grid-connected systems have the technical potential to contribute up to 6.5 TWh of electrical energy to Nepal's energy supply.

Ministry of Water Supply, Irrigation and Energy (MoWSIE) is among the agencies that have a keen interest in developing and promoting such grid-connected solar systems due to several reasons, some of which being the socio-economic status of Koshi Province being favourable for solar grid-connected system, aided by the presence of a good amount of commercial and industrial zone. Koshi Province is one of the leading contributors to the national economy. There are more than 800 registered industries and 76 thousand small-scale industries along with 21 thousand commercial businesses registered which together account for 18% of Nepal's private sector establishments. Similarly, the contribution to the national GDP from Koshi Province is 16% which is the second highest among the provinces, the first being Bagmati Province. Likewise, the contribution from agricultural produce from Koshi Province is 22% which is the highest among all the provinces thus aiding the need for the establishment of processing mills. The major industrial districts (Morang, Sunsari and Jhapa) in Koshi Province are more than 90% electrified with dedicated feeder and trunk line networks for industrial corridors, thus paving a clear path for stable electricity supply to the industrial corridor.

The potential of grid-connected solar PV is immense in Koshi Province. It allows individual house owners, commercial entities and industries to generate power locally which ultimately reduces grid system losses, and improves system reliability and voltage level. Similarly, being a prominent cleaner technology, solar PV can reduce greenhouse gas emissions (GHG) reduction significantly. Together, these factors support the claim that solar electricity is expected to be cost-competitive with other sources such as hydropower.

[1] The potential for rooftop photovoltaic systems in Nepal – www.mdpi.com/1996-1073/16/2/747

FOREWORD
By Executive Director of AEPC

Solar PV has become the most prominent source of electricity both in developed and developing countries. It is expected that by 2050 almost 90% of electricity will be generated through solar panels and wind turbines. Solar PV systems are a smart, safe, inexpensive, and environmentally friendly source of energy. It can also produce massive financial benefits for residential, commercial, and industrial buildings. Because of high solar radiation and a large number of sunshine days, Nepal offers substantial potential for solar power generation.

The Alternative Energy Promotion Centre (AEPC) seeks to mainstream renewable energy and energy efficiency for improved living conditions of the people of Nepal and combatting climate change globally. AEPC has been partnering with government agencies, development partners, provincial governments, local levels, the private sector, user groups, and other stakeholders to promote various renewable energy technologies including solar PV.

The Ministry of Water Supply, Irrigation and Energy (MoWSIE), Koshi Province is keen to promote, among other things, grid-connected solar PV systems (solar rooftops) in residential buildings and commercial and industrial (C&I) properties. Similarly, AEPC together with various development partners is also providing technical and subsidy support for such technologies. For accurate planning and development of grid-connected solar rooftop and ground-mounted solar PV systems, the ministry has decided to prepare this guideline for provincial and local governments, house owners and owners of commercial and industrial establishments.

The POSTED project of GIZ was instrumental in the preparation of this guideline as per the request of MoWSIE, Koshi Province. I would like to express our gratitude to Felix Nitz, the Team Leader, Dr. Bharat Raj Poudel, the Deputy Team Leader, and Nipun Regmi, the Solar PV Specialist. I would also like to express our sincere thanks to Narayan Kafle (international lead expert), Oscar Mones (international expert), Aashish Chalise (national expert) and Sujan Tuladhar (national expert) who worked hard to prepare this guideline. Likewise, I would like to express gratitude to Dr. Narayan Adhikari, Director, Dr. Laxman Prasad Ghimire, Assistant Director of AEPC and the entire team of AEPC who continuously supported and provided suggestions and assistance during the preparation of this guideline.

Finally, I would also like to thank the MoWSIE, Koshi Province family including the then Secretary Mr. Nabin Raj Singh and the current Secretary Mr. Arun Kumar Jha, who coordinated with the POSTED project and supervised the preparation of this guideline. Finally, I express our sincere gratitude to the experts, employees of various offices and communities of the solar rooftops projects who participated in the discussions at various stages during the preparation of the guideline.

Nawa Raj Dhakal
Executive Director
Alternative Energy Promotion Centre

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List of Abbreviations

AC	Alternating current
AEPC	Alternative Energy Promotion Centre
BOS	Balance of system
BoQ	Bill of quantity
B.S.	Bikram Sambat
CAPEX	Capital expenditure
CBTL	Certification body testing laboratory
DC	Direct current
DCS	Distribution and consumer service
DFS	Detailed feasibility study
ESCO	Energy service company
GHG	Greenhouse gas emissions
GoN	Government of Nepal
GWh	Gigawatt hour
FiT	Feed-in tariff
IPP	Independent power producer
IRR	Internal rate of return
IS	Indian standards
I_{SC}	Short circuit current
ISO	International Organization for Standardization
KVA	Kilovolt ampere
kW	Kilowatt
kWh	Kilowatt hour
kW_P	Kilowatt peak
LCOE	Levelized cost of electricity
MCB	Miniature circuit breaker
MPPT	Maximum power point tracker
MW	Mega watt
NCB	National certification body
NEA	Nepal Electricity Authority
NEPQA	Nepal Photovoltaic Quality Assurance
NPV	Net present value
NS	Nepal Standard
OPEX	Operating expenditure
PIT	Production introduction test
PPA	Power purchase agreement
PPP	Public-private partnership
PV	Photovoltaic
RCC	Reinforced cement concrete
RECB	Renewable energy certification body

RETL	Renewable energy testing laboratory
RETS	Renewable Energy Test Station
SHS	Solar home system
SPD	Surge protection devices
SRT	Solar rooftop
STC	Standard test conditions
THD	Total harmonic distortion
ToD	Time of day
TWh	Terawatt hour
V	Volt
VGF	Viability gap fund
W_P	Watt peak

Glossary

Alternating current (AC) is an electrical current in which the direction of electron flow reverses at regular intervals. In an AC circuit, electric charge changes polarity in a cyclical pattern. In general, the grid electricity provides AC current.

Balance of system (BOS) are all system components in a photovoltaic (PV) system other than solar panels and inverters. It includes PV racking, batteries, enclosures, disconnects, combiner boxes, charge controllers, cables and connectors, switches, protection and safety devices, and monitoring and control systems.

Commercial and industrial solar PV systems are solar PV systems installed on a non-residential structure. According to the NEA directive, a commercial system is officially designated as one exceeding 10 kW up to 500 kW output, while an industrial (utility) scale system surpasses 500 kW output.

Current carrying capacity is the maximum continuous current that a conductor (or wire) can safely carry without exceeding its rated temperature.

Direct current (DC) is an electrical current characterized by its steady and unchanging flow in a singular direction. For reference, all batteries produce direct current.

Energy service companies (ESCO) are specialized companies providing energy as a service to help clients lower electricity bills through renewable energy and/or energy efficiency. ESCOs typically own, operate, and maintain the energy infrastructure, while the client benefits from clean energy generation without the upfront capital costs. Clients enter into agreements such as power purchase agreements (PPAs) or leasing arrangements with ESCO, where they agree to purchase the energy generated by the system over a specified period at predetermined rates.

Internal rate of return (IRR) is a financial metric used to evaluate the potential profitability and attractiveness of an investment or project. It represents the discount rate at which the net present value (NPV) of future cash flows from the investment becomes zero. In other words, it is the rate at which an investment breaks even in terms of its cash flows.

Levelized cost of electricity (LCOE) represents the total cost of producing electricity (NPR per kWh) from a solar system or an energy source. This calculation spans the anticipated lifespan of the project and encompasses various elements, including construction, operation, maintenance, financing, and eventual decommissioning costs. It also considers the projected electricity output generated by the facility during its operational lifetime.

Net metering is a billing system that enables individuals or businesses with on-site renewable energy systems to consume the electricity they generate and when generation exceeds their consumption, export the surplus electricity to the grid through a bi-directional meter. Customers receive credit for the excess electricity, which can offset their future electricity bills.

Payback period is a financial indicator that represents the length of time it takes to recover the initial investment or cost of a solar project through the net cash inflows it generates. It is expressed in years and/or months and is a measure of how quickly an investment will break even and start generating positive returns.

Power purchase agreements (PPA) are legally binding contracts between a power producer or developer (ESCO) and a consumer or the utility (NEA), in which the producer agrees to generate and sell electrical power to the buyer over a specified period. PPAs are commonly used to facilitate the development and financing of power generation projects, particularly in the renewable energy sector, by providing revenue certainty for the producer and a stable energy supply for the purchaser. PPA define two major aspects, namely tariff and duration of the agreement

PV (photovoltaic) arrays are a grouping of multiple solar panels or solar modules interconnected together to generate electricity from sunlight. PV arrays are a fundamental component of solar power systems and are typically installed on rooftops or open ground areas to capture sunlight and convert it into electrical energy. A solar system can comprise one or multiple PV arrays.

PV (photovoltaic) systems are a complete set of components for converting sunlight into electricity by the photovoltaic process using solar PV panels. Such a system includes panels, inverters and a balance of the system to be a complete PV system.

Residential solar PV systems are solar systems designed to not exceed 1,000 V_{DC} for use in homes and residential properties. They consist of solar panels, an inverter, mounting structures, and associated components that work together to capture sunlight and convert it into usable electricity for household consumption.

Slope (of a roof) also known as roof pitch or roof angle, refers to the steepness or incline of a roof surface relative to the horizontal plane. It is typically measured as the ratio of the vertical rise (height) of the roof to the horizontal run (span) of the roof or degrees.

Solar grid-tied systems, also known as **grid-connected** systems, are systems where the solar panels are connected to an inverter that converts the direct current (DC) generated by the panels into alternating current (AC) that is also connected to the utility grid to sell excess electricity if approved by the utility company, e.g. Nepal Electricity Authority (NEA).

Solar inverters convert the direct current (DC) generated by the solar panels into alternating current (AC) that could be used within premises or fed into the utility grid.

Solar irradiation is the total amount of direct and diffused solar radiation received on a horizontal surface. It is measured in watt/m^2 on a horizontal surface.

Watt peak is the maximum electrical power that a solar cell can yield under standard testing conditions. While these conditions may not match those on a given site the value is used as a reference for comparing the performance of solar panels.

PART 1
ABOUT THE GUIDELINE

1.1 Purpose

This guideline has been prepared to aid readers without prior subject knowledge in planning and developing grid-connected solar PV systems. Though it does not qualify readers for the technical tasks involved, it provides the required high-level guidance on the vital process steps which include design, installation, testing and commissioning, financial analysis and management. The overarching aim is to enable non-technical readers to successfully develop and implement well-designed projects.

Note that the implementation of solar PV systems will require additional expertise. For example, experts should be engaged in assessing project feasibility, designing and sizing the system, analysing financial performance and development of the system on the ground. However, if carefully followed, this guideline educates readers to become conversant with the scope of work and the terminology, helps determine the specialist expertise needed and aids the validation of work produced by experts.

This document is intended for Nepal's federal, provincial and municipal governments. It is also intended for potentially interested house owners and owners of commercial and industrial establishments who are considering installing PV systems. Also, this guideline serves as a reference for developers of solar PV systems, financial institutions and the Renewable Energy Testing Station (RETS).

Structure of this guideline

Chapter 2: Why solar grid-connected systems?	▪ What are the benefits of solar PV systems? ▪ Does the government provide subsidies? ▪ What is the potential of solar systems in Nepal?
Chapter 3: Things to consider for planning a project	▪ What are the criteria to be considered? ▪ Which standards and regulations should be kept in mind? ▪ Which institutions are involved in a project?
Chapter 4: Assessing project feasibility	▪ How to assess the feasibility of a residential system? ▪ How to assess the feasibility of commercial and industrial systems?
Chapter 5: Does it make economic sense?	▪ How are the financial prospects analysed? ▪ Deciding whether or not to go ahead with a project
Chapter 6: Implementation of projects	▪ What are the steps in the project development? ▪ What permits and approvals do I need? ▪ How to connect my PV system to the grid?

1.2 Use of this guideline

For each of the intended audiences, this guideline offers practical advice for planning and developing grid-connected solar PV systems. Please note: the terms "must" or "shall" indicate aspects that are mandatory from a technical, financial, regulatory or operational perspective while "can" or "should" are used to indicate recommendations.

For planning, design and implementation	1) Clarifies the steps involved and criteria to be considered for developing solar PV projects. 2) Provides guidance on processes that require experts to be engaged for assessing project feasibility, system design, selection of components, determining costs and benefits, and evaluating the result of the work of experts. 3) Provides guidance on site assessment and design tools, system sizing approaches, required space and estimation of power generation. 4) Provides templates such as for detailed feasibility studies, along with reporting requirements to engage experts and monitor their performance. 5) Determines technical standards to be considered. 6) Provides a tool for determining the financial viability of solar projects. It allows the calculation of key indicators, namely the internal rate of return (IRR), payback period, and levelized cost of electricity (LCOE). 7) Provide valuable resources for provincial governments, LGs and developers in the implementation of solar grid-connected systems including system installation steps and timeline. 8) Provides information on quality control and monitoring of system components and the system. 9) Guides stakeholders on the grid connection process of solar PV systems and the technical and legal requirements.
For policy formulation	1) Comprehensive reference for promoting grid-connected systems within jurisdiction. 2) Provides guidance to policy formulation. 3) Provides key inputs that can be used for creating awareness at the community level to promote solar PV systems. 4) Identifies national-level stakeholders involved in solar rooftop systems and their respective roles.

PART 2 WHY SOLAR GRID-CONNECTED SYSTEMS?

2.1 The benefits of grid-connected solar systems

Grid-connected systems, also known as grid-tied systems or on-grid systems are solar PV systems interconnected to the electricity grid. Apart from generating electricity to be consumed in-house, they allow excess electricity to be fed in and sold to the grid, subject to permission of the utility (i.e., Nepal Electricity Authority-NEA).

For a grid-connected solar system, solar panels are installed on rooftops or open spaces to capture sunlight and convert it into electricity. The panels generate direct current (DC) electricity, which is then converted into alternating current (AC) electricity by an inverter. The AC electricity is compatible with the electricity grid and can also be used to power in-house appliances such as lights, computers and refrigerators.

When the solar panels produce more electricity than required on-premises, the excess electricity is automatically fed into the grid. This process is known as "net metering" based on a feed-in-tariff notified by NEA. The excess electricity is measured by a bi-directional meter, and the owner is usually credited for the exported electricity, which offsets their electricity bill.

When the solar panels do not produce enough electricity to meet the building's demand, for example during cloudy days, the system draws electricity from the grid to compensate for the shortfall. This ensures a continuous and reliable electricity supply.

Grid-connected solar systems allow buildings to generate clean energy, reducing energy consumption from the grid thereby reducing electricity bills. Additionally, the export and sale of excess energy are generating additional income while contributing to the nation’s supply of clean energy from renewable sources.

2.2 Types of systems

2.2.1 Residential systems

A residential solar photovoltaic (PV) system is a solar power setup designed not exceeding 1,000 V_{DC} for use in homes and residential properties. It consists of solar panels, an inverter, mounting structures, and associated components that work together to capture sunlight and convert it into usable electricity. Residential grid-connected systems primarily serve for self-consumption of solar electricity in order to become less dependent on grid electricity and to reduce electricity bills. The automatic export of surplus energy to the grid can generate additional income.

The popularity of residential solar grid-connected systems worldwide has increased in recent years. Australia, for example, has an impressive penetration rate of approximately 30% of the total of 11 million residential buildings. Customers are increasingly opting to install solar panels due to heightened awareness of renewable energy's importance in mitigating global warming. Moreover, they directly witness the advantages through their electricity bills that come with the installation of solar panels on their roofs. These benefits include offsetting their electricity consumption and receiving credits on their bills for surplus energy exported to the grid.

Furthermore, the Australian governments at both the federal and provincial levels have implemented various incentives to promote the adoption of solar panel installations among customers. Additionally, the straightforward process of connecting solar systems to the local distribution lines has also played a significant role in encouraging customers to embrace solar PV in Australia.

2.2.2 Commercial and industrial (C&I) systems

A solar PV system installed on a non-residential structure and operating up to 1,500 V_{DC} voltage falls into the commercial and industrial solar PV systems category. Due to its high DC voltage level, public access to this system is strictly prohibited. However, according to the NEA directive, a commercial system is officially designated as one exceeding 10 kW up to 500 kW output, while an industrial (utility) scale system surpasses 500 kW output.

Many commercial and industrial establishments own diesel generators to ensure electricity supply during blackouts. As of 2021, electricity costs from diesel gensets in Nepal range from 25 to 30 NPR per kWh dependent on the running costs and the diesel price.

Typically, such establishments have large roof areas on their buildings, manufacturing facilities, and warehouses. These tend to lend themselves more easily to the installation of solar panels at lower cost compared to residential buildings. As of 2023, the levelized cost of electricity from solar rooftop PV systems is in the range of 7 to 15 NPR per kWh depending on the size and components of the system. Technically, there is no difference between residential and commercial/industrial systems although the latter can be significantly larger.

2.3 Solar PV potential in Nepal

2.3.1 Technical potential

Nepal's equatorial proximity and varying altitude contribute to high levels of solar radiation year-round. With an average solar radiation range of 3.5 to 6.6 kWh per kW_P installed per day and approximately 300 days of sunshine, Nepal offers substantial potential for solar power generation.

Urbanization in Nepal has increased by more than 4% annually over the last ten years, resulting in a growing number of urban households connected to the grid. A study[1] conducted in five major cities – Kathmandu, Pokhara, Butwal, Nepalgunj, and Biratnagar – found that the technical potential of solar grid-connected systems of Nepalese households is 5 MWh per year (based on an average roof area of 93 m^2 per household). As of 2021, NEA serves around 5 million domestic consumers, 87,000 commercial clients, and about 16,000 industrial clients. Many of them may have the potential for grid-connected systems using net-metering. The continued intermittence of electricity supply, the abundance of solar resources, mature technology, and financial advantages combined with the net-metering policy make solar grid-connected systems a viable option in the country. With an urban population of about 6 million in 2020, grid-connected systems have the technical potential to contribute up to 6.5 TWh of electrical energy to Nepal's energy supply.

[1] The potential for rooftop photovoltaic systems in Nepal – www.mdpi.com/1996-1073/16/2/747

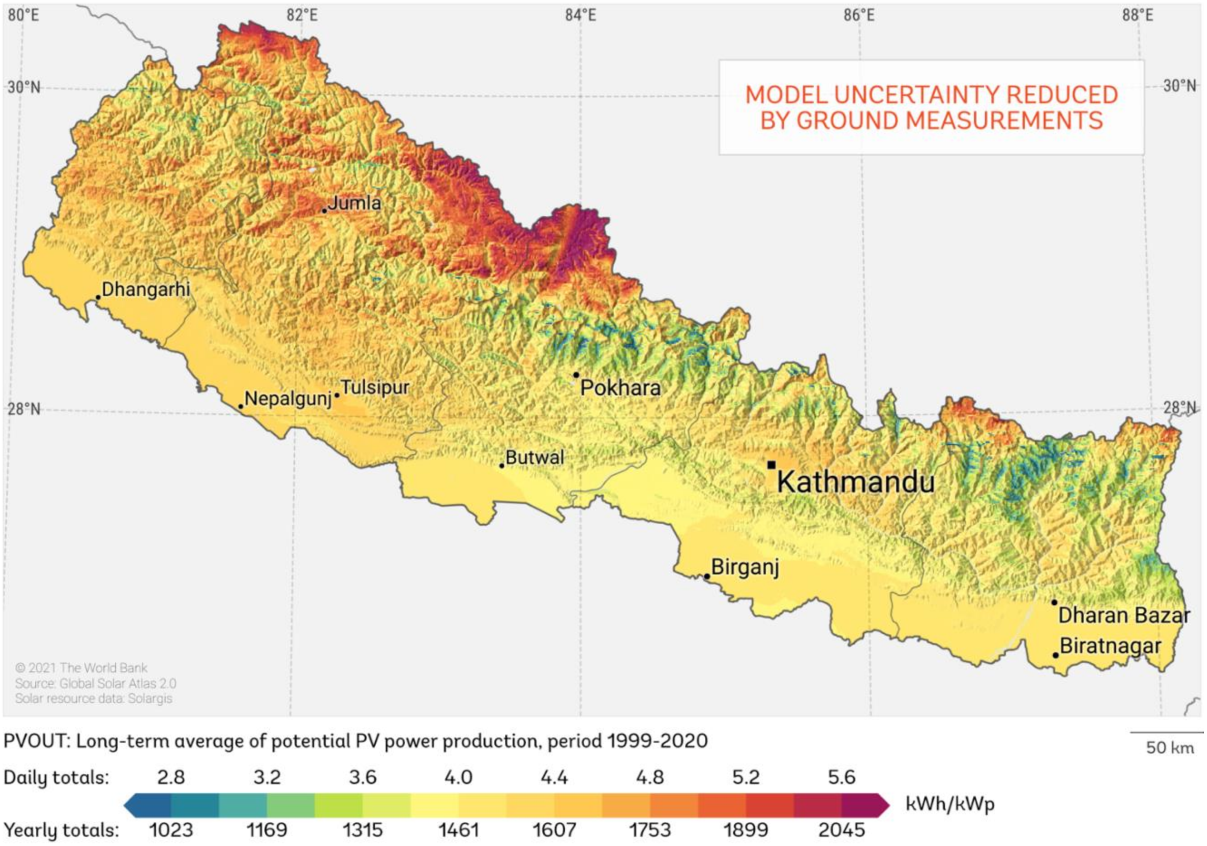


Figure 1: Photovoltaic potential in Nepal – Source: World Bank Group (ESMAP)

2.4 Economic potential

The decreasing cost of PV components progressively increases the affordability and accessibility of solar energy, while the rising prices of grid electricity make solar power an appealing alternative. Further, it allows individual house owners, commercial entities and industries to generate power locally which ultimately improves system reliability and voltage level. Similarly, being a prominent clean technology, solar PV can reduce greenhouse gas emissions (GHG) significantly. Together, these factors support the claim that solar electricity is expected to be cost-competitive with other sources such as hydropower. Chapter 5 provides guidance on the evaluation of economic viability and returns on solar PV projects.

2.5 Policies and incentives

Alternative Energy Promotion Centre (AEPC) continues to play a vital role in scaling up the adoption of grid-connected solar PV systems through subsidies, rebates, training, and policies. Nepal Electricity Authority (NEA), on the other hand, as the sole national off-taker of solar-generated electricity, provides the needed incentive through net-metering. The collaborative endeavour of AEPC and NEA is poised to promote wider implementation of grid-connected systems throughout the nation. The most pivotal incentives are explained in the following chapters.

2.5.1 Subsidy

AEPC has been providing various financial incentives under the current RE Subsidy Policy 2078 B.S. for solar rooftop systems. For commercial establishments such as companies, industries, factories, commercial buildings, and private offices with solar PV capacity exceeding

1,500 W_P, AEPC extends two options for support. This includes a 50% interest subsidy[1] on bank loans for five years or 1.5 Rupees per kilowatt hour (kWh) of energy generated[2] over a five-year period. Conversely, at the household level, AEPC offers a substantial 75% interest subsidy[3] on bank loans spanning five years for solar PV capacities exceeding 500 W_P. Furthermore, the existing subsidy policy facilitates a 50% subsidy[4] for solar rooftop systems under the public-private partnership (PPP) model through the Viability Gap Fund (VGF). To apply for the subsidy, users will have to fill up a form and get it endorsed by AEPC (refer to Annex 4).

2.5.2 VAT and import customs duty waivers

Solar panels and grid-connected solar PV inverters are fully exempted from value-added tax (VAT) while the import customs duty for these stands is reduced to 1%. PV racking, cables, switch/control gear, enclosures and cable trays also enjoy reduced import customs duty on a per-project basis based on the recommendation of AEPC. Solar developers who wish to benefit from these must apply with a specific set of documents to qualify, the list of documents will be provided by AEPC upon request. The waivers are designed to encourage adoption by reducing the financial burden on consumers.

Table 1: VAT and import customs duty waivers for Solar PV

Components	Incentives	Reference
Grid inverters	VAT free Import customs duty reduced to 1%	Finance Act, 2020 Section 22 (12) of Schedule 1
Solar panels		
Cables	Import customs duty reduced to 1% but requires AEPC recommendation	
Cable trays		
Enclosures		
PV racking		
Switch/control gear		

2.5.3 Net metering policy

In 2018, the Ministry of Energy, Water Resources and Irrigation (MoEWRI) issued the Grid Connected Alternative Energy Working Procedure that removed significant barriers to entry for solar energy producers in Nepal. Updates and amendments of the directive in 2021 and most recently in February 2023 categorize the process based on system capacity. Grid-connected solar systems of capacities of up to 500 kW do not require a license (while those above 500 kW require a license) and can be connected to the national grid under the net metering policy through NEA (refer to Annex 18).

[1] AEPC, RE Subsidy Policy 2022, Annex 11, 11.3.4, Page 12

[2] AEPC, CREF Operational Manual 2071 (1st Ammendment 2078), Annex 5, Page 29

[3] AEPC, RE Subsidy Policy 2022, Annex 11, 11.3.4, Page 12

[4] AEPC, CREF Operational Manual 2071 (1st Ammendment 2078), Annex 5, Page 29

2.6 Promotion by PGs and LGs

The Federal Government of Nepal formulates the policy to promote renewable energy in the country. The provincial and local governments are vital for implementing and meeting these targets by formulating their policies and targets. Considering the mandate granted to provincial and local governments for framing their policies by the constitution, some suggestions are provided that could promote the implementation of grid-connected systems. Based on the policy formulated, actions could be taken on the following aspects.

Targets: Provincial and local governments can set annual targets for installing grid-connected systems based on a certain total capacity or a certain number of households per year. This could be followed up with a plan to realise these targets and monitoring.

> **Example from Australia**
>
> The New South Wales Government set the ambitious target for zero-emissions by 2050. To support the state, the city council of Wagga Wagga has set a target to meet net zero emissions on council's corporate buildings by 2040 and in individual households by 2050. The city council has formulated specific strategies such as the promotion of solar rooftop systems on council and residential buildings. The council's ability to sell greenhouse gas emissions avoided to the state and federal government enables it to use this revenue to promote solar rooftop system in the council.

Mandatory installation: Governments could make mandatory solar rooftop systems for new residential buildings.

Incentives: Governments can offer incentives to commercial and industrial customers who install solar systems on their premises such as soft loans.

Equity fund: Provincial governments could set up equity funds to promote solar rooftop systems. The fund can be used to provide soft loans to residential, commercial and industrial customers.

Tax incentives: Governments could design programmes to incentivise commercial and industrial customers in tax on solar components or encourage them to install solar on their tax remittances or provide tax incentives on their products if they install solar systems.

Generation-based subsidies: Governments could offer generation-based subsidies to solar energy generators to promote solar rooftop systems. Subsidies could be based on the grid electricity or CO_2 emissions offset.

Rating systems: To encourage the installation of solar rooftop systems for factories, governments could introduce rating systems such as green tags or star systems against certain product categories of products.

PART 3
THINGS TO CONSIDER FOR PLANNING A PROJECT

Special note	Solar PV projects **require experts that need to be engaged** for the feasibility study as detailed in Chapter 4. It would be advantageous, however, for anyone seeking to develop a project to be conversant with the principal criteria, standards and design considerations. This would enable even non-technical readers to become conversant with these aspects, enable them to provide critical review of the options, proposed experts and **take informed decisions.** This chapter thus seeks to familiarise readers with the essentials.

3.1 Essential aspects

When considering a project, it is important to keep in a clear view certain essential aspect. These need to be evaluated based on factual information. The most vital aspects to be considered are described below.

- **Installation area:** The availability of space for the installation of PV panels is the most pivotal criteria for the system size and capacity. Selected spaces must not be exposed to daily or seasonal shading. Projects with more space can generate more electricity and provide a better return on investment. Roof space is generally well suited for such purpose because it cannot be used for other purposes. Alternatively, panels can be installed on the ground with suitable mounting structures.
- **Electricity consumption:** The energy consumption of the building or institution considered for the solar project also helps to determine the size and capacity of the system. Projects with higher energy consumption may require larger systems to meet their energy needs. A requirement for net metering is that the total energy being exported to the grid must not be more than 90% of the total consumption of the electricity by the customers.
- **Sunlight:** The amount of sunlight reaching the installation area, called solar irradiance (refer to Figure 1) determines the output and viability of a solar project. Areas with high irradiance are more attractive than those with lower levels.
- **Financial viability:** Financial viability determines the project's feasibility and sustainability. Project costs, incentives, and revenue streams must be carefully evaluated to ensure a positive return on investment.
- **Technical feasibility:** To be realized, a project must be technically feasible. The assessment of technical feasibility evaluates, among other things, installation structures (roof, roofing structure, columns and beams, etc.), the project design, the electrical capacity, and interconnections.

- **Regulatory compliance:** Projects must be compliant with applicable regulations and standards. This includes the NEA's directives on electrical codes and connection types, the Nepal National Building Code and the zoning regulations from the Land Use Policy 2015. Residential systems must have an inverter compatible with the grid at 230 V or 400 V with 50 Hz frequency. PV systems with a capacity greater than 10 kW are classified as institutional and must have a 400 V_{AC} and above 40 kW require an 11,000 V supply and extra protection. The DC side of a solar system should be designed and installed below 1,000 V_{DC} for residential systems and up to 1,500 V_{DC} for commercial and industrial systems regardless of their AC classification.

Table 2: Categorization of grid-connected solar PV systems as per NEA directives 2078 B.S.

Category	Size	Modality	Connection voltage
Residential systems	500-10,000 W	Net metering	230 V – Below 5 kW 400 V – Above 5 kW
Commercial and industrial systems	>10-500 kW	Net metering	400 V – Below 40 kW 11 kV – Above 40 kW
Utility-scale systems (*not part of this guideline*)	Above 500 kW	Feed-in tariff	Connection at substation

3.2 Roles of institutions

Promoting renewable energy and solar PV technology has several goals. These include improving the availability of clean energy, augmenting grid electricity supply, increasing the non-hydro power generation mix in the national grid for the country's energy security, and addressing global warming and climate change concerns by reducing GHG emissions.

Several institutions are involved in the promotion and adoption of grid-connected solar PV systems in Nepal. They have distinct roles, ranging from formulating policies to installing systems to providing financial incentives, to providing quality assurance and monitoring. Coordination and collaborative efforts among these entities are crucial for expanding access to solar energy and decreasing carbon emissions. The most important institutions and their main roles are outlined in the table.

Table 3: Stakeholders and their roles and responsibilities

Stakeholders	Roles and responsibilities
Ministry of Energy, Water Resources and Irrigation (MoEWRI)	Develops policies that aid in scaling up grid-connected solar PV systems and other renewable energy technologies, set national targets with a specific timeline, and implement international agreements related to the promotion of clean energy as ratified by the government
Provincial governments	Develop provincial policies and financial incentives to promote grid-connected solar systems in their respective jurisdiction
Local governments	Develop strategies to implement renewable energy and achieve targets for solar PV systems. Create financial incentives to encourage the adoption of such technologies within their jurisdiction
Nepal Electricity Authority (NEA)	▪ Ensures the implementation of net metering ▪ Approves grid connection of the solar system based on application ▪ Installs bi-directional energy meters ▪ Regulates AC side connection and compliance
Alternative Energy Promotion Centre (AEPC)	▪ Facilitates VAT and customs waivers for the import of solar components ▪ Formulates standards for solar panels, inverters, and other components. ▪ Can assist provincial and local level departments in connecting with federal-level government departments
Renewable Energy Test Station (RETS)	▪ Assures compliance with technical standards for grid-connected solar PV systems. ▪ Establishes a prequalification process for large-scale solar grid-connected systems. ▪ Conducts testing and certification of solar grid-connected systems. ▪ Establishes pre-approved designs and defines certification protocols for all equipment used in solar grid-connected systems.
Solar projects developers	▪ Prepare project plans and gain necessary approvals for installation and connection. ▪ May assist in arranging finance (equity or loan) for the project ▪ Engage local stakeholders in project planning and design ▪ Design and develop solar grid-connected systems
Energy services company (ESCO)	▪ Design, build, own, operate, and maintain solar PV systems shouldering the upfront capital costs. ▪ Establish PPAs or leasing arrangements for the purchase of the energy generated by the system by the client over a specified period at predetermined rates.
Users (house owners, owners of commercial and industrial establishments)	▪ Keep the system clean ▪ Monitor system performance ▪ Secure the system and components against theft ▪ Inform qualified technicians in case of issues ▪ Check the electricity bill that the solar export is credited by NEA ▪ To maximise benefits, operate appliances preferably during sunshine hours

3.3 Standards and by-laws

AEPC has developed the Nepal Photovoltaic Quality Assurance (NEPQA) to regulate PV industry in Nepal. To date, NEPQA is the primary document that specifies the documents and technical requirements of the components used in solar PV systems. Currently, the NEPQA 2015, Rev. 1 published in February 2016 is in effect. The solar sector in Nepal, including the PV component testing lab, Renewable Energy Test Station (RETS), is regulated based on the standards set in NEPQA.

For solar grid-connected systems where the major components are solar PV modules and grid-connected inverters, the technical requirements of the system defined in NEPQA are currently limited to solar PV modules only. It does not set standards for grid-connected inverters or other components. For components not included in NEPQA, IEC and other international standards should be referred. To connect the system to the national grid, the user must submit a letter of request along with a grid connection agreement with the NEA (refer to Annex 2). NEA will gauge the system's integrity and standard for connection only after the letter is submitted and the system is verified by RETs.

3.4 Design considerations

3.4.1 Technical factors determine economics

The design of the system and selection of system components (refer to Annex 1), form part of the feasibility study detailed in Chapter 4. For both, it is essential to consider technical aspects carefully as they will determine the economics.

Orientation of PV array	The orientation of the PV array significantly impacts power generation. If the site offers flexibility in positioning the solar panels towards due south, it is advisable to do so. If there are costs associated with realizing the best orientation, a careful comparison between the costs and the potential benefits shall be made. It is helpful to use simulation software (detailed in Chapter 4) to ensure that the considered orientation offers the best or sufficiently good economics.
Tilt angle of PV array	Power generation also varies with tilt angles. The optimum tilt should be determined for the site. It is advantageous to aim for the optimum angle provided it can be realized without a significant increase in costs. If the installation space is a roof, aesthetic aspects invariably also come into consideration and compromise may have to be worked out. It is helpful to use simulation software (detailed in Chapter 4) to ensure that the considered tilt offers the best or sufficiently good economics.
Quality of components	The project's economics are tied to the electricity output. Besides the system design, electricity output in turn relies heavily on the quality of the components. Higher-quality components typically come with a higher price tag. Due care must be taken in the selection process to compare component costs with additional benefits they offer, such as extended warranties, increased efficiency, and other benefits.

3.4.2 Which type of system is right?

The principal design considerations for grid-connected systems are whether or not to include a battery. For a better understanding of each system type with respect to the components connected, refer to Annex 14.

Grid-connected systems without battery: Typically, these systems are below 500 kW. Systems equal to or above 500 kW are considered "utility-scale" PV systems which are outside the purview of this guideline. The energy produced can be used for self-consumption while surplus electricity can be exported to the grid under net-metering regulations. To be eligible for net metering, NEA requires systems to be below 500 kW and the majority of electricity being used for self-consumption.

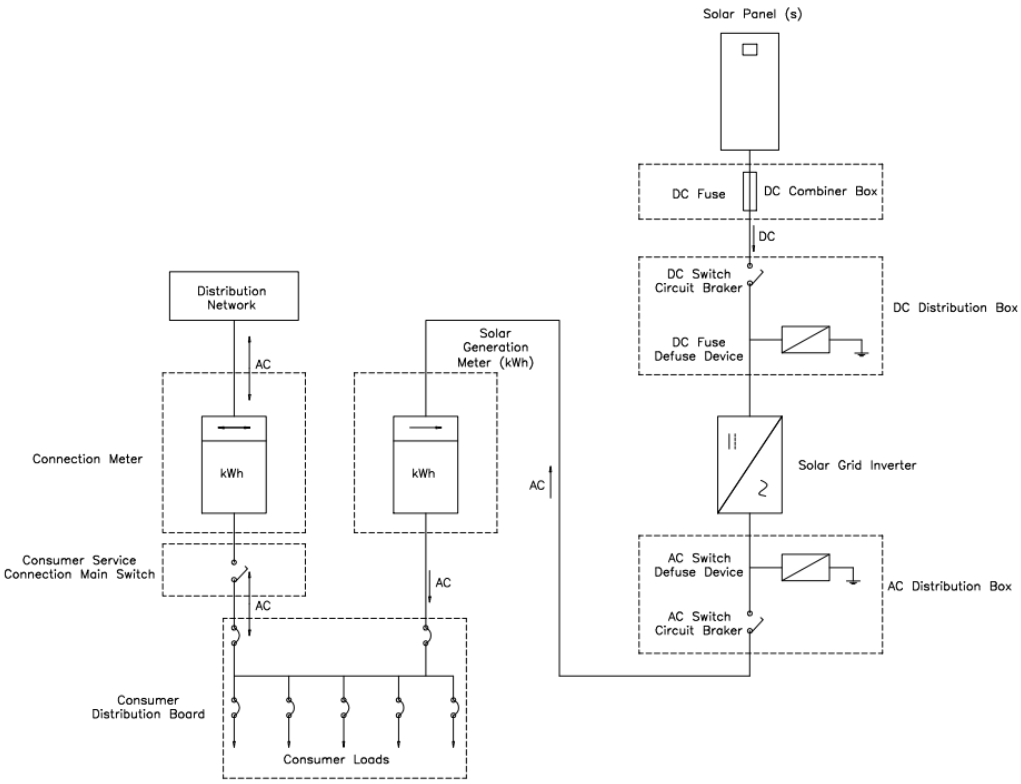


Figure 2: Single line diagram of a grid-connected system without battery

Special note	Systems without batteries are used in areas where net metering is in practice and the grid supply is fairly stable.

Grid-connected systems with battery, DC coupled: These systems include a battery on the DC (direct current) side of the inverter. Once the battery is fully charged, the excess electricity will be directed to the loads for self-consumption or surplus exported to the national grid depending upon the priority set between sources and loads. Primarily, hybrid inverters with in-built charge controllers are connected to the battery bank.

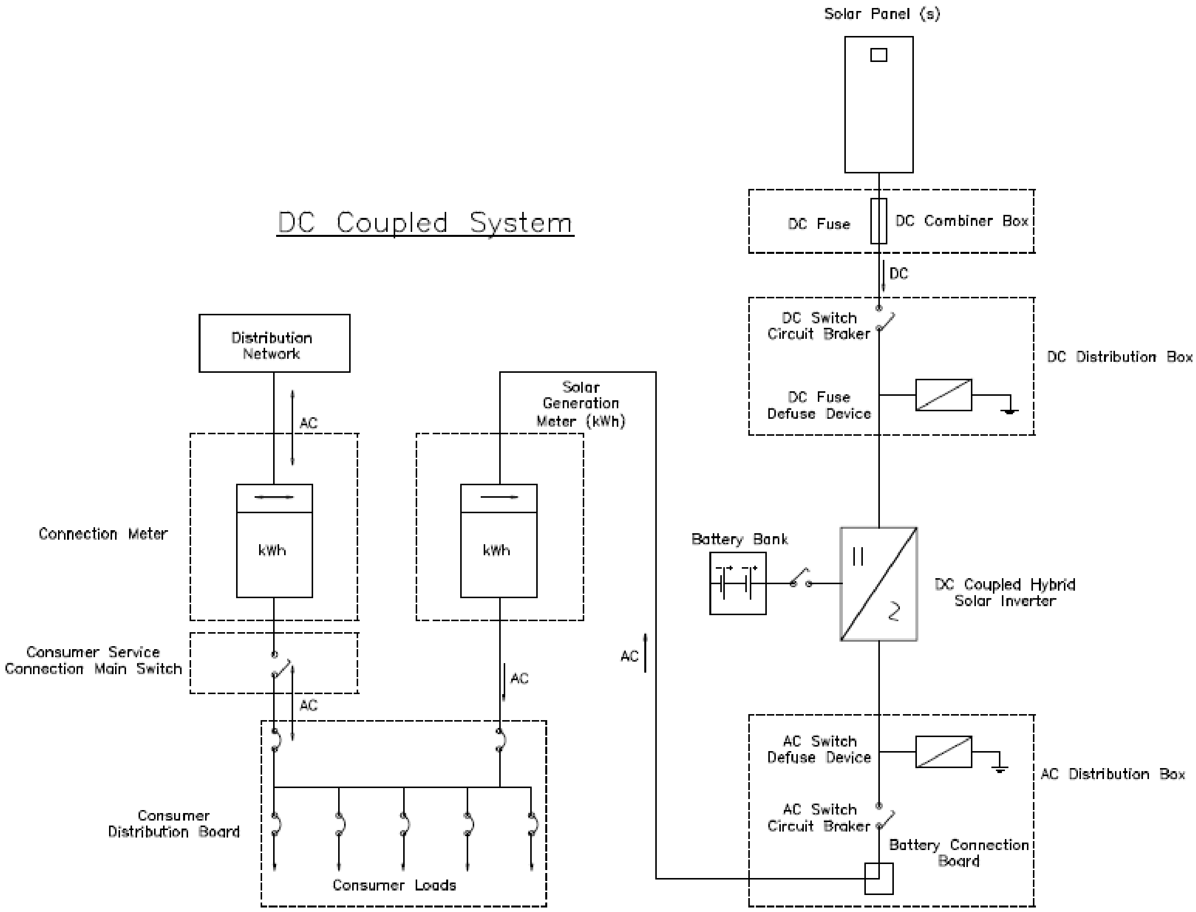


Figure 3: Diagram of a grid-connected system with battery, DC coupled

Special note	These systems are mostly used when the grid is less reliable, when the power demand is not enormous and when the priority is self-consumption.

Grid-connected systems with battery, AC coupled: These systems include a battery inverter as well as PV inverter coupled on the AC side of the inverter. The AC output from the inverter can be utilized for self-consumption, to charge the battery or for exporting to the national grid depending upon supply and usage.

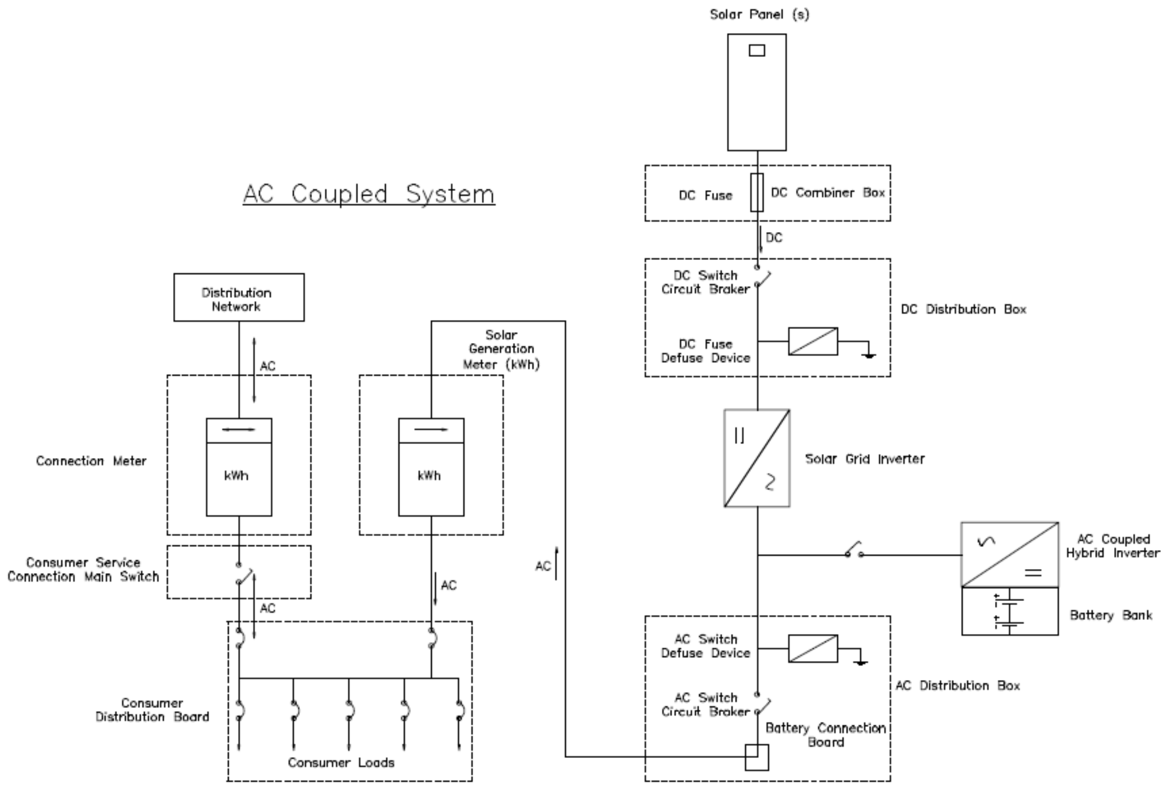


Figure 4: Diagram of a grid-connected system with battery, AC coupled

Special note	These systems are mostly used when the grid is less reliable, where the load demand is high and where flexibility for future expansion of the system is desired.

3.4.3 What is the energy yield?

The average daily solar radiation in Nepal ranges from approximately 3.5 to 6.6 kWh per kW_P installed per day. However, the amount of solar energy received at a particular location depends on the latitude, time of the year and day, atmospheric conditions, altitude and elevation, obstructions and shading, seasonal variations and long-term climate patterns.

To obtain solar radiation data of a particular location, reliable online solar maps are recommended. Even better would be the use of measuring equipment such as the Solmetric SunEye to assess the location's solar energy potential. Alternatively, solar handbooks or maps published as books may be used. While using such data, the following steps are recommended:

- Locate the place on the solar map to get radiation data of the intended location. The solar radiation is expressed in terms of kWh/m^2/day or MJ/m^2/day. If the radiation is measured in MJ, then divide the MJ value by 3.6 to get to kWh.
- Once the solar resource at the location is figured out, then estimate the electricity generation from the system using the method described at Annex 1.
- However, it is recommended to use dedicated software rather than manual calculation for better accuracy. Various software tools are in common use by practitioners. All of them allow for the simulation of the orientation, the tilt angle and optimizing the system design for the best energy yield. The software also helps in project planning and determining the economics. The most widely used software and its features are listed below for further

reference. In the selection of experts for the feasibility study, it is recommended to ask which simulation software they intend to use.

Table 4: Software for system simulation

Modelling software	Features
HelioScope	Site analysis, design and layout, performance modelling, financial analysis, module database, shade analysis, customised reports, simulation reports, integration with remote sensing data, collaboration and sharing, compliance and support.
Homer PRO	System modelling, load profiling, resource assessment, optimisation, scenario analysis, economic analysis, technical analysis, reporting, user-friendly interface, and integration with other software.
PVsyst	PV module database, system design and simulation, weather data, data analysis, user-friendly interface, simulated output of the PV system, determining if the project is bankable.
PVSol	3D visualisation, solar irradiance calculation, system design, performance modelling, financial analysis, module database, battery storage, simulation and analysis.
RETScreen	Clean energy project analysis, project lifecycle analysis, energy performance analysis, GHG emission analysis, geographic data, customisable reporting, energy project database, and training resources.
System advisory model (SAM)	Models and assess the performance and financial feasibility of various renewable energy technologies, including solar PV systems. SAM provides advanced modelling capabilities, including system configuration, energy output estimates, financial analysis, and sensitivity analysis.

3.4.4 What is the performance ratio?

To get an idea of how a grid-connected solar PV system is performing compared to its expected output under ideal conditions; an assessment of the performance ratio (PR) of a system is carried out. The performance ratio is a measure of the quality of a solar PV plant independent of location and therefore is sometimes described as a quality factor. It is the ratio of system energy (actual) to expected energy output (theoretical/calculated), as an indicator, the higher the performance ratio the better is the system performance. In general, a performance ratio of 70 – 90%, depending on the specific technology, location, and environmental conditions is considered to be good for a well-designed and well-maintained solar PV system. If the performance ratio is below 50%, it indicates that the system has issues related to design and/or maintenance (such as panel or inverter malfunctions, shading issues, or wiring problems) which need to be addressed soonest.

$$PR = \frac{E_{syst}}{E_{ideal}}$$

E_{syst} = Total amount of electricity produced by the PV system in a year (kWh or MWh).

E_{ideal} = This is the energy that the PV system could potentially produce if it operated under perfect conditions, with maximum sunlight exposure and no losses due to factors like shading, soiling, temperature, and other losses measured in kWh or MWh.

Regular monitoring of the performance ratio is essential to identify any changes in system performance over time, track the impact of maintenance activities, and ensure that the solar PV system is operating optimally.

3.4.5 Selecting solar panels and inverter

The NEPQA guidelines and NEA directives must be adhered to when selecting and designing the system and components. In cases where specific guidelines or standards are not available for a certain component, IEC standards or the closest available guidelines shall be followed.

3.4.5.1 Solar PV panels

One of the most important tasks in a grid-connected solar PV system is selecting and designing PV module. The PV modules must be certified by RETS in order to be eligible for incentives. Factors that are essential before selecting PV panels, including their suitability for use in Nepal are mentioned below:

- For a residential grid-connected solar PV system, it is recommended to limit the DC voltage of the array up to 1,000 Volts, while the maximum voltage of 1,500 Volts should be selected for commercial and utility-scale solar PV systems. For roofs surrounded by shading objects like trees, chimneys, or overhead cables, and in areas with low solar radiation, thin film panels are preferred over crystalline panels to achieve the intended system capacity. The designer/installer shall confirm the panel grounding protocol with the module manufacturer since it may differ from standard practices.
- Rigid panels are recommended for flat or sloped roofs, while flexible panels are preferred for curved roofs, if available.
- The fill factor of proposed crystalline modules above 150 W_P and thin film modules shall be at least 75%.
- The junction box of the panel must have an IP67 water ingress protection rating, and the cable lead should be long enough to create a wiring loop during panel installation.
- Panels with high wattage and a low physical footprint, i.e., higher efficiency, should be selected for any project. However, the selection is subject to factors such as financials and client requirements.
- (For example, 350 W_P and above panels will have an efficiency of at least 18%. The module efficiency for the thin film module shall be at least 12%).
- If a number of solar PV modules fulfils the criteria mentioned above, Table 5 can be used to select a suitable panel.

Table 5: Solar panel specifications to be met for eligibility for incentives

Monitoring indicators	Reference values
Power tolerance (if any)	Plus, or minus 3%
Power warranty	Linear power warranty of at least 25 years
Light-induced degradation	Not more than 3% (the less the better)
Degradation of power per year	Not more than 0.7% of the STC value
Loss of power in 10 years	Not more than 10% (the less the better)
Loss of power in 25 years	Not more than 20% (the less the better)
Mechanical warranty	At least 12 years (the higher the better)
Frame construction	Anodised aluminium

Mono-crystalline panels offer better performance than poly-crystalline panels in terms of efficiency. If front-row shading is unavoidable, half-cut panels are preferable over full-cell panels.

Special note	Only solar PV panels of the same type, wattage and voltage must be combined to form one string. Solar PV panels installed in different orientations must not be combined in one string.

3.4.5.2 Solar PV inverter

The selection of the right type and size inverter is vital for grid-connected solar PV systems. The inverter must comply with the Electricity Regulation 1993, clauses (a) and (b) of sub-rule (1) of Chapter 4. The inverter shall have AC voltages and frequency ratings compatible with the NEA grid code. The nominal voltage at the point of supply is 230 V AC for single-phase and 400 V_{AC} three-phase line-to-line with a tolerance of ± 10% and frequency of 50 Hz ± 2.5%. Also, the selected grid-connected inverter shall have the capacity of bi-directional power flow, total harmonic distortion (THD) shall be less than 5%, anti-islanding function and power factor within 0.8 lag and 0.95 lead at the inverter terminal.

The aim is to match the PV array size to the inverter to ensure that the system can deliver its full power. When a system is well designed, the solar PV array's output voltage, current and power must be within the inverter operating range at all times. Basic considerations to be noted while selecting inverters are:

- It is important to avoid an undersized or oversized inverter. The former may lead to overloading while the latter depresses the economic viability. It is recommended to choose an inverter offering a solar PV array-to-inverter ratio of between 1-1.33 to accommodate derating of solar PV array performance.
- The size and voltage of the string, or strings, must be within the inverter's maximum DC input capacity and voltage range. The solar grid connected system design, estimate, and performance manual tool in Annex 1 can provide a calculation method to determine the maximum and minimum number of panels per input.
- Mismatches of solar PV panels and strings with different orientations should be avoided. However, panels facing a difference of no more than 5 degrees can be mixed, and equal numbers of panels facing 2 directions can be connected to form an array. For example, it is possible to connect strings of 6 panels facing east and 6 panels facing south to one maximum power point tracker (MPPT), preferably with blocking diodes at the combiner box.

- If outdoor inverters are to be installed, it is essential to select inverters with suitable IP ratings, with most outdoor inverters rated at IP65 or above.
- If the customer intends to install a battery bank soon or later, a suitable hybrid inverter system should be selected. It is important to ensure that the selected inverter complies with the NEPQA and that its AC output adheres to NEA directives.

Table 6: Inverter output specifications to be met for eligibility for incentives

Parameters	Value / Range	Regulation
Voltage	230 V_{AC} line to neutral 400 V_{AC} line to line (±10%)	NEA grid code
Frequency	50 Hz (±2.5%)	NEA grid code
Power factor	0.8 leading to 0.95 lagging for all output from 20-100% of rated output	
Total harmonic distortion	±5%	IEC 61000

3.4.6 Selecting other components

The components required for the functioning of a solar PV system, excluding the solar panels and inverters, are collectively referred to as the balance of system (BOS). This encompasses electrical, mechanical, and structural components. The following section details the selection process and design considerations for the balance of the system.

3.4.6.1 Cables

The type of cable to be used is determined by the application (e.g., DC, AC, indoor, outdoor, voltage level, etc.) and size is determined by the current considering the allowable voltage drop. However, grid-connected solar PV systems shall have DC-rated cables for suitable voltage and current ratings before the inverter input and AC-rated cables for suitable voltage and current ratings after the inverter output. The calculation of cable size should be based on its current carrying capacity while accounting for relevant derating factors. Voltage drop analysis should also be conducted to determine if any cable size needs to be increased to reduce the voltage drop. The cable shall be sized to carry at least 1.25 times the maximum short circuit current on the conductors. Some of the factors used to calculate cable size are listed below.

Current carrying capacity: The maximum continuous current that a conductor can safely carry without exceeding its rated temperature, sometimes referred to as ampacity. Selecting an inadequate cable size for the continuous current capacity can result in cable damage and pose safety risks during installations.

Short-circuit temperature limit: This is the temperature that cables can adequately handle when exposed to their maximum prospective short circuit current.

Voltage drop: The loss of voltage occurring along the cable run due to the cable's internal resistance is known as voltage drop. Voltage drop is very significant especially when currents are high and the voltage is low such as on the DC side of solar PV systems. It is important to take this into account when sizing PV cables. After determining the cable size based on maximum current carrying capacity and relevant rating, derating, and multiplication factors, the voltage drop for the cable's size and length is to be checked. If the voltage drop is within the acceptable limit, the cable size is selected; otherwise, the cable size is increased to restrict the voltage drop (with a maximum allowable voltage drop of up to 3% on the AC and DC side). DC side voltage drop shall be calculated considering the distance from the farthest panel to the inverter input and AC side voltage drop shall be calculated from the inverter output point to the point of supply (connection point for NEA supply). Ensuring that the system complies with the condition is the job of a consultant/engineer hired to carry out the task. A template for the ToR of the consultant can be found in Annex 3.

DC side voltage drop can be calculated as follows:

$$Vd\% = \frac{\mathrm{I}_{\mathrm{SC}} \mathrm{x}\ 2\ \mathrm{x}\ \mathrm{L}\ \mathrm{x}\ \mathrm{R}_{\mathrm{C}}}{1000\ \mathrm{x}\ \mathrm{V}_{\mathrm{mp}}}$$

Where,

I_{SC}: Short circuit current

L: Length of cable route from origin to termination

R_C: Resistance of cable in ohms per kilometre

V_{mp}: Array voltage

Alternatively, this online calculation tool can be used to calculate voltage drop: https://photovoltaic-software.com/solar-tools/voltage-drop-calculator-dc-ac

3.4.7 Protection systems

Solar PV systems must be protected against potential damage caused by electrical faults. They are essential for ensuring the safety and reliability of the system. This section explains the protection systems that are recommended.

3.4.7.1 Isolators and circuit breakers

Isolators, miniature circuit breakers (MCBs) and enclosures are crucial for solar PV systems' safety and reliability. Proper installation and maintenance are necessary to prevent damage and hazards. When installing isolators or MCBs or other disconnection devices, use a suitable IP enclosure depending upon outdoor or indoor use. The switchgear should have a current rating of 1.25 times the highest possible current in the cable. Over-current devices must comply with IEC 60947-2 and must not be polarity-sensitive. For residential applications, MCBs should have a voltage rating of at least 1,000 V_{DC}, while for commercial applications, they should be at least 1,500 V_{DC}. All DC-side components must have a suitable voltage and current rating. Outdoor equipment and enclosures should be at least IP65-rated and resistant to ultraviolet (UV) rays.

3.4.7.2 Surge protection devices

Surge protection devices (SPDs) safeguard the solar PV system from voltage surges and transient overvoltage events such as may be caused by lightning strikes or switching. For solar applications, they are required for both DC and AC sides. Please note that surge protection devices for DC differ from those for AC. The selection of the type also depends on the maximum continuous operating voltage, the voltage protection level and the nominal discharge current.

SPDs should be installed upstream of the devices they will protect. The number and placement on the DC side depend on the cable length between the panels and the inverter. If the cable length is 10 metres or less, one is sufficient which should be mounted with the inverter. Above 10 metres two devices are required, one with the panel and one with the inverter. If the inverter is more than 30 metres from the nearest combiner box, an extra device is required at the DC input of the inverter.

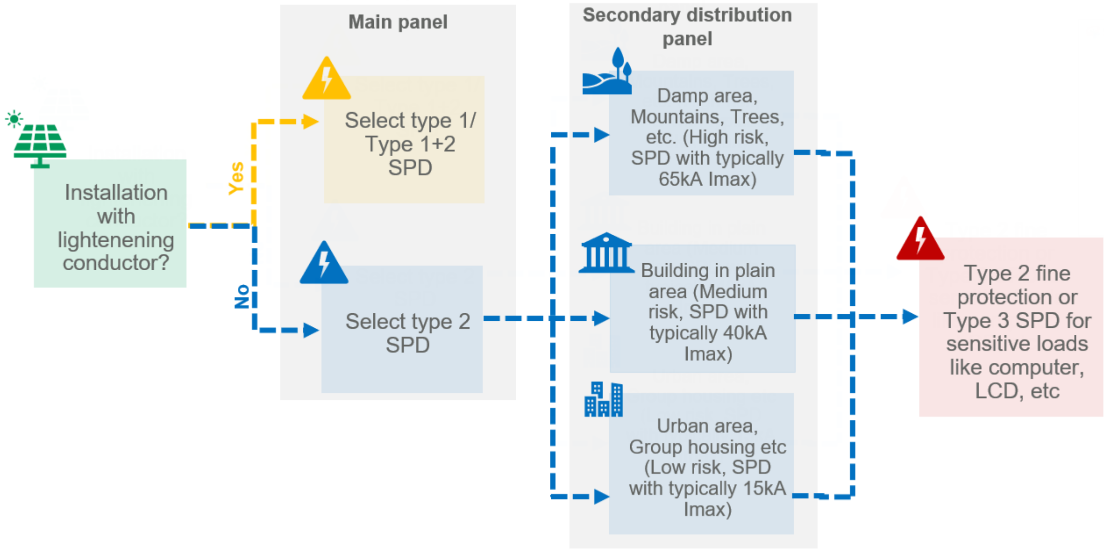


Figure 5: Decision tree for selection of AC side surge protection devices

3.4.7.3 Lightning protection

Notwithstanding the absence of any specific guidelines on lightning protection systems for grid-connected solar PV systems in Nepal, solar service providers are advised to install lightning protection that covers the area of the solar system installation. Every solar PV module must be earthed continuously using an earthing cable of suitable size (at least 4 mm^2) through PV frames in accordance with the manufacturer's recommendations and PV racking.

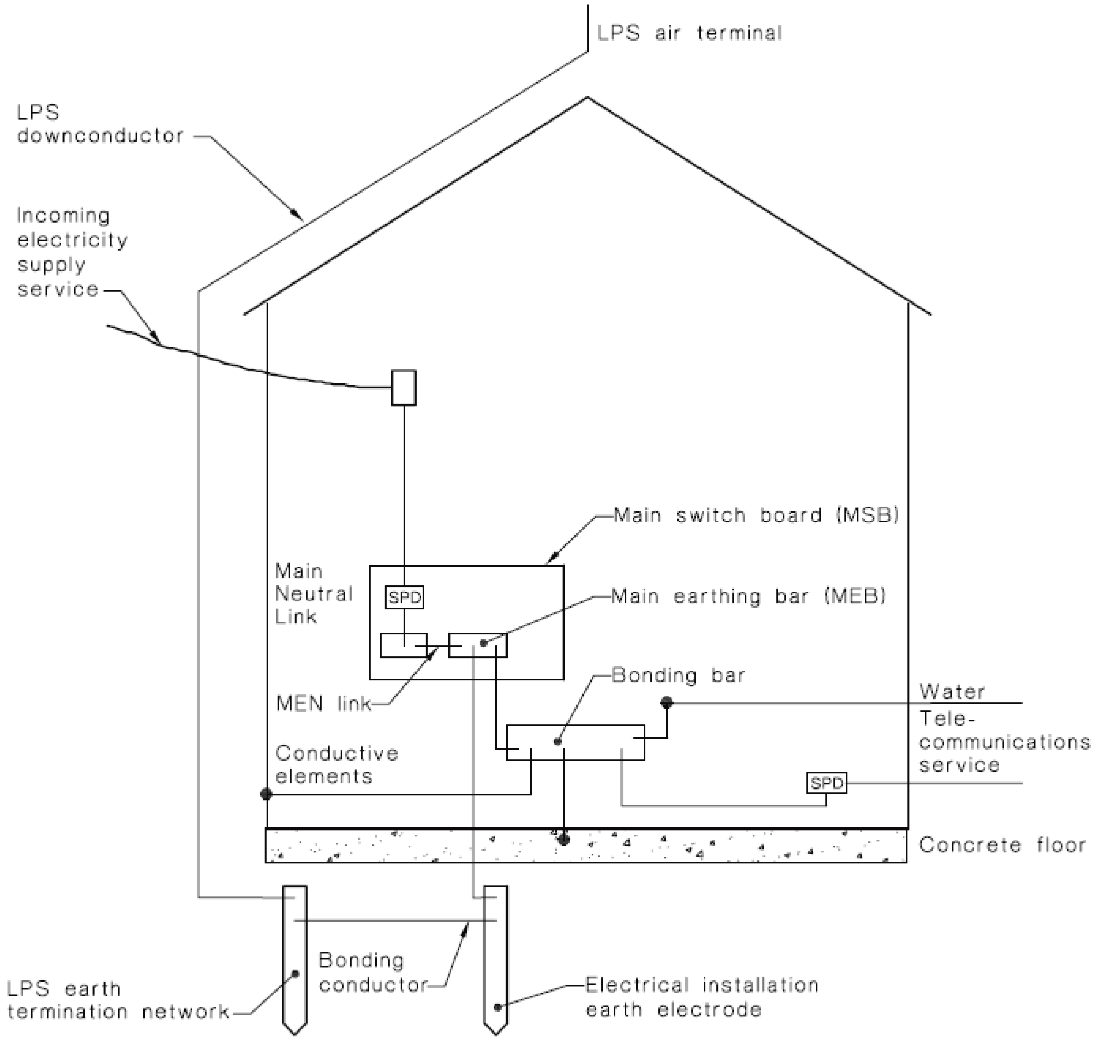


Figure 6: Example of a lightning protection system (LPS)

All grid-connected PV systems are to be connected to the earth (grounding). Any inverter with an earth connection means the system must be grounded as well. Typically, a 10 mm² AC cable with a 4 mm² earthing conductor is used for grounding the inverter in most situations. However, if the inverter is a 10 kW single-phase and a 16 mm² AC cable is used instead, and the distance from the switchboard is significant (e.g., 50 m), a 6 mm² PV array earth cable should be used.

It is common to install 100 kW inverters in large C&I PV systems, which require a 25 mm² earth conductor to the inverter. Without DC overcurrent protection, a 25mm² earth conductor must be run to the array. The use of DC overcurrent protection would allow the sizing of the earthing conductor according to the size of the active DC conductors.

3.4.8 Structures and foundations

It is crucial to design and build an array mounting structure that rests on foundations capable of absorbing the wind load. Regardless of the installation type, it is advisable to follow the specifications set by AEPC for standard installations, while customized designs should be done with respect to the site conditions. It is highly recommended to seek guidance from an experienced solar engineer to evaluate site-specific factors and develop tailored designs to meet the requirements of the project (refer to Annex 24). Some basic information related to solar PV mounting structures are provided below.

3.4.8.1 Ground mount for a fixed tilted installation

The spacing between trusses shall not exceed 2.5 metres. Another truss shall be inserted between them if the spacing is greater. The column height of the lower end of the PV panel should be at least 0.85 metres from the ground. If the length of the purlin cannot be limited to 2 metres an additional truss shall be installed between them to ensure that the purlin does not exceed its maximum length. All structure components should be more than 80 microns hot deep galvanized. A tilt angle between 20 to 35 degrees should be considered, depending upon location and site conditions.

3.4.8.2 Flat roof mount (metal or concrete)

When installing reinforced cement concrete (RCC) roofs, it is recommended to use non-corrosive stainless steel thread studs. The studs should have a minimum diameter of 10 mm and a length of 150 mm. Fix the studs securely using an industry-grade ready-mix mortar or epoxy grout, etc. The spacing between roof fixtures should not exceed 850 mm or as specified in the design.

For metal roofs, it is best to use the existing penetrations to fasten the PV racking system using self-tapping screws. Roof penetrations, if any, must be properly sealed using silicone or epoxy grouting. Note that roofing materials less than 0.45 mm thick are not suitable for the installation of PV panels.

Spacing between trusses shall not exceed 2.5 metres. Another truss shall be inserted between them if the spacing is greater. If the length of the purlin cannot be limited to 2 meters an additional truss shall be installed between them to ensure that the purlin does not exceed its maximum length. PV panels should not project beyond the roof ridge or the building edge. If panels are installed at a higher tilt angle, cross-bracing for structural stability should be provided in consultation with the structural engineer. Roofing clamps, L-feet, rails, splices, mid and end clamps and all types of joiners (connectors) nuts and bolts should be certified to withstand design wind speeds. Spacing between two rows should be at least twice the height of the upper end of the front row. Online calculation tools can assist in determining the appropriate spacing.

3.4.8.3 Slope roof mount (flush mount)

The gap between the underside of the panel and the roof should be no less than 50 mm and no more than 300 mm. If the length of a purlin cannot be kept within 2 metres, another truss shall be placed in between them so that the purlin does not exceed its maximum length. Proper walkways of approx. 600 to 750 mm width should be provided for access to panels for cleaning and service. The offset of the edge of the solar panel from the roof edge shall be 1 metre or more. The offset of the edge of the solar panel from the roof ridge shall be not less than 2 times the gap between the underside of the solar panel and the roof. However, offsets also depend on the width and height of the building.

3.4.8.4 Foundation requirements

The depth of the foundation for the support pillars should be 1/3 of the height of the solar structure and no less than 600 mm, whichever is larger. Adequate foundation depth and size should be provided as per design requirements. Finite element modelling should be used to assess the risk of overturning of the structure due to wind load. Soil tests shall be carried out on site to calculate the bearing capacity of the soil. A minimum value of 150 N/mm^2 shall be taken as a design consideration. The strength of concrete should not be taken less than M20 MPa.

3.4.8.5 Wind load considerations

For areas that lie above 3,000 metres altitude, a minimum of 55 metres/second should be adopted for the design wind speed and 47 metres/second sites below 3,000 metres. Accurate designs should consider also factors such as the risk coefficient and the ground/terrain and topography type.

3.4.9 Quality and standards

This chapter compiles nationally and internationally practised key benchmarks for PV system components and related services. Compliance with these helps ensure the reliability, safety, and longevity of the solar system.

Table 7: Quality benchmarks

Descriptions	National practice standards	International practice standard
Components		
Solar panels	RETS certified	
Inverter	RETS certified	
Cables		
DC cables		All DC cables are suitably designed to minimize voltage drop (max. 3%) and double sheath Copper or Aluminium cables. The cable shall be marked "DC cable" and "Do not disconnect under load" at every 2 metres.
Cable connectors		All cable connectors shall be the same type from the same manufacturer.
Outdoor / Indoor cable runs		Shall be enclosed in hard conduits and secured and sealed properly.
Roof cable runs		Shall be run in a suitable metal cable tray fixed properly on the roof and provided with a lid to protect from UV rays. Cables are to be secured in position at suitable intervals. If different types of cables are run in the same cable tray, they shall be mechanically separated.
Design		
Design	Domestic grid-connected solar PV systems will not be designed for more than 1,000 V_{DC} and non-domestic systems will not be designed for more than 1,500 V_{DC}.	
Voltage drop		Total voltage drop shall be less than 3% from the farthest PV panel to the point of supply
Installation		
Installation	Inverters to be set up as per NEA's requirement.	Shall be installed with a main DC Isolator and an AC isolator at the inverter location.

Inverter installation spot		Inverters shall not be installed at the spot of direct sunlight. All outdoor installation of inverters (even if they are outdoor IP rated at least IP65) shall be provided with owning to protect them from direct sunlight or water etc.
Paralleling strings		Not more than 2 strings shall be paralleled in one isolator until the module manufacturer advises to do so. When more than two strings are paralleled together, each string will be provided with suitable fuses.
Cable routing		Cables shall be routed via the shortest route to minimize voltage drop.
Elimination of hazards		Zero hazard measures shall be taken while routing cable/ installing cable trays, etc. where possible. If cannot be eliminated, tiger tape or special hazard signs shall be attached at the location.
Earthing		All panels shall be bonded together through their frame and PV racking and connected to the property's earthing system.
	Warranties	
System warranty		Not less than 5 years (extended warranty provisions apply)
PV racking		Not less than 15 years or as provided by the manufacturer
Mechanical warranty		As provided by the manufacturer – at least 12 years
Energy production warranty		Year 1: not less than 2% Every year: not more than 0.5% power degradation Year 10: not less than 88% Year 25: not less than 82%
Installation warranty		5 years (while users may negotiate for a higher warranty period)
	Commissioning and maintenance	
Quality assurance	Refer Annex 11	
Commissioning of the system	Refer Annex 12	
Maintenance of the system	Refer Annex 13, Annex 16, Annex 17	

PART 4
ASSESSING PROJECT FEASIBILITY

4.1 Residential systems

Step	**Conduct a feasibility assessment of the system under consideration**
Owner's role	Hire expert, facilitate site inspection, check the completion and clarity of report
Carried out by	Expert with experience in the design and development of solar PV systems
Alternative pathway	**Could be *initiated* and *carried out* by an energy service company** that invests in and owns the system and is paid by the house owner from the proceeds of savings
Approx. duration	1-2 days
Expected cost	NPR 10-30K
Templates	Annex 3, Annex 4, Annex 5, Annex 6, Annex 7

The feasibility assessment provides the owner of the building with the information required to decide whether or not to develop the system that is being envisaged.

1) **Obtain electricity bills:** Obtain and share electricity bills for the past 12 months with the expert engaged.
2) **Estimate electricity demand** based on the electricity bills.
3) **Determine installation options:** Conduct a site visit of the building to inspect the roof area available for the installation of solar panels and in doing so determine the following:
   a) The type of roof: tin, tile, concrete, etc.
   b) The slope (in degrees) and orientation (East, South-East, South, South-West, West, etc.).
   c) The dimensions (length and width) of the roof area and prepare a sketch.
   d) Any nearby structures that may cause shading of the roof and measure the distance, direction and dimension of the shading object. Prepare a sketch of the shading object.
   e) Location of the meter, distribution box, size of the feeder cable and space available for the inverter in proximity, preferably with photos.
   f) Location of NEA's Distribution and Consumer Service (DCS) for future communication for grid connection of the solar system.
4) **Design the system:** Based on the information gathered, the expert designs the system using software (recommended) or a manual process. Refer to Table 4 for suitable software and Annex 1 for the manual calculation method. The design should be based either on the demand for electricity or the available roof space. This step includes the selection of solar panels (brand and size) and the inverter.
5) **Estimate electricity generation:** Based on the number of panels and size, the expert estimates the system output using software (recommended) or manual methods. Different orientation and tilt angle options shall be simulated to get the best possible output from the

system to be compared with the demand on a daily and seasonal basis. In doing so the system output is estimated on a yearly, monthly, and daily basis.

6) **Determine the bill of quantity (BoQ)** for all components required including prices, refer to Annex 20.

7) **Prepare report:** Once the system has been designed, a brief report shall be prepared including the following minimum information. For the report, the template in Annex 7 is recommended. The integral parts of the PFS report are provided below for quick reference. The report shall have:

    a) System size in kW_P
    b) Brand, size and number of solar panels with datasheet with warranty information
    c) Brand, size and number of solar inverters with warranty information
    d) Description of the panel layout, tilt angle and orientation.
    e) Estimated electricity generation per year including what percentage of the current demand this constitutes and the greenhouse gas emissions avoided
    f) Estimated cost of the system before subsidy or financial incentives
    g) The amount of subsidy or other financial incentives available
    h) Estimated payback period of the system

Next step	Take decision
Owner's role	Decide whether to invest in the solar grid-connected system or not based on the investment and payback period. In the case of Yes, seek quotations for the supply, installation, and O&M based on the design and the report.

4.2 Commercial and industrial systems

4.2.1 Pre-feasibility study

Step	**Conduct a pre-feasibility study for the system under consideration**
Owner's role	Hire expert, facilitate site inspection, check the completion and clarity of report
Carried out by	Expert(s) with experience in the design and development of solar PV systems
Expected cost	NPR 50-100K (The cost may vary depending upon site conditions)
Alternative pathway	**Could be *initiated* and *carried out* by an energy service company** that invests in and owns the system and is paid by the house owner from the proceeds of savings
Approx. duration	5-10 days (including travel)
Templates	Annex 3, Annex 4, Annex 5, Annex 6, Annex 7

Commercial and industrial systems tend to be larger in size (10-500 kW_P) than residential systems (0.5-10 kW_P) and assessing feasibility is more time-consuming and expensive. For this reason, it is customary to conduct a pre-feasibility study first in order to decide whether investing in a feasibility study is promising. Technical and financial information is evaluated at this stage, entailing a desk study with limited site visits. The pre-feasibility study should include the following steps:

1) **Determining electricity consumption:** The expert determines electricity consumption through multiple means, namely:
   a) Electricity bills of the establishment for the past 12 months. This informs power consumed through NEA, the electricity tariff and the site address.
   b) To know the exact grid electricity consumption, it is recommended to install temporarily, a datalogger on the supply side of the main switch board for a period of one year. This will establish the daily and seasonal consumption patterns.
   c) If the establishment has another source of electricity supply such as a generator, the yearly operating hours and reason for operation shall be collected from the operator so that it can be considered in the assessment of electricity demand.
2) **Collecting site information:** Site information such as the location of different service points (including installation, and load centres) are gathered from site visits. A site map shall be prepared that could be based on satellite information (Google maps) to specify the location of the area considered for installation of solar panels, the electricity supply point, the location of the meter and distribution box, and access points and other relevant structural aspects, as applicable.
3) **Collect information on the area for installation of panels:** Determine the size of the proposed installation area of solar panels. In the case of roofs, this includes the lengths, widths and slope (in degrees) along with roofing material and support structures. In the case of ground mounting, this includes the available area. For either option, determine the orientation (East, South-East, South, South-West, West, etc.) along with nearby structures that may cause shading of the area considered for solar panels, their distance, direction and dimensions. Prepare a sketch of the shading object.
4) **Preliminary sizing and design:** Based on the electricity demand or the available area for installation of solar panels, a preliminary system design shall be done using software (recommended) or following a manual calculation process. Refer to Table 4 for a list of software and Annex 1 for the manual calculation method. The system design includes the selection of solar panels (brand and size) and the inverter.
5) **Preliminary estimation of electricity generation:** Once the preliminary system design is known, the system's expected generation is simulated using software. Different orientation

and tilt angle options shall be tried to get the best possible output from the system to be compared with the demand on a daily and seasonal basis.

6) **Indicative layout:** Once the indicative system size and expected generation are accepted, the expert proceeds to determine the required panel layout as well as site layout indicating the electricity supply point, location of the meter and distribution box and appropriate locations for the inverter, and combiner boxes. The indicative layout aims at minimising the cable lengths for DC currents to minimise losses and reduce costs.

7) **Determining the bill of quantity (BoQ):** Based on the indicative design and system size, a bill of quantity for all components is to be prepared (Refer to Annex 20). The indicative cost of the system shall be determined before and after potential rebates or subsidies.

8) **Financial performance:** In the next step, the financial performance is evaluated on a preliminary basis so the owner knows what can be expected from the system. Key performance indicators are the internal rate of return (IRR), the payback period and the levelized cost of electricity (LCOE).

9) **Documentation:** The pre-feasibility study report should be short, clear and well-articulated, in adherence to specific reporting requirements. A standard report template is presented in Annex 7. If the clients require any other specific information to be included in the report.

Next step	**Review the pre-feasibility report and take the decision**
Owner's role	Decide on whether or not to conduct a detailed feasibility study (DFS). A detailed feasibility study should be conducted only if the results of the pre-feasibility study promise fair financial benefits.

4.2.2 Detailed feasibility study (DFS)

Step	**Conduct a feasibility study for the system under consideration**
Owner's role	Hire expert, facilitate site inspection, check the completion and clarity of report
Carried out by	Expert(s) with experience in the design and development of solar PV systems
Expected cost	NPR 100-200K
Alternative pathway	**Could be *initiated* and *carried out* by an ESCO** that invests in and owns the system and is paid by the house owner from the proceeds of savings
Approx. duration	7-15 days (including travel)
Templates	Annex 3, Annex 8, Annex 9, Annex 10

A detailed feasibility study is a comprehensive in-depth analysis to assess the viability of a solar grid-connected project. Parameters extracted from the pre-feasibility study are verified and elaborated through additional assessments and documented in a report. The report should contain precise design and technical information, a detailed financial analysis, environmental and social impacts as well as regulatory and legal aspects of the project.

4.2.2.1 Site assessment

Site assessment involves a detailed analysis of the physical and environmental characteristics of the location of the site. This includes careful examination and record of the roof access points, roof hazards, roofing profile, roofing material and support structure. The size of the roof section including their slope and orientation shall be measured using a tape measure, a tilt meter and a compass respectively. If a sophisticated device like the Solmetric SunEye is to be used, it can measure solar angle, resource availability throughout the season and shading, if any. The size of any shading object and its distance from the installation roof shall be recorded. This information needs to be entered into the simulation software while designing a system. Key factors to consider during a site assessment for a grid-connected system include:

1) **Determining** the roof size, slope, orientation, roofing material type, and profile. If the system is ground-mounted, the structure shall be facing towards the south in 25-30-degree slope unless the system is installed with a tracking mechanism for an optimum generation.
2) **Site survey:** Conducting a comprehensive site survey to assess the solar resources potential of the location selected for solar panels. This involves measuring solar irradiance and conducting shading analysis, either by using pyranometers, software applications or satellite imagery. For ground-mounted systems, information on topography, soil type, heritage and environmental aspects shall also be acquired.
3) **Evaluating the structural integrity** of the building and assessing its suitability for a rooftop solar installation, including the load-bearing capacity calculations. It is also necessary to determine if the roof requires any reinforcement or repair to support the solar panels. For ground-mounted systems, the structure shall be installed as per the design provided by the structural engineer.
4) **Assessing the electrical infrastructure** of the property/building and determining the necessary upgrades required to support solar generation, in-house supply, and export. Determine the appropriate inverter size and the number of panels that can be installed.
5) **Checking the supply side's capacity** to cater to the solar feed internally and export, such as ensuring that the time-of-day (ToD) meter rating is sufficient to handle solar export. Verify that the AC miniature circuit breaker (MCB) at the client's side can handle the inverter's output, and check if the distribution box busbar has space for solar interconnection and the size of the transformer (if applicable) is of sufficient capacity. Information on the transmission line (like cable size, type and length from the site to the sub-station shall be collected.
6) **Identifying potential safety hazards** and developing a plan to mitigate them, such as fall protection and fire safety measures.
7) **Considering local weather conditions**, such as wind and snow loads, and design the system accordingly by using appropriate mounting structures and modules.
8) **Determining orientation and tilt** of the solar panels for maximum energy yield. Use one of the simulation tools presented in Table 4 to optimize system performance by modelling under different weather conditions and adjusting parameters like panel tilt and inverter size.
9) **Conducting a shading analysis** to identify potential shading sources such as nearby buildings or trees.
10) **Identifying relevant regulations** and requirements to ensure that the system design meets all necessary requirements by NEPQA and NEA directives/guidelines (refer to Annex 18). Some of the component's standards are not present in the afore mentioned government templates, in such cases, IEC standards should be followed (refer to Annex 22).
11) **Verifying electricity consumption:** Temporary installation of a data logger to record electricity consumption for a period of 12 months[1]. Analysing the data, keeping in view the electricity bills presented and the information obtained on the operation of diesel genset in the pre-feasibility study.

[1] This is an ideal condition for annual variation of electricity consumption. Such a data logger can also be installed for daily electricity consumption records for a few days.

4.2.2.2 Energy yield analysis

Energy yield analysis shall be performed using industry-standard software as presented in Table 4 to estimate the amount of energy that can be generated by the proposed PV system, based on the site-specific conditions.

4.2.2.3 Verification of designed system size and simulated generation

Once onsite information is collected, the system size and design developed at the pre-feasibility stage shall be verified and amended in the pre-feasibility report if needed. During this stage, the solar panels, grid inverters and BOS shall be selected on their *techno-economic analysis* of different components options. Once the system size and selection of panels, inverters and BOS are finalized, a system design simulation shall be performed to estimate the system's energy yield using the software. If the software does not take account of shading issues, then it is recommended to enter the parameter manually. The software's technical, financial and ecological information shall be presented as a part of the DFS report.

4.2.2.4 BoQ with datasheets and warranty information

Once the system design and simulation based on site-verified information is performed, an updated BoQ shall be prepared. At this stage, details of components and the costing of each component including eligible rebates and subsidies are outlined in the costing. The BoQ shall include precise technical information on each component including warranty information. Along with that a detailed technical specification sheet is required (refer to Annex 21). Also, the costing shall include any AC side upgrades and structural assessment and upgrades if needed, application and regulatory fees and delivery and lifting-related costs.

4.2.2.5 Financial analysis

Based on the detailed design and costing of the system, financial analysis shall be performed using the financial analysis tool (refer to Annex 15). Financial indicators for each option shall be presented in the report. Indicators like IRR, payback, and LCOE shall be interpreted in the report so that investors will have a clear picture of what they are investing in. Guidance on reviewing the detailed analysis is available in Chapter 5 of this document.

4.2.2.6 Legal and regulatory aspect

Any legal and regulatory aspects like approval from the local government (if any), approval NEA (for solar connection, net metering and installation of meter), approval from the aviation department if the installation falls on commercial aircraft flight paths etc. should also be included in the detailed feasibility study report.

4.2.2.7 Environmental and social aspect

If the system is ground-mounted, the project may need to go through environmental impact assessment and social impact study and reporting as well.

4.2.2.8 Reporting requirements

A detailed feasibility study report is a comprehensive document that provides an analysis of the technical, financial, and environmental viability of a project. The requirements of a report vary depending on the project's size, complexity, and specific requirements of the stakeholders. A standard detailed feasibility study report template is presented in Annex 10 of this document.

Next step	Review feasibility study report and take implementation decision
Owner's role	Decide on whether or not to implement a grid-connected solar PV project. One should consider implementing such projects if the results of the feasibility study promise technical attractiveness and fair financial benefits.

PART 5
DOES IT MAKE ECONOMIC SENSE?

Special note	The financial analysis is part of the feasibility study carried out by experts. It is difficult for non-experts to judge these aspects. However, considering that economics is pivotal in taking the right decision about the development of a project, it is advantageous and even necessary for anyone seeking to develop a project to be conversant with the basic economic aspects. This chapter thus seeks to familiarize readers with these essentials. This will enable non-technical readers to become conversant with these aspects, enable them to provide critical review of the options proposed by experts and take informed decisions.

Grid-connected systems offer economic benefits by reducing reliance on fossil fuels and lowering energy expenses for residential, commercial, and industrial users. This section provides guidance on the financial aspects, including funding sources, and incentives. It emphasizes evaluating relevant parameters such as operating expenses, import costs, taxes, and subsidies, to ensure financial sustainability. The section also outlines the most important business models for solar grid-connected systems.

5.1 Financing options

5.1.1 Equity financing (cash)

Serval options exist to raise funds for the installation and operation of the solar PV project.

- **Using company liquidity**: Using the company's cash reserves or cash flow to fund the project is known as using internal equity financing. This option does not dilute the ownership of existing shareholders. However, using internal equity financing can also mean that the company has less cash on hand for other projects or expenses.
- **Energy service company (ESCO)**: An ESCO is a specialized company providing energy services to help clients lower electricity bills, through renewable energy services and energy efficiency. ESCO typically owns, operates, and maintains the (renewable) energy infrastructure, while the client benefits from (clean) energy generation without the upfront capital costs. Clients enter into agreements such as PPAs or leasing arrangements with ESCO (refer to Annex 19), where they agree to purchase the energy generated by the system over a specified period at predetermined rates.
- **Selling shares**: In this option, the company issues new shares of stock to raise money for the solar project. These shares can be sold to investors, such as individuals or venture capitalists in exchange for an equity stake in the company. The company can use the proceeds from the sale of shares to fund the solar rooftop project.
- **Special purpose vehicle (SPV)**: Another approach found in Nepal is to create a so-called special purpose vehicle where an ESCO co-owns the SPV together with a foreign company providing the investment. The disadvantage is that it dilutes the ownership of existing shareholders implying that profit will need to be shared or simply reduce the company's liquidity.

5.1.2 Debt financing (loans)

Borrowing money from a lender such as a commercial bank allows funding projects without giving up ownership, albeit at the cost of regular payments of interest and principal. As of August 2023, commercial banks in Nepal offer interest rates of approx. **10% (subject to change)** for renewable energy projects. Apart from the prevailing interest rates, rates also depend on the risk profile of the project and the borrower's creditworthiness. Specific schemes tailored to the financing of renewable energy projects may exist that may have more favourable terms than general loans, such as lower interest rates, longer repayment periods, and more flexible collateral requirements. Eligibility criteria may apply, and the availability of such products may change based on the bank's risk management strategies. Thorough research and comparison of available options are recommended before deciding. Several commercial banks in Nepal provide financing for renewable energy projects, such as NMB Bank Limited.

5.1.3 Subsidies and grants

Involves receiving funds from a grant-making organization, such as a government agency or non-profit, to support specific projects or activities, which may require the support of international organizations or agencies. This type of financing does not have to be repaid, but it may come with certain conditions, such as reporting requirements or restrictions on how the funds can be used. Subsidies available for solar rooftop solar are briefly discussed in Chapter 2.

5.2 Fixed and variable costs

5.2.1 Capital expenditure (CAPEX)

Capital expenditure (CAPEX) refers to the costs incurred during the installation phase of a solar rooftop project. These vary based on location, scale, complexity, equipment, market rates, availability, negotiations, lot size, equipment quality, taxes, and transportation and include:

- **Project development:** Includes activities such as project planning, site selection, and obtaining necessary permits and approvals.
- **Installation:** Includes equipment and labour required to physically install the solar panels on the rooftop.
- **Logistics:** Includes transportation and storage of equipment and materials to and from the project site.
- **PV panels:** Photovoltaic panels that will be used to generate electricity. The choice of panel technology can also have an impact on costs, with monocrystalline panels typically costing more than polycrystalline, but offering slightly higher efficiencies and better performance at higher temperatures.
- **Mounting:** Equipment and materials used to mount the PV panels on the rooftop.
- **Inverters:** Devices that convert the DC electricity generated by the PV panels into AC electricity.
- **Balance of system (BOS):** Other equipment and materials required for the operation of the solar rooftop system, such as cabling, monitoring systems, and electrical protection devices.
- **Cabling:** Electrical cables and wiring are used to connect the PV panels to the inverters and the building's electrical system.
- **Protection equipment:** Equipment that protects the system, for example from damage caused by lightning strikes.

Based on feedback from stakeholders obtained during the development of this guideline, approximate costs were estimated for the capital expenditure per watt peak (W_P) installed in

Nepal. These estimates are provided in the table below as a reference and should not be considered as accurate.

Table 8: Reference capital costs per watt peak (W_P)

Type of parameter	Parameter	Value	Unit
Unit costs	PV panels	36	NPR/W_P
	PV combiner box	100	NPR/W_P
	Roof mounting	9	NPR/W_P
	DC cabling	1.5	NPR/W_P
	AC cabling	0.6	NPR/W_P
	Grid-connected solar inverter	15	NPR/W_P
	Remote monitoring	40,000	Per unit
	Circuit breakers	5,000	Per unit
	Energy meters	31,000	Per unit
	Lighting arrestor	80,000	Per unit
	Earthing rod	10,000	Per unit
	Fuel price	182	Per litre
Other costs	Project development costs	50,000-1,000,000	NPR/ project
	Installation costs	4	NPR/W_P
	Civil costs	Based on the site condition	
	Logistics	~2	NPR/W_P
	Insurance costs	0.30%	project cost
	Operation and maintenance	Varies from one user to another	

Additionally, the business model of the project can also affect capital expenditure, as projects operating on an operating expenditure (OPEX) based model tend to have lower overall costs. This is due to the fact that the installer who is responsible for raising finance under this model, recouping the investment and achieving profitability, has a strong incentive to implement cost-efficient measures.

Rule of thumb	The capital expenditure cost of grid-connected solar rooftop systems in Nepal in 2023 is in the order of 60-80 NPR per watt peak (NPR/W_P).

5.2.2 Operational expenditure (OPEX)

It is essential to take into account the operational cost. These vary depending on a range of factors, including the size of the system, the quality of the components, and the location and climate where it is installed. By carefully monitoring and managing the system, however, it is possible to minimize these costs and ensure the system is able to provide reliable and efficient power for the entire duration of the project's lifetime. Operating costs arise from the following:

- **Maintenance and repairs:** Regular maintenance is essential to keep the system running at peak efficiency. This may include checking the wiring and connectors and replacing any damaged components. Any repairs that are needed should also be addressed promptly to minimize downtime and ensure that the system is functioning properly.

- **Monitoring and management:** It is important to monitor the performance of the system on a regular basis, and to adjust settings or make repairs as needed. This may involve installing sensors or other equipment to track performance, as well as software or other tools to analyse data and identify potential issues.
- **Cleaning and replacement of components:** Over time, the panels, inverters, and other components of the system may need to be cleaned or replaced. This can be a significant expense, particularly if the system is large or has been in operation for many years.
- **Insurance:** Solar PV installations represent a significant investment, and it is important to protect this investment with appropriate insurance coverage. This may include coverage for damage caused by weather events or other factors, as well as liability coverage for any accidents or injuries that may occur.
- **Financing costs:** If the installation was financed through a loan, there would be ongoing costs that need to be accounted for. These may include payments for the interest and the principal, fees, and other charges associated with the loan.

5.2.3 Business models

Business models for solar grid-connected projects vary depending on the needs and goals of the parties involved. These models can be broadly categorized into two main types: customer-owned and third-party owned.

- **Capital expenditure (CAPEX) based model:** The customer bears the upfront capital costs of installing the solar rooftop system and owns the system.
- **Energy service company (ESCO) model:** A third-party company designs, finances, installs, and operates the solar system on the customer's property, and the customer pays for the energy produced by the system at a lower rate than the utility's rate.

5.2.3.1 CAPEX-based model

In the CAPEX-based business model the customer, typically a property owner, bears the upfront capital costs of installing the system and owns the system. The customer then generates revenue from the sale of excess power to the grid and from energy savings.

Advantages of CAPEX-based models include the ability for the customer to own the assets and receive 65% accelerated depreciation in the first year of the project. This can be a significant motivation for property owners. However, there are also disadvantages to CAPEX-based models. One major disadvantage is that these models are typically limited to smaller project sizes due to the high upfront capital costs that fall on the customer. Additionally, many companies that struggle with their core business would strongly hesitate before investing part of their equity or cash into cleaner or cheaper energy, rather than in their own business.

The target for the IRR for a CAPEX-based model is typically above 15%, and the payback period is around 5-6 years. Additionally, some banks offer loan types that cater specifically to solar rooftop projects, such as the NMB Bank, which only requires the solar system as collateral. Other banks may require a personal guarantee or offer the same services.

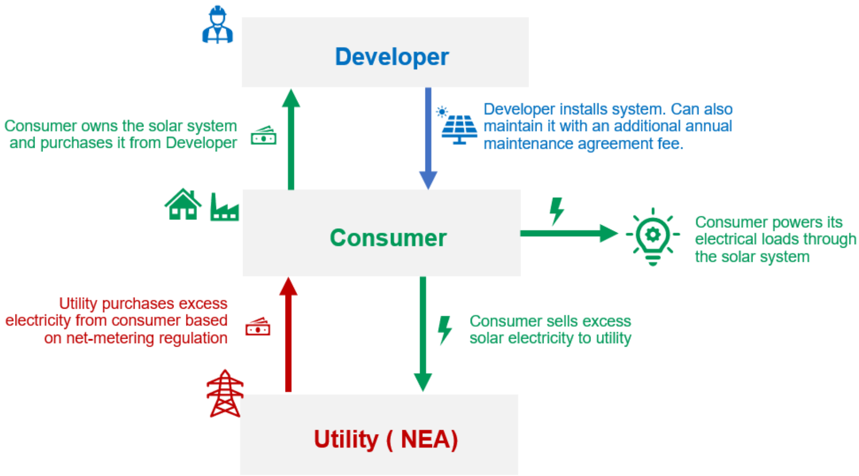


Figure 7: CAPEX-based model schematic

5.2.3.2 ESCO model

An ESCO model for solar rooftops involves a third-party service provider, known as an energy service company (ESCO), owning and maintaining the solar rooftop system on a customer's property. The customer enters into a power purchase agreement (PPA) with the ESCO, agreeing to purchase energy at a fixed price per unit, which is typically cheaper than the tariff paid to NEA.

ESCO models offer advantages such as significant energy savings, typically 10-30%, without the upfront capital costs of a solar rooftop system. The Energy service company is also responsible for maintaining and operating the system, which is beneficial for customers who lack the technical expertise to do so themselves. However, there are also disadvantages to ESCO models. Customers are locked into a long-term PPA with the ESCO, typically 10-12 years or more. At the end of the PPA, the customer must either negotiate a new PPA or purchase the solar rooftop system from the ESCO at a discounted price. PPAs specify a price per unit of energy, which is always cheaper than NEA's tariff, and include net metering provisions for excess energy sold to NEA. The ESCO model's payback period is typically 6-7 years, but scalability limitations exist due to funding. Joint ventures between local companies and foreign investors can be created to address this limitation.

The illustration below conveys one typical set-up for OPEX models, although other configurations are possible, where excess energy could be sold to the utility by the consumer instead of by the developer, for instance.

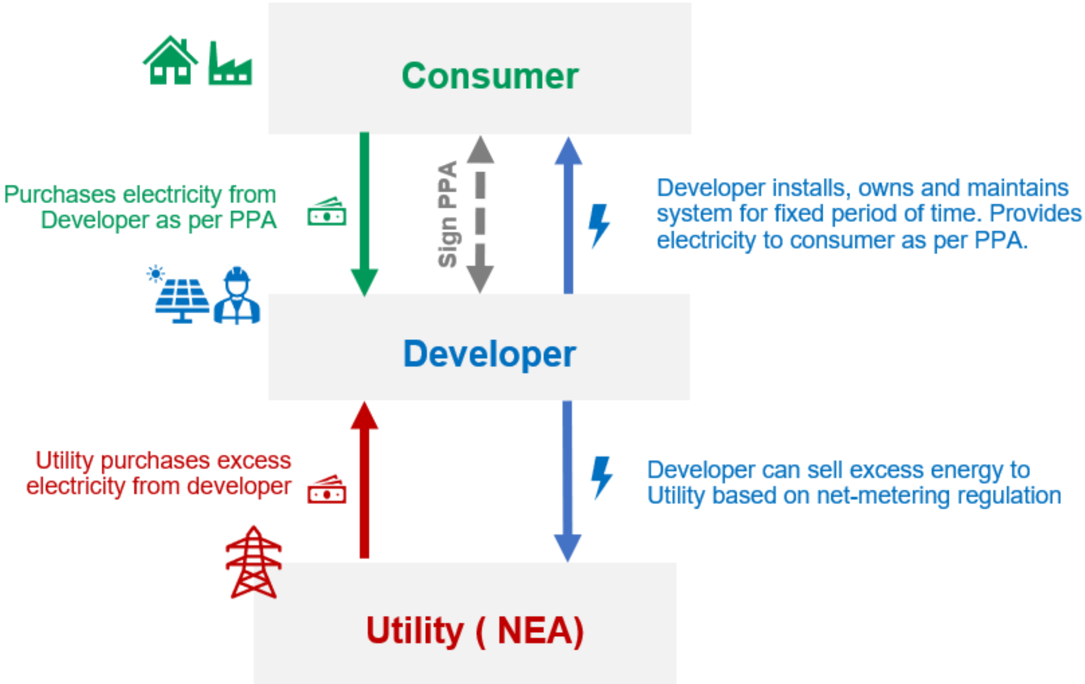


Figure 8: OPEX-based model schematic

5.2.4 Net-metering

Net metering is a billing mechanism that allows customers to feed excess electricity into the grid and be credited for it on their utility bill. This allows customers to offset the cost of energy they consume from the grid with the energy they produce from their own renewable energy systems. Net metering is typically implemented through a special meter, known as a bi-directional meter, that can measure both the electricity flowing into a customer's home or business and the electricity flowing out to the grid.

In Nepal, net metering is regulated by NEA. The billing rate is 5.94 Rupees per kWh and will be valid until 2024. After that, there is uncertainty regarding what the future value might be. This uncertainty has caused most ESCO companies to target conservative sizes of projects, so they can ensure that exported electricity will not have a significant share and mitigate the risk of an unclear net metering regulation. For example, a 24/7 operation and a load of 5 MW, 500 kW_P of solar guarantee a minimum level of exports, minimizing the risk of unfavourable future net metering regulation.

5.3 Financial analysis tools

5.3.1 Project payback period

The payback period is a crucial financial evaluation tool for rooftop solar projects. It should be noted that payback periods can vary based on factors such as system size, location, and available incentives. It is important to consider both upfront costs and ongoing operational expenses when calculating payback periods. In addition to energy savings, potential revenue sources such as government incentives or selling excess energy back to the grid should be considered. These can significantly impact the payback period and overall project profitability. Inflation can also affect the payback period, as rising energy costs increase the savings generated by the solar system, while increased financing costs can lengthen the payback period. A shorter payback period, typically 5-7 years, is more appealing to investors and lenders. However, longer payback periods may still be viable if the project generates significant ongoing savings or revenue. It is important to remember that payback periods are only one aspect of evaluating the financial viability of a solar project. Other tools such as IRR and LCOE, should be considered for a comprehensive understanding of the project's financial performance.

5.3.2 Interest rates

Interest rates impact the cost of financing and the profitability of solar projects. Commercial lending rates in Nepal are currently at around 13% while some commercial banks offer interest rates of approx.**10%** for renewable energy projects. This has significant implications for the industry, as it increases the cost of financing and makes it harder for companies to secure funding. High rates can decrease the net present value of the project and make it less attractive to investors. It can also slow down the growth of the solar industry. High-interest rates increase the project's overall cost and payback period, so they must be considered when evaluating the financial viability.

5.3.3 Internal rate of return (IRR)

The internal rate of return (IRR) is a critical metric for evaluating the profitability of solar projects. It is the discounting rate that results in a net present value (NPV) of zero, and it is used to assess the rate of return on investment. In simpler form, IRR can be compared with the bank's interest rate on fixed deposits. For projects funded by a mix of debt and equity, two different IRRs are considered: Project IRR and equity IRR. Project IRR uses overall project cash flows (except for financing costs), and it is required to be higher than the weighted average cost of capital (WACC). Equity IRR is an indication of the returns for the investor after the debts have been paid off, and it is calculated using cash flows after the deduction of all costs.

A higher IRR indicates a more profitable project and a minimum IRR of 10–20% is generally considered reasonable for grid-connected solar projects. However, the IRR varies depending on factors such as the size of the project, the risk involved, and the cost of capital. Interest rates from banks can affect the desired IRR for a project. High interest rates increase the cost of capital, making it more challenging to achieve the desired IRR, while low interest rates make it easier to achieve the desired IRR.

5.3.4 Levelized cost of energy (LCOE)

Levelized cost of energy (LCOE), represents the total cost of producing electricity (NPR per kWh) from a solar system or an energy source. This calculation spans the anticipated lifespan of the project and encompasses various elements, including construction, operation, maintenance, financing, and eventual decommissioning costs. It also considers the projected electricity output generated by the facility during its operational lifetime.

5.4 Lifecycle costing

In evaluating the financial viability of a solar rooftop installation, it is important to consider the long-term costs and performance. Lifecycle costing and degradation analysis are critical tools that should be utilized to optimize the overall financial performance of the project. Lifecycle costing is a process of estimating the total cost of a project over its entire lifespan, including both the initial investment and ongoing maintenance costs. Key components to consider in the lifecycle costing of a solar rooftop installation include the solar panels, inverters, mounting systems, wiring, and other electrical components. This can help identify potential cost savings and optimize the overall financial performance of the project.

It is also important to consider the performance degradation of the solar panels over time. Solar panels typically degrade at a rate of around 0.4-0.5% per year, which can result in a significant decrease in overall performance. To account for this degradation, it is important to adjust revenue projections accordingly and ensure that the project remains financially viable over its entire lifespan. The average lifetime and degradation rates of important components are as follows:

- Solar panels have an average lifespan of 25-30 years, with a degradation rate of typically around 0.5% per year.
- Inverters have a lifespan of 5-15 years depending upon quality and brand, with a degradation rate of around 1% per year.
- Mounting systems have a lifespan of 20-25 years, with a degradation rate of around 0.5% per year.
- Batteries, if included, have a lifespan of 5-15 years, with a degradation rate of typically around 2-3% per year.
- Cables and wiring have an average lifespan of 25-30 years, with minimal degradation.

It is important to note that the lifespan and degradation rates of these components can vary depending on factors such as the quality of the equipment, installation conditions, and level of maintenance. Regular maintenance and inspections can help identify potential issues and ensure that the system continues to perform at its optimal level over its lifespan.

In conclusion, considering lifecycle costing and degradation analysis are essential for evaluating the long-term financial viability of a solar rooftop installation. Accounting for the degradation of the solar panels and adjusting revenue projections accordingly is crucial to ensure the project remains financially viable over its entire lifespan. Regular maintenance and inspections can help optimize the system's performance and maximize its financial returns.

5.5 Use of the financial tool

The financial tool provided in Annex 15 is recommended for users of this guideline. The annex shows a static preview but the tool is also available separately as a Microsoft Excel file for actual use. Typically, solar experts use solar PV design software to estimate energy yields and other financial parameters in the feasibility study. However, solar project planners and developers who are not familiar with the design software can benefit largely from using this tool. More specifically, commercial and industrial clients can evaluate the financial benefits (IRR and payback period) of potential solar PV projects before investing in the projects.

PART 6 IMPLEMENTATION OF PROJECTS

Step	**Developing the system if the decision is favourable**
Owner's role	Selection of contractor, getting approvals, arranging finance, obtaining grants/subsidies (if available), obtaining permits and letters for import and exemption of VAT/Tax
Carried out by	Qualified suppliers/installation companies
Alternative pathway	**Could be implemented by an energy service company** that invests in and owns the system. In such case, the company should sign a power purchase agreement with the house facility owner
Approx. duration	3-6 months depending on size, permit requirement and financing method.
Expected cost	As per the results of the feasibility study
Templates	Annex 23

6.1 Planning

A solar grid-connected system project requires a set of tasks to be carried out before, during, and after the installation process. These sequential implementation steps are presented in Annex 23 of this guideline. Depending on whether the installation is on a new site (ground-mounted) or an existing site (roof-mounted), the site preparation process varies. For rooftop solar installations, the preparation of the installation site commences with a preliminary inspection conducted by an accredited designer.

It is important to create a clear view of all the steps necessary for the implementation of a project. The steps include site identification, site assessment, design, proposal and contracting, permits and approvals (including from the utility), procurement and installation, testing and commissioning, interconnection, and monitoring and maintenance. The duration of the timeline may depend on various factors such as project size, location, and its complexity. However, a residential system (1-10 kW) may take about 4-6 weeks to complete the process, a small to medium-sized project (10-500 kW) may take about 6-8 months to complete.

The implementation of grid-connected solar PV system installations includes choosing a qualified contractor, obtaining the required permits and approvals, and ensuring compliance with applicable regulations and standards. The following are the step-by-step process for the implementation of grid-connected solar PV projects.

- Develop a comprehensive project plan that outlines the scope, schedule, and budget for the solar installation, utilizing project management software.
- Obtain necessary permits and approvals, including pre-installation permits, connection and net metering (from NEA), testing and certifications, and approvals from the stakeholders.
- Identify and select a qualified and experienced solar contractor to design and install the system, utilizing a request for proposal process.

- Develop a plan for the commissioning and testing of the system to ensure that it meets performance and safety standards, including testing the functionality of the inverter and other components.
- Develop a plan for long-term monitoring and maintenance of the solar installation to ensure optimal performance, including scheduling regular cleaning and inspections, and monitoring energy production and system performance using a data monitoring system.
- Develop a plan for operation and maintenance training for building staff, including regular training sessions and providing documentation and procedures for ongoing maintenance.
- Develop a plan for warranty and post-warranty support, including identifying the warranty period for the solar equipment and securing maintenance agreements with the contractor or a third-party service provider.
- Develop a plan for emergency response and repair, including identifying key personnel and procedures to follow in case of equipment failure or other issues.
- Develop a plan for decommissioning and disposal of the solar system at the end of its useful life, including identifying a responsible party and procedures for the safe disposal of the equipment.
- Develop a plan to track and measure the financial and environmental performance of the solar installation over time.

7 months

1 month	**Demand, site assessment and design**: First step is to determine the electricity demand on site and carry out an assessment for the potential of solar installation. This activity includes evaluation of site orientation, PV array size and capacity, shading and structural integrity. Solar system is then developed considering the factors and energy consumption.
2-3 weeks	**Proposal and PPA contract:** At this stage a proposal is prepared outlining the project's scope of work, costs, and timeline. Once the proposal is accepted, a PPA contract is signed and the project development process begins.
1 month	**Permits and approvals:** This stage involves obtaining the necessary permits and approvals (if needed) from NEA and other authorities.
3 months	**Procurement and installation:** Once necessary permits and approvals are obtained, the solar equipments are procured and the installation begins. This stage includes installation of the solar panels, inverters and balance of systems.
2-3 weeks	**Testing, commissioning, RETS certification and net metering:** After the installation is complete, the system is tested and commissioned to ensure it is functioning correctly and producing the expected amount is energy. Once the system is commissioned, application for RETS certification is submitted. After the system receives RETS certification, application for interconnection and net metering shall be lodged at the NEA's Distribution and Consumer Services office.
1 month	**Interconnection and installation of net metering:** Once the system receives approval for connection to the national grid and net metering, the NEA shall perform the interconnection and installation net metering. The system starts generating revenue.
Post-testing & commissioning	**Monitoring and maintenance:** After the system is connected and operational, it shall be regularly monitored and maintained to ensure it continues to function correctly and produce energy at the maximum efficiency.

Figure 9: Typical time required for implementation of a project of 100-500 kW

6.2 Permits, approvals and VAT exemptions

The following process outlines how a developer of a solar project can import components for a grid-connected solar PV system, obtain VAT and customs exemptions certification, and obtain net metering if required.

6.2.1 Required certification

To receive VAT and customs exemptions for imports of solar panels and inverters, it must comply with the NEPQA standards and RETS testing procedures. RETS conducts two types of tests on products: the product introduction test (PIT) and the random sampling test. RETS prepares and updates the Sampling Plan and Test Procedure based on its existing resources and capacity. The document called Sampling Plan and Test Procedure of RETS defines the sampling sizes and testing procedures. If a product is being imported into Nepal for the first time, it must undergo a product introduction test at RETS, for a certificate. Once the consignment is received, RETS performs a random sampling test by selecting some items from the consignment and issuing a random sampling test certificate as per the RETS guideline.

6.2.2 Import, customs and VAT incentives

After receiving the PIT certificate from RETS, companies shall submit a completed application along with a set of documents to AEPC for VAT and customs exemptions. The letters issued by AEPC shall be presented to the customs office to obtain customs exemption.

6.3 The application process

This guideline is for grid-connected solar systems up to 500 kW. These do not require a license to install, produce electricity, and connect to the national grid for net metering. However, guidelines, directives and regulations must be followed during installation and operation to ensure the safety and reliability of the system. Using the national standards, NEA's classification and guidelines shall be followed closely for designing and installing a solar system. The stages that need to be completed to do a net metering are provided below.

6.3.1 Preapproval for grid connection and net metering

While preapproval is not currently required for the installation of grid-connected solar systems in Nepal, there is a possibility that NEA or the local authorities may begin enforcing the need to obtain pre-approval for grid connection and net metering from NEA, prior to conducting a detailed feasibility study for solar system installations. This could simplify the installation process and provide assurance that the system will be connected to the grid following inspection and approval by RETS and NEA, thereby enhancing the confidence of developers, service providers, and end-users.

6.3.2 Connection approval

After accepting a (conditional) quotation from an accredited service provider, the client or the service provider shall apply for connection approval and for any rebates and subsidies that the solar system might be eligible for. If needed, the client can also initiate a loan application with a bank or other third-party financial institution. Moreover, this is the stage when the client needs to obtain approval from the local authority (if required) for the installation of the solar system. The permission may include but is not limited to approval from the local municipality and permission from transportation and aviation authorities.

6.3.3 Application for system inspection

After a solar system has been tested and commissioned, the system shall be inspected and certified by the Renewable Energy Test Station (RETS). The report from RETS is required for the customer to apply for grid connection and net metering with NEA.

6.3.4 Application for grid connection and net metering

Upon completion of RETS certification, the client applies to request for grid interconnection and net metering. For this, the system must meet the grid connection requirements of NEA directive 2078 B.S.(refer to Annex 18), NEA's electricity distribution manual 2069 B.S. and NEA's net metering guideline. The application should be accompanied by all necessary documents as per Annex 2 and is to be submitted to the local NEA Distribution and Consumer Service (DCS) office. NEA will then carry out a technical assessment to ensure compliance with guidelines and regulations. If the application meets the criteria, the authority will perform the necessary task on-site and change the meter, allowing the solar system to start generating credits. The excess electricity produced will be sold to the grid at a fixed rate predetermined by NEA.

6.4 Connecting to the grid

6.4.1 Regulatory permits

There are no pre-permit requirements to be adhered to before the installation of the system except for categories stated in NEA directive 2078 B.S. However, for grid connection and net metering, an observation certification from RETS is mandatory.

Other approvals may have to be obtained at a suitable stage before proceeding with the installation if there are potentially affected stakeholders. For instance, if the installation is near the airport, permission and approval from the Civil Aviation Authority of Nepal must be obtained. Also, approval from the municipality may have to be obtained. Depending on the size of the system, location and environmental regulations, additional permits related to environmental impact assessments, land use, or conservation may be necessary.

6.4.2 Owner's consent

The designer and installer must obtain permits from the client to perform tasks on-site and deal with third parties on their behalf. These include:

- Consent to visit the site; to gain access to the electrical panels and install data meters for obtaining more accurate information on the electricity consumption; to utilize the facilities on the property (if required) and for storage and use of equipment on the premises; to use tools and equipment for system installation, considering the potential hazards, noise or inconvenience they may create; for connecting the solar output to the electricity network which includes causing supply disruptions in the process of connecting to the existing system, for any necessary modifications, both structural and non-structural and, if necessary, consent for relocation of facilities (such as TV antennas) and removal of potential shading objects (such as chimneys and trees).
- Consent for land use for the installation of the solar system.
- Consent to submit applications for rebates/subsidies and obtain necessary approvals from relevant authorities, as well as arrange inspections for grid connection and metering purposes, and any other required communication with the authorities on the client's behalf.

6.4.3 Installation of meter

Once a grid-connected solar PV system is approved for connection to the national grid, NEA endorses the appropriate net metering system and installs a meter. At the moment NEA offers single-phase smart meters with bidirectional capacity as well as three-phase time-of-day (ToD) bidirectional smart meters suitable for net-metering of the systems. The installed meter is under NEA's custody since revenue-side meters (except in private PPA contracts) cannot be installed by other parties.

6.5 Monitoring of the system

It is highly recommended to monitor the system performance and component status closely. This helps to ensure the proper functioning of the system and the detection of faults, if any, early on. Typically, there are hardwired communication options for onsite monitoring and cloud-based options for monitoring from afar. Almost every inverter manufacturer has a mobile application for monitoring the system output.

Conclusion	The system has now been installed and is in operation. In case the system is self-owned, the owner performs the routine functions of cleaning and monitoring. In case of technical problems, a qualified technician is being called in, preferably from the same company that installed the system. In case the system is owned by an ESCO, the company performs the routine functions of cleaning, monitoring and repairs in case of technical problems.

ANNEXES

A.1 Solar grid-connected system manual design and estimate tool

Calculation of demand			
#A1	Yearly electrical usage		
#A2	Daily electrical usage	#A1/365	
#A3	Peak Sun Hours of the site	[user input], reference value: 4.5 (3.6-6.2)	
#A4	Array derating factor	[user input], reference value: 0.76	

Measurement of available roof area			
#B1	The total gross area of installation roof		
#B2	Any necessary deduction for roof edge offsets and shading objects		
#B3	Area available for solar panel installation	#B1 - #B2	
#B4	Flat-on-roof installation		
#B5	Tilt leg installation		
#B6	Net area for installation	If option #4; B3x 0.8 and if option #5; B3x 0.52	
#B7			

Estimation of available system size			
#C1	Select a panel – its physical footprint and associated space for installation.		
#C2	Panel wattage		
#C3	Calculate the number of panels needed (N) that can be installed.	#B6/#C1	
#C4	Estimation of system size (kW_P)	#C2 x #C3/1000	

Selection of inverter – PV array DC output shall not be more than 1.33 times the inverter's AC output			
#D1	Effective cell temperature	Tcell.eff = Ta.day+Tr. Where: Tcell.eff: Average daily effective cell temperature in degrees C. Ta.day: The daytime ambient temperature in degrees C Tr: Effective temperature rise for the specific type of installation.	
#D2	Temperature rise applications	Parallel to the roof (<150mm standoff): +35°C Rack-type mount (>150mm standoff): +30°C Ground mounted / top-of-pole mount, free-standing frame and frame on the roof with tilt angle of about + 20 degrees to slope of roof: +25°C.	
#D3	Temperature derating factor	$ftemp = 1 + (\gamma \times (Tcell.eff - T_{STC}))$ ftemp = temperature de-rating factor, dimensionless γ = value of power temperature coefficient per degree C. (typically 0.005 for crystalline cells) T_{STC} = cell temperature at standard test conditions in degrees C.	

#D4	Maximum open circuit voltage	$$Vmax_{\_oc} = Voc_{STC} + [\gamma v \times (Tmin - T_{STC})]$$ $Vmax_{\_oc}$ = Open circuit voltage at minimum temperature in volts V_{oc_STC} = Open circuit voltage at STC in volts γv = Voltage temperature Voc Co-efficient, -V/degrees C T_{STC} = Cell Temperature at STC degrees C	
#D5	Min panel voltage	$$Vmp_{cell}.eff = Vmp_{STC} + [\gamma v \times (Tcell.eff - T_{STC})]$$ Where: *Vmp_cell.eff* = Maximum power point voltage at effective cell temperature, in volts. *Vmp-STC* = Maximum power point voltage at STC, in volts. γv = Voltage temperature (Vmp) coefficient in volts per °C. *Tcell_eff* = cell temperature at specified ambient temperature, measured in °C T_{STC} = cell temperature at STC, measured in °C.	
#D6	Inverter voltage window	$$\#D4 < Inverter\ input\ voltage < \#5$$	
#D7	Minimum number of panels per string	$$Nmin\_per\_string = \frac{V_{inv\_min}}{V_{min\_mpp\_inv}}$$ Where, V_{inv_min} = the *minimum* inverter input voltage $V_{min\_mpp\_inv}$ = the effective minimum MPP voltage of a module at the inverter at maximum effective cell temperature *Please allow a 10% safety margin for the quality of solar cells.*	

#D8	Max number of panels per string	$$Nmax\_per\_string = \frac{V_{inv\_max}}{V_{oc\_max}}$$ V_{inv_max} = Max DC voltage input of inverter *The total short circuit current of the array does not exceed the max DC input current specification of the inverter.*	
SELECT THE RIGHT INVERTER.			

Estimation of system generation			
#E1	Estimation of energy yield (daily)	$Esyst = Parray_{STC} \times Total\ derating \times PSH$	

A.2 Grid connection agreement and application letter format (Nepali)

नेपाल विद्युत प्राधिकरण

वितरण तथा ग्राहक सेवा निर्देशनालय

... ... क्षेत्रीय कार्यालय

... ... वितरण केन्द्र

नेपाल विद्युत प्राधिकरण

र

[सेवा प्रदायक संघ / संस्थाको नाम]बीच भएको

सम्झौता

कार्य विवरण :

५०० वाट वा सोभन्दा बढी क्षमताका फोटोभोल्टेक सौर्य प्रणाली जडान गरी ने.वि.प्रा.को वितरण प्रणालीमा Net Metering मार्फत कनेक्सन गर्न ।

सम्झौता नं. ... ...

मिति : ... साल ... महिना ... गते ... दिन ।

नेपाल विद्युत प्राधिकरण

वितरण तथा ग्राहक सेवा निर्देशनालय

… … क्षेत्रीय कार्यालय

… … वितरण केन्द्र

लिखितम्… … … जिल्ला, … … … महानगरपालिका/नगरपालिका/गा.वि.स. स्थित … … … वितरण केन्द्र/शाखा नेपाल विद्युत प्राधिकरणको तर्फवाट अख्तियार प्राप्त … … … … … श्री … … … … (जसलाई यसपछि यस सम्झौतामा प्राधिकरण अर्थात प्रथम पक्ष भनी सम्बोधन गरिनेछ), श्री कम्पनी रजिष्ट्रारको कार्यालय त्रिपुरेश्वर काठमाडौंमा दर्ता नं. … … मा दर्ता भएको … … …… … … महानगरपालिका/नगरपालिका/गा.वि.स. वडा नं. … … स्थित मुख्य कार्यालय रहेको … … तर्फवाट अख्तियार प्राप्त … … … … … श्री … … … …. (जसलाई यसपछि यस सम्झौतामा व्यक्ति /संघ /संस्था अर्थात द्धितीय पक्ष भनी संबोधन गरिनेछ) आगे हामी दुई पक्षका बीच यस श्री… … … … … … … . (संघ /संस्था) को … … … अवस्थीत फोटोभोल्टेक सौर्य उर्जाबाट … …… … (वाट) क्षमताको सौर्य उर्जा नेपाल विद्युत प्राधिकरणको फोटोभोल्टेक सौर्य प्रणालीबाट प्राप्त हुने ऊर्जासम्बन्धी कार्यविधि- २०७४ बमोजिम नेपाल विद्युत प्राधिकरणको वितरण प्रणालीमा Net Metering मार्फत कनेक्सन गर्न दुवै पक्षको आपसी सहमति र समभ्रुदारी अनुसार यो सम्झौतामा हस्ताक्षर गरी एक/एक प्रति लियौं/दियौं ।

<u>सम्झौताका शर्तहरु:</u>

१ परिभाषा र व्याख्या

विषय वा प्रसंगले अर्को अर्थ नलागेमा यस सम्झौतामा,

(क) "फोटोभोल्टेक सौर्य प्रणाली" भन्नाले फोटोभोल्टेक प्रविधिबाट सूर्यको प्रकाशलाई विद्युत शक्तिमा रुपान्तरण गर्ने प्रणाली सम्झनु पर्छ ।

(ख) "ग्राहक" भन्नाले ने.वि.प्रा.को विद्युत विधिवत उपभोग गर्ने ग्राहक सम्झनु पर्छ ।

(ग) "प्राधिकरण" भन्नाले नेपाल विद्युत प्राधिकरण सम्झनु पर्छ ।

(घ) "वितरण केन्द्र" भन्नाले ने.वि.प्रा., वितरण तथा ग्राहक सेवा निर्देशनालय अर्न्तगत सम्बन्धीत क्षेत्रमा विद्युत वितरण कार्य गर्ने कार्यालय सम्झनुपर्छ ।

(ङ) "Net Metering" भन्नाले अनूसुची २ बमोजिम नेपाल विद्युत प्राधिकरण र ग्राहकले लिए दिएको विद्युतको बिलिङ्ग गर्ने व्यवस्थालाई सम्झनुपर्छ।

२ <u>सम्झौताको अवधि</u>

यस सम्झौता दुवै पक्षले हस्ताक्षर गरेको मिति देखि २ (दुई) वर्ष सम्म कायम रहनेछ । सम्झौताको अवधि समाप्त हुनु १ (एक) महिना अघि निवेदन दिई दुबै पक्षको सहमतिमा यो सम्झौता आवश्यक्तानुसार पूनः नविकरण गर्न सकिनेछ ।

३ <u>ग्राहकले उपलब्ध गराउने सौर्य उर्जाको गुणस्तर देहाय बमोजिम हुनुपर्नेछ :</u>

(१) फ्रिक्वेन्सी : 50 Hz

(२) भोल्टेज स्तर : 230 V/ 400 V/ 11 kV ± 5%

(३) भोल्टेज वेभफर्म : Sinusoidal

(४) थ्री फेज सप्लाई भएमा फेज भोल्टेज अनब्यालेन्स (अधिकतम) : 1%

(५) हार्मोनिक डिस्टरसन (THD): ≤ 3%

४. सौर्य प्रणालीको क्षमता :

ग्राहकले जडान गर्ने फोटोभोल्टेक प्रणालीको न्यूनतम क्षमता ५०० वाट हुनु पर्नेछ । ने.वि.प्रा.का ग्राहकहरुले भोल्टेज स्तर अनुसार नेट मिटरिङ्ग प्रयोजनका लागि निम्न बमोजिम जडित क्षमतामा सौर्य उर्जा प्रणाली जडान गर्नुपर्नेछ ।

(१) २३० भोल्टमा ५ कि.वा. सम्म ।

(२) ४०० भोल्टमा ५ कि.वा. भन्दा माथि ४० कि.वा. सम्म ।

(३) ११००० भोल्टमा ४० कि.वा. भन्दा माथि ।

५. सौर्य प्रणाली जडान :

सौर्य प्रणालीबाट प्राप्त हुने उर्जाको औषत वार्षिक खपतको ९०(नब्बे) प्रतिशत भन्दा बढी नहुनेगरी ग्राहकले सौर्य प्रणाली जडान गरेको हुनुपर्नेछ । ग्राहकले आफुकाहाँ जडित सौर्य प्रणालीबाट उत्पादन हुने विद्युतको पावर फ्याक्टर ०.८५ ल्याग र ०.९५ लिडका बीचमा हुने गरी नेपाल विद्युत प्राधिकरणको वितरण प्रणालीमा जोड्ने व्यवस्था सुनिश्चित गरेको हुनुपर्नेछ ।

६ Net Metering सम्बन्धी व्यवस्था :

(क) ग्राहकले नेपाल विद्युत प्राधिकरणकालाई उपलब्ध गराउने उर्जा (Import) र नेपाल विद्युत प्राधिकरणकाले ग्राहकलाई सप्लाई गर्ने उर्जा (Export) मापनका लागि Bi-directional इनर्जी मिटर जडान गर्नुपर्नेछ ।

(ख) मिटर/मिटरिङ प्रणाली सम्बन्धी अन्य व्यवस्था ने.वि.प्रा.को विद्युत वितरण विनियमावली, २०६९ मा व्यवस्था भए बमोजिम हुनेछ ।

७ ग्रीड सप्लाई नभएको अवस्था :

मर्मतसंभार लगायत अन्य कुनै पनि कारणले नेपाल विद्युत प्राधिकरणको विद्युत वितरण प्रणालिमा विद्युत प्रवाह नभएको अवस्थाले गर्दा ग्राहकको सौर्य प्रणालिबाट उत्पादित उर्जा नेपाल विद्युत प्राधिकरणलाई ग्राहकले सप्लाई गर्न नसकेमा सो वापत ग्राहकले नेपाल विद्युत प्राधिकरणलाई कुनै क्षतिपूर्ति दावि गर्न पाउने छैन ।

८ सौर्य प्रणालिबाट नेपाल विद्युत प्राधिकरणलाई उर्जा दिन नसकेको अवस्था :

मर्मतसंभार लगायत अन्य कुनै पनि कारणले नेपाल विद्युत प्राधिकरणको विद्युत वितरण प्रणालिमा आंशिक वा पूर्ण क्षमतामा ग्राहकले सौर्य उर्जा सप्लाई गर्न नसकेमा सो वापत नेपाल विद्युत प्राधिकरणले ग्राहकलाई कुनै क्षतिपूर्ति दावि गर्न पाउने छैन ।

९. सुरक्षा सम्बन्धी व्यवस्था :

नेपाल विद्युत प्राधिकरणको ग्रीड सप्लाई नभएको अवस्थामा ग्राहकको सौर्य प्रणालीबाट नेपाल विद्युत प्राधिकरणको वितरण प्रणाली स्वतः अलग्गिने (Isolated) व्यवस्थाका लागि उपयुक्त सुरक्षा उपकरण (Protection Device) ग्राहक स्वयंले जडान गर्नुपर्ने छ ।

१०. अर्थिङ्ग (Earthing),फल्ट क्लीयरेन्स समय (Fault clearance time) सम्बन्धी व्यवस्था :

ग्राहकले आफ्नो सौर्य प्रणालीमा जडान हुने उपकरणहरु अर्थ फल्ट/ओभर करेन्ट/Frequency Fluctuation का कारण ट्रिप हुँदा सोको Fault Clearance समय IEC/IEEE ले तोकेको मापदण्ड बमोजिम हुनुपर्नेछ ।

११. <u>सौर्य उर्जा सम्बन्धी लेखांकन तथा समायोजन :</u>

ग्राहकले नेपाल विद्युत प्राधिकरणको प्रणालीबाट प्राप्त गर्ने उर्जाको युनिट र नेपाल विद्युत प्राधिकरणको प्रणालीमा सप्लाई गर्ने उर्जा युनिट हरेक महिना हिसाव गर्दा ग्राहकबाट कुनै महिनामा बढी उर्जा प्राप्त हुन आएमा सोहि महिनामा वा त्यसपछिको अर्को महिनामा समायोजन गरिनेछ र आर्थिक बर्षको अन्त्यमा ग्राहकबाट बढी उर्जा प्राप्त भएको देखिएमा सो बापत ग्राहकले नेपाल विद्युत प्राधिकरण संग कुनै दावि गर्न पाउने छैन ।

तर यसरी समायोजन गरिने सौर्य प्रणालीको उर्जा नेपाल विद्युत प्राधिकरणबाट ग्राहकले प्राप्त गर्ने बार्षिक उर्जाको ९० (नब्बे) प्रतिशतभन्दा बढी हुने छैन ।

१२ <u>विद्युत उर्जाको विलिङ्ग सम्बन्धी व्यवस्था :</u>

Net Metering मार्फत उर्जा प्राप्त गरी हुने मिटर जडान भएका ग्राहकहरुको मासिक उर्जा विलिङ्गका लागि अनुसुची-२ बमोजिमको बिल सम्बन्धित वितरण केन्द्रले प्रयोगमा ल्याउनेछ । डिमाण्ड शुल्क तिर्नुपर्ने ग्राहक भएमा अनुसुची-२ को ढाँचामा आवश्यक परिमार्जन गरी विलिङ्ग गर्न सकिनेछ ।

१३. <u>लागु हुने कानून</u>

यो सम्झौतामा उल्लेख गरिएका कुराहरुको हकमा "फोटो भोल्टेक सौर्य प्रणालीबाट प्राप्त हुने उर्जासम्बन्धि कार्यविधि -२०७४" बमोजिम लागु हुनेछ र उल्लेख नभएका कुराहरुको हकमा सम्झौताको व्याख्या तथा कार्यान्वयन प्रचलित नेपाल कानुन बमोजिम नै हुनेछ ।

१४. <u>सम्झौतामा संसोधन</u>

यो सम्झौता दुवै पक्षको लिखित सहमति अनुसार "फोटो भोल्टेक सौर्य प्रणालीबाट प्राप्त हुने उर्जासम्बन्धि कार्यविधि -२०७४" विपरित नहुने गरी मात्र संशोधन गर्न सकिनेछ ।

१५ <u>सम्झौताको समाप्ति/ रद्द हुने अवस्था:</u>

नेपालको प्रचलित कानून अनुसार सम्झौता रद्द गर्नु पर्ने अवस्था आइ परेमा दुवै पक्षले आपसि सहमतिमा यो सम्झौता जुन सुकै बेला रद्द गर्न सक्नेछन् ।

१६. सम्झौताको अविधमा दुवैपक्षबीच कुनै विवाद भएमा आपसि सहमतिमा विवादको निरुपण गरिनेछ ।

१७. यो संझौता कार्यान्वयन क्रममा पत्राचार गर्नु परेमा निम्न निकायमा गर्नु पर्नेछ ।

[नेपाल विद्युत प्राधिकरणवाट अधिकार प्राप्त प्रतिनिधि]

[सेवा प्रदायक संध /संस्थावाट अधिकार प्राप्त प्रतिनिधि]

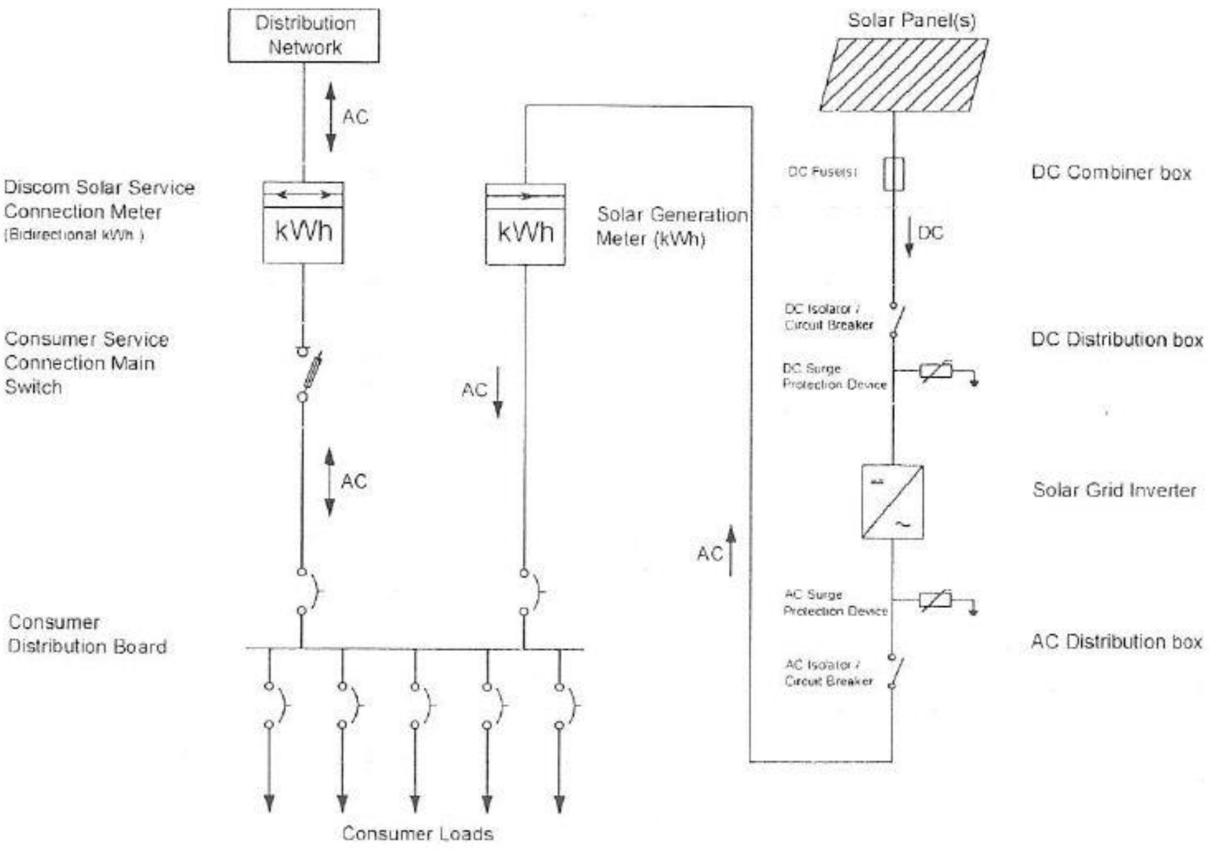
यो संझौता दुबै पक्षको सहमतीले अधिकार प्राप्त व्यक्तिहरुबाट तल उल्लेख गरिएका साक्षीहरुको रोहबरमा [नेपाल विद्युत प्राधिकरणले तोकेको ठाउँ] मा [सम्झौता मिति], बसी हस्ताक्षर गरी सम्झौता गर्दछौं ।

... ...	... ...
द्वितीय पक्षको तर्फबाट	**प्रथम पक्ष वा कार्यालयको तर्फबाट**
सेवा प्रदायक संघ/संस्थाको अधिकार प्राप्त व्यक्तिको नाम :	ने.वि.प्रा.को अधिकार प्राप्त व्यक्तिको नाम : ... ...
दर्जाः	दर्जाः ... ...
दस्तखतः...	दस्तखतः... ... ...
मितिः.	मितिः... ... ...
संघ/संस्थाको छाप	कार्यालयको छाप
साक्षी :	साक्षी :
१.	१ ... ...
२.	२ ... ...

इति संवत ... ... साल .... महिना ... ... गते रोज ... ... शुभम् ।

अनुसुची-१

ग्रीड कनेक्टेड सौर्य फोटोभोल्टेक प्रणालीको Typical wiring diagram



Net Metering को विलिङ्गसम्बन्धि तालीका
नेपाल विद्युत प्राधिकरण
वितरण तथा ग्राहक सेवा निर्देशनालय
.... वितरण केन्द्र

ग्राहकको नाम :
ग्राहक संख्या :

स्वीकृत क्षमता :
महिना/साल :

समय	ने.वि.प्रा. बाट सप्लाई भएको उर्जा (X_1) KWh			ग्राहकबाट प्राप्त भएको सौर्य उर्जा (X_2) KWh			विलिङ गनुपर्ने उर्जा (X_3) KWh $[X_3]=[X_1]-[X_2]$ KWh	उर्जाको विल रकम रु ($X_1 \geq X_2$)	समायोजन हुन बाँकि रहेको उर्जा ($X_1<X_2$) KWh
	हालको अंक [A]	साविक को अंक [B]	युनिट $[X_1=A-B]$	हालको अंक [C]	साविकको अंक [D]	युनिट $[X_2=C-D]$			
T_1 (Peak)									
T_2 (Normal)									
T_3 (Off Peak)									

नोटः TOD मिटर जडान नभएका ग्राहकहरुको हकमा उपरोक्त बमोजिमको अलग अलग समयको लागि विद्युत महशुल दर लागू हुनेछैन ।

Date:

To,

[DCS name],

[Address],

Nepal Electricity Authority

Subject: Intent to apply for net metering of [user input] kW rooftop solar

Dear Sir/Madam,

We would like to inform that we have recently installed a **[user input] kW** solar rooftop grid-connected system. We want to go through the process of Net Metering Application as per NEA rules and regulations. We have attached the Renewable Energy Testing Service (RETS) certification of the (PV) system, used solar module and grid-tie inverter with the letter, also, attached are the single-line diagram and technical specification of the products. We seek full cooperation from your side.

Sincerely,

…………………………………………

(Name)

(Designation)

A.3 Pre/detailed feasibility study • Template for terms of reference

Feasibility studies of Solar grid-connected system

for [*Project name*]

at [*Address*]

1. Introduction

1.1 Background

[Provide a brief overview of the background and context for the solar rooftop project, including its purpose and goals.]

1.2 Purpose of the pre-feasibility study

The purpose of this pre-feasibility study is to assess the viability of implementing a solar rooftop project at *[Location/Building]*. The study aims to provide key insights into the technical, financial, environmental, and regulatory aspects of the project.

2. Objectives of the study

The main objectives of the pre-feasibility study are as follows:

2.1 Assess the technical feasibility of installing solar panels on the rooftops of *[Location/Building]*.

2.2. Estimate the initial capital investment required for the project.

2.3. Evaluate the financial viability, including potential revenue streams and return on investment.

2.4. Analyse the environmental impact and sustainability of the project.

2.5. Identify regulatory and permitting requirements.

3. Scope of work:

3.1 Assessment of resources

- To provide essential data for financial analysis, system design, and overall project planning
- Minimize uncertainties, improves project viability, and supports informed decision-making throughout the project development process.

3.2 Site assessment

- Site visits and assessment of the rooftops for solar panel installation.
- Identification of any technical constraints or limitations

3.3 Technical feasibility

- Solar irradiance assessment
- Assessment of rooftop structural integrity
- Evaluation of solar panel technology options
- Preliminary system design

3.4 Financial analysis

- Cost estimation for equipment, installation, and maintenance
- Revenue projections, including feed-in tariffs and energy savings
- Preliminary financial modelling

3.5 Grid integration study

- Identify potential technical challenges and constraints related to grid connection
- Evaluate the grid's ability to accommodate the variability and intermittency of renewable energy generation
- Identify any upgrades or modifications needed to the grid infrastructure
- Evaluate voltage profiles, power flows, and fault analysis

3.6 Economic and environmental impact assessment

- Understand, evaluate, and address potential environmental effects associated with a project
- Ensure that projects are planned, designed, and executed in a manner that minimizes harm to the environment
- Mitigate risk by identifying potential environmental risks early in the project development process

3.7 Risk analysis

- Financial viability: Identify potential financial risks and uncertainties associated with the project
- ROI Estimation: Accurate risk analysis to provide a more realistic projection of the return on investment (ROI)
- Resource variability: To assess the variability in solar resource availability and its impact on energy generation
- Technical risks: Risks such as equipment failures or maintenance issues that can impact project performance and profitability
- Regulatory, market, operational and financial risk assessment

3.8 Feasibility report

4. Team and expertise

- Project lead: Oversee the entire feasibility study process, coordinating the team, managing timelines, and ensuring that the study stays on track and within budget
- Technical experts
  - **Solar engineer:** Assess the technical aspects of the project, including system design, equipment selection, and solar resource assessment
  - **Electrical engineer:** Assessment of the electrical aspects of the project, including grid integration, wiring, and safety considerations
  - **Structural engineer**: Evaluate the structural integrity of the rooftops and any mounting systems for solar panels
  - **Environmental specialist:** Assess the environmental impact of the project and ensure compliance with environmental regulations

- Financial, legal and regulatory expert
  - For conducting financial modelling and cost-benefit analysis
  - Knowledgeable about local, state, and national regulations related to solar energy projects including regulatory requirements

5. Timeline of activities

Provide a timeline for the completion of the pre-feasibility study, including key milestones and deadlines.

6. Budget

Include an estimated budget for conducting the study, including personnel costs, equipment, and any other expenses.

7. Reporting

Specify the reporting structure and communication channels for progress updates and final report submission.

8. Reporting format

Title Page

Title of the Report: "Pre/Detailed feasibility study for solar rooftop project at *[Location]*"

Date of submission

Project name and identifier

Names and contact information of the project team and stakeholders

Table of contents:

(Include page numbers for each section and subsection.)

Executive summary

- A concise summary of the key findings and recommendations
- Highlights the project's viability and key financial metrics
- Provides a quick overview of the studies and methods

1. Introduction

- Background and purpose of the feasibility study
- Objectives and scope of the study
- Overview of the solar rooftop project and location

2. Methodology

- Explanation of the research methods, data sources, and assumptions used in the study
- Description of data collection and analysis procedures

3. Site assessment

- Assessment of the physical site and rooftop conditions
- Solar resource assessment, including solar irradiance data and shading analysis

- Structural assessment of rooftop support for solar panels
- Identification of technical constraints or limitations

4. Technical feasibility
    - Description of the proposed solar energy system, including panel type, inverter, and mounting structure
    - Preliminary system design, including sizing and configuration
    - Analysis of system efficiency and expected energy generation

5. Financial analysis
    - Capital cost estimation, including equipment, installation, and permitting
    - Revenue projections, including feed-in tariffs, net metering, and energy savings
    - Financial model with cash flow projections
    - Sensitivity analysis to assess the impact of variables on financial outcomes

6. Environmental impact assessment
    - Evaluation of the project's environmental impact, including carbon emissions reduction
    - Compliance with environmental regulations
    - Proposed mitigation measures

7. Regulatory and permitting requirements
    - Identification of local, state, and national regulations and permitting requirements
    - Status of permit applications and approvals
    - Discussion of grid connection and interconnection requirements

8. Risk analysis
    - Identification and assessment of project risks (technical, financial, regulatory, etc.)
    - Risk mitigation strategies and contingency plans

9. Market analysis
    - Assessment of the energy market, including pricing trends and competition
    - Identification of potential off-take agreements

10. Conclusion and recommendations
    - Summary of key findings and conclusions
    - Recommendations for moving forward with the solar rooftop project, including "Go/No-Go" decision

11. Appendices
    - Additional supporting information, data, and technical details
    - Detailed financial models, charts, and graphs
    - Maps, diagrams, and photos of the site and proposed system

12. References
    - List of sources, references, and data used in the report

13. Glossary
    - Definitions of technical terms and acronyms used in the report

A.4 Pre-feasibility study • AEPC application form (if the subsidy is sought)

Government of Nepal

Ministry of Energy, Water Resources and Irrigation

Alternative Energy Promotion Centre (AEPC)

Promotion of Solar Energy in Rural and Semi-urban Regions of Nepal

Application form for solar rooftop PV

Name of the commercial and industrial (C&I) entity:		
Address:		
Name of the energy service company-ESCO (if applicable):		
Address:		
Project location:	Latitude:	Longitude:
Province:	District:	Municipality:
Ward no:	Tole:	Street name:
Name of the contact person:		
Position:	Email ID:	Telephone:
Type of industry or commerce: Education and Health Food and Beverage Others C&I Entity……………	Company registrationnumber of applicant: Date of Registration:	PAN/VAT number of applicant:
Turnover of Last FY (NPR):	………………………………………	
Total number of employees: ……	Male employee: ……………	Female employee: ……………
Type of roof (Flat/Inclined):	Age of building/roof: _______Years	Building height (m): ____
Roof Space in Sq. ft:____Non-shaded Roof space in Sq. ft. ______ Additional unused shadow-free ground space within the premises, if applicable:_Sq. ft.		
Is the proposed site adjacent to or within any of the following sensitive receptors?	YES	NO

a) Natural habitats and/ or legally protected areas (wetlands, forests, estuary, buffer zones, nature reserves)?		
b) Is the site located near airport? If **YES** approx. distance (km): _		
Approved Load (NEA):_kVA, Transformer Capacity:_____kVA, Number of Transformer:Average Monthly electricity bill (NPR): __		
If applicable: Diesel fuel consumption to run Diesel Generator set (Liter per annum): …………………….. Electricity supply (kWh/year) by the Diesel Generator set, if available: …………………….		
Estimated Rooftop Solar PV capacity (kWp):______ (if known)		

Government of Nepal
Ministry of Energy, Water Resources and Irrigation

Alternative Energy Promotion Centre (AEPC)

Promotion of Solar Energy in Rural and Semi-urban Regions of Nepal

Source of financing for the proposed Rooftop PV project	A) Equity (%): B) Bank loan (%):

Declaration:

I/We have studied the notice call for the Rooftop Solar PV demand application carefully and hereby agreeto the terms and conditions put forwarded on it. I/We hereby certify that the information filled up in this application form is correct and that if found otherwise, may result in invalidation of the application.

Authorized Signature: …………………………

Name: …………………………

Position: ………………………………

Mobile Number: ……………………

Date: ………………

List of documents to be submitted:

- Letter of application along with the complete filled out demand form
- Photos of the building and roof area where PV array is proposed to be installed
- Copy of the electricity bills for the immediate past financial year
- Copy of company/firm registration certificate with updated renewal
- Copy of board meeting minutes showing commitment for solar rooftop PV installation

- Copy of PAN/VAT registration certificate
- Copy of TAX clearance certificate of F.Y 2078/79
- Copy of building completion certificate
- Copy of land and building ownership document (Lalpurja), agreement between property owner andESCO/C&I entity for using entity's roof space.
- Company profile including audit report of F.Y. 2078/79

Information for the applicant:

- From 100kWp up to 1MWp solar PV array capacity.
- The site must have electricity access to the national grid.
- The entity shall have minimum 51% self-consumption of the annual PV energy (in case of net metering).
- Detailed feasibility study shall be conducted by applicant and approved by AEPC.
- Applicant must have capacity and commitment for carrying out environmental and social management measures.
- Subprojects in disputed property will not be eligible, ownership and access rights must be clearly defined.
- Comply with the Environmental and Social Management Framework (ESMF) and Stakeholders Engagement Framework (SEF) of the project.

A.5 Pre-feasibility study • Template

Grid-connected solar system site survey format for rooftop project

Information to be collected	Value/data
General information	
Date of survey	
Name of institutions	
Address	
City	
Latitude/Longitude of site	............°N, ...°E
Surveyed by:	
Checked by:	

Describe the customer's aspirations/expectations for installing a solar grid-connected system:

Information to be collected	Value/data
No. of roofs	
Roof type – RCC, GI sheet, etc.	
What are the items installed on the roof that could obstruct solar module installation?	
Usable area for installation of solar modules (sq.m)	
Age of the roof (years since construction)	
Accessibility to the roof	
Load bearing capacity	
Building(s) orientation	
Roof(s) type - pitched/slant roof	....
Roof(s) orientation	....
Roof(s) tilt angle	....

Roof(s) material	………………………. ………………………. ……………………….
Roof(s) age	………………………. ………………………. ……………………….
Roof structure - material, load-bearing capacity	………………………. ………………………. ……………………….
Accessibility and convenience to work on the roof	
Assess potential sources for near and far shadow	
Shadow from trees and vegetation	
Shadow from other buildings	
Shadow from the natural landscape in hilly areas	
Maximum wind velocity	
Environment: dust, pollution	
How is the building separated from the roof?	
Activities under the roof	………………………. ………………………. ……………………….
Are there any flammable materials inside?	
Space available for the installation of inverter	
Load details – List of appliances and working hours	
Peak load, day and time	
Average monthly expenditure on electricity bills	
Details of standby power supply system, if any	
Average monthly expenditure of standby power supply system, if any	
Location of balance of systems equipment	
Health, safety and environmental risks	

Photo of the roof from the site

Roof measurement with tentative dimension in mm

A.6 Pre-feasibility study • Due diligence checklist

Pre-feasibility study (PFS) due-diligence checklist

Please give a score between 0 and 4 for each question.

Yes, this aspect is fully satisfied	4
Yes, this aspect is mostly satisfied	3
Yes, but some important information is still missing	2
Yes, but much important information is still missing	1
No, this aspect is not fulfilled	0

	Points
Do you have all the essential data required to assess the project?	
Is the Demand/PFS form properly filled?	
Are the data sources reliable and are the data collected of good quality?	
Is the information on the site location adequately provided?	
Is the information on roof space adequately provided?	
Is the information on site location within sensitive receptors provided?	
Is the information on the electrical system (e.g., transformer size, approved load etc.) adequately provided?	
Is the estimated solar PV capacity provided?	
Is the information of the financing source adequately provided?	
Have all supporting documents mentioned in the demand form provided?	
Total points	

Recommendations	Points
PFS is satisfactory with definite conclusions on the way forward	32-40
Please collect more data and information	20-31
PFS is not satisfactory, thus not approved	0-19

A.7 Pre-feasibility study • Report format

Pre-feasibility study of

[Site name]

Solar grid-connected system

Project title: [Title]

Project code: [Code]

Date: [Date]

Prepared by	Submitted to
[Company name]	[Organization name]
[Company address]	[Organization address]

List of separate attachments submitted along with this report:

i) NEA electricity bills for the last 3 years
ii) Load list
iii) Software simulation report

Glossary

EXECUTIVE SUMMARY

*Describe briefly in **half page** the design and outcomes of the pre-feasibility study. The Executive Summary should include the key information of the study.*

Paragraph #1

i. *Site location*
ii. *Information about the project site, owner's discretion*
iii. *Information on how the data for the pre-feasibility was obtained*

Paragraph #2

i. *Current sources of electricity used*
ii. *Estimated load and energy demand scenario (short-term and long-term)*

Paragraph #3

i. *Land/roof space availability for the solar array, powerhouse and power evacuation approach*
ii. *System description (solar array capacity, inverter ratings, system architecture)*
iii. *Estimated annual energy production and savings*

Paragraph #4

i. *Total system cost*
ii. *Cost of electromechanical system, powerhouse and power evacuation*
iii. *Indicative financial and economic analysis like NPV, IRR and payback period*

Paragraph #5

i. *Conclusion*

SITE DETAILS

Location

Describe the location of the site and provide information about,

i. *Site address (Rural municipality/municipality, district and province)*
ii. *Site coordinates*
iii. *Registered business and nature of business*

Site access

Describe the accessibility of the site. Provide information about,

i. *Access route description (vehicle access, type of road/path e.g., earthen, gravel, black topped (mention accessibility month-wise, etc.)*
ii. *Name and distance from the nearest city and airport*

Ownership and source of fund

Describe the ownership modality and funding mechanism or the business model. Provide information about,

i. *Owner/Co-owner and model (CAPEX, OPEX/ESCO)*
ii. *Indication of funding mechanism and involved parties' contribution (if known)*

Security

Describe briefly the security aspects of the site area from the perspective of the solar grid-connected system that is to be built. Provide information about,

i. *Security of solar array location (remote observation is acceptable)*
ii. *Security of powerhouse location (remote observation is acceptable)*

Telecommunications and internet access

Describe coverage of mobile network and internet access.

Climate

Describe the climate of the region based on data trends obtained from reliable sources (such as, nearest weather stations, Meteonorm software, etc.). Provide information about,

i. *Graph on annual temperature trends*
ii. *Graph on annual precipitation trends*
iii. *Any information provided by the client regarding extremities in climate and weather-conditions like flooding, landslide, lightning, etc.*

Current sources of electricity

Describe the current sources of electricity used by the facility. Provide information about,

i. *Type and technology of the electricity sources, their capacity*
ii. *The energy mix scenario when new source is added*

SITE ASSESSMENT

Solar array location

i. *Estimated land/roof area, ownership details, GPS coordinates, topography, orientation and azimuth, near and far shading (if known), slope and land/roof type, etc.*
ii. *Should have a general assessment of usability with respect to natural calamities such as floods, landslides, lightning, etc.*

Photo suggestions

i. *Any photo of the roof or ground where the solar array can possibly be located*

Powerhouse location

i. *Estimated area available/allocated area, ownership, GPS coordinates, topography, orientation, current use of the designated area, slope and soil type, etc.*
ii. *Should have a general assessment of usability with respect to natural calamities such as floods, landslides, etc.*

iii. Distance between the power generation and the evacuation transmission line which may be 400V, 11KV, or the substation for larger projects

Photo suggestions

i. Any photo of the powerhouse where the power conditioning units can possibly be installed

LOAD AND ENERGY DEMAND ANALYSIS

Daily load and energy demand analysis

Describe the analysis done for estimated daily load demand analysis.

TECHNICAL DETAILS OF SOLAR GRID-CONNECTED SYSTEM

Design summary

Describe and summarize the selection, sizing, ratings, system architecture, estimations and assumptions, and calculations used to come up with the perceived design in a short paragraph as well as in tabular form.

System architecture

Present a block diagram and explain the significance of the system architecture chosen for the project. Explain its advantages with respect to the design and the project parameters.

Energy generation

Present the energy generation scenario using manual calculations, forecast energy generation based on the report produced by using software such as PVsyst, homer, etc. and an online database of irradiance for the specific site location. Use graphical representation to present sun path diagrams, GHI, losses, monthly energy generation profiles, etc.

Shading analysis

Near and far shading

i. Clearly mentioning the criteria, formula, tools etc. used in determining the shading analysis
ii. Shading analysis for the proposed array over the period of 12 months with December 22nd data in focus, simulations (if needed)

Solar PV array

i. Module specifications used for calculations, drawings, and analysis
ii. The sizing, design, distribution, and positioning of solar PV array within the facility along with coverage area

Module mounting structure

i. *The type of material proposed, its strength, advantage, selection procedure and other technical parameters and specifications must be clearly mentioned*

On-grid inverter(s)

i. *Must include the selection criteria, design basis, and calculations including losses related to the inverter sizing and selection*
ii. *Must include specifications relevant to design and selection*
iii. *Must choose inverter citing compatibility to the other selected components*
iv. *Must represent the distribution of modules with respect to array size(kW), string sizing calculations, etc.*
v. *Describe a proprietary or third-party online monitoring system compatible with the system*

Power evacuation plan

i. *Must include a description of the power evacuation plan from the facility*

SAFETY CONSIDERATIONS

i. *Any measures that must be taken for the safety of the system including PV array, powerhouse, power evacuation units etc. must be clearly mentioned*

BILL OF QUANTITY AND COST

Electromechanical system

i. *BoQ for the proposed system with the breakdown of major components must be done. Other items of the balance of systems can be lumped together*
ii. *BoQ for services and goods must be separated*
iii. *Vatable and non-vatable items must be distinguished*
iv. *Currency used must be in NPR with commas as a separator*

FINANCIAL ANALYSIS

Source of funds

i. *Indicative sources of funds may vary in %, cash or kind from different sources. All the sources of funds must be clearly mentioned and stated in tabular form accompanied by a narrative.*

Financial indicators

i. *Financial indicators such as IRR, Payback period, LCOE, Cashflow diagram, ADSCR, lifecycle costing, etc. must be calculated and presented*
ii. *If the financial indicators don't produce the desired results, possible business cases and solutions must be devised and presented*

iii. For clarity and better understanding, graphs, charts and flow diagrams must be used along with tables and figures to showcase financial indicators
iv. In the case of the ESCO model, the PPA rate within the parties must be taken as a reference for calculation. However, PPA for net metering issued as per the directives for net metering by NEA must be considered depending upon the modalities of operation agreed upon

CONCLUSION

Provide a summary of the system architecture, per unit cost reduction potential, project cost and outcomes of the economic analysis to showcase the profitability to the users of the system.

ANNEX

Software simulation report

Load list

Site photos (if available)

A.8 Detailed feasibility study • Template

Solar grid-connected site survey form

Version 3, 14 February 2023

Note to surveyor: Please take as many photographs as possible, GPS location tagging and videos of the project location specific to the sections in the form below (for example, solar array location, powerhouse, power evacuation location etc.)

= take photos = record the GPS point(s) = use measuring tape

Tools required during the survey	Checklist
GPS device	☐
Measuring tape (>50 meters)	☐
Power analyser	☐
Mobile phones with camera, calculator, angle meter	☐
Pen and notebook	☐
A3 printout of google map/field papers with positions of the facility, etc., (for easy layout of site details)	☐
Civil and architecture drawings of the facility	☐
Suitable mobile application to find and record sun path diagrams for 12 months	☐

Documents to be collected from the site	Checklist
NEA electricity bills for the last 3 years	☐
Diesel generator set log sheet for at least 1 year (3 years preferred)	☐
Distributor side statutory requirements, limitation, capacity	☐
Single line diagram/Electrical as-built diagram of the whole facility	☐
Site load list (list of all the electrical equipment with ratings)	☐
[Insert]	☐

The following section gathers data about the selected site and related information which will be helpful in planning and designing the system and operational modality.

Location information			
Name of the Organisation/Customer			
Key contact person	Name:	Contact no.:	Email:
Tole name			Ward no.:
Village/Town			

Rural municipality/Municipality/Metro-Sub metro						
District						
Province						
Nature of business						
Facility expansion plans	Yes ☐			No ☐		
	If yes, mention details:					
Which mobile network works best?	☐ NTC ☐ Ncell ☐ Others: ____________					
Geographical coordinates of the site	Latitude		Longitude		Elevation	
Temperature range	Minimum (^{0}C)			Maximum (^{0}C)		
Preferred model	☐ CAPEX			☐ OPEX/ESCO		
	☐ Others (mention):					

General information

Study team

SN	Name	Designation	Phone no.	Signature
1.				
2.				
3.				

Ownership
(Information from the Commercial/Industrial facility)

Probable ownership of the system *(tick all that apply)*	☐ Self-owned	☐ Installer	☐ Third party(mention):
Probable management of the system *(tick all that apply)*	☐ Self-managed	☐ Installer	☐ Third party(mention):

Source of project funds *(estimated)*	Contribution (NPR)	Remarks *(if % share is applicable, indicate here)*
Subsidy (mention the donor agency) e.g., AEPC		
Contribution from the beneficiary		

PG/LG contribution		
Third-party contribution		
For OPEX/ESCO, contribution from developer		
Financial institutions-FIs *(loan/equity)*		
In the case of loans from financial institutions (FI)		
Name of FI	Interest rate per annum	Term period *(years)*
Loan/credit experience		
Does the organization have prior loan/credit experience? For purchase of diesel generator, online UPS, solar PV system, etc.	☐ Yes ☐ No	
If yes, for what purposes was the loan taken?	1. ______ 2. ______ 3. ______ 4. ______	

Site accessibility				
Name of the road up to the facility				
Is the road motorable (From the road-head to the project site)?	☐ Yes ☐ No If yes, road type: ☐ Asphalt coated ☐ Gravel ☐ Earthen			
	If no, mention the means of access (E.g., Walking, two-wheeler only etc.):			
If access to the site is NOT motorable	Name of the nearest motorable road from the site: ______________________________ Type of vehicle access: ☐ 22ft truck ☐ Tractor ☐ Pickup trucks ☐ Hand-held tractors Distance from the site to the nearest accessible road: ___________ Km Time taken to reach the nearest motorable road (From the site): ___________ hours Road type: ☐ Asphalt coated ☐ Gravel ☐ Earthen			
Indicate the months when the site is accessible/not accessible	January	Accessible ☐ Not accessible ☐	July	Accessible ☐ Not accessible ☐
	February	Accessible ☐ Not accessible ☐	August	Accessible ☐ Not accessible ☐
	March	Accessible ☐ Not accessible ☐	September	Accessible ☐ Not accessible ☐
	April	Accessible ☐ Not accessible ☐	October	Accessible ☐ Not accessible ☐
	May	Accessible ☐ Not accessible ☐	November	Accessible ☐ Not accessible ☐
	June	Accessible ☐ Not accessible ☐	December	Accessible ☐ Not accessible ☐
What is the nearest airport?	Name of the airport: ______________________________ Walking distance from the airport to the site: ___________Km Estimated time for porter to reach the site: ___________ hrs.			

Describe directions to the facility (for example, landmarks, key directions)	*(The purpose of the collection of this data is to guide anyone who wants to reach the site by enquiring with the dwellers)*

The following section gathers information on the electricity demand of the facility, existing energy sources scenario etc., vital information for designing the type and size of the system.

Electricity demand, plant operation and current energy source information						
Current source of electricity *(Please use extra sheets, if required)*						
SN	Type of energy source					
1.	Primary source (E.g., national grid)	Transformer (kVA)		☐ 1- phase		☐ 3-phase
		Load (Ampere)				
2.	Secondary source (E.g., diesel generator)	Capacity (kVA)		☐ 1-phase		☐ 3-phase
3.	Non-utility generation (If any- e.g., biomass gasifier)	Capacity (kVA)		☐ 1-phase		☐ 3-phase
	If solar PV system	System size (kW_P)		PV inverter size(kW/Phase)		
		Battery size (kWh)		Battery inverter size (kW/Phase)		
4.	Other sources (E.g., UPS battery backup)	Capacity (kVA/kWh)		☐ 1-phase		☐ 3-phase
5.	Does a power cut exist?	☐ No	☐ Yes	If yes, mention the schedule:		
				Average outage time (Hrs.):		
6.	Diesel generator (DG)	Capacity (kVA)	Fuel consumption/hour	Usage (hours)		
				Per day	Per week	Per month
	DG 1					
	DG 2					
	DG 3					
7.	Changeover type	Automatic ☐ Manual ☐				

Operation hours/days				
Is the plant operational for 365 days?	☐ Yes	☐ No (provide details):		
Days	Sunday	☐ 24 hours	☐ 12 hours	☐ Others (mention): ____________
	Monday	☐ 24 hours	☐ 12 hours	☐ Others (mention): ____________
	Tuesday	☐ 24 hours	☐ 12 hours	☐ Others (mention): ____________
	Wednesday	☐ 24 hours	☐ 12 hours	☐ Others (mention): ____________
	Thursday	☐ 24 hours	☐ 12 hours	☐ Others (mention): ____________
	Friday	☐ 24 hours	☐ 12 hours	☐ Others (mention): ____________
	Saturday	☐ 24 hours	☐ 12 hours	☐ Others (mention): ____________

The following section gathers information to access solar PV potential and assessment of location used for designing and installation of solar mini grid at the given location.

Assessment for solar grid-connected design			
Solar photovoltaic energy assessment			
Winter (shortest day)		Summer (longest day)	
Sunrise (above horizon)	Sunset (above horizon)	Sunrise (above horizon)	Sunset (above horizon)

Are there any obstacles on the horizon during sunshine hours throughout the year or on seasons? (use PV application for sun path diagrams)	Yes ☐	No ☐	If no, describe the time and hours of shading:

Solar array and powerhouse location

Identify the location for solar panel considering the following criteria:

- *South-facing roof/land with maximum sunlight*
- *Free from tall trees, buildings, and obstacles (no shading)*
- *Safe from exposure to chemicals, and industrial waste, not falling on the right of way*
- *Permanent structures with the capacity to lodge distributed static loads*
- *Near the powerhouse*
- *The powerhouse must be chosen in such a way that it lies close to the solar PV array location (Advocate the beneficiary on the benefits and risks of having a powerhouse at a farther end)*
- *Structure analysis of the roof designated for installation of solar PV modules (Visual inspection as well as analysis report)*

SN	Parameters	Value				Remarks
	Solar PV array location					
	For ground mount type installation					
1.	Is the feasible land area available?	Yes ☐		No ☐		
2.	Type of land	Own ☐		lease ☐		
3.	Total land area available (m^2)					
4.	Land facing direction (if applicable)	E ☐	W ☐	N ☐	S ☐	
	Azimuth angle	___________ ^{0}				
5.	In the case of lease, land lease agreement tenure?	Yes ☐		No ☐		
	If yes, agreement timeline (in years)	_______________ years				
	Land lease amount/year	_____________ NPR/year				
6.	Exact PV array location	Pictures				
		Taken ☐		Not taken ☐		
7.	GPS coordinates of the exact array location	________ N		________ E		
8.	Free from shading from all directions	Yes ☐		No ☐		
9.	Type of land available	Flat ☐ Inclined land ☐ Damp area ☐ Rocky area ☐ Others (Mention):				
10.	Is any noticeable wind blowing observed? Describe, if any mishaps occurred due to extreme wind in the past.	Yes ☐		No ☐		Mention (if any):

For roof mount type installation (use extra sheets if required)				
	Roof 1	Roof 2	Roof 3	Roof 4
Height of the roof from the ground (meters)				
Ownership of the roof (self/rental)				
In case of lease, lease agreement tenure (years)				
Land lease amount/ Year (NPR/year)				
Age of the roof and relevant structure (years)				
~Slope (degrees)				
Accessibility to the roof	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐
Free from shading from all directions	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐
Planned future expansion of the roof	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐
Is this roof considered for installation purposes?	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐
Will roof penetration be allowed (with proper sealants for water proofing)?	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐

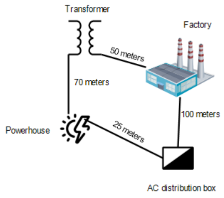
In case of more than 1 roof				
Roof 1	Type:	Orientation:	Total Area (m^2):	**Use an extra sheet to draw the perimeter and shape*
Roof 2	Type:	Orientation:	Total Area (m^2):	**Use an extra sheet to draw the perimeter and shape*
Roof 3	Type:	Orientation:	Total Area (m^2):	**Use an extra sheet to draw the perimeter and shape*
Roof 4	Type:	Orientation:	Total Area (m^2):	**Use an extra sheet to draw the perimeter and shape*
Roof 5	Type:	Orientation:	Total Area (m^2):	**Use an extra sheet to draw the perimeter and shape*
Roof 6	Type:	Orientation:	Total Area (m^2):	**Use extra sheet to draw the perimeter and shape*
Roof 7	Type:	Orientation:	Total Area (m^2):	**Use extra sheet to draw the perimeter and shape*

Powerhouse location				
1.	Should the powerhouse be constructed?	Yes ☐ (Space for construction will be availed) No ☐		
2.	Distance of powerhouse from the solar array location	______________Meters		
3.	Total area allocated for powerhouse	__________________ m^2		
4.	Allocated powerhouse area	Open ground ☐		Inside the facility ☐
				Allocated area (e.g., basement/warehouse):
5.	In the case of a lease, land lease agreement done?	Yes ☐ No ☐		
	If yes, for how many years? (mention)	____________ years		
	Land lease amount/year	_____________ NPR/year		
6.	Exact powerhouse location	Pictures		
		Taken ☐	Not taken ☐	
7.	GPS coordinates of the proposed powerhouse location	________ N	________ E	
8.	Cable route plan (from PV array to PH)	Underground via		a. Existing cable trench ☐ b. New cable trench ☐
		Overhead via existing poles ☐		Using new cable trays in the buildings ☐
		Overhead using existing cable trays on the exterior part of the building ☐		
		Overhead using existing cable trays on the interior part of the building ☐		
		Both underground and overhead OR others (explain):		

Power evacuation plan and others				
SN	Items			
1.	Existing transformer size	___________kVA	I/P voltage(kV):	O/P voltage(kV):
2.	Metering	Type of meter used:	Rating:	
3.	Existing earthing	Nos. of earthing pits:	Termination point 1:	Value: ___ohm
			Termination point 2:	Value: ___ohm
			Termination point 3:	Value: ___ohm
			Termination point 4:	Value: ___ohm
			Termination point 5	Value: ___ohm
			Termination point 6:	Value: ___ohm
			Termination point 7:	Value: ___ohm
4.	Lightning arrestors	Nos. of lightning Arrestors:	Type:	
5.	Existing AC distribution boards	Distance from the powerhouse(m):	Rated voltage(V):	
		Capacity: kVA	Type of circuit breaker used:	
		Presence of SPDs	Yes ☐	No ☐
		The presence of an extra slot for connection	Yes ☐	No ☐

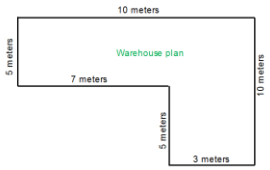
Sketch the overall project layout including solar array location, powerhouse, power evacuation points, existing relevant civil and electrical infrastructures, etc.

For example



Sketch the roof layout plan, size, perimeter, and shape.

For example



North

The following section gathers information about loads and energy demand and consumption scenarios within the facility which will be used for designing the system.

Use of power analysers *(Use a 3-phase power analyser to record the following, download the data from the logger in the format obtained from the logger to process for further use)*		
72-hour load profile(weekdays), 48 hours (weekends or scheduled office/factory closure)	Done ☐	Not done ☐
72-hour power and energy profiles-real, apparent and reactive power consumption, power factor etc. (weekdays), 48 hours (weekends or scheduled office/factory closure)	Done ☐	Not done ☐

Major load list
(Use extra sheets, if required)

SN	Loads	Quantity (A)	Estimated power demand (kW) (B)	Total power (C=A x B)	Usage hours (Over a 24-hour period)
1.	E.g., Motor (3-phase)	2	20	40	9 AM-1 PM
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					
Total power demand (kW)					

Labour cost				
SN	Type of labour	Available at site (Yes/No)	Rate (NPR/day)	Remarks
1.	Unskilled			
2.	Skilled (Mason)			
3.	Solar technician/Electrician			
4.	Electrical engineer			
5.	Porter			

Checklist			
SN	Description	Remarks	
1.	Pictures of the area allocated for solar PV installation (all the designated roof/total land area)	Taken☐	Not taken☐
2.	Pictures of the area allocated for the powerhouse	Taken☐	Not taken☐
3.	Picture of the existing main AC distribution board	Taken☐	Not taken☐
4.	Picture of the land/roof lease agreement (if applicable)	Taken☐	Not taken☐
5.	Picture of the road condition to reach the site	Taken☐	Not taken☐
6.	Picture of the transformer and existing meter	Taken☐	Not taken☐
7.	Other relevant pictures to be used for design and installation	Taken☐	Not taken☐

Construction materials cost				
SN	Materials	Place of availability and distance from site (km)	Rate/unit	Comments
1.	Stone			
2.	Brick			
3.	Sand			
4.	Aggregate			
5.	Bamboo			
6.	Wood			
7.	Cement (53 grade, OPC/PPC)			
8.	Steel bar/TMT rod			
9.	Binding wire			
10.	Diesel cost			
11.	Others			

Additional information	
Remarks (any other relevant information)	

Name of the consultant:

____

Date: ________________________________

Signature: ______________________________

Phone number: __________________________

Name of the beneficiary representative:

____

Date: ________________________________

Signature: ______________________________

Phone number: __________________________

A.9 Detailed feasibility study • Due diligence checklist

Detailed feasibility study (DFS) due-diligence checklist

Please give a scoring between 0 and 4 for each question.

Yes, this aspect is fully satisfied	4
Yes, this aspect is mostly satisfied	3
Yes, but some important information is still missing	2
Yes, but much important information is still missing	1
No, this aspect is not fulfilled	0

		Points
Data availability/Quality	Do you have all the essential data required to assess electrification options?	
	Is the DFS report in an acceptable standard format?	
	Does the DFS include an on-site survey to collect site-specific data?	
	Are the data sources reliable and are the data collected of good quality?	
	Were interviews conducted with other parties to collect site-specific data?	
	Were the beneficiary's needs and capabilities considered during site-data collection?	
Design and analysis	Is the accessibility to the site location adequately described?	
	Is the nature of the facility/institution adequately described?	
	Is the current reliability of grid electricity and information on other generation sources adequately described?	
	Are the locations of major system features (solar array and power conditioning equipment) defined with evidence of permits (for example, meeting minutes)?	
	Are sufficient natural resources (land, solar energy) available?	
	Is the energy audit satisfactory?	
	Are all the components of the system defined in detail with adequate justification?	
	Is the map of the system in the facility/institution provided (array location, power conditioning equipment etc.)?	
	Are adequate photos of the site provided?	
	Are the risks of the project adequately assessed and options for mitigation presented?	
	Is a detailed bill of quantity and costs provided with justification of rates?	
	Are all technical drawings, specifications sheets, single-line diagrams, site layouts, etc. provided?	
	Is the economic and financial analysis of the project provided?	
	Is the assessment of environmental, safety and social aspects provided?	
	Is the justification for the system the best technical and least-cost option given?	
	Is the operation and maintenance plan described?	
Oper ation	Is the operational model of the project adequately described?	
	Is there a definite conclusion that deems the project feasible or not?	
	Total points	

Recommendations	Points
DFS is satisfactory with definite conclusions on the way forward	80-96
Please collect more data and information	48-80
DFS is not satisfactory, thus not approved	0-48

A.10 Detailed feasibility study • Report template

Detailed feasibility study of [Site name] Solar grid connected system

Project title: [Title]

Project code: [Code]

Date: [Insert date]

Prepared by

[Company name]
[Company address]

Submitted to

[Organization name]
[Organization address]

List of separate attachments submitted along with this report:

i) NEA electricity bills for the last 3 years
ii) Load list
iii) Software simulation report
iv) Powerhouse layout drawings
v) Structure analysis calculations and report
vi) Equipment datasheets
vii) Single line diagram
viii) Site map layout (Google Earth .kml file)
ix) Diesel generator log sheet for at least 1 year

Glossary

EXECUTIVE SUMMARY

Describe briefly in one page the design and outcomes of the detailed feasibility study. The executive summary should include the key information of the study.

Paragraph #1

i. *Site location*
ii. *Information about the project site, owner's discretion*
iii. *Date when the on-site survey was carried out*

Paragraph #2

i. *Current sources of electricity used*
ii. *Load and energy demand scenario (short-term and long-term)*

Paragraph #3

i. *Land/roof space availability for the solar array, powerhouse and power evacuation approach*
ii. *System description (solar array capacity, inverter ratings, system architecture)*
iii. *Annual energy production and savings*

Paragraph #4

i. *Total system cost*
ii. *Cost of electromechanical system, powerhouse and power evacuation*
iii. *Financial and economic analysis like NPV, IRR and payback period*

Paragraph #5

i. *Major project risks and mitigations*
ii. *Conclusion*

SITE DETAILS

Location

Describe the location of the site and provide information about,

i. *Site address (ward number, rural municipality, district and province)*
ii. *Site coordinates*
iii. *Registered business and nature of business*

Figure suggestions

i. *Bird's eye view of the site with boundary marking*

Site access

Describe the accessibility of the site. Provide information about,

i. *Access route description (vehicle access, type of road/path e.g., earthen, gravel, black topped (mention accessibility month-wise, etc.)*
ii. *Observations on vicinity coverage and implications on the delivery of equipment (if any)*
iii. *Name and distance from the nearest city and airport*

Photo suggestions

i. Bird's eye view of the site location within a few hundred meters of ground elevation
ii. Bird's eye view of the site location showing pinned site location and nearest city

Ownership and source of fund

Describe the ownership modality and funding mechanism or the business model. Provide information about,

i. Owner/Co-owner and model (CAPEX, OPEX/ESCO)
ii. Funding mechanism and involved parties' contribution
iii. Financial institutions and loan experience of the project owner (if applicable)

Security

Describe the security aspects of the site area from the perspective of the solar grid-connected system that is to be built. Provide information about,

i. Security of solar array location
ii. Security of powerhouse location

Photo suggestions

i. North, South, East and West view of solar array location
ii. North, South, East and West view of powerhouse location

Telecommunications and internet access

Describe coverage of mobile network and internet access. Provide information about,

i. Best mobile carrier name and internet service provider
ii. Type of mobile data connection (for example, calls only, 2G only, 3G only, 4G, etc.)
iii. Reliability of mobile network
iv. Nearest facility with internet access and its distance from the powerhouse

Climate

Describe the climate of the region based on data trends obtained from reliable sources (such as nearest weather stations, Meteonorm software, etc.). Provide information about,

i. Graph on annual temperature trends
ii. Graph on annual precipitation trends
iii. Notes from DFS regarding extremities in climate and weather- conditions like flooding, landslide, lightning, etc.

Current sources of electricity

Describe the current sources of electricity used by the facility. Provide information about,

i. Type and technology of the electricity sources, their specification and capacity
ii. The energy mix scenario when a new source is added
iii. Location of the main distribution panel and distance from the powerhouse

iv. *Remarks on electricity infrastructure at the site (for example, location for powerhouse built/exist, cable trenches/trays available, transformer size needs upgradation, etc.)*

User perspective

Describe the observations and findings from the survey and based on the discussions with the user. Provide information about,

i. *Awareness of the users about solar grid-connected systems (for example, knowing that the system is only meant for use to reduce the electricity bills during sunshine hours only and would not have any backup)*
ii. *Willingness for long-term agreement, understanding tariff mechanism in comparison with NEA*
iii. *Willingness for kind and cash contributions if needed*
iv. *Any technical/financial/regulatory concerns regarding the solar grid-connected project*
v. *Knowledge on solar grid-connected net-metering system*

Local/Provincial government perspective

i. *Willingness for financial contribution if needed*
ii. *Facilitation of net metering services with NEA*

SITE ASSESSMENT

Solar array location

i. *Must include the available land/roof area, safe roof access pathway, ownership details, GPS coordinates, topography, orientation and azimuth, near and far shading, current use of space, permissions for use, slope and land/roof type, roof-wise area calculation for solar PV installation, wind loading, height of the roof from ground etc.*
ii. *Should have a general assessment of usability with respect to natural calamities such as floods, landslides, lightning, etc.*
iii. *Structure analysis report for roof mount type installation, safety from exposure to chemicals, industrial waste, etc.*

Photo suggestions

i. *Bird's eye view of obtained data and site with boundary markings*
ii. *Photos of each building and its roof or ground area where the solar array will be installed*

Powerhouse location

i. *Must include the available/allocated area, ownership and permission, GPS coordinates, topography, orientation, current use of the designated area, slope and soil type, structure analysis, etc.*
ii. *Should have a general assessment of usability with respect to natural calamities such as floods, landslides, etc.*
iii. *Should have assessment related to safety from exposure to chemicals, industrial waste, etc.*
iv. *Oversee and present if the allocated location is suitable with respect to distance, cable route, space for air vents or if air conditioning is required.*
v. *Distance between the power generation and the evacuation transmission line which may be 400V, 11KV, or the substation for larger projects*

Photo suggestions

Bird's eye view of obtained data and site with boundary markings.

Existing infrastructure

Describe any existing infrastructure that the system can utilize. For example, existing power poles, cable trenches, cable trays, transformers and their ratings, number of earthing present, earth resistance, earthing termination points, presence of lightning arrestors and SPDs, etc.

Photo suggestions

Bird's eye view of obtained data and existing infrastructure that could be used in designing and installation of upcoming systems.

Environmental and social assessment

i. *Information about environmental impacts, potential biodiversity impacts and socio-economic impacts resulting from the installation of the system with a degree of adversity*
ii. *The total boundary covered by the project and its impact on natural habitats, vegetation, culture, settlement, social coercion, etc.*
iii. *Project's impact on indigenous people, their lifestyle, use of resources, livelihood, livestock, water source etc. along with information about loss of forest/trees to avoid shading in the solar array must be included*

Photo suggestions

Bird's eye view of obtained data and site assessment along with any adversaries that were observed during the DFS stage must be attached here.

LOAD AND ENERGY DEMAND ANALYSIS

Daily load and energy demand analysis

Describe, draw, calculate and show in tables and graphs the daily load demand analysis for a 24 hours time period to establish a relationship between the obtained data and the design parameters.

The data collected by using power loggers should be presented with information about active, reactive, apparent power, power factor, observations related to voltage, current spike, total energy consumption, maximum load demand, etc.

TECHNICAL DETAILS OF SOLAR GRID-CONNECTED SYSTEM

Design summary

Describe and summarize the selection, sizing, ratings, system architecture, standards, formulas and calculations, assumptions and derivations used to come up with the perceived design in a short paragraph as well as in tabular form. Graphical representation of the energy mix scenario *showing the energy consumption from the national grid, solar PV systems, and diesel generator systems.*

System architecture

Present a block diagram and explain the significance of the system architecture chosen for the project. Explain its advantages with respect to the design and the project parameters.

Energy generation

Present the energy generation scenario using manual calculations, forecast energy generation based on the report produced by using software such as PVsyst, homer, etc. and an online database of irradiance for the specific site location. Use graphical representation to present sun path diagrams, GHI, losses, monthly energy generation profiles, etc.

Single line diagram

i. *Will include labelling of the project name, system size, cable sizes, and all the component sizes including MCBs, SPDs, etc. along with the legend*
ii. *Must represent the array, inverter, switchgear configuration, etc.*
iii. *Each component used in the SLD must be recognized well despite its size, and the quality and printing layout must be maintained for A3-size paper*

Site layout

i. *Overall project map layout using CAD inclusive of PV array, powerhouse, evacuation point, termination units, etc.*
ii. *Measurements of data related to the size, topography, terrain, soil condition (where applicable), etc. and plotting them using CAD or similar software*
iii. *The presented data and drawings must fulfil the need of serving the purpose of tendering proceedings*
iv. *Separate drawings and descriptions for powerhouse, civil structures, land levelling requirements and standards, roof structure, wind loading analysis report, etc.*

Shading analysis

Near and far shading

i. *Mention the criteria, formula, tools, etc. used in determining the shading analysis*
ii. *Shading analysis for the proposed array over 12 months with December 22nd data in focus, simulations (if needed)*
iii. *Each row of the proposed array should have its shading analysis done and projected, and calculations and results for inter-row spacing must be shown clearly*

Solar PV array

i. *Module specifications used for calculations, drawings, and analysis*
ii. *The sizing, design, distribution, and positioning of solar PV array within the facility along with coverage area*
iii. *Sizing, design, and placement of combiner boxes, relevant accessories, power evacuation channels, earth points, etc.*

Module mounting structure

i. *Must include a sample drawing for the envisaged module mounting structure*
ii. *Calculations related to wind loading requirements, changes sought after in the rooftop space/civil foundation requirements, information about required penetrations and drill holes, size of vertical legs, purlins, braces and struts, rafters, base plates, joints, mid-clamps, end clams, etc. must be presented*
iii. *For rooftop installations, proper sealing, waterproofing of surfaces using grouts, etc. must be mentioned*
iv. *The type of material proposed, its strength, advantage, selection procedure and other technical parameters and specifications must be clearly mentioned*

On-grid inverter(s)

i. *Must include the selection criteria, design basis, and calculations including losses related to the inverter sizing and selection*
ii. *Must include specifications relevant to design and selection*
iii. *Must choose inverter citing compatibility to the other selected components*
iv. *Must represent the distribution of modules with respect to array size (kW), string sizing calculations, breakers and isolators sizing to be placed before MPPT input terminals etc.*
v. *Describe a proprietary or third-party online monitoring system compatible with the system*

Powerhouse

i. *Must include the drawings, specification, and civil components description including fencing requirements (if any)*
ii. *Must include plan and side views showing tentative placement of envisaged equipment*
iii. *Must include details regarding construction materials, structure analysis, PCC, roofing, doors and windows with proper ventilation, foundation, etc. meeting statutory regulations, standards and requirements for civil construction, design, and drawings*
iv. *Mention if existing space adhering to the requirements of the system will be provided*

Power evacuation plan

i. *Must include a table with a summary of design, lengths, conductors used, accessories used, poles, insulators, lightning arrestors, transformer sizing and specification wherever necessary, etc.*
ii. *Must include main distribution panel capacity and ratings of circuit breakers used, extra slot for connection, metering arrangements, etc. Basis of selection of cable types-underground (armoured), overhead outdoors (UV), etc.*
iii. *Must include the requirement for additional units of switchgear, SPDs, transfer switches, etc. for seamless operation of on-grid inverters*
iv. *The evacuation plan will be accompanied by drawings and layout fit for A3 size paper indicating all the components used, powerhouse, evacuation plan, route plan, termination guidelines, specification of components used, etc.*
v. *Detailed specifications and meter type used or to be used must be produced as per the agreed standards and regulatory requirements set by NEA*

Cables

i. Cable sizing for DC and AC cables must be done and presented. Formulae used for calculation must be included
ii. Different cable types and sizes must be proposed for different sections. E.g., UV cable of suitable diameter for outdoors, flexible multistrand cables for DC side, XLPE for AC output, etc.
iii. The type of cables e.g., Single core, three core, etc. must be mentioned and a chart of cables used in the SMG must be presented
iv. AC, DC, and communication cables must be distinguished and labelled well in the SLD

Others (MCBs, SPDs, AC/DC combiner boxes, etc.)

i. MCBs sizing and calculations must be shown. Different MCBs for each string (string breakers), DC MCBs for the DC side, AC MCBs for the AC side and appropriate circuit breakers on the output must be designed as per the site conditions and detailed specifications including the class, type, etc. must be mentioned. All the accessories must comply with the agreed standards and guidelines.
ii. SPDs are major components thus, SPDs as per the agreed SLD and requirements in each PV, DC and AC termination points must be designed including the class, type and standards.
iii. AC/DC combiner boxes must be sized in such a way that a multiple number of cables, isolators, SPDs, fuses, etc. could easily accommodate and if necessary, more than 1 combiner box must be proposed. They must comply with the agreed specifications and standards. The combiner box must be chosen to meet the IP standards for outdoor and indoor applications accordingly.

Cable routing plan

i. The cable route must be shown in the overall electrical layout diagram to and from the array, the powerhouse and the evacuation location
ii. The shortest possible route without compromising the laying of cables overhead, underground, etc. as per the site condition must be proposed
iii. The use of cable trays, cable baskets, ducts and conduits of appropriate size chosen in a way to avoid stress and strain in the cables must be proposed, specific to the indoor and outdoor conditions and applications

Protection equipment

Lightning arrestors

i. Lightning arrestors (LA) must be proposed in such a way that they cover the total area occupied by the solar PV array as well as the powerhouse. If one LA is not enough, 2 LAs or more must be proposed.
ii. The grounding of LA must be mentioned along with its termination points and specifications. The type and ratings of LA must adhere to the agreed specifications and standards.
iii. All the accessories used in LA including down conductor, pole, etc. must be clearly specified with ratings

Earthing and SPDs

i. *Total numbers of earthing as per the design and site conditions must be mentioned. Clear instructions about its connection and termination points must be mentioned.*
ii. *The type of earthing proposed, its specification, installation standard, and details about the accessories used in earthing must be mentioned clearly*
iii. *Must mention the sought-after earth resistance and ways to attain the value complying with the agreed specification*
iv. *Along with the earthing, earthing test pits must also be considered, and size, and specifications related to earthing pit must be provided in detail*

SAFETY CONSIDERATIONS

i. *Measures that must be taken for the safety of the system including PV array, powerhouse, power evacuation units, etc. must be mentioned*
ii. *Measures that must be taken for safe roof access*
iii. *Precautions and measures such as fencing, operation and management authority, safe handling and safe use of appliances must be mentioned*
iv. *Other safety measures that were recorded from the DFS stage must be mentioned in this section including but not limited to operational safety adhering to relevant points from Occupational Health and Safety Management System (OHSMS) manual*

SITE CLEARANCE

i. *The need for site clearance and its impact must be mentioned in the report*
ii. *Basics of site clearance covering the total project area that could be breached during the installation phase must be clearly instructed*
iii. *The originality of the project area must be retained and the ways to protect, amend or preserve the original condition of the site must be explained in points so that they can be referred to during the bidding and execution phase*

OPERATION AND MAINTENANCE

i. *Describe whether the institution already has technical resources that can be capacitated for O&M of solar grid-connected systems*
ii. *Describe water access near the solar PV array for effective system performance*

BILL OF QUANTITY AND COST

Electromechanical system

i. *Detailed BoQ for the proposed system with the breakdown of each component must be done*
ii. *Detailing in the BoQ should be such that, if possible, every component used such as the breakdown of distribution boards and its components, MCBs, MCCBs, busbars, etc. must be proposed in specifics instead of lump sum*
iii. *BoQ for services and goods must be separated*
iv. *Vatable and non-vatable items must be distinguished*
v. *Currency used must be in NPR with commas as a separator*
vi. *The basis of rate for each component/ rate analysis of components that are available within district rates published by GoN must be considered*

FINANCIAL ANALYSIS

Source of funds

i. *The source of funds may vary in %, cash or kind from different sources. All the sources of funds must be mentioned and stated in tabular form accompanied by a narrative*

Financial indicators

i. *Financial indicators such as IRR, Payback period, LCOE, cash flow diagram, ADSCR, lifecycle costing, etc. must be calculated and presented*
ii. *If the financial indicators don't produce the desired results, possible business cases and solutions must be devised and presented*
iii. *For clarity and better understanding, graphs, charts and flow diagrams must be used along with tables and figures to showcase financial indicators*
iv. *In the case of the ESCO model, the PPA rate within the parties must be taken as a reference for calculation. However, PPA for net metering issued as per the Directives for Net-metering by NEA must be considered depending upon the modalities of operation agreed upon.*

CONCLUSION

Provide a summary of the system architecture, per unit cost reduction potential, project cost and outcomes of the economic analysis to showcase the profitability to the users of the system.

ANNEX

Load list

Software simulation report

Rate analysis for each component used

Powerhouse layout

Detailed drawings of components

Power evacuation plan and layout

Site photos

Product datasheet

A.11 Quality benchmark compliance checklist

Quality benchmark compliance checklist

Descriptions	Remarks	
Is the system residential and design DC voltage not more than 1,000 Volts?	Yes ☐	No ☐
Is the system commercial/Industrial and design DC voltage not more than 1,500V?	Yes ☐	No ☐
Does the total voltage drop on DC and AC side not exceed more than 3% in total?	Yes ☐	No ☐
Labelling and signage provided as needed?	Yes ☐	No ☐
Are inverters installed indoor or outdoor?	Indoor ☐	Outdoor ☐
	Both ☐	
Are outdoor inverters appropriately IP-rated?	Yes ☐	No ☐
Are the inverters installed on north facing wall?	Yes ☐	No ☐
Are the inverters provided with ownings?	Yes ☐	No ☐
All dissimilar metals shall be properly separated.	Yes ☐	No ☐
All cable connectors shall be the same type from the same manufacturer.	Yes ☐	No ☐
All DC cables are suitably designed to minimize voltage drop and double sheath Copper or Aluminium. The cables marked "DC cable" and "Do not disconnect under load" at every 2 meter.	Yes ☐	No ☐
Components warranty:10 years as provided by the manufacturer	Yes ☐	No ☐
Components warranty: 5 years as provided by the manufacturer	Yes ☐	No ☐
Cables enclosed in hard conduits	Yes ☐	No ☐
Cables run in a suitable metal cable tray fixed properly on the roof and provided with a lid to protect from UV rays. Cables secured in position at suitable intervals. If different types of cables are run in the same cable tray, they are mechanically separated.	Yes ☐	No ☐
Not more than 2 strings are paralleled in one isolator until the module manufacturer advises to do so. When more than two strings are paralleled together, each string is provided with suitable fuses.	Yes ☐	No ☐
Cables are routed via the shortest route to minimize voltage drop.	Yes ☐	No ☐
All panels bonded together through its frame and PV racking and connected to the property's multiple earthed neutral (MEN) system.	Yes ☐	No ☐

A.12 System testing commissioning and handover format

Installation, commissioning and handover checklist for solar PV on-grid systems

Date: ______________________

Commissioning engineers' information	
Name	
Email	
Phone number	
Signature	

Project stakeholders	
Design	
Engineering	
Installation	
Post-installation check	
Maintenance	
Other	

Key recommendations

SN	Components affected	Recommendation	Priority level	Assigned to
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				

Customer information	
Contact name	
Address	
Phone number	
Email	

Installation and commissioning information

Date of commissioning	
Place	
Describe the weather conditions	

Key indicators of solar PV system

Total annual generation (MWh)	………………………………………….. (P50) ………………………………………….. (P75) ………………………………………….. (P90)
Specific annual output (kWh/kW$_P$/year)	…………………………………………..
Performance ratio (%)	…………………………………………..

Grid information

NEA grid connection type *(Single phase, three phases)*	
Incoming grid voltage (V)	
Number and size of transformers	Numbers: .... T1 (kVA): .... T2 (kVA): .... T3 (kVA): .... T4 (kVA): ....
Institution operating voltage (V)	
Average monthly electricity cost (NPR)	
Describe the average frequency of grid downtime per day	
Describe the duration of grid downtime	
Peak load of institution	

Describe the load-test performance of the system by observing it for a day. Write your observations and findings below.

SECTION I

(Solar PV system)

Rooftop solar PV on-grid site information		
Site address:		
Latitude:	Longitude:	Elevation(m):
Describe the weather conditions:		
Solar radiation and time of measurement: ....W/m²; Time:		
Is the site located in a disaster-prone area? (For example, *the possibility of landslides, earthquakes, floods, etc.)*		
On a scale of 1-5, how accessible is the roof? ☐ Very easy ☐ Easy ☐ Moderate ☐ Difficult ☐ Very difficult Describe the access to the roof:		

Electrical checklist

Individual module specification				
SN	Items	Units	Observations	Remarks
1.	Manufacturer			
2.	Model no.			
3.	Rated power peak	Watt		
4.	Open circuit voltage	V		
5.	Short circuit current	A		
6.	Rated voltage	V		
7.	Rated current	A		
9.	Efficiency	European efficiency		

Draw a basic layout of panel placement showing each block relative to each other.

N

PV array block information

SN	Block ID	Block in front *(Mention which block lies in front of the block you are specifying)*	Block Behind *(Mention which block lies behind the block that you are specifying)*	Azimuth *(with reference to true south)* Degrees	Panel to Panel spacing *(mm)*	Panel arrangement *(Landscape or portrait)*	Roof specification *(RCC, sheet metal roof, tiled roof, etc.)*	Panel angle of tilt in degrees	Is there shading on any panel of the block? *(Yes/No)*

Solar panel checklists

String specification											
Str. ID:	No. of panels in Series	No. of panels in parallel	Circuit Breaker Rating *(A)*	Open Circuit Voltage *(V_{oc})*	Voltage *(V_{mp})*	Current *(I_{mp})*	Grounding Connection *(Yes/No)*	Cable insulation *(Yes/No)*	Cable labelling *(Phase or neutral)*	Continuity check *(Ok / Faulty)*	Panel back temperature *(Degree Celsius)*

DC circuit breakers

Total number of DC fuses: ……………………….

Total number of DC MCBs: ……………………….

SN	Items	Description	Measurement/Visual data	Remarks
1.	Location/Placement	*Check whether the MCB is placed in a safe location.*		
2.	Junction box protection type	*If indoor: min. IP54* *If outdoor: min. IP65*		
3.	Physical damage	*Check for any physical damage, over-heating, or faulty breakers.*		
4.	Input and output side continuity	*Check for the continuity between the input and output side*		
5.	SPD in each DC input	*Check whether SPD is given in each DC input*		
6.	Rating of SPD	*Rating in ampere*		

On-grid inverters

Manufacturer and model number: ....

Max. efficiency/European efficiency (%): ....

The number of inverters used: ....

Maximum output current: .... A

Maximum input current: .... A

IP rating: ....

Rated output voltage: V

Input side

SN	Items	Description	Measurement/Visual data	Remarks
1.	Location/Placement	*Check whether the inverter is placed in a safe and dry place with proper ventilation. Check the manufacturer manual for detailed specifications*		
2.	Physical damage	*Inspect for any physical damages. Ensure that the inverter is in proper working condition*		
3.	Continuity tests	*OK/Faulty*		
4.	Cable shoe	*OK/Faulty*		
5.	Input side disconnection device	*OK/Faulty*		
6.	Ground fault monitoring	*OK/Faulty*		
7.	DC reverse polarity protection	*OK/Faulty*		
8.	Inverter ground connection	*OK/Faulty*		
9.	Surge protection rating			

Output side

SN	Items	Description	Measurement/Visual data	Remarks
1.	Connection type	*What kind of connection does the terminal have? For example, screw terminals, ring terminals, fork terminals, etc.)*		
2.	Clearance of inverter	*The inverter manual has specific instructions to mount*		
3.	Continuity tests	*OK/Faulty*		
4.	Cable shoe	*OK/Faulty*		
5.	Output side disconnection device	*OK/Faulty*		
6.	AC short circuit protection	*OK/Faulty*		
7.	Frequency of output signal	*Check the frequency of the output signal*		

Draw the connection arrangement of the inverters

Individual inverter specifications

SN	Inverter ID	Capacity (kW)	Instantaneous input voltage (V)	Instantaneous input current (A)	Instantaneous output line-line voltage (V)	Instantaneous output current (A)	Total number of inputs available	Total number of inputs used	Total number of independent MPPT	Total number of MPPT used	Input MPPT range	Maximum MPPT voltage

Draw the SLD of the system clearly showing the incoming grid and the solar tapping point

AC combiner box

SN	Items	Description	Measurement and observation	Remarks
1.	Placement/ Installation	*Is the AC combiner box installed securely?*		
2.	Grounding of AC combiner box	*Check whether the AC combiner box is properly grounded.*		
3.	AC inputs	*How many AC connection points are in the combiner box? Are there any live connection points left exposed?*		
4.	Instantaneous voltage in the AC combiner box	*Measure the instantaneous voltage in the combiner box and ensure that it doesn't exceed the rated value of the combiner box.*		
5.	Instantaneous current in the AC combiner box	*Ensure that the measured current doesn't exceed the rated current capacity of the AC combiner box*		
6.	Combiner box type	*Single-phase or three-phase*		
7.	Protection rating	*IP rating of the box. For indoor minimum IP54 rating is necessary and for outdoor minimum of IP65 rating is needed.*		
8.	MCCB ratings	*kA*		

Cables

DC cables checklist

Cables from solar panel to DC combiner box

SN	Cable from *(String ID/ Panel ID)*	Cable to *(DC Breaker ID)*	Manufacturer	Armoured/ Unarmoured	Phase wire colour code	Neutral wire colour code	Size of cable	Conductor material	Number of cores:	Cable termination materials	Cable routing *(Conduits, Cable trays or others; specify)*

Cables from DC combiner box to inverter

SN	Cable from *(DC Breaker ID)*	Cable to *(Inverter ID)*	Manufacturer	Armoured /Unarmoured	Phase wire colour Code	Neutral wire colour Code	Size of cable	Conductor material	Number of cores:	Cable termination materials	Cable Routing *(Conduits, Cable trays or others; specify)*

AC cables checklist

Cables from Inverter to AC Breakers

SN	Cable from *(Inverter ID)*	Cable to *(Breaker ID)*	Manufacturer	Armoured /Unarmoured	Phase wire colour code	Neutral wire colour code	Size of cable	Conductor material	Number of cores:	Cable termination materials

Cables from AC breakers to AC combiner box

SN	Cable from *(Breaker ID)*	Manufacturer	Armoured/ Unarmoured	Phase wire colour code	Neutral wire colour code	Size of cable	Conductor material	Number of cores	Cable termination materials

Tap-in point information

Incoming grid voltage	 V
Transformer rating	.... MVA
Transformer low voltage rating	 V
Transformer high voltage rating	V
Circuit breaker rating	.... A
Voltage at tap-in point	 V
Current through tap-in point	.... A
Current transformer (CT) rating	....
CT ratio	....
If a stabilizer is used, mention the stabilizer rating.	................................MVA
Capacitor bank capacity	................................kVAr

Control room

Size of the room (length x breadth x height)	....
Construction type Plastered/Unplastered RCC/Sheet metal roofing	 ....
Is the room partitioned or not? If yes, then what is the material used for partition *(brick wall, aluminium, etc.)*	

Remote monitoring unit (RMU)

Is the remote monitoring unit in-built in an inverter or external?	
If external, mention the name of the manufacturer and model.	
Is the RMU based on WIFI or GPRS?	

SECTION II

(Mechanical system)

Roof details

Slope	
Direction of slope	
Type of roof	
Describe the walking space between blocks for O&M	

Panel mounting structure

Type of structure: *(RCC, steel frame, aluminium, etc.)*	
Clearance between the roof and back of the panel (mm)	
Mounting structure type *(Adhesive type, nut bolt type, welding type, etc.)*	
Are all structures bolted/adhesive secure? (Yes/No)	

Panel O&M checklist

Describe the panel cleaning mechanism. *(Manual, robotic, others. Specify)*	
Are there dedicated people for the O&M of the project? If yes, please mention their name.	
Is there availability of the O&M manual?	

System performance

1. If an online monitoring system is available, extract electricity generation data for a 72-hour period and conduct an analysis in reference to the design.
2. If an online monitoring system is not available, use a power analyser to record electricity generation data for a 72-hour period and conduct a performance analysis in reference to the design.

Method chosen:

☐ Data from online monitoring

☐ Data from the power analyser

Dates for which system data was obtained: from ………………….. to …………………..

Present the data in charts in the project completion report.

Comments on system performance during the checks:

Annex

Photos

At least, include photos of,

i. Solar array
ii. Power conditioning equipment
iii. Combiner and distribution boxes
iv. Earthing pits with visible connection points
v. Energy meter

Documents

- Equipment datasheets
- As-built engineering drawings
- Single line diagram
- Snapshots of the as-built site map
- Snapshots of the site map demarcating locations of the solar array, power conditioning equipment and the distribution board

IN WITNESS WHEREOF, the Parties hereto have executed this handover of the system stated above as of date [dd/mm/yyyy] first above written.

For and on behalf of	For and on behalf of
[Owner/User]	[Installer/Contractor]
___________________	___________________
[***]	[***]
[Position]	[Position]
[Witness 1]	[Witness 2]
Name/address:	Name/address:
Signature/date:	Signature/date:

A.13 Service contract agreement format

Operation and maintenance contract – Template

Disclaimer

This model contract is developed by GIZ for Nepal. GIZ POSTED project in Nepal has modified the content of this document to suit Nepal's national regulatory requirement. This model contract can be used as a template from which a specific agreement can be developed. As with any model contract, the parties will need to finalise and tailor it to their specific situation and circumstances and the commercial agreement that the parties are looking to document. Any interested parties are recommended to obtain legal, tax and technical advice to adapt the document for each specific situation. While to the maximum extent possible the authors of these Guidelines have attempted to provide legally correct information, the document or its authors and publishers cannot be held legally responsible for its full accuracy.

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ROOFTOP SOLAR OPERATION AND MAINTENANCE CONTRACT

This **ROOFTOP SOLAR OPERATION AND MAINTENANCE CONTRACT** (the "**Agreement**") is made on **[***]**[1]

BETWEEN

1. **[***]**[2] a [[limited liability/joint stock] company incorporated in Nepal, with personal account number (PAN) [***], issued on [***] by the Department of [***] of [***] and whose registered office is at [***]] OR [a [***] citizen, holding ID Card No. [***] issued on [***] and residing at [***] (the "**Project owner**"); and
2. [***][3] [a [limited liability/joint stock] company incorporated in Nepal, with personal account number (PAN) [***], issued on [***] by the Department of [***] of [***] and whose registered office is at [***] (the "**O&M contractor**")

(Each of the project owners and the O&M contractor is hereinafter referred to as a "Party" and collectively as the "**Parties**"). [4]

WHEREAS:

A. The O&M contractor is engaged and experienced in the business of operating and maintaining rooftop solar PV systems.

B. The project owner wishes to engage the O&M contractor to operate and maintain a rooftop solar PV system at the Site and the O&M contractor agrees to be engaged by the project owner for these purposes, on the terms and conditions of this agreement. [5]

IT IS HEREBY AGREED AS FOLLOWS:

1. DEFINITIONS

1.1 In this agreement, words and expressions shall save as the context otherwise requires, have the following meaning:

"Annual operating and maintenance schedule" has the meaning given in Clause 8.1.

"Bi-directional meter" means the alternating-current meter installed as required by the utility for connection of the solar PV system to the grid and for the purposes of the utility PPA.

"Business day" means a day on which commercial banks are open for business in Nepal and excludes any Saturday and public holidays in Nepal.

"Confidential information" has the meaning given in Clause 29.1.

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[1] As a general comment, all sections shown in square brackets are to be modified by the parties based on specific circumstances and/or to be completed with the details pertaining to the parties' situation.

[2] Name and details of the project owner would be included here.

[3] Name and details of the O&M contractor would be included here. This template has been prepared for use by a O&M contractor being either a domestic Nepalese company or a 100% foreign owned Nepalese subsidiary providing the services to a Nepal-based project owner. Further points to be noted based on this: (i) all prices in this agreement must be stated in Nepalese rupee and cannot refer to foreign currency or adjusted based on any foreign currency exchange rate; and (ii) the governing law must be the laws of Nepal.

[4] Parties to input specific details including, incorporation/registration number, and registered address in respect of the O&M contractor and the project owner, if it is an enterprise, or personal details for the project owner in the case of this contract being used for installation at a residence.

[5] This is a general background to the contract and should be able to be applied to any circumstance without any need to be amended. However, additional background to the transaction can be added as appropriate.

"Contract year" means the date from the effective date to the date being twelve (12) months after such date, and/or each succeeding twelve (12) month period thereafter until termination of the agreement.

"Corrective maintenance" means corrective maintenance activities to be carried out by the O&M Contractor on detection of any breakdown or malfunction of the solar PV system including but not limited to:

a. returning the solar PV system to a safe state;

b. undertaking any reset, repair, of the solar PV system or component thereof replacement and/or other work related to the operation of the Solar PV System where such work has been identified as reasonably necessary by observation in the course of Preventative Maintenance activities, through notification by the Project Owner, or has or should have been identified by the O&M contractor acting in accordance with the standards expected of a reasonable and prudent operator;

c. attending to any failure or malfunction of the solar PV system or component thereof and carrying out repairs or replacement as necessary and in accordance with the O&M manuals, the manufacturer and supply warranties and any other applicable manufacturer's recommendations, guidelines, specifications, instructions and warranty conditions published by the relevant manufacturer from time to time;

d. providing any standard equipment and/or standard tools that may be required to perform the O&M services;

e. taking specific actions to remedy any breakdown or malfunction of the solar PV system, consequential faults and/or incidents relating to the solar PV system;

f. evaluation and diagnosis of the reason for the relevant breakdown or malfunction of the solar PV system;

g. management of the spare parts;

h. ensuring in accordance with this agreement the proper functioning of the solar PV system following any repair or maintenance work done thereto.

"Disclosing party" has the meaning given in Clause 29.1.

"Effective date" means the date of signing of this agreement.

"Energy output" means the electricity generated by the solar PV system measured in kWh.

"Event of force majeure" has the meaning given in Clause 23.1.

"Governmental authority" means any statutory authority, government department, agency, commission, board, court or other institution in Nepal authorized to make Laws.

"Grid" means the local electricity distribution network.

"Insolvency event" means in respect of a person any of the following:

a. an inability to pay debts as they fall due or presumed inability to do so;

b. for a body corporate, any corporate action, or any other steps, and/ or legal proceedings have been started or threatened against the Person, for its liquidation or bankruptcy or the appointment of a liquidation committee, team of receivers or similar officer or officers in respect of it or any or all of its assets subject to claims which by law have priority.

"kWh" means kilowatt-hour alternating current.

"Manufacturer and supply warranties" means warranties from the manufacturers and suppliers of the solar PV system, any component parts of the solar PV system and the spare parts.

"Monthly service fee" means the monthly service fee payable by the project owner to the O&M contractor in consideration of the O&M services of NPR[***] per month.

"O&M manuals" means the manufacturer's maintenance manual for the solar PV system or, in the absence of a maintenance manual, the maintenance of the solar PV system in accordance with good industry practice.

"O&M services" mean all required services for the successful operation, optimum energy generation and maintenance of the solar PV system the O&M contractor is engaged for hereunder and as set out in Schedule 2.

"Performance guarantee" has the meaning given in Clause 16.1.

"Performance penalties" has the meaning given in Clause 17.1.

"Performance ratio" means the measure of the quality of the solar PV system that is independent of location. The performance ratio is stated as percent and describes the relationship between the actual and theoretical energy outputs of the solar PV system as calculated in accordance with Schedule 3.

"Premises" means the building and the location of the site where the solar PV system is installed and the O&M contractor shall provide the O&M services in accordance with this agreement.

"Preventative maintenance" has the meaning given in Clause 5.

"Reasonable and prudent operator" means a person acting in good faith with the intention of performing its contractual obligations and who, in so doing, and in the general conduct of its undertaking, exercises the degree of skill, diligence, prudence and foresight which would reasonably and ordinarily be exercised by a skilled and experienced person complying with applicable laws and regulations and observing all applicable standard industry practices and guidelines engaged in the operation and maintenance of photovoltaic solar electric generating rooftop systems similar to the solar PV system.

"Relevant party" has the meaning given in Clause 27.1.

"Site" means the rooftop of the premises on which the solar PV system is installed and as further defined and highlighted in the relevant drawing listed in Schedule 1.

"Solar PV system" means the solar electric power generation equipment, including without limitation, solar panels, mounting racks, brackets, substrates or supports, power inverters and micro-inverters, optimizers, service equipment, metering equipment, controls, switches, connections, conduit, wires and other equipment installed at the site and as described in Schedule 1.[1]

"Spare parts" means spare parts, consumables and any fungible materials that will be procured by the project owner and or the O&M contractor under this agreement for the operation, maintenance and repair of the solar PV system.

"Spare parts list" means the list of spare parts required to ensure the proper maintenance of the solar PV system pursuant to this agreement.

"Subcontractor" means any appointed subcontractor engaged by the O&M contractor under a separate subcontract agreement who will supply services to the project owner on behalf of the O&M contractor pursuant to the terms of this agreement.

"Taxes" means all taxes, duties, imposts, fees and withholdings (including, without limitation, any value-added taxes and corporate income taxes), import duties and/or import surcharges

[1] This description is wide to encompass most aspects of a solar PV rooftop system that may be installed under this contract, but can be modified based on the actual Solar PV System specifications.

imposed by any governmental authority of any country having jurisdiction over any matter related to this agreement.

"Term" has the meaning given in Clause 24.

"Utility" means the Nepal Electricity Authority (NEA) or its authorized member entity.

[**"Utility PPA"** means any agreement between the project owner and the utility pursuant to which the project owner receives payment from the utility for any energy output delivered to the grid as recorded by the Bi-directional meter.] [1]

"Nepal" means the Federal Democratic Republic of Nepal;

"Nepalese law" or **"Law or Laws"** means (i) all law applicable in the Federal Democratic Republic of Nepal; and (ii) any regulatory policies, guidelines or industry codes which apply to the operation and maintenance of the solar PV system pursuant to this agreement; and (iii) any directions, rules or regulations issued by any competent or regulatory authorities.

"NPR" means the lawful currency of Nepal.

SECTION I: ENGAGEMENT AND RELATIONSHIP

2. ENGAGEMENT AND RELATIONSHIP OF THE PARTIES[2]

2.1 The O&M contractor undertakes to operate, maintain, repair and manage the solar PV system on behalf of the project owner throughout the term and the project owner agrees to engage the O&M contractor throughout the term to carry out the O&M services and further activities contemplated under this agreement and on the terms and conditions of this agreement.[3]

2.2 The O&M contractor has been retained by the project owner as an independent contractor to operate and maintain the solar PV system, with the O&M manuals and to the standard of a reasonable and prudent operator.

3. PERFORMANCE STANDARDS[4]

3.1 The O&M contractor shall perform the O&M services and other services as contemplated hereunder in accordance with the following:

a. This agreement and its schedules and annexes;
b. The O&M manuals;
c. The applicable manufacturer and supply warranties;
d. The requirements of the utility;
e. Applicable insurance policies obtained and maintained by the O&M contractor in accordance with this agreement;
f. All applicable Nepalese laws; and
g. any other documents to be signed between the parties for the purposes of the performance of this agreement.

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[1] To be retained or removed depending on whether it is intended to enter into a utility PPA or not.

[2] This sets out the general engagement and scope of services of the O&M contractor under this agreement.

[3] Schedule 1 sets out a detailed description of the solar PV System, its components and the various equipment and a description of the site.

[4] Recommended to set out the relevant applicable standards and regulations the O&M contractor must perform in compliance with as these will not all be included specifically in this agreement but rather referred to (such as the O&M manuals and manufacturer and supply warranties).

4. [UTILITY PPA][1]

4.1 The O&M contractor will manage ongoing arrangements with the utility on behalf of the project owner in relation to meter readings and follow up on invoices to the utility where applicable under the utility PPA.

[1] To delete or retain depending on whether the project owner will enter into a utility PPA or not.

SECTION II: OPERATION AND MAINTENANCE SERVICES

5. PREVENTATIVE MAINTENANCE

5.1 The O&M contractor agrees and acknowledges that the continuous operation of the solar PV system is essential, especially during day hours therefore the work of repairs, maintenance, rebuild and tests must be planned in such a way that interruptions to the solar PV system operation are kept to a minimum and as a consequence the O&M contractor at its own cost will apply a higher standard of diligence to perform during night hours to the extent possible in order to minimize interruptions and maximize production.[1]

5.2 The O&M contractor will provide all materials, tools, staff and labour requirements, as well as its staff expenses, and so on in order to carry out the tasks, except otherwise agreed in this agreement.

5.3 The preventative maintenance of the solar PV system will be comprised of regular visits to all the equipment composing such solar PV system, replacement of materials and correction of those systems where foreseeable with materials, tools, and labour, pursuant to the provisions of the O&M manual and will be carried out in accordance with the relevant annual operating and maintenance schedule and other relevant provisions of this agreement, including Schedule 2.[2]

6. MONITORING, FAILURE DETECTION AND INITIATION OF CORRECTIVE MAINTENANCE[3]

6.1 For the purposes of determining when repair and maintenance services are necessary, the O&M contractor shall monitor and evaluate the information gathered through remote monitoring of the solar PV system in addition to the maintenance and inspection site visits.

6.2 In case of a breakdown or malfunction of the solar PV system, the O&M contractor shall take all measures necessary to remedy such breakdown in order to make it work properly and conduct all necessary corrective maintenance in accordance with the agreed performance specifications and the relevant provisions of Schedule 2.

7. SPARE PARTS[4]

7.1 The O&M contractor shall prepare the spare parts list for the solar PV system and provide this to the project owner within [ten (10)] days of the effective date.

7.2 The project owner shall procure and supply the spare parts as necessary for the operation and maintenance of the solar PV system and such spare parts shall remain the property of the project owner at all times.

7.3 Notwithstanding the foregoing, the O&M contractor may directly procure spare parts on behalf of the project owner as necessary for the solar PV system provided that: (i) the project owner shall be liable for and make direct payment to any supplier or reimburse the O&M contractor as duly invoiced to the O&M contractor for any spare parts and

[1] Suggest this is agreed to avoid interruption of the project owner's (or relevant customer's) production at the premises.

[2] General provision on preventative maintenance is provided here with further details in Schedule 2. However, the detailed plan should be agreed in the Annual Operating and Maintenance Manual as particular to the solar PV system and project.

[3] This applies to maintenance and repair services to be provided outside of the scheduled preventative maintenance services, such as in the case of breakdown of the solar PV system as notified by the project owner.

[4] The solar PV system will require a stock of spare parts for its maintenance and repair. The costs for such spare parts should be borne by the project owner, which will be taken into account when agreeing the monthly service fee. In addition, ownership of the spare parts should be with the project owner at all times.

other items required for the repair of the solar PV system provided that the project owner shall be entitled to prior approve the order and purchase of any items or combined order of a value of NPR[***] or more; and (ii) such spare parts shall remain the property of the project owner at all times.

7.4 The O&M contractor shall be fully responsible for, at its cost, storing and securing all spare parts as necessary for the solar PV system.

7.5 At the request of the project owner, the O&M contractor shall conduct an audit of the spare parts list to detail:

a. The spare parts that have been used and require replacement;
b. The spare parts that have been procured by the project owner since the last audit conducted pursuant to this Clause; and
c. [***].

8. PLANS AND REPORTING[1]

8.1 The O&M contractor shall maintain up-to-date operating logs, records and reports regarding the operation and maintenance of the solar PV system.

8.2 The O&M contractor shall submit to the project owner an annual program of scheduled maintenance, prior to the commencement of each contract year (with the first such plan being provided within fifteen (15) days of the effective date) (such annual programs being the "Annual Operating and Maintenance Schedule").

8.3 The O&M contractor shall within seven (07) business days after the end of the relevant contract year, submit to the project owner an operations report covering the operations and maintenance conducted for the solar PV system during the preceding contract year.

8.4 The O&M contractor shall within [five (05)] business days after the end of each calendar month submit to the project owner a monthly operation, including but not limited to:

a. The operations and maintenance conducted during such preceding calendar month;
b. The meter readings for the production of energy output of the solar PV system for the preceding calendar month; and
c. [***].

8.5 The O&M contractor shall provide the project owner reasonably necessary assistance in connection with the project owner's compliance with reporting requirements under applicable laws or any other agreement to which the project owner is a party relating to the solar PV system, including providing reports, records, logs and other information that the project owner may reasonably request related to the solar PV system.

9 HEALTH AND SAFETY

9.1 The O&M contractor must comply at all times during the performance of the O&M services with all applicable occupational health and safety laws and regulations, and all occupational health and safety guidelines, rules and procedures provided by the project owner to the O&M contractor as applicable to the premises.

[1] The O&M contractor should provide reports and plans for O&M services to ensure efficient coordination between the project owner and the O&M contractor and for the project owner to be able to verify the O&M contractor is fulfilling its duties under this agreement. In addition, this should include assisting with providing meter readings and other reports required under agreements the project owner may have entered into in relation to the solar PV system (such as a power purchase agreement, or a utility PPA).

9.2 The O&M contractor shall provide all fire prevention and safety equipment for the solar PV system as required under law and to ensure safe operation of the solar PV system.

9.3 The O&M contractor shall be responsible for providing all personal protective equipment as may be required for its personnel assigned to work at the site.

10 PERSONNEL

10.1 The O&M contractor represents and warrants that its personnel are trained and skilled practitioners at performing work similar to the O&M services and will perform the O&M services in accordance with the terms and conditions of this agreement.

10.2 If the conduct or performance of any of the O&M contractor's personnel, in the project owner's opinion, is unsatisfactory, the project owner may advise the O&M contractor and the O&M contractor at its own cost and expense at the O&M contractor's sole cost and expense, shall replace such personnel with personnel suitably qualified and acceptable to the project owner.[1]

SECTION III: O&M SERVICE FEE AND PAYMENT TERMS

11 O&M SERVICE FEE

11.1 The project owner shall pay the O&M contractor the monthly service fee throughout the term in consideration of the O&M services.

12 FEE FOR NON-STANDARD MAINTENANCE SERVICES AND PARTS[2]

12.1 If any repair or maintenance of the solar PV system is required due to:

a. Conditions at the premises;
b. The project owner's breach of any provisions of this agreement;
c. The negligent act or wilful misconduct of the project owner;
d. Any work carried out on the solar PV system by the project owner or any third party other than as prior approved by the O&M contractor; or
e. Inaccuracy of any information provided by the project owner and relied upon by the O&M contractor,

The project owner shall fully reimburse the O&M contractor the cost and expense for such maintenance and repair at the O&M contractor's, or if applicable the subcontractors, then current standard rates in addition to the monthly service fee.

13 TAXES

13.1 All prices are stated exclusive of any applicable taxes and the O&M contractor shall add any such applicable value-added taxes and other applicable taxes to its invoices and charge them to the project owner in accordance with laws.

14 PAYMENT TERMS

14.1 The payments to the O&M contractor of the monthly service fee and any other payments under this agreement shall be made in accordance with Clause 14.

14.2 The monthly service fee shall be paid monthly in arrears as invoiced by the O&M

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[1] Suggest the project owner should be entitled to request replacement of personnel of the O&M contractor if they behave in an unsatisfactory way as they will be attending to the project owner's location or representing the project owner as a subcontractor.

[2] Suggest the O&M contractor would be entitled to an additional fee for performing services where these are required due to a breach by the project owner of its obligations under this agreement and so on.

contractor to the project owner and within [15] days of the date of issuance of the relevant invoice.

14.3 All payments to the O&M contractor under this agreement shall be made by bank transfer to the bank account of the O&M contractor as may be notified by the O&M contractor to the project owner from time to time.

14.4 If the project owner fails to pay the O&M contractor any sum payable to the O&M contractor when due pursuant to the agreement, the project owner shall be liable to pay interest to the O&M contractor on such sum from the due date for payment at the annual rate of [***%] per annum accruing on a daily basis until payment is made.

SECTION IV: PERFORMANCE PENALTIES AND PERFORMANCE GUARANTEE

15 FAILURE OF THE SOLAR PV SYSTEM[1]

15.1 If the solar PV system completely fails to provide energy output during more than [***] hours of daylight in one day on more than [five (5)] instances in any three-month period during the term the project owner shall be entitled to either:

a. Terminate this agreement upon giving at least [30] days' notice to the O&M contractor expiring not later than the end of the second month following the relevant three-month period pursuant to this Clause; or

b. A penalty payment of [***] NPR from the O&M contractor and such penalty payment will be deducted from the next relevant monthly service fee.

16 [PERFORMANCE GUARANTEE][2]

16.1 The O&M contractor hereby warrants that the solar PV system shall be capable of generating a minimum performance ratio of [***%] in each contract year (the "Performance guarantee").

16.2 It is agreed and acknowledged by the parties that in the event the performance guarantee is not achieved for any contract year the O&M contractor shall pay performance penalties to the project owner in accordance with Clause 0.

[1] Suggest this as a reasonable performance guarantee provided by the O&M contractor particularly if it is a different service provider from the engineering, procurement and construction (EPC) contractor that installed the system.

[2] Provided suggested performance ratio guarantee and penalties for failure to achieve this. This would be appropriate where the O&M contractor also provided EPC services for the system. Nevertheless, the project owner may request this from the O&M contractor in any event.

17 PERFORMANCE PENALTIES[1]

17.1 If for any contract year, the performance ratio is less than the performance guarantee then the O&M contractor shall be liable to pay a penalty to the project owner in an amount equal to [NPR***] for each 0.1% shortfall between the performance ratio and the performance guarantee up to a maximum amount equivalent to [8%] of the total aggregate monthly service fees payable for such contract year ("Performance penalties").

17.2 The O&M contractor shall within fifteen (15) business days following the end of each relevant contract year calculate the performance ratio (in accordance with schedule 3) in respect of that contract year and, if applicable, calculate the amount of performance penalties payable in respect of the relevant contract year and notify the same to the project owner as soon as reasonably practicable.

17.3 Any performance penalties payable under this agreement shall be payable to the project owner by bank transfer to the project owner's designated account within [five (05)] days following demand thereof from the project owner.

17.4 It is agreed the project owner shall be entitled to avail itself of its right to claim damages and apply any other available remedy available to it under law for any such failure of the performance guarantee to be achieved in addition to its right to receive such performance penalties payments.

17.5 It is agreed the performance penalties shall not be applied in the event the failure to achieve the performance guarantee is caused by the act or breach of this agreement by the project owner.

[1] Suggest structuring these as penalties rather than liquidated damages. This is preferred under Nepalese law governed contracts as penalty provisions are clearly established under Nepalese law (liquidated damages are less so). Nepalese law also permits the parties to agree that penalties are either an exclusive remedy for the relevant matter at hand or are payable in addition to the compensation for damages (it being noted that the project owner would need to demonstrate and evidence such damages).

SECTION V: PROJECT OWNER'S OBLIGATIONS[1]

18 The project owner shall:

a. Provide or procure for the O&M contractor at no charge, all requisite access to the site, plus access to utilities at the premises including electrical power, light and water as reasonably required by the O&M contractor in order to perform the O&M services;

b. Pay for all ongoing costs relating to the supply of electricity to the site and telecommunications used by the O&M contractor at the site for the purpose of carrying out the O&M services;

c. Provide the O&M contractor with all necessary information about the solar PV system, the premises, and the site to enable the O&M contractor to carry out the O&M Services;

d. Pay the monthly service fee and any other fees due in accordance with and subject to the further terms and conditions of this agreement; and

e. [***].

[1] This section provides further general obligations of the project owner and may be added to or revised as necessary.

SECTION VI: GENERAL MATTERS

19 SUB-CONTRACTING

19.1 The O&M contractor may only subcontract part (but not all) of the services to be performed under this agreement during the term with the prior written consent of the project owner (such consent not to be unreasonably withheld).

19.2 Notwithstanding Clause 19.1, the O&M contractor shall remain liable for the provision of any and all such work and services to the project owner.[1]

20 O&M CONTRACTOR RIGHT OF ACCESS[2]

20.1 The project owner grants the O&M contractor and its employees, agents and subcontractors, throughout the term of this agreement:

a. A right of egress and ingress over all walkways and roads at all times to the Premises; and

b. A right to enter and obtain access to the site through the premises, including the right to access and use all elevators, stairways or other access points of egress and ingress for the purposes of accessing the site,

For the purposes of performing the services contemplated by this agreement, the project owner shall provide such cooperation and assistance to enable the O&M contractor (including its employees, agents and subcontractors) to operate, repair and maintain the solar PV system and carry out all other services contemplated under this agreement on the terms and conditions of this agreement.

20.2 If the project owner refuses the right of access or obstructs such right of access it will be deemed a material breach of the terms of this agreement by the project owner. [3]

21 INSURANCE[4]

21.1 The O&M contractor shall procure and maintain the following insurance policies and maintain comprehensive policies of insurance in respect of the following matters and in the minimum amounts set out below:

a. Contractor all risk insurance in an amount of not less than [NPR***];

b. Third-party liability insurance in an amount of not less than [NPR***]].

21.2 The O&M contractor will not do anything or omit to do anything which could cause

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[1] It is understood it is the intention that the O&M contractor will perform most if not all of the services under this agreement, but may need to engage subcontractor's for performance of certain services over the course of the long-term contract with the project owner's approval. However, it should be noted by the O&M contractor that the O&M contractor will remain liable for the provision of the services to the project owner under this agreement and for that reason, the O&M contractor should take all precautions to ensure it is equally protected under any separate subcontract agreements it enters into with local service provider(s).

[2] As the solar PV system will be installed on the rooftop, the O&M contractor will require a right of access to the solar PV system in order to effectively perform its obligations under the contract. Such right of access must be granted to the O&M contractor, its authorized personnel and importantly extended to the subcontractor(s) throughout the term of the contract. The extension of this right to subcontractors is necessary for the O&M contractor to be able to grant the right of access to the subcontractors, who may be engaged to perform certain of the O&M contractor's services and as such would need to enter upon the project owner's premises to do so. in the case the project owner is a solar service company, and not the facility owner, this should be a back-to-back granting of access as the solar service company has been granted by the facility owner.

[3] Due to the vital importance of this right of access for the O&M contractor to be able to perform its obligations under the agreement, such right should be irrevocable during the term and if the project owner denies, obstructs or in any way refuses such access it will be considered a material breach of the agreement.

[4] Appropriate insurance types and levels should be agreed here and procured based on standard industry practice.

any insurance policy referred to in this Clause 21, to become wholly or partly void or voidable, and will comply with all requirements and recommendations of any such insurers; and give immediate notice to the project owner of any event that might affect any such insurance policy (including any claims made under it).

22 [PROJECT OWNER AND O&M CONTRACTOR REPRESENTATIVES][1]

22.1 The O&M contractor and the project owner shall each nominate a representative for communication throughout the term of this agreement and provide the other party with the respective representative's details, including name, position and contact information. Such representatives will be the first point of contact for each party. If either party wishes to change such representative, it must give reasonable prior notification to the other party of the replacement representative.

22.2 Further to Clause 22.1, the O&M contractor's and project owner's respective representatives shall meet on a [monthly] basis (or at such other intervals as the representatives may mutually agree) to:

a. Consult and discuss the arrangement and implementation of each phase of the Agreement; and
b. Discuss and settle any issues which may arise throughout the term of this agreement.]

23 FORCE MAJEURE[2]

23.1 If the performance of any obligation under this agreement by a party should be prevented or delayed by an event of force majeure ("Event of Force Majeure"), such as fire, natural disaster, war, rebellion, sabotage, embargo, epidemic, act of God, or act, rule, regulation, order or directive of any Governmental Authority or the order of any court of competent jurisdiction, that party's duty to perform their obligations affected by the event of force majeure shall be suspended for a period equal to the delay directly resulting from the occurrence of such event, provided such event is without the fault of and beyond the reasonable control of the party invoking force majeure. In the event of force majeure, the party invoking force majeure shall not be responsible for any damage, increased costs or loss which the other parties may sustain by reason of such a failure or delay of performance.

23.2 In the event that a party wishes to invoke force majeure, such party shall, within seven days after the occurrence of the event of force majeure has become known to such party, send written notice thereof to the other party. The party affected by force majeure shall take appropriate measures to minimise or remove the effects of force majeure and, within the shortest possible time, attempt to resume the performance of its obligations affected by the event of force majeure.

[1] This is recommended in such case to ensure ease of communication between the parties and to avoid and/or deal with issues efficiently and effectively as these arise during the term.

[2] This is an important clause and should be retained to allow either party to suspend or terminate the performance of its obligations when certain circumstances beyond their control arise, making performance inadvisable, commercially impracticable, illegal, or impossible. The list of events to be included is a matter of negotiation between the parties, but the clause as drafted is typical and should include "*regulation, order or directive of any Governmental Authority*" as Nepalese law is developing, and regulations can change in nature relatively often compared to other legal systems.

24 TERM AND TERMINATION[1]

24.1 This agreement shall be effective from the effective date until the date being the [****] of the effective date ("Term")[2] unless it is early terminated in accordance with this Clause 24 or other applicable provisions of this agreement.

24.2 This agreement may be terminated in the following circumstances:

a. Upon the expiration of the term without any requirement for further notice;
b. The parties mutually agree to terminate this agreement;
c. By written notice to the other party on breach of any obligation under this agreement by the other party, and, where capable of remedy, such breach remains unremedied after [thirty (30)] days of such notice;
d. By written notice to the other party with immediate effect at any time if an insolvency event occurs in respect of such other party; and
e. Pursuant to any other right of unilateral termination a party may have under this agreement and Nepalese law.

24.3 Termination of this agreement is without prejudice to any rights and obligations that have already accrued to a party prior to the termination.

24.4 On termination of this agreement for whatever reason:

a. The O&M contractor shall leave the solar PV system in as good condition as it was on the effective date normal wear and tear and casualty excepted;
b. The O&M contractor shall use commercially reasonable efforts to cooperate with the project owner or a succeeding operator to assure that the operation and maintenance of the solar PV system is not disrupted, including but not limited to taking all reasonable steps requested by the project owner required to effect the assumption of any contracts with third party service providers or suppliers related to the solar PV system operation and maintenance; and
c. Subject as otherwise provided in this agreement and to any rights or obligations which have accrued prior to termination, neither party shall have any further obligation to the other under this agreement.

25 INDEMNITY

25.1 The O&M contractor agrees to indemnify and hold harmless the project owner and its directors, officers, employees and agents from any claims, causes of action, or liabilities, loss (including consequential loss), sickness, injury or death of its personnel, which arise out of the breach of any of the warranties, undertakings, obligations and representations under this agreement by the O&M contractor.

26 LIMITATION OF LIABILITY

26.1 Each party's liability under this agreement shall be limited to direct actual damages only.[3]

26.2 Nothing in these conditions excludes or limits the liability of the O&M contractor for death or personal injury caused by the O&M contractor's negligence; for any matter

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[1] These provisions for early termination include standard cases such as agreement between the Parties, material and unremedied breach, and bankruptcy/winding up of either party. Further specific events that may enable either party to terminate the agreement may be agreed between the parties based on commercial concerns and so on at such time.

[2] This should be agreed between the parties but may be for a specific period such as five years or for the entire lifespan of the system or in line with the term of the underlying agreements related to the solar PV system (power purchase agreement, utility PPA and so on).

[3] The parties' liability should be limited to direct damages only.

which it would be illegal for the O&M contractor to exclude or attempt to exclude its liability; or for fraud or fraudulent misrepresentation.

27 WARRANTIES

27.1 Each party (a "Relevant party") represents, warrants and covenants to each other party that:

a. The relevant party is duly incorporated, validly existing and in good standing order under the law of its jurisdiction of incorporation;

b. The relevant party has the full power and authority to enter into and perform its obligations under this agreement;

c. This agreement constitutes binding obligations on the relevant party in accordance with its terms, subject to any principles of equity or insolvency law;

d. Other than as expressly stated in this agreement, the relevant party has obtained all applicable corporate approvals, licenses, waivers or exemptions as required under its constitutional documents, applicable law, and as required by any government authority to empower it to enter into and perform its obligations under this agreement.

27.2 Warranties given by the O&M contractor

a. The O&M contractor represents, warrants and covenants to the project owner:

b. The O&M services will be performed with all the skill and care to be expected of an appropriately qualified and experienced contractor with experience in performing services of a similar size, type, nature and complexity to the O&M services;

c. The O&M services will be performed in a timely and professional manner in accordance with all applicable Nepalese laws and this agreement;

d. The O&M services will be performed with the highest regard for the safety and protection of the environment so that the solar PV system is capable of being operated and utilized in accordance with all applicable Nepalese laws and this agreement; and

e. Tthe O&M Services will be carried out in accordance with the standards on environmental, social, and health and safety set by the project owner and all Nepalese national standards on electric, environmental, social, environmental protection, and fire protection.

28 NOTICES[1]

All notices shall be made in writing and shall be deemed given or made as of the date delivered, whether by personal delivery, courier or email to the address set out in the introduction, or to such other postal or email address of which the sender has received prior written notice from the recipient advising the sender that correspondence in connection with this Agreement should be sent to such other postal or email address.

29 CONFIDENTIALITY AND PUBLICITY[2]

29.1 The Parties shall (and shall ensure that each of their agents and where applicable officers and employees shall) at all times keep confidential any confidential

[1] This is a standard clause and should not require to be amended. Also, it sets agreement on deemed delivery of notice, which shall trigger time lines under other clauses such as Clause 24.2c, under which a party must remedy a breach of contract within 30 days of receiving notice from the other party otherwise the agreement may be terminated.

[2] This is a standard clause on confidentiality and should not require much modification, other than specifying which information shall be included as confidential. It also includes exceptions on disclosing such confidential information, such as to advisors and as required under law necessary in practice.

information which it may acquire during any communications preceding or after the execution and during the performance of this agreement in relation to the other party and this agreement, and shall not use or disclose such confidential information to any other person. For the purposes of this clause, "Confidential information" shall include in respect of the disclosing party (the "Disclosing party"), any and all information and know-how in any form, whether of a technical, financial, business or other nature, including, without limitation, the disclosing party's activities, operations, research, development, finances, marketing plans, product specifications, operations, systems, policies, procedures, practices, data, methods, any ideas, concepts, sketches, copy, art-work, documentation or notes conceived related to the solar PV system, any information, analyses, compilations, studies and other material generated pursuant to this agreement which contains, reflects, or is/are derived from, any of the foregoing, and any other sensitive information or communications which would reasonably be deemed to be confidential that is or has been disclosed to or otherwise received or obtained, directly or indirectly, by the other party, whether or not in connection with or pursuant to this agreement, and the details, terms and conditions of this agreement.

29.2 Each party shall cause its personnel, agents and any subcontractors engaged in the performance of this agreement to treat all such confidential information in Clause 29.1 as confidential, as well as any third party, who has been given access to such confidential information shall treat it as confidential so as to ensure that such confidential information will not be made available to any unauthorized third party.

29.3 Notwithstanding Clauses 29.1 and 29.2:

a. the parties may disclose confidential information if and to the extent:

   i. Required by any Governmental authority;
   ii. Required by any applicable law;
   iii. Disclosed to the professional advisors, auditors and/or bankers of each party;
   iv. The confidential information has come into the public domain through no fault of that party; or
   v. The other party has given its prior written approval of the disclosure,

provided that any confidential information so disclosed will be disclosed only after consultation with the other party and such consultation is lawful and reasonably practicable;

30 VARIATIONS

No variation to this agreement shall be effective unless it expressly refers to this agreement and is made in writing and signed by or on behalf of the parties.

31 SEVERABILITY

If any provision of this agreement is determined by any arbitral tribunal, court or other competent authority to be unlawful and/or unenforceable, the other provisions of this agreement will continue in effect. If any unlawful and/or unenforceable provision would be lawful or enforceable if part of it were deleted, that part will be deemed to be deleted, and the rest of the provision will continue in effect (unless that would contradict the clear intention of the parties, in which case the entirety of the relevant provision will be deemed to be deleted).

32 ASSIGNMENT

32.1 The O&M contractor may not without the prior written consent of the project owner assign, transfer, charge, license or otherwise deal in or dispose of any contractual rights or obligations under this agreement.

32.2 The project owner may assign, transfer, charge, license or otherwise deal in or dispose of any contractual rights and obligations under this agreement on giving thirty (30) days' prior notice to the O&M contractor without the prior written approval of the O&M contractor.[1]

33 LAW, LANGUAGE AND COPIES

33.1 This agreement (together with all documents referred to herein) shall be governed by and construed according to Nepalese laws.

33.2 This agreement shall be entered into in [English and] Nepalese in two (2) original copies of each version. In the event of any inconsistency between the English and Nepalese language versions, the [English]/[Nepalese] language version shall prevail.

34 DISPUTES

34.1 Any dispute arising out of or in connection with the agreement shall be resolved in accordance with this Clause 34. Before referring a dispute to the arbitration, the parties shall endeavour to resolve any dispute amicably within 30 days of a party giving notice to the other party that a dispute has arisen.

34.2 Any such dispute which cannot be resolved amicably shall be resolved by arbitration at the Nepal 's relevant lawful bodies in accordance with its Rules of Arbitration. The number of arbitrators shall be three. Each party shall appoint one arbitrator, with the third to be appointed by such two appointed arbitrators. The place of arbitration shall be [***], Nepal. The language to be used in the arbitral proceedings shall be English.

[*SIGNATURE PAGE TO FOLLOW*]

[1] The right of the O&M contractor to assign its contractual obligations with prior written consent of the project owner must be included to allow the O&M contractor to engage a subcontractor to perform certain of its obligations if necessary.

IN WITNESS WHEREOF, the parties hereto have executed this agreement as of the day and year first above written.

For and on behalf of	For and on behalf of
[The O&M contractor]	**[The project owner]**
______________________	______________________
[***]	[***]
[Position]	[Position]

SCHEDULE 1 – SOLAR PV SYSTEM SPECIFICATIONS[1]

1. System Installed Capacity (kW): [***]

2. Module(s):

Manufacturer/Model	Specifications	Quantity
[***]	[***]	[***]
[***]	[***]	[***]

2. Inverter(s):

Manufacturer/Model	Specifications	Quantity
[***]	[***]	[***]
[***]	[***]	[***]

3. Premises and site

   [To add the written description of the premises and site]

4. List of accompanying drawings

   [To be added by the O&M Contractor as necessary, including drawing of the solar PV system, site and so on]

[1] The contractor and project owner shall insert a full technical description of the relevant equipment and so on. This should cover make, specification, age and condition at the effective date. Records of any the maintenance and servicing prior to entering into this agreement should be included if available. This should also include all ancillary equipment. This shall take the form of written records, photographs and scaled plans and sections.

SCHEDULE 2 – O&M SERVICES[1]

PART 1: PREVENTATIVE MAINTENANCE SERVICES

During the term, the O&M contractor shall perform regular preventative maintenance services for the solar PV system, including:

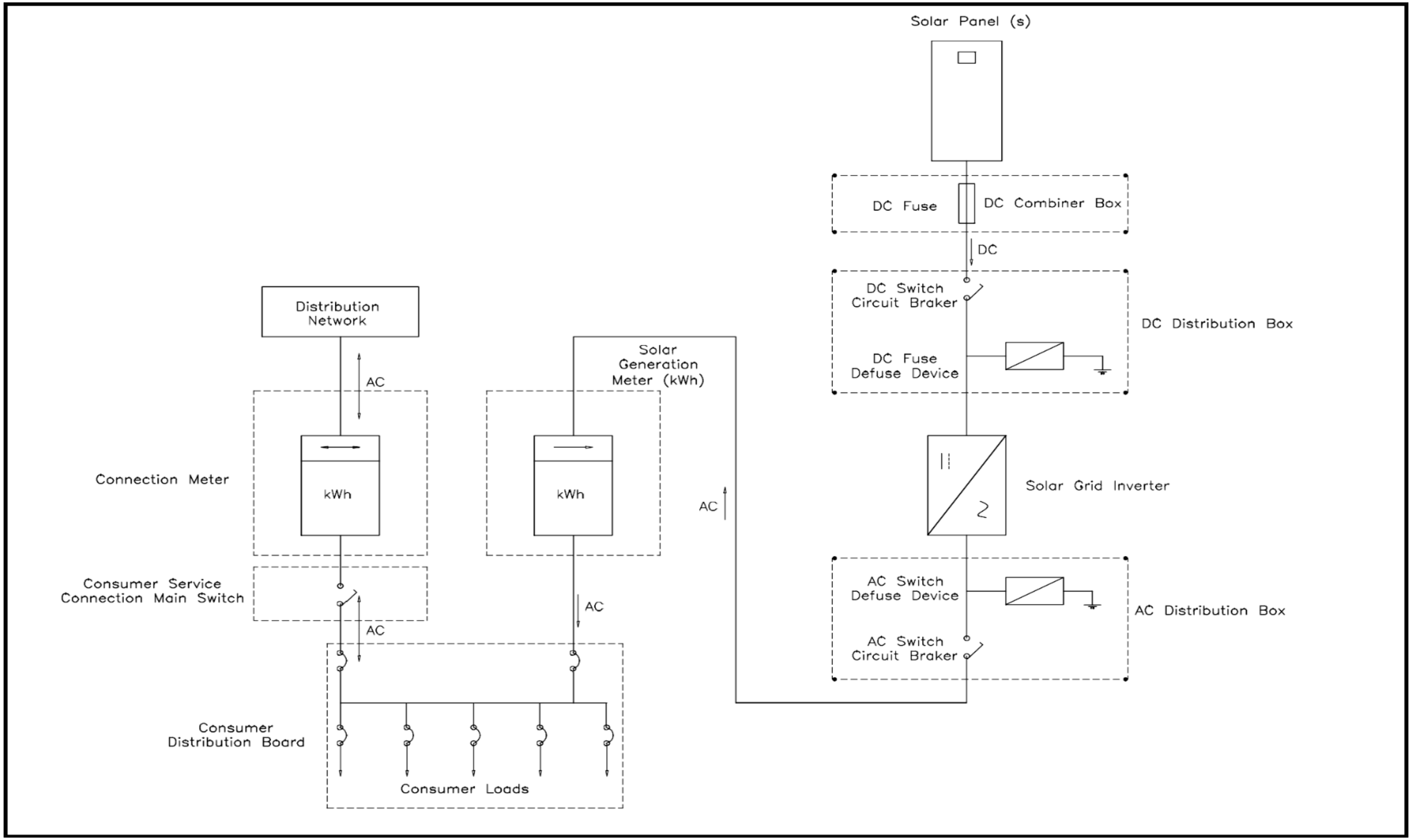
a. [Quarterly] Site visits per contract year to conduct inspections and solar PV system check-ups;
b. Daily SCADA monitoring to ensure any issues are dealt with as soon as practically possible;
c. Undertake monthly system meter readings;
d. [Quarterly] cleaning of the solar PV system; and
e. [***].

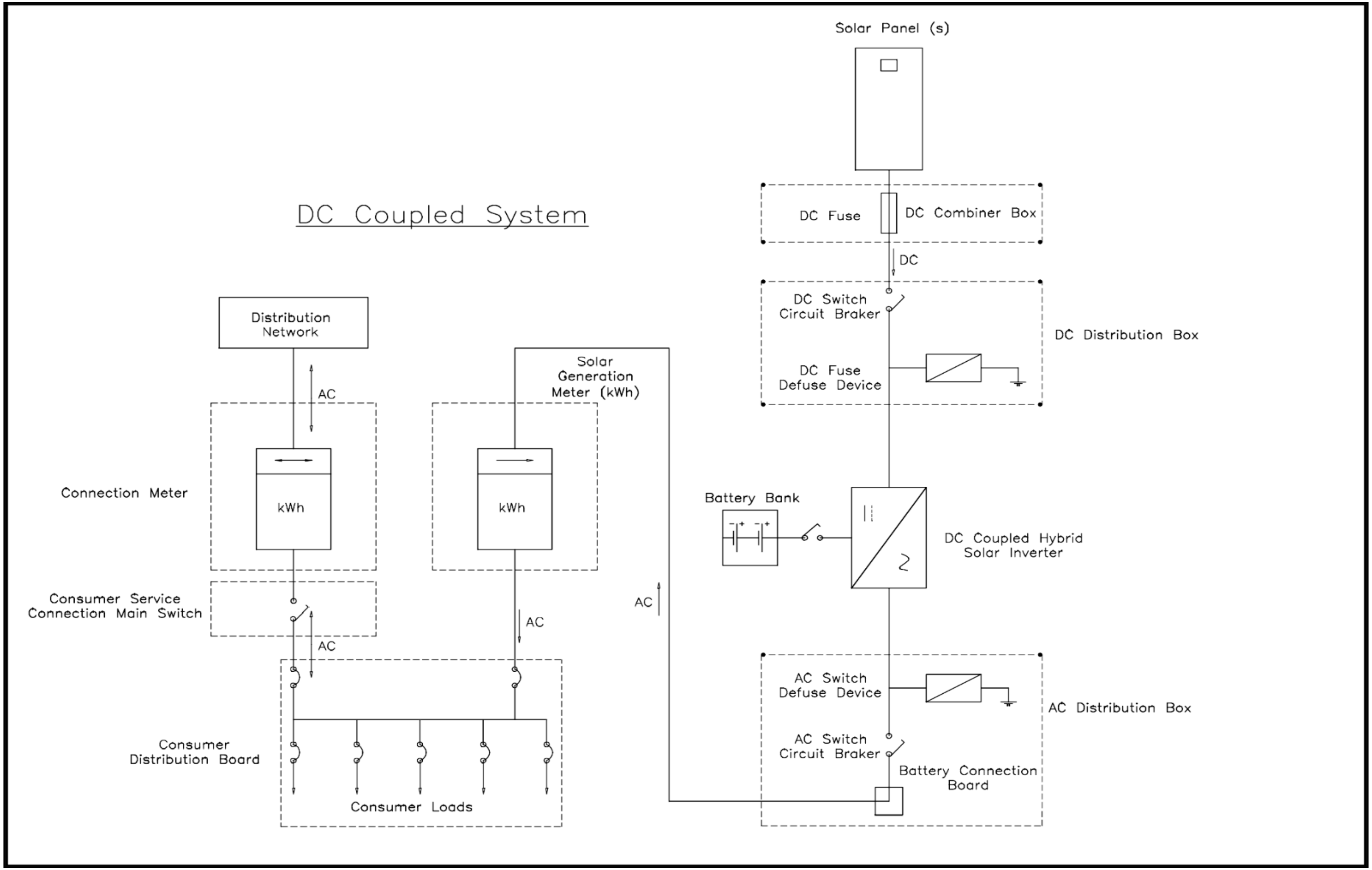
PART 2: CORRECTIVE MAINTENANCE SERVICES

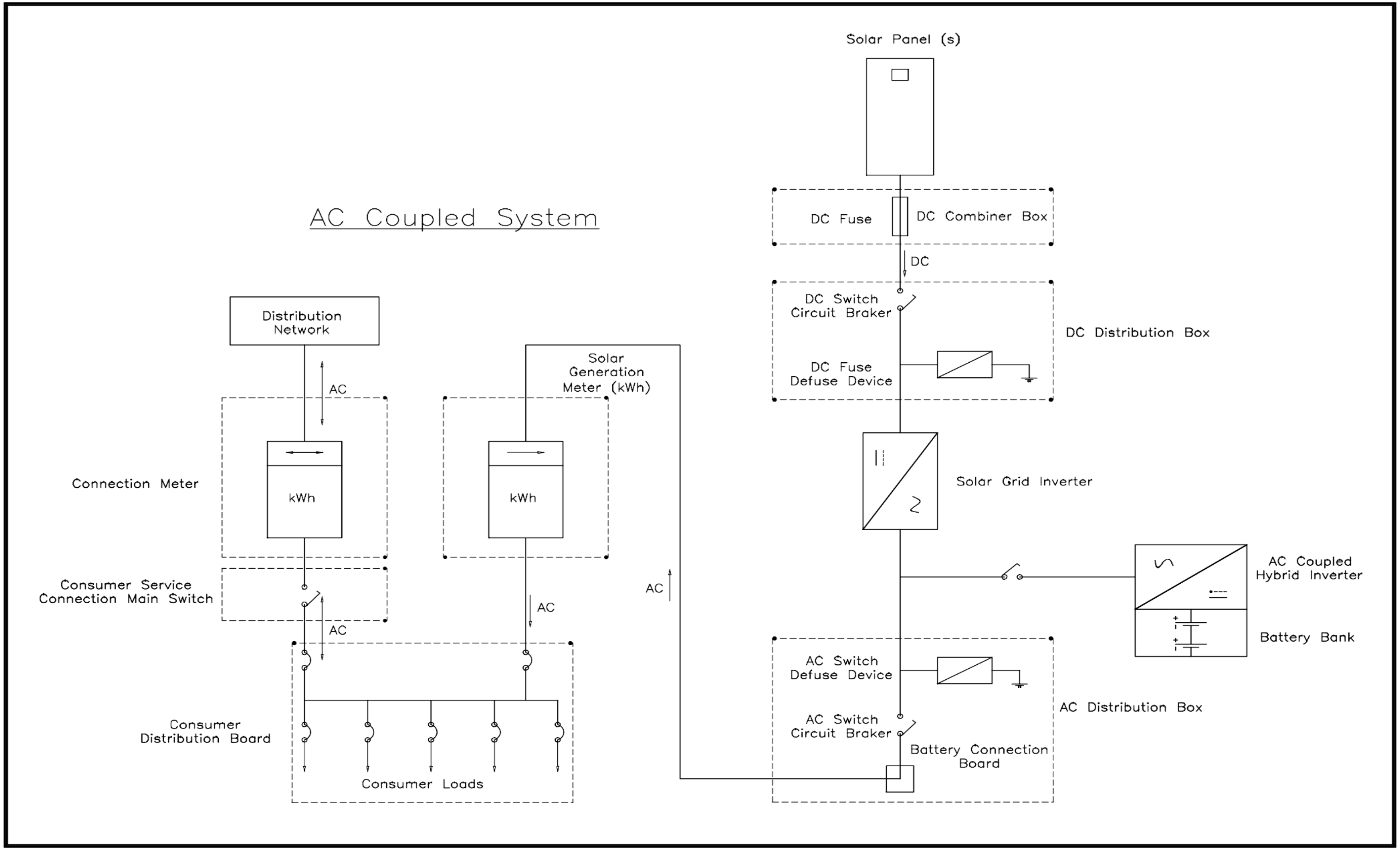
a. The O&M contractor shall notify the project owner within twenty-four (24) hours following the O&M contractor's discovery of any material malfunction in the operation of the solar PV system.
b. The project owner shall notify the O&M contractor immediately upon the discovery of any condition adversely affecting the operation of the solar PV system.
c. The parties shall each designate personnel and establish procedures such that each party may provide notice of such conditions requiring the O&M contractor's repair or alteration of the solar PV system throughout the term.
d. The O&M contractor shall use best efforts to conduct required corrective maintenance to remedy any material malfunction in the solar PV system within [three (3)] days of either:
    i. Notifying the project owner of such material malfunction pursuant to paragraph (a) above; or
    ii. Receiving notification from the project owner pursuant to paragraph (b) above.

[1] The list of regular preventative maintenance and corrective maintenance services obligation should be agreed and set out here. An indicative list is provided here for guidance purposes only.

A.14 Single-line diagram of different system types




DC Coupled System
Solar Panel (s)
DC Fuse
DC Combiner Box
DC
DC Switch
Circuit Braker
DC Distribution Box
DC Fuse
Defuse Device
Distribution
Network
AC
Solar
Generation
Meter (kWh)
Connection Meter
kWh
kWh
Battery Bank
DC Coupled Hybrid
Solar Inverter
Consumer Service
Connection Main Switch
AC
AC
AC
AC Switch
Defuse Device
AC Distribution Box
Consumer
Distribution Board
AC Switch
Circuit Braker
Battery Connection
Board
Consumer Loads


Solar Panel (s)
AC Coupled System
DC Fuse
DC Combiner Box
DC
DC Switch
Circuit Braker
DC Distribution Box
DC Fuse
Defuse Device
Distribution
Network
AC
Solar
Generation
Meter (kWh)
Connection Meter
kWh
kWh
Solar Grid Inverter
AC Coupled
Hybrid Inverter
Consumer Service
Connection Main Switch
AC
AC
AC
Battery Bank
AC Switch
Defuse Device
AC Distribution Box
Consumer
Distribution Board
AC Switch
Circuit Braker
Battery Connection
Board
Consumer Loads

A.15 Financial modelling tool

The following screenshots merely seek to introduce the calculation tool which is available separately from the report for calculation as a Microsoft Excel file.

The tool consists of three sheets:

Financial Model

This sheet is the main body of the financial model and consists of the following sections:

Project Setup
Key Assumptions (Currency,Taxation, Grant, Equity, Debt)
Expenses (CAPEX and OPEX)
Revenues (connection fee, electricity sales)
Depreciation and Reinvestment
Project Performance
Income Statement
Cashflow Statement
Balance Sheet
Key Performance Matrices

Dashboard

This sheets provides an overview of the project variables and gives the most important information at a glance

Technical Project Overview
System Configuration
Energy Supply
Energy Demand and Sales
Financial Project Overview
Financing Structure
CAPEX
OPEX
Key Performance Indicators
LCOE
Tariff
DSCR
NPV
IRR
Payback

Sensitivity

This sheets allows to conduct sensitivity analysis of the project on the following paramaters:

Project Setup

Key Assumptions

Time Related Parameters		
Project Start Year	2023	
Start of Loan	2023	
Project Life	25	years
Currency Related Parameters		
Currency Depreciation	0.0%	%
Discount Rate	8.4%	%
Taxation		
VAT	13.0%	%
Income Tax Period 1	0.0%	%
Duration of Period 1	10	years
Income Tax Period 2	5.0%	%
Duration of Perdiod 2	5	years
Income Tax Period 3	25.0%	%
Duration of Period	remaining	years
Other Tax	0.0%	%
Grant		
Grant as % of CAPEX	0%	%
Project Grant	-	USD
% grant in year 0	100%	%
Project Grant in year 0	-	USD
% remaining Grant	0%	%
Remaining Project Grant	-	USD
Disbursement year of remaining grant	5	years
Equity		
Developer Equity	0%	%
Investor Equity	50%	%
Equity IRR from risk-less investments	8%	%

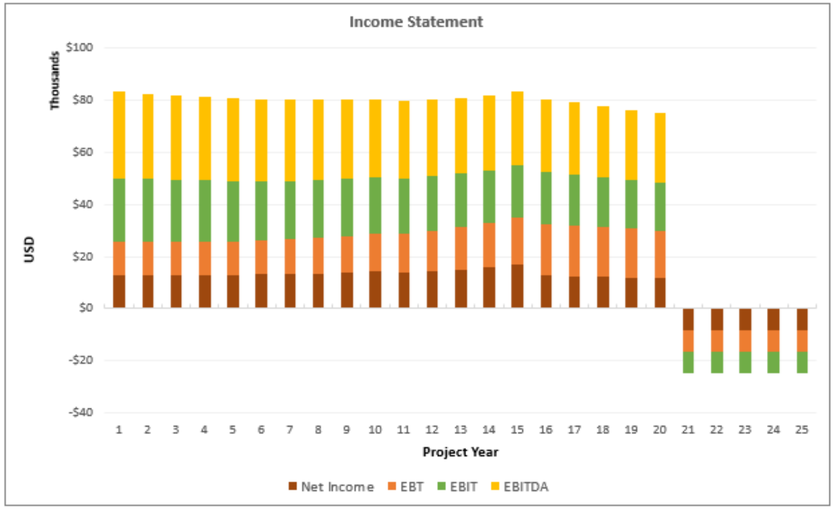
Technical Project Overview

System Configuration

System component	Value	Unit
Solar PV Panels	500	kWp
Battery Storage System	0	kWh
Diesel Genset (Optional)	0	kW
Fuel Consumption	#DIV/0!	Litres/yr
Grid Purchases	0	kWh/yr

Energy Supply

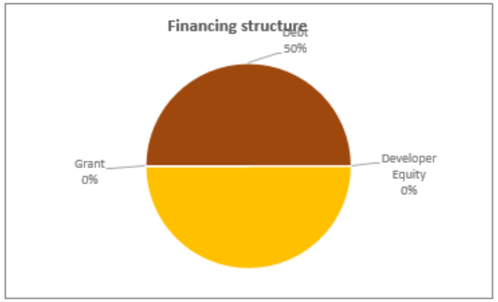
Supply source	Energy	%	Unit
Solar PV Panels	710	100%	MWh
Battery Storage System	0	0%	MWh
Diesel Genset (Optional)	0	0%	MWh
Grid	0	0%	MWh
Total	**710**	**100%**	**MWh**



Financial Project Overview

Financing Structure

Source	Value		Unit
Developer Equity	0	0%	k$
Investor Equity	97	50%	k$
Grant	0	0%	k$
Debt	97	50%	k$
Total	**194**	**100%**	**k$**



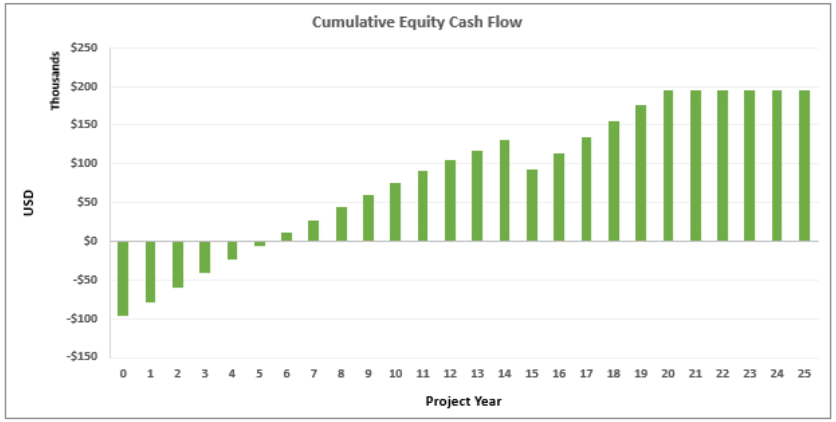
Key Performance Indicators

Overall performance

Indicator	Value	Unit
LCOE without Grant	0.04	$/kWh
LCOE with Grant	0.04	$/kWh
Minimum DSCR	1.90	ratio

Overall performance

Indicator	Value	Unit
Project NPV	3,146	$
Equity NPV	56,748	$
Project IRR	8.6%	%
Equity IRR	16.2%	%
Equity payback	6	yrs



A.16 Basic troubleshooting instructions

Troubleshooting of a system

When troubleshooting a grid-connected PV system, the process generally entails detecting and resolving problems associated with the solar panels, inverters, wiring, and grid connection. It's important to note that **dealing with electricity can pose potential risks. In case of a lack of confidence or feel of uneasiness about troubleshooting any part of the PV system, it is strongly recommended to seek professional help to ensure both safety and effective resolution of the issue.**

Some steps that can aid you in troubleshooting your grid-connected PV system are mentioned below:

- ✓ **Validate the grid connection**: Ensure that the grid connection is secure and there are no power outages in the area. Confirm that the system is properly connected to the electrical grid and activate the grid connection switch.
- ✓ **Inspect the solar panels:** Thoroughly examine the solar panels for any physical damage such as cracks, fractures, or shading. Clean the panels to remove dirt, debris, or snow that can reduce their efficiency.
- ✓ **Examine the wiring:** Carefully inspect the wiring connections between the solar panels, combiner box (if applicable), and the inverter. Look for loose connections, damaged cables, or burnt-out components. Tighten any loose connections and replace faulty components.
- ✓ **Monitor the inverter**: Check the inverter's display or monitoring system for error messages, fault codes, or unusual behaviour. Refer to the inverter's user manual or specific error codes and troubleshooting steps.
- ✓ **Test the DC voltage:** Measure the DC voltage at various points and terminals in the system, including the solar panel output, combiner box, and inverter input.
- ✓ **Verify the AC voltage:** Measure the AC voltage at the inverter's output terminals. Confirm that the voltage matches the grid voltage and falls within the acceptable range. Low voltage or absence of voltage may indicate an issue with the inverter or grid connection.
- ✓ **Inspect the protection devices:** Verify that protection devices like DC disconnect switches, AC disconnect switches, and surge protectors are functioning properly. Ensure they have not been tripped or damaged.
- ✓ **Review the monitoring system:** If the PV system has a monitoring system, carefully review the provided data and alerts. Look for any irregularities in power output, voltage, or current readings. Compare these readings with historical data to identify sudden drops or fluctuations.
- ✓ **Seek professional assistance:** If you are unable to identify or resolve the issue independently, it is advisable to consult a qualified solar installer or electrician experienced in PV systems.

DOs and DON'Ts

DOs	DONTs
Do hire a professional	Don't attempt DIY installations unless you have expertise
Do choose high-quality components	Don't shade your panels
Do comply with local regulations	Don't tamper with electrical components
Do take care of your system components	Don't assume unlimited power generation
Do monitor your system's performance	Don't block access to the system
Do perform regular maintenance	Don't overlook warranty and insurance
Do get trained people to perform any checks/maintenance work.	Don't neglect safety precautions
	Don't overlook warranty and service agreements
	Don't ignore any error messages.
	Don't assume anything unless you are sure of something.

A.17 Basic troubleshooting manual

Solar grid-connected systems

User manual

[Site name]

[Location]

INTRODUCTION

This document introduces the operation and maintenance of your solar PV system in the solar grid-connected system. Your system is designed to meet all of Nepal's conditions and regulations. Although it is very low maintenance, it must always be remembered that the system generates electricity and we recommend that you do not attempt to service it unless you are suitably qualified. Your safety is our primary concern.

EQUIPMENT SUPPLIER

[Please mention the equipment supplier's details such as name, address, etc.]

EQUIPMENT INSTALLER AND COMMISSIONER

Name: ……………………………………..

Address: ……………………………………..

Emergency phone no.: ……………………………………..

Telephone no.: ……………………………………..

Mobile no.: ……………………………………..

ABOUT THIS DOCUMENT

No liability is accepted for incorrect use, unauthorized changes to the assembly components, or the resulting consequences. All information and instructions in this manual refer to the current state of development.

OWNER MAINTENANCE

For your safety, we recommend that you do not attempt any servicing yourself unless recommended by a professional technician.

The solar panels work best when clean. Regular rainfall or washing with a hose will maintain their cleanliness. If they do become excessively soiled they can be cleaned with cold water. It is strongly recommended that you avoid climbing and use the services of a qualified professional who is trained in occupational health and safety procedures.

Shading of the solar panels will affect efficiency and performance. Plant and tree growth that may cause shading at various times of the year, should be monitored and dealt with as required. Likewise leaves, bird droppings and other debris coming to rest either on or around the solar modules should be carefully removed.

If you notice your system is not operating correctly, please check the **Trouble shooting** section of this document.

If you need to shut down the system, please follow these steps in order.

- Switch off the **DC isolator/breaker** adjacent to the Inverter
- Switch off the **AC isolator/breaker** adjacent to the Inverter

Following these steps will safely isolate the solar array. To switch it back on, you simply reverse the procedure. Always remember that your system will be generating electricity during daylight hours and care should always be taken to eliminate the risk of electric shock. Refer to the *OPERATING INSTRUCTIONS* in this document for more information.

COMPONENTS OF GRID-CONNECTED PV SYSTEM

The components of the grid-connected solar PV systems are summarized below:

- PV module/array: Getting the sunlight, the PV modules generate electricity,
- Circuit Breaker: In case of a short circuit, the circuit breaker automatically cuts off the circuit.
- Grid Inverter: The grid inverter converts the DC input of the solar PV modules to AC output and synchronizes with the grid supply.

HOW YOUR SOLAR GRID-CONNECTED SYSTEM WORK?

The following illustration and narrative explain how the solar grid-connected system works –

[Put a system architecture drawing here to show the solar grid-connected system working principle]

- *The solar electric modules are usually fitted to the roof or ground. The number of modules will depend on thenominal size of your system and, collectively, they are known as the solar array. The solar array converts daylight into direct current (DC) electricity.*
- *The DC electricity is fed to the inverter. The inverter converts the DC electricity to AC electricity which is compatible with the electricity supplied to the house. The inverters have a digital readout so you can monitor information such as the amount of solar electricity produced, etc. Refer to the separate inverter owner's manual for more information.*
- *The power produced by the PV system is now consumed by the electric loads in the building. Only the electricity not first consumed by the building will be exported to the grid.*

SYSTEM PERFORMANCE

During daylight hours, your system will be generating electricity at varying rates depending on the amount of sunshine. The more sunlight falling on the solar array the more electricity is generated; variable factors such as cloud cover, seasonal solar angle variations, shading or soiling of the solar array will affect the electricity output.

Note that you do not need to change your energy usage lifestyle to correspond with your solar system. Your energy consumption will be supplied by solar energy or the grid.

ENERGY CONSERVATION

Your solar electricity system represents an investment in your future energy needs as well as a benefit to the environment. Unlike conventional generators of electricity that have been causing major environmental problems such as smog, acid rain and global warming, your solar electricity system does not produce any air or water pollution while it is generating electricity.

Considering that it generates free electricity from daylight, it makes sense to consider the other side of the energy equation – your electricity consumption.

OPERATING INSTRUCTIONS

Your solar grid-connected system is designed for automatic operation without the need for user intervention. There are no moving parts or need for the owner to interact during its normal operation.

In the case of ***mains grid supply failure,*** the inverter will immediately and automatically be disabled. This is known as ***"anti-islanding"*** and it protects linesmen from an electric shock from your system when they assume the grid is "dead". Once the grid power has been restored, the inverter will be automatically re-enabled.

OPERATING SAFETY INSTRUCTIONS

- *Do not attempt to service the system unless you are fully qualified to do so. To service any electrical connection, you have experience as an electrical technician with training provided by the operating company. You must also be guided by a qualified professional from the operating company.*
- *All service work must be carried out in strict compliance with all local and national electrical regulations and standards.*
- *Review and follow all safety instructions supplied with all components of your solar electricity system.*
- *Do not attempt to clean or come in contact with the surface of a solar module with broken glass. This could result in a dangerous electric shock.*
- *Be aware that power may be present at any point in electrical circuits despite the opening of circuit breakers or isolators.*
- *Circuit breakers can trip automatically if problems occur. If the circuit breaker is switched back to the closed or "on" position and it immediately trips back to the open or "off" position, there is a problem.*

USING YOUR INVERTER

The inverter converts the DC power produced by the solar panels into useful AC power while also monitoring and displaying the energy yield.

Front panel display

[Put a front display of your Inverter that clearly shows the LED indications if any.]

LED status indicator lights

[Put a table in this section showing the different LEDs and what they depict, like what it means when it is solid and what it means when it is flashing.]

Keypad

[Put a picture and a table in this section showing different keypads and what it is used for. Also, put a process to function different steps to operate and check the parameters on the LCD.]

LCD

The two-line liquid crystal display (LCD) is located on the front panel of the inverter which shows the following information:

- *Inverter operation status and data;*
- *Service messages for the operator*
- *Alarm messages and fault indications*

[Put a picture of the LCD and a table showing different LCD functions and status details, alarm details or any messages for the operator.]

Start and stop

Start the inverter

[Put a procedure on how to start the Inverter.]

Inverter working status

[Put a different status indication and LCD showing the Inverter is working in normal or different conditions.]

Stop the inverter

[Put steps for stopping the Inverter during maintenance or emergency condition.]

Operation

[During normal operation, the display alternately shows the power and the operation status with each screen lasting for a few seconds. Put a flowchart or steps showing the operation status of the inverter.]

Main menu

[This section is used to put the main menu where different functions and menus are available. Put a step on how to get to the Main Menu of the display and mention different options available in the Main Menu.]

Lock screen

[Put a step showing the lock screen usage and the way how to protect it from unauthorized interference.]

Settings

Set Time

[Put a step on how to set a time.]

Advanced info – technicians only

[Put a step on how to set the advanced info option. This is used for professional technicians only.]

Alarm message

[Put a step on what different alarm codes are mentioned and what are the causes of the alarms. Check if the alarm messages are in line with the issues.]

TROUBLESHOOTING

Troubleshooting PV panels

- *You can mention here what you should require to check at the first step such as checking the output of the entire system or inverter.*
- *Secondly, you can check the inverter input voltage from the PV array and current.*
- *Either you will find the entire PV array system is not producing any power or the output power is lower than expected. Mention the current and voltage as it is noted by the multimeter.*
- *Check physically at first if all the PV modules are ready or not, then after check the combiner boxes for any fuses that may be blown.*

Troubleshooting PV inverters

- *Please mention where are the basic location that should be checked for the voltage and the standard expected parameters that need to be observed.*
- *Is there any display note down as if there are any alarm signals or statuses that are abnormal? If there is some concern, then further inspection shall be required to be done from the product user manual or troubleshooting details.*
- *You then need to describe the contact person that shall be required to contact for a detailed inspection.*

If the inverter is unable to work properly, please refer to the table troubleshooting in the user manual provided by the inverter manufacturer. The troubleshooting shall have the following general but not limited to faults listed below:

Troubleshooting list

Faults	Diagnosis and solutions
Grid fault	
PV over-voltage fault	
DC INJ high	
Relay short	
Relay open	
Self-testing fault	
Other faults	

WARRANTY DETAILS

[In this section, please mention the warranty of the different equipment used in the solar PV system.]

Installer details (to be completed by the installer)
As a designer/installer of the PV system, I,

***[Name of installer]*, *[Address of installer]* declare that this installation has been performed following all relevant standards in force at this date.**

Contact: ……………………………………………………………………….

Phone: ………………………………………………………………………….

Signature of the installer

(with name and position): ……………………………………………………….

Date of installation and commissioning: ……………………………….

Inverter details

Make: ……………………………………….

Model: ……………………………………….

Size: ………………………………………..

Solar PV details

Make: ……………………………………….

Model: ……………………………………….

Size: ………………………………………..

Other BOS details

Make: ……………………………………….

Model: ……………………………………….

Size: ………………………………………...

A.18 NEA net metering directive (Nepali)

नेपाल सरकार

ऊर्जा, जलश्रोत तथा सिंचाइ मन्त्रालय

नेपाल सरकार
ऊर्जा, जलश्रोत तथा सिंचाइ मन्त्रालय
२०७४

मन्त्रालयबाट स्वीकृत मितिः २०७८/०१/१३

ग्रीड कनेक्टेड वैकल्पिक विद्युत विकास सम्बन्धी कार्यविधि,२०७८

प्रस्तावना : ग्रीड कनेक्टेड वैकल्पिक विद्युत उत्पादन आयोजनाहरु तथा यससँग सम्वन्धित प्रसारण लाइनलाई राष्ट्रिय ग्रीडमा जोड्न सरल, सहज र पारदर्शी तुल्याई प्रभावकारी कार्यान्वयन गर्न आवश्यक भएकोले विद्युत नियमावली, २०५० को नियम ९४ (क) ले दिएको अधिकार प्रयोग गरी ऊर्जा, जलश्रोत तथा सिंचाइ मन्त्रालयले यो कार्यविधि बनाएको छ ।

१. <u>संक्षिप्त नाम र प्रारम्भः</u>

(१) यस कार्यविधिको नाम "ग्रीड कनेक्टेड वैकल्पिक विद्युत विकास सम्बन्धी कार्यविधि, २०७८" रहेको छ ।

(२) यो कार्यविधी वैकल्पिक विद्युत विकास तथा नियमनसँग सम्वन्धित काम कारवाही र निर्णय प्रक्रियामा लागु हुनेछ ।

(३) यो कार्यविधि मन्त्रालयले स्वीकृत गरेको मितिदेखि लागु हुनेछ ।

२. <u>परिभाषाः</u>

(१) विषय वा प्रसंगले अर्को अर्थ नलागेमा यस कार्यविधिमा

(क) "आयोजना" भन्नाले वैकल्पिक विद्युत उत्पादन वा प्रसारण सम्वन्धी आयोजना सम्झनु पर्छ ।

(ख) "कार्यविधि" भन्नाले ग्रीड कनेक्टेड वैकल्पिक विद्युत विकास सम्बन्धी कार्यविधि, २०७८ सम्झनु पर्छ ।

(ग) "केन्द्र" भन्नाले वैकल्पिक ऊर्जा प्रवर्द्धन केन्द्र सम्झनु पर्छ ।

(घ) "घरेलु सौर्य प्रणाली" भन्नाले कुनै व्यक्ति तथा संस्थाले आफ्नो उपयोगका लागि आफ्नो परिसरमा जडान गरेको सौर्य विद्युत प्रणालीलाई सम्झनु पर्छ।

(ङ) "निर्देशिका" भन्नाले विद्युत आयोजनाको अनुमतिपत्र सम्वन्धी निर्देशिका, २०७५ (संशोधन सहित) सम्झनुपर्छ ।

(च) "नियमावली" भन्नाले विद्युत नियमावली, २०५० सम्झनु पर्छ ।

(छ) "नेट मिटरिङ्ग" भन्नाले प्राधिकरणले प्रवर्द्धकलाई दिएको विद्युत र प्रवर्द्धकले प्राधिकरणलाई दिएको विद्युतको फरक सम्झनु पर्छ।

(ज) "प्रवर्द्धक" भन्नाले प्रचलित कानून बमोजिम कुनै वैकल्पिक विद्युतको सर्वेक्षण, उत्पादन तथा यससँग सम्बन्धित प्रसारण अनुमतिपत्रका लागि दरखास्त दिएका वा अनुमतिपत्र प्राप्त गरेका व्यक्ति वा संस्थालाई सम्झनु पर्छ ।

(झ) "प्राधिकरण" भन्नाले नेपाल विद्युत प्राधिकरण सम्झनु पर्छ ।

(ञ) "विभाग" भन्नाले विद्युत विकास विभाग सम्झनु पर्छ ।

(ट) "वैकल्पिक विद्युत" भन्नाले सौर्य, वायु, जैविक ऊर्जा (वायोमास तथा वायोग्यास), हाइड्रोजन प्रविधि, चुम्बकीय प्रविधि, भूतापीय प्रविधि वा अन्य वैकल्पिक प्रविधिवाट उत्पादित विद्युतलाई सम्झनु पर्छ ।

(ठ) "मन्त्रालय" भन्नाले ऊर्जा, जलश्रोत तथा सिंचाइ मन्त्रालय सम्झनु पर्छ ।

३. <u>१ मेगावाट सम्म जडित क्षमताका वैकल्पिक विद्युत आयोजना सम्बन्धमा:</u>

(क) वैकल्पिक विद्युतलाई राष्ट्रिय ग्रीडमा जडान गर्न इच्छुक प्रवर्द्धकले प्राधिकरणमा निवेदन दिनु पर्नेछ ।

(ख) राष्ट्रिय ग्रीडमा आवद्ध हुन चाहने प्रवर्द्धकले प्राधिकरणमा निवेदन पेश गर्दा निजले कानून वमोजिम अधिकार प्राप्त निकायको विद्युत उत्पादनको अनुमतिपत्र प्राप्त गरेको हुनु पर्नेछ । तर, घरेलु सौर्य प्रणालीबाट उत्पादित सौर्य विद्युतको नेट मिटरिङ्ग गर्दा विद्युत उत्पादनको अनुमतिपत्र आवश्यक पर्ने छैन ।

४. **१ मेगावाट भन्दा बढी जडित क्षमताका वैकल्पिक विद्युत आयोजना सम्बन्धमाः**

(क) वैकल्पिक विद्युत उत्पादनको सर्वेक्षण अनुमतिपत्र प्राप्त गर्न प्रवर्द्धकले नियमावली तथा निर्देशिकामा तोकिए बमोजिमको ढाँचामा विभागमा निवेदन दिनु पर्नेछ ।

(ख) सर्वेक्षण अध्ययनको लागि एक वर्षको समयावधी दिइनेछ । उक्त समयसम्म आयोजनाको अध्ययन सम्पन्न हुन नसकेमा कार्य प्रगति र औचित्यको आधारमा सर्वेक्षण अनुमतिपत्रको म्याद नविकरण गर्न सकिनेछ।

(ग) उत्पादन तथा प्रसारण अनुमतिपत्र सम्बन्धी व्यवस्था:

(अ) वैकल्पिक विद्युत उत्पादन तथा प्रसारण गर्न प्रवर्द्धकले नियमावली तथा निर्देशिकामा तोकिए बमोजिमको ढाँचामा सर्वेक्षण अनुमतिपत्रको अवधि समाप्त हुनु अगावै विभागमा निवेदन दिनु पर्नेछ ।

(आ) प्रवर्द्धकले वैकल्पिक विद्युत प्रसारण लाइनको टावर/पोल निर्माण गर्न आवश्यक जग्गा प्रचलित कानून बमोजिम प्राप्त गर्नुपर्ने र विद्युतीय मार्गको अधिकार (Right of Way) को लागि मुआव्जा वितरण गरी जग्गा प्रयोग गर्नुपर्नेछ । तर सरकारी जग्गाको हकमा प्रचलित कानून बमोजिम लिजमा लिनु पर्नेछ ।

(इ) आयोजनाको उत्पादन अनुमतिपत्रको अवधि २५ वर्षको हुनेछ। सो अवधि समाप्त हुनु भन्दा अगावै प्रवर्द्धकले उत्पादन अनुमतिपत्रको अवधि नवीकरण गर्न चाहेमा विभागमा निवेदन दिन सक्नेछ।

(ई) आयोजनाले उत्पादन अनुमतिपत्र प्राप्त गरेपछि ६ महिना भित्र निर्माण कार्य शुरु गरी, दुई बर्ष भित्रमा निर्माण सम्पन्न गरी विद्युत उत्पादन शुरु गरिसकेको हुनु पर्नेछ । कुनै कारणले सो अवधि भित्र आयोजना सम्पन्न हुन नसकेको स्थितिमा सम्पन्न हुन नसकेको स्पष्ट कारण सहित विभागमा निवेदन दिनु पर्नेछ ।

(उ) उत्पादन अनुमतिपत्रको अवधि समाप्त भए पछि वातावरणमा प्रतिकुल असर नपर्ने गरी आयोजनामा जडान भएका सम्पूर्ण उपकरण तथा पार्ट पुर्जाहरुको उचित व्यवस्थापन प्रवर्द्धकले गर्नु पर्नेछ । तर वैकल्पिक विद्युत प्रसारण संरचना र सोले चर्चेको जग्गासहित नेपाल सरकारलाई हस्तान्तरण गर्नु पर्नेछ।

५ सौर्य विद्युत सम्बन्धी थप व्यवस्था

(क)१ मेगावाट भन्दा बढी जडित क्षमताका सौर्य विद्युत आयोजनाको विद्युत सर्वेक्षण र निर्माण गरिने क्षेत्र सिंचाइ योग्य जमिन, निकुञ्ज तथा आरक्षण क्षेत्र भित्र पर्ने गरी अनुमतिपत्र दिइने छैन । प्रवर्द्धकले प्रस्तावित आयोजना सो क्षेत्रभित्र नपर्ने भनी सिंचाइ योग्य जमिनको हकमा जलस्रोत तथा सिंचाइ विभाग वा प्रदेश सरकार अन्तर्गतको भौतिक पूर्वाधार विकास मन्त्रालय र निकुन्ज तथा आरक्षण क्षेत्रको हकमा वन तथा वातावरण मन्त्रालयबाट सिफारिस पत्र सहित नियमावली तथा निर्देशिकामा तोके बमोजिमको ढाँचामा विभागमा निवेदन दिनुपर्नेछ ।

सिंचाइ योग्य जमिन भन्नाले केन्द्र सरकार तथा प्रदेश सरकारबाट निर्माण सम्पन्न भईसकेका तथा निर्माणको चरणमा रहेका सिंचाइ आयोजनाबाट सिंचित हुनसक्ने जमिनलाई जनाउनेछ।

(ख) प्रवर्द्धकले घरेलु सौर्य प्रणालीबाट उत्पादित विद्युत नेट मिटरिङ्ग गर्न चाहेमा प्राधिकरणमा निवेदन दिनु पर्नेछ । घरेलु सौर्य प्रणालीले राष्ट्रिय ग्रिड प्रणालीबाट लिएको ऊर्जा भन्दा ग्रिड प्रणालीमा दिएको ऊर्जा बढी भएमा बढी भएको ऊर्जाको दर दफा ६(२) बमोजिम प्राधिकरणले भुक्तानी गर्नेछ । तर, घरेलु सौर्य प्रणालीले राष्ट्रिय ग्रिड प्रणालीबाट लिएको ऊर्जा भन्दा ग्रिड प्रणालीमा दिएको ऊर्जा कम भएमा कम भएको ऊर्जाको दर आयोगले ग्राहकवर्गका लागि तोके बमोजिम प्रवर्द्धकले प्राधिकरणलाई भुक्तानी गर्नुपर्नेछ । मिटरिङ्ग सम्बन्धी व्यवस्था प्राधिकरणबाट तोकिए बमोजिम हुनेछ ।

६. विद्युत खरिद सम्बन्धी व्यवस्था:

(१) प्राधिकरणबाट खरिद गरिने वैकल्पिक विद्युतको खरिद दर नेपाली मुद्रामा गरिनेछ ।

(२) आयोजनाबाट खरिद गरिने वैकल्पिक विद्युतको खरिद दर विद्युत नियमन आयोगले तोके बमोजिम हुनेछ । वैकल्पिक विद्युतको प्रविधि अनुसार विद्युत खरिद दर फरक फरक हुन सक्नेछ।

तर आयोगले जारी गरेको "विद्युत खरिद बिक्री तथा अनुमतिपत्र प्राप्त व्यक्तिले पालना गर्नुपर्ने शर्त सम्बन्धी विनियमावली, २०७६" कायम रहेसम्म सोही विनियमावलीको विनियम ७ को उपविनियम (५) मा उल्लेखित दर नै कायम रहनेछ ।

(क) विद्युतको खरिद दर निर्धारण गर्दा आयोजनाको लागत (project cost), ऋणको ब्याजदर (loan interest), ह्रासकट्टी (depreciation), स्वलगानीमा प्रतिफल (ROE), साधारण खर्च (general expenses), संचालन खर्च (operation cost), मर्मत खर्च (maintenance cost), आम्दानी (revenue), कर (tax), थप पुँजी (additional capitalization), ऋण र पुँजीको अनुपात (loan and equity ratio), उपकरणको लागत (equipment cost), ब्याट्री संचित क्षमता आदिलाई आधार लिन सकिनेछ ।

(ख) वैकल्पिक विद्युत आयोजनाको लागत निकाल्दा जग्गाको हकमा आयोजनाले चर्चेको जग्गाको (प्रशारण लाइन वाहेक) प्रचलित भाडा दरलाई आधार लिनु पर्नेछ ।

७. <u>अनुमतिपत्र दस्तुर सम्बन्धीव्यवस्था:</u> अनुमतिपत्र दस्तुर सम्बन्धी व्यवस्था प्रचलित कानून अनुसार हुनेछ ।

८. <u>कर तथा अन्य छुट/सुविधा सम्बन्धी व्यवस्था:</u> कर, भन्सार तथा मूल्य अभिवृद्धि कर छुट लगायत अन्य छुट तथा सुविधाहरु प्रचलित कानून अनुसार हुनेछन् ।

९. <u>आयोजनाको लागि जग्गा तथा अन्य पुर्वाधार सम्बन्धी व्यवस्था :</u> आयोजनाको लागि आवश्यक जग्गा, वाटो, विद्युत जडान विन्दुसम्म प्रसारण लाईन आदिको व्यवस्था प्रवर्द्धकले आफै गर्नु पर्नेछ । सरकारी जग्गाको हकमा संघ, सम्वन्धीत प्रदेश तथा स्थानीय तहवीच आवश्यकता अनुसार समन्वय र सहजिकरण गरिनेछ ।

१०. <u>कर तथा रोयल्टी सम्वन्धी व्यवस्था:</u> प्रचलित कानूनमा भएको व्यवस्था अनुसार वैकल्पिक विद्युतमा रोयल्टी एवं अन्यकर लाग्नेछन् ।

११. <u>विविध:</u>

(१) सव-स्टेशनमा सम्भव भए सम्म **Connection Bay** का लागि आवश्यक ठाउँ प्राधिकरणले निशुल्क उपलब्ध गराउनेछ ।

(२) राष्ट्रिय ग्रिडमा कूल जडित क्षमताको १०% सम्म वैकल्पिक विद्युत जडान गर्न विद्युत खरिद सम्झौता गरिनेछ ।

(३) अन्य प्राविधिक मापदण्ड सम्वन्धी व्यवस्था प्राधिकरण तथा केन्द्र बाट तोकिए बमोजिम हुनेछ ।

(४) प्राधिकरण तथा केन्द्रले प्राविधिक मापदण्ड लगायतका आवश्यक विवरण यथाशीघ्र तयार गरि लागु गर्नेछ ।

१२. <u>खारेजी र बचाउ:</u>

(१) ग्रीड कनेक्टेड वैकल्पिक विद्युत ऊर्जा विकास सम्बन्धी कार्यविधि, २०७४ खारेज गरिएको छ ।

(२) ग्रिड कनेक्टेड वैकल्पिक विद्युत ऊर्जा विकास सम्वन्धी कार्यविधि, २०७४ वमोजिम भए गरेका सम्पूर्ण काम कारवाहीहरु यसै कार्यविधि बमोजिम भए गरेको मानिनेछ ।

फोटोभोल्टेक सौर्य प्रणालीबाट प्राप्त हुने उर्जा Net Metering मार्फत ने.वि.प्रा.को वितरण प्रणालीमा जडान गर्ने सम्बन्धमा ने.वि.प्रा. संचालक समितिबाट भएका केही महत्वपूर्ण निर्णयहरु

राष्ट्रिय ऊर्जा संकट निवारण तथा विद्युत विकास दशक सम्बन्धी अवधारणा पत्र र कार्ययोजना, २०७२ को क्र.सं. ५२(ख) मा उल्लेखित "५०० वाट वा सोभन्दा बढी क्षमताका फोटोभोल्टेक सौर्य प्रणालीबाट उत्पादन भई बढी हुन जाने विद्युत प्रयोगमा ल्याउने सम्बन्धमा राष्ट्रिय ग्रीडको पहुँच पुगेका स्थानहरुमा सम्भव भएसम्म Net Metering को व्यवस्था क्रमिक रुपमा गर्ने ।" भन्ने गतिविधि रहेको र सोका लागि ने.वि.प्रा.लाई मुख्य जिम्मेवार निकाय तोकिएकोले सो सम्बन्धमा ने.वि.प्रा. बाट भएका तपशिल बमोजिमका निर्णयहरु सम्बन्धित सबैलाई जानकारी गराइएको छ ।

क) ने.वि.प्रा. संचालक समितिको मिति २०७४।०१।१३ को ७५१ औं बैठकबाट स्वीकृत फोटोभोल्टेक सौर्य प्रणालीबाट प्राप्त हुने ऊर्जा सम्बन्धि कार्यविधि-२०७४

फोटो-भोल्टेक सौर्य प्रणालीबाट प्राप्त हुने ऊर्जासम्बन्धी

कार्यविधि – २०७४

पाँच सय वाट वा सोभन्दा बढी क्षमताको फोटो-भोल्टेक सौर्य प्रणालीबाट प्राप्त हुने ऊर्जा सम्बन्धमा आवश्यक व्यवस्था गर्न उपयुक्त देखिएकोले नेपाल विद्युत प्राधिकरणले यो कार्यविधि बनाएको छ ।

१. <u>संक्षिप्त नाम र प्रारम्भः</u>

(क) यस कार्यविधिको नाम "फोटो-भोल्टेक सौर्य प्रणालीबाट प्राप्त हुने ऊर्जासम्बन्धी कार्यविधि-२०७४" रहेको छ ।

(ख) यो कार्यविधि नेपाल विद्युत प्राधिकरणको सञ्चालक समितिबाट स्वीकृत भएपश्चात् तुरुन्त प्रारम्भ हुनेछ ।

२. <u>परिभाषाः</u>

विषय वा प्रसङ्गले अर्को अर्थ नलागेमा यस कार्यविधिमाः

(क) "फोटो-भोल्टेक सौर्य प्रणाली" भन्नाले फोटो-भोल्टेक प्रविधिबाट सूर्यको प्रकाशलाई विद्युत शक्तिमा रुपान्तरण गर्ने प्रणाली सम्झनुपर्छ ।

(ख) "ग्राहक" भन्नाले नेपाल विद्युत प्राधिकरणको विद्युत विधिवत उपभोग गर्ने ग्राहक सम्झनुपर्छ ।

(ग) "प्राधिकरण" भन्नाले नेपाल विद्युत प्राधिकरण सम्झनुपर्छ ।

(घ) "वितरण केन्द्र" भन्नाले नेपाल विद्युत प्राधिकरण, वितरण तथा ग्राहक सेवा निर्देशनालय अन्तरगत सम्बन्धित क्षेत्रमा विद्युत वितरण कार्य गर्ने कार्यालय सम्झनुपर्छ ।

(ङ) "Net-metering" भन्नाले अनुसुची-२ बमोजिम नेपाल विद्युत प्राधिकरण र ग्राहकले लिए-दिएको विद्युतको बिलिङ्ग गर्ने व्यवस्थालाई सम्झनुपर्छ ।

3. <u>Net-metering का लागि सम्बन्धित ग्राहकले निवेदन दिनुपर्ने:</u>

(क) Net-metering माग गर्ने ग्राहकले सम्बन्धित वितरण केन्द्रसमक्ष सौर्य प्रणालीको क्षमता खुलाई अन्य प्राविधिक विवरण एवं उक्त प्रणालीको Single Line Diagram सहित निवेदन दिनुपर्ने छ । ग्रिड कनेक्टेड सौर्य फोटो-भोल्टेक प्रणालीको Typical Wiring Diagram अनुसुची-१, मा देखाइएको छ ।

(ख) सम्बन्धित वितरण केन्द्रले सौर्य ऊर्जा जोडिने वितरण प्रणालीको क्षमता एवं भोल्टेज स्तरका आधारमा अन्य प्राविधिक पक्षसमेत जाँचबुझ गरी Net-metering का लागि प्राप्त निवेदन स्वीकृत वा अस्वीकृत गर्न सक्नेछ ।

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४. ग्राहकले उपलब्ध गराउने सौर्य ऊर्जाको गुणस्तर देहायबमोजिम हुनुपर्नेछः

(१) फ्रिक्वेन्सीः 50 Hz

(२) भोल्टेज स्तरः 230 V/ 400 V/ 11 kV ± 5%

(३) भोल्टेज वेभफर्मः Sinusoidal

(४) थ्री फेज सप्लाई भएमा फेज भोल्टेज अनब्यालेन्स (अधिकतम): 1%

(५) हार्मोनिक डिस्टरसन (THD): ≤ 3%

५. सौर्य प्रणालीको क्षमताः

ग्राहकले जडान गर्ने फोटो-भोल्टेक प्रणालीको न्यूनतम क्षमता ५०० वाट हुनुपर्नेछ । नेपाल विद्युत प्राधिकरणका ग्राहकहरूले भोल्टेज स्तरअनुसार Net-metering प्रयोजनका लागि निम्नबमोजिम जडित क्षमतामा सौर्य ऊर्जा प्रणाली जडान गर्नुपर्नेछः

(क) २३० भोल्टमा ५ कि.वा. सम्म ।

(ख) ४०० भोल्टमा ५ कि.वा. भन्दा माथि ४० कि.वा. सम्म ।

(ग) ११००० भोल्टमा ४० कि.वा. भन्दामाथि ।

६. सौर्य प्रणाली जडानः

सौर्य प्रणालीबाट प्राप्त हुने ऊर्जाको औषत वार्षिक खपतको ९० प्रतिशतभन्दा बढी नहुनेगरी ग्राहकले सौर्य प्रणाली जडान गरेको हुनुपर्नेछ । ग्राहकले आफूकहाँ जडित सौर्य प्रणालीबाट उत्पादन हुने विद्युतको पावर फ्याक्टर ०.८५ ल्याग र ०.९५ लिड्का बीचमा हुनेगरी नेपाल विद्युत प्राधिकरणको वितरण प्रणालीमा जोड्ने व्यवस्था सुनिश्चित गरेको हुनुपर्नेछ ।

७. Net-metering सम्बन्धी व्यवस्थाः

(क) ग्राहकले नेपाल विद्युत प्राधिकरणलाई उपलब्ध गराउने ऊर्जा (Import) र नेपाल विद्युत प्राधिकरणले ग्राहकलाई सप्लाई गर्ने ऊर्जा (Export) मापनका लागि Bi-directional इनर्जी मिटर जडान गर्नुपर्नेछ ।

(ख) मिटर/मिटरिङ प्रणालीसम्बन्धी अन्य व्यवस्था नेपाल विद्युत प्राधिकरण, विद्युत वितरण विनियमावली - २०६९ मा व्यवस्था भएबमोजिम हुनेछ ।

८. ग्रीड सप्लाई नभएको अवस्थाः

मर्मतसम्भार लगायत अन्य कुनै कारणले नेपाल विद्युत प्राधिकरणको विद्युत वितरण प्रणालीमा विद्युत प्रवाह नभएको अवस्थाले गर्दा ग्राहकको सौर्य प्रणालीबाट उत्पादित ऊर्जा नेपाल विद्युत प्राधिकरणलाई ग्राहकले सप्लाई गर्न नसकेमा सो बापत ग्राहकले नेपाल विद्युत प्राधिकरणलाई कुनै क्षतिपूर्ति दाबी गर्न पाउने छैन ।

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९. **सौर्य प्रणालीबाट नेपाल विद्युत प्राधिकरणलाई ऊर्जा दिन नसकेको अवस्थाः**

मर्मतसम्भार लगायत अन्य कुनै पनि कारणले नेपाल विद्युत प्राधिकरणको विद्युत वितरण प्रणालिमा आँशिक वा पूर्ण क्षमतामा ग्राहकले सौर्य ऊर्जा सप्लाई गर्न नसकेमा सो बापत नेपाल विद्युत प्राधिकरणले ग्राहकलाई कुनै क्षतिपूर्ति दाबी गर्न पाउने छैन ।

१०. **सुरक्षासम्बन्धी व्यवस्थाः**

नेपाल विद्युत प्राधिकरणको ग्रीड सप्लाई नभएको अवस्थामा ग्राहकको सौर्य प्रणालीबाट नेपाल विद्युत प्राधिकरणको वितरण प्रणाली स्वतः अलग्गिने (Isolated) व्यवस्थाका लागि उपयुक्त सुरक्षा उपकरण (Protection Device) ग्राहक स्वयंले जडान गर्नुपर्नेछ ।

११. **अर्थिङ्ग (Earthing) फल्ट क्लीयरेन्स समय (Fault Clearance Time):**

ग्राहकले आफ्नो सौर्य प्रणालीमा जडान हुने उपकरणहरु अर्थ फल्ट/ओभर करेन्ट/Frequency Fluctuation का कारण ट्रिप हुँदा सोको Fault Clearance समय IEC/IEEE ले तोकेको मापदण्ड बमोजिम हुनुपर्नेछ ।

१२. **सौर्य ऊर्जासम्बन्धी लेखाङ्कन तथा समायोजनः**

ग्राहकले नेपाल विद्युत प्राधिकरणको प्रणालीबाट प्राप्त गर्ने ऊर्जाको युनिट र नेपाल विद्युत प्राधिकरणको प्रणालीमा सप्लाई गर्ने ऊर्जा युनिट हरेक महिना हिसाब गर्दा ग्राहकबाट कुनै महिनामा बढी ऊर्जा प्राप्त हुन आएमा सोहि महिनामा वा त्यसपछिको अर्को महिनामा समायोजन गरिनेछ र आर्थिक वर्षको अन्त्यमा ग्राहकबाट बढी ऊर्जा प्राप्त भएको देखिएमा सो बापत ग्राहकले नेपाल विद्युत प्राधिकरणसँग कुनै दाबी गर्न पाउने छैन ।

तर यसरी समायोजन गरिने सौर्य प्रणालीको ऊर्जा नेपाल विद्युत प्राधिकरणबाट ग्राहकले प्राप्त गर्ने वार्षिक ऊर्जाको ९० (नब्बे) प्रतिशतभन्दा बढी हुने छैन ।

१३. **विद्युत ऊर्जाको बिलिङ्गसम्बन्धी व्यवस्थाः**

Net-metering मार्फत् ऊर्जा प्राप्त गरी दुवै मिटर जडान भएका ग्राहकहरुको मासिक ऊर्जा बिलिङ्गका लागि अनुसूची-२ बमोजिमको बिल सम्बन्धित वितरण केन्द्रले प्रयोगमा ल्याउनेछ । डिमाण्ड शुल्क तिर्नुपर्ने ग्राहक भएमा अनुसूची-२ बमोजिमको ढाँचामा आवश्यक परिमार्जन गरी बिलिङ्ग गर्न सकिने छ ।

१४. नेपाल विद्युत प्राधिकरणले आवश्यकताअनुसार यस कार्यविधिमा संशोधन गर्न सक्नेछ ।

१५. सम्झौताको अवधिमा दुवैपक्षबीच कुनै विवाद भएमा आपसी सहमतिमा विवादको निरुपण गरिनेछ ।

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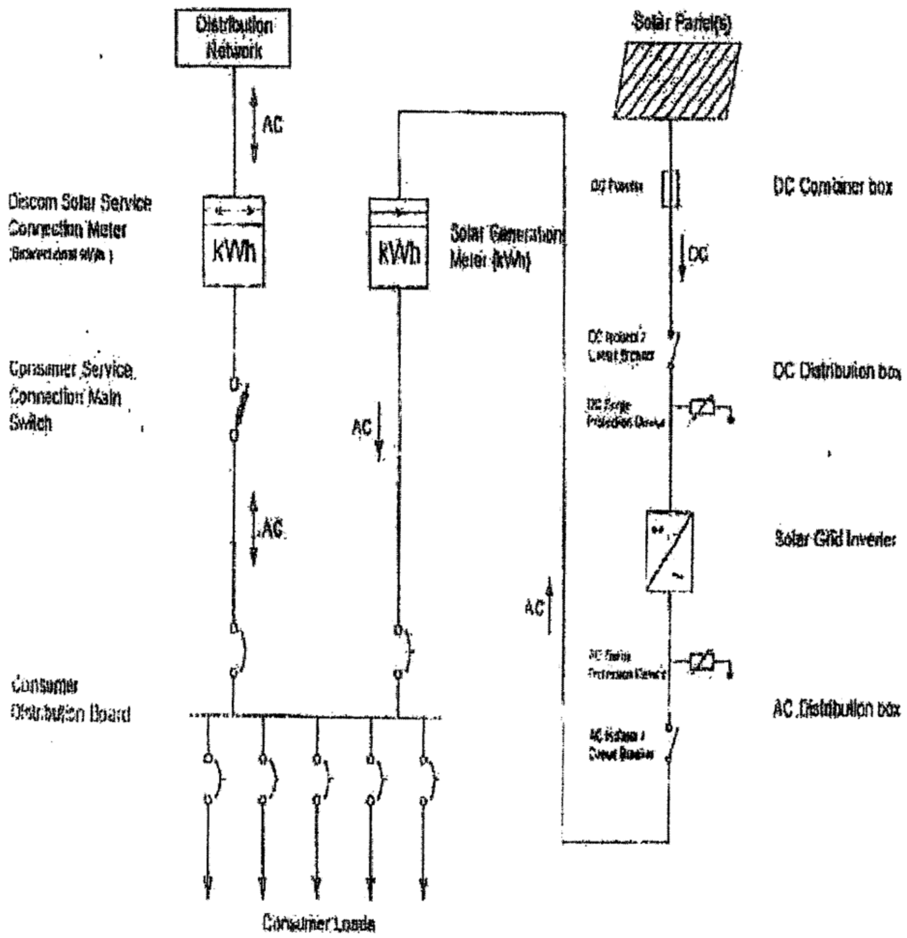
अनुसूची-१

<u>ग्रिड कनेक्टेड सौर्य फोटो-भोल्टेक प्रणालीको</u>

<u>Typical Wiring Diagram</u>



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अनुसूची - २

<u>दफा १७ सँग सम्बन्धित:</u>

Net-metering को विलिङ्गसम्बन्धी तालिका

नेपाल विद्युत प्राधिकरण

वितरण तथा ग्राहक सेवा निर्देशनालय

......................वितरण केन्द्र

ग्राहकको नाम: स्वीकृत क्षमता:

ग्राहक सँख्या: महिना/साल:

समय	नेपाल विद्युत प्राधिकरणले सप्लाई गरेको ऊर्जा (X_1) KWh			ग्राहकबाट प्राप्त सौर्य ऊर्जा (X_2) KWh			विलिङ्ग गर्नुपर्ने ऊर्जा (X_3) KWh $[X_3]=[X_1]-[X_2]$ KWh	ऊर्जाको बिल रकम रु ($X_1 \geq X_2$)	[illegible] हुन बाँकी ऊर्जा (X [illegible] X) K
	हाल को अङ्क [A]	साबिक को अङ्क [B]	युनिट $[X_1=A-B]$	हाल को अङ्क [C]	साबिकको अङ्क [D]	युनिट $(X_2=C-D)$			
T_1 (Peak)									
T_2 (Normal)									
T_3 (Off Peak)									

नोट: TOD मिटर जडान नभएका ग्राहकहरुको हकमा उपरोक्त बमोजिमको अलग-अलग समयको लागि विद्युत महशुल दर लागू हुनेछैन ।

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५. सौर्य प्रणालीको क्षमता तथा वर्गिकरण :

(क) ग्राहकले जडान गर्ने फोटोभोल्टेक प्रणालीको न्युनतम क्षमता ५०० वाट हुनु पर्नेछ । ने.वि.प्रा.को ग्राहकहरुले भोल्टेज स्तर अनुसार नेट मिटरिङ्ग प्रयोजनका लागि निम्न बमोजिम जडित सौर्य उर्जा प्रणाली जडान गर्नु पर्नेछ :

(१) २३० भोल्टमा ५ कि.वा सम्म ।
(२) ४०० भोल्टमा ५ कि.वा भन्दा माथी ४० कि.वा. सम्म ।
(३) ११००० भोल्टमा ४० कि.वा भन्दा माथि ।

(ख) सौर्य उर्जा प्रणालीको वर्गिकरण देहायबमोजिम हुनेछ :

(१) घरायसी (रुफटप) सौर्य विघुत उर्जा
५०० वाट देखि १० कि.वा सम्म ।
(२) संस्थागत सौर्य विद्युत उर्जा
१० किलोवाट देखि माथि ।
(३) व्याषारिक सौर्य विद्युत उर्जा
५०० किलोवाट देखि माथि ।

नेपाल विद्युत प्राधिकरण

फोटोभोल्टेक सौर्य प्रणालीबाट प्राप्त हुने उर्जा NET metering गर्ने सम्बन्धि सूचना ।

नेपाल विद्युत प्राधिकरण लोडसेडिङ न्यूनिकरण कार्यमा निरन्तर प्रयासरत रहेको छ । राष्ट्रिय ऊर्जा संकट निवारण तथा विद्युत विकास दशक सम्वन्धि अवधारणापत्र र कार्ययोजना, २०७२ मा भएको व्यवस्था अनुसार लोडसेडिङ न्यूनिकरणको लागि विभिन्न वैकल्पिक ऊर्जाको माध्यमवाट समेत विद्युत आपूर्तिको व्यवस्था गर्नका लागि ५०० वाट वा सो भन्दा बढी क्षमताको फोटोभोल्टेक सौर्य प्रणाली जडान गरि वढी हुन जाने विद्युत NET metering मार्फत ने.वि.प्रा.को वितरण प्रणालीमा उपलब्ध गराउन ईच्छुक व्यक्ति/संघ/संस्थाहरुवाट "फोटोभोल्टेक सौर्य प्रणालीवाट प्राप्तहुने ऊर्जा सम्वन्धि कार्यविधि, २०७४" मा रहेको निम्न व्यवस्था अनुसार ने.वि.प्रा. को स्थानिय कार्यालयमा Format बमोजिमको आ-आफ्नो प्रस्ताव उपलव्ध गराउन अनुरोध गरिन्छ ।

- NET metering का लागि सम्वन्धित ग्राहकले सम्बन्धित वितरण केन्द्र समक्ष निवेदन दिनुपर्ने ।
- ग्राहकले उपलव्ध गराउने सौर्य ऊर्जा गुणस्तरीय हुनुपर्ने ।
- ग्राहकले जडान गर्ने फोटोभोल्टेक प्रणालीको न्युनतम ५०० वाट हुनु पर्नेछ । ने.वि.प्रा.का ग्राहकहरुले भोल्टेज स्तर अनुसार NET metering प्रयोजनका लागि निम्न बमोजिम जडित क्षमतामा सौर्य ऊर्जा प्रणाली जडान गर्नु पर्ने:
  १. २३० भोल्टमा ५ कि.वा. सम्म ।
  २. ४०० भोल्टमा ५ कि.वा. भन्दा माथि ४० कि.वा. सम्म ।
  ३. ११००० भोल्टमा ४० कि.वा. भन्दा माथि ।
- ग्राहकले जडान गरेको सौर्य प्रणालीवाट उत्पादन हुने विद्युतको Power Factor ०.८५ ल्याग र ०.९५ लिडका विचमा हुने गरि ने.वि.प्रा.को वितरण प्रणालीमा जोड्ने व्यवस्था सुनिश्चित गरेको हुनु पर्ने ।
- NET metering प्रयोजनका लागि Bi-directional ईनर्जी मिटर जडान गर्नुपर्ने । मिटर/मिटरिङ प्रणाली सम्वन्धि अन्य व्यवस्था ने.वि.प्रा.को विद्युत वितरण विनियमावली, २०६९ मा व्यवस्था भए बमोजिम हुनेछ ।
- उपयुक्त सुरक्षा उपकरण (Protection Device) ग्राहक स्वयंले जडान गर्नुपर्ने ।
- आर्थिक वर्षको अन्त्यमा ग्राहकवाट प्राप्त भएको ऊर्जा वढी आएको देखिन आएमा सो युनिट वापत ग्राहकले ने.वि.प्रा. संग कुनै दावी गर्न पाउने छैन । तर यसरी समायोजन गरिने सौर्य प्रणालीको ऊर्जा ने.वि.प्रा. बाट ग्राहकले प्राप्त गर्ने वार्षिक ऊर्जाको ९० (नब्वे) प्रतिशतभन्दा वढी हुने छैन ।
- साथै अन्य जानकारीको लागि ने.वि.प्रा.को website, www.nea.org.np वा स्थानिय कार्यालयमा सर्म्पक राख्नुहुन समेत अनुरोध छ ।

नेपाल विद्युत प्राधिकरण
वितरण तथा ग्राहक सेवा निर्देशनालय
दरवारमार्ग, काठमाडौं ।
मिति:२०७४/०३/१७

नेपाल विद्युत प्राधिकरण

(नेपाल सरकारको स्वामित्व)
कार्यकारी निर्देशकको सचिवालय
दरबारमार्ग, काठमाडौं

प.सं. ०७६/७७ का.नि.स.,च.नं. ८६२ | मितिः २०७६।११।०५

श्री उपकार्यकारी निर्देशकज्यू,
वितरण तथा ग्राहक सेवा निर्देशनालय, नें.वि.प्रा.।

३२६८
२०७६/११/०५

विषयः सञ्चालक समितिको निर्णय पठाइएको।

नेपाल विद्युत प्राधिकरण सञ्चालक समितिको मिति २०७६।१०।२३ को ८२३औं बैठकबाट त्यस निर्देशनालयसँग सम्बद्ध निम्नलिखित विषयहरुमा भएको निर्णयको उतारप्रति संलग्न गरी आवश्यक कार्यार्थ पठाइएको व्यहोरा अनुरोध छ।

विषयः

१. सामुदायिक वितरक संस्था दुर्गा युवा क्लब, मरहिया ४, धनुषासँग भएको सम्झौता रद्द गर्नेबारे ।
२. खाँदबारी साना जलविद्युत केन्द्र, संखुवासभाको लिज सम्झौता अवधिबारे।
३. सामुदायिक वितरक संस्था समाज उत्थान क्लब, सुगा निकाश, धनुषासँग भएको सम्झौता रद्द गर्नेबारे।
४. सोनारी वघौडा ग्रामीण सामुदायिक विद्युतिकरण मूल समिति संग भएको सम्झौता रद्द गर्नेबारे।
५. फोटो भोल्टेक सौर्य प्रणालीबाट प्राप्त हुने ऊर्जा सम्बन्धि कार्यविधि, २०७४ (संशोधन सहित) संशोधन गर्नेबारे।

(शिव कुमार अधिकारी)
निर्देशक

४. सोनारी वघौंडा ग्रामीण सामुदायिक विद्युतिकरण मूल समितिसँग भएको सम्झौता रद्द गर्नेबारे।

नेपाल विद्युत प्राधिकरण, प्रादेशिक कार्यालय, बुटवल मातहत प्रदेश डिभिजन कार्यालय नेपालगंजको कार्यक्षेत्र अन्तर्गत बाँके जिल्लाको हालको राप्ती सोनारी गाँउपालिका र नरैनापुर गाँउपालिका क्षेत्रमा विद्युतिकरण कार्य गर्न सामुदायिक ग्रामीण विद्युतिकरण गर्न नेपाल विद्युत प्राधिकरण सामुदायिक ग्रामीण विद्युतिकरण बिभाग र सोनारी वघौंडा ग्रामीण सामुदायिक विद्युतिकरण मूल समिति बीच मिति २०६६।०७।१० मा सम्झौता भएको देखिन्छ। विगत लामो समयसम्म यस उपभोक्ता समितिको काम अगाडी बढ्न नसकेकोमा हाल सबै ठेक्काहरू कार्यान्वयनको विभिन्न चरणमा रहेको र कार्य सम्पन्न भैसकेका केही टाँउहरूमा मिटर जडान गर्नसमेत सामुदायिक वितरक संस्थाको सहयोग नभएको जानकारी स्थानीय निकायहरूको पत्रबाट देखिन्छ।

उक्त वितरक संस्थाले लामो समयसम्म कार्य सम्पन्न नगरेको कारण सो क्षेत्रमा रहेका जनताहरू विद्युत सेवाबाट बन्चित हुनु परेकोले प्रतिनिधिसभा सदस्य, प्रदेश सभा सदस्य र स्थानीय निकायका जनप्रतिनिधिहरूको सर्वपक्षिय बैठकले उक्त वितरक संस्थाको सदस्य नबनी नेपाल विद्युत प्राधिकरणको ग्राहक बनि सेवा लिने निर्णय भएकोले सोनारी वघौंडा ग्रामीण सामुदायिक विद्युतिकरण मूल समितिसँग भएको सम्झौता रद्द गर्न प्रदेश डिभिजन कार्यालय, नेपालगंज र प्रदेश नं. ५, प्रादेशिक कार्यालय, बुटवलबाट सिफारिस भइआएको छ।

तत्कालिन अवस्थामा उक्त सामुदायिक वितरक संस्थाको तर्फबाट जम्मा गर्नु पर्ने २०% रकमसमेत स्थानीय निकायबाट लगानी भएको बुझिन्छ। हाल दुवै स्थानीय निकायहरू राप्ती सोनारी गाँउपालिका र नरैनापुर गाँउपालिकाबाट उक्त सामुदायिक उपभोक्ता समितिको विघटन गरि प्राधिकरण कै प्रत्यक्ष नियन्त्रणमा बाँकी काम सम्पन्न गर्न र प्राधिकरणबाट सामुदायिक संस्था खारेज गरी आफै सञ्चालन गर्न अनुरोध भई आएको छ। यस विषयमा सोही स्थानबाट प्रतिनिधित्व गर्नुहुने संघिय तथा प्रदेश सांसदज्यूहरूको पनि समर्थन रहेको देखिन्छ।

नेपाल विद्युत प्राधिकरण सामुदायिक ग्रामीण विद्युतिकरण विनियमावली, २०७१ को विनियम २४(४) मा "नेपाल सरकार वा प्राधिकरणबाट सम्झौता रद्द हुने भनी नीतिगत निर्णय भएमा" कुनै संस्थासँग भएको सम्झौता स्वत: समाप्त हुने व्यवस्था रहेको छ।

नेपाल विद्युत प्राधिकरण, सामुदायिक ग्रामीण विद्युतिकरण विभाग र सोनारी वघौंडा ग्रामीण सामुदायिक विद्युतिकरण मूल समिति बीच भएको सम्झौता रद्द गर्ने स्वीकृतिका लागि कार्यकारी निर्देशकले समितिसमक्ष प्रस्ताव गर्नुहुँदा विस्तृत छलफल भई निम्नानुसार निर्णय भयो:

निर्णय:

नेपाल विद्युत प्राधिकरण सामुदायिक ग्रामीण विद्युतिकरण विनियमावली, २०७१ को विनियम २४(४) बमोजिम सामुदायिक ग्रामीण विद्युतिकरण विभाग र सोनारी वघौंडा ग्रामीण सामुदायिक विद्युतिकरण मूल समिति बीच भएको सम्झौता रद्द गर्ने।

५. **फोटो भोल्टेक सौर्य प्रणालीबाट प्राप्त हुने ऊर्जा सम्बन्धि कार्यविधि, २०७४ (संशोधन सहित) संशोधन गर्नेबारे।**

ग्रीड प्रणालीमा वैकल्पिक ऊर्जा श्रोतहरुको समेत उचित समिश्रण (Energy Mix) गराई दिगो र सुलभ ऊर्जा प्रदान गर्ने नेपाल सरकारको नीति अनुसार सञ्चालक समितिको मिति २०७४।०१।१३ को ७५१औं बैठकबाट "फोटो भोल्टेक सौर्य प्रणालीबाट प्राप्त हुने ऊर्जा सम्बन्धि कार्यविधि-२०७४" स्वीकृत भएको थियो। तत्पश्चात विद्युत नियमावली, २०५० को नियम ९४(क) ले दिएको अधिकार प्रयोग गरी ऊर्जा जलश्रोत तथा सिंचाइ मन्त्रालयबाट मिति ०७४।१०।२५ को स्वीकृतिबमोजिम ग्रीड कनेक्टेड बैकल्पिक विद्युत ऊर्जा विकास सम्बन्धि कार्यविधि-२०७४" जारी गरिएको थियो। सो कार्यविधिमा उल्लेखित विभिन्न बुँदाहरुसँग सादृश्यता गर्न सञ्चालक समितिबाट मिति २०७४।११।१३ को ७५१औं बैठकबाट स्वीकृत कार्यविधिका केही बुँदाहरु (जस्तै विद्युत खरिदको दररेट, ऊर्जा प्रणालीको वर्गिकरण आदी) लाईसमेत समावेश गर्न आवश्यक देखिएकाले सञ्चालक समितिको मिति २०७५।६।८ को ७७६औं बैठकबाट संशोधन भएको थियो।

हालसम्म पनि फोटो भोल्टेक सौर्य प्रणालीबाट विद्युत उत्पादन गर्ने घरायसी तथा संस्थागत वर्गका ग्राहकहरुले Net Metering विधिबाट प्राधिकरणसँग सम्झौता गरी ऊर्जा उपलब्ध गराउन खासै उत्साहित भएको देखिदैन र यस्ता ग्राहकको संख्या अत्यन्त न्यून छ। यसै बीच केही व्यक्ति तथा संस्थाहरुले सम्झौताको अवधि र विद्युत महशुलको भुक्तानी लगायतका केही बुँदाहरुमा परिमार्जन हुनु पर्ने माँग गरेकाले "फोटो भोल्टेक सौर्य प्रणालीबाट प्राप्त हुने ऊर्जा सम्बन्धि कार्यविधि-२०७४ (संशोधन सहित)" मा थप संशोधन गर्न र सोही अनुसार सम्झौता पत्रमासमेत संशोधन गर्न आवश्यक देखिएको छ।

नेपाल सरकारबाट कुल विद्युत उत्पादनको १०% सम्म बैकल्पिक ऊर्जाका श्रोतबाट आपूर्ति गरी ऊर्जा समिश्रणलाई प्रभावकारी बनाउने नेपाल सरकारको घोषित नीति रहेको छ। यसका लागि प्राधिकरणको ग्राहकको रुपमा रहेको कुनै व्यक्ति संस्थाहरुले पनि आफुले उत्पादन गरेको सौर्य विद्युत ऊर्जा Net Metering को विधिबाट प्राधिकरणको प्रणालीमा आपूर्ति गर्न सक्ने गरि कार्यविधिसमेत स्वीकृत गरीएको छ। विशेष गरी संस्थागत रुपमा स्थापना हुने त्यस्ता सौर्य विद्युत प्रणालीका लागि विभिन्न वित्तिय संस्थाहरुबाट ऋण लिनु पर्ने हुन्छ तर विद्यमान सम्झौताका केही बुँदाहरुमा भएको प्रावधानले गर्दा यसरी ऋण लिन कठिनाई भएको कुरा केही व्यक्ति संस्थाबाट जानकारी प्राप्त भई संशोधनका लागि अनुरोध गरेका छन।

यसर्थ फोटो भोल्टेक सौर्य प्रणालीबाट प्राप्त हुने ऊर्जा सम्वन्धि कार्यविधि २०७४ (संशोधन सहित) मा भएका केहि बुँदाहरुमा थप संशोधन गर्न उपयुक्त देखिएको छ।

फोटो भोल्टेक सौर्य ऊर्जा प्रणालीबाट प्राप्त हुने ऊर्जा सम्वन्धि कार्यविधि-२०७४ (संशोधन सहित) सञ्चालक समितिको मिति २०७५।०६।०८ को ७७६औं बैठकबाट स्वीकृत भएकोमा सौर्य विद्युत ऊर्जा उत्पादन गरी Net Metering विधि अनुसार प्राधिकरणलाई विद्युत आपूर्ति गर्ने ग्राहकसँग गरिने सम्झौता पत्रलाई अद्यावधिक गर्न आवश्यक देखिएकोले सोको

लागि कार्यविधिमा थप संशोधनका लागि कार्यकारी निर्देशकले समितिसमक्ष प्रस्ताव गर्नुहुँदा विस्तृत छलफल भई निम्नानुसार निर्णय भयो:

<u>निर्णय:</u>

नेपाल विद्युत प्राधिकरणको फोटो भोल्टेक सौर्य प्रणालीवाट प्राप्त हुने ऊर्जा सम्वन्धी कार्यविधि, २०७४ (संशोधन सहित) मा संशोधन एवम् कार्यान्वयनवारे देहायबमोजिम गर्ने:

१. फोटो भोल्टेक सौर्य ऊर्जा प्रणालीवाट प्राप्त हुने ऊर्जा सम्वन्धि कार्यविधि, २०७४ मा उल्लेखित विभिन्न दफाहरुमा संलग्न संशोधन प्रस्तावबमोजिम संशोधन गर्ने।

२. खण्ड (१) बमोजिमको कार्यविधिको व्यवस्था २०७९ असार मसान्तसम्म प्राधिकरणको ग्रीडमा कनेक्शन हुने सौर्य ऊर्जाका हकमा मात्र लागू हुनेछ। } Check

३. खण्ड (१) बमोजिमको कार्यविधिको व्यवस्थाको अधिनमा रही प्राधिकरण र विद्युत प्रदायक व्यक्ति/संघ संस्था बीच भएको/हुने सम्झौताहरुमा परिमार्जन गर्न कार्यकारी निर्देशक वा निजले तोकेको अधिकारीलाई अख्तियारी दिने।

बोर्ड-८२३ ९

अनुसूची १

फोटो भोल्टेक सौर्य प्रणालीबाट प्राप्त हुने ऊर्जा सम्बन्धि कार्यविधि , २०७४ (संशोधन सहित) मा थप संशोधन गर्नु पर्ने दफाहरु:

विवरण	विद्यमान व्यवस्था	प्रस्तावित व्यवस्था
दफा २ सम्झौताको अवधि	यस सम्झौता दुवै पक्षले हस्ताक्षर गरेको मिति देखि २ (दुई) वर्ष सम्म कायम रहने छ। सम्झौताको अवधि समाप्त हुन १ (एक) महिना अघि निवेदन दिइ दुवै पक्षको सहमतिमा यो सम्झौता आवश्यक्ता अनुसार पुनः नविकरण गर्न सकिनेछ ।	यस सम्झौता दुवै पक्षले हस्ताक्षर गरेको मिति देखि १५ (पन्ध्र) वर्ष सम्म कायम रहने छ । सम्झौताको अवधि समाप्त हुन १ (एक) महिना अघि निवेदन दिइ दुवै पक्षको सहमतिमा यो सम्झौता आवश्यक्ता अनुसार पुनः नविकरण गर्न सकिनेछ ।
दफा ५ (ख) सौर्य प्रणालिको क्षमता तथा वर्गिकरण	सौर्य ऊर्जाको वर्गिकरण देहाय बमोजिम हुनेछ । (१) घरायसी (रुफटप) सौर्य विद्युत ऊर्जा ५०० वाट देखि १० किलोवाट सम्म (२) संस्थागत सौर्य विद्युत ऊर्जा १० किलोवाट देखि माथि	सौर्य ऊर्जाको वर्गिकरण देहाय बमोजिम हुनेछ । (१) घरायसी (रुफटप) सौर्य विद्युत ऊर्जा ५०० वाट देखि १० किलोवाट सम्म (२) संस्थागत सौर्य विद्युत ऊर्जा १० किलोवाट देखि माथि ५०० कि.वा.सम्म (३) व्यापारिक सौर्य विद्युत ऊर्जा ५०० किलोवाट देखि माथि • बुँदा नं. (१) र (२) मा उल्लेखित बर्गिकरणका सौर्य ऊर्जा प्रणलीबाट प्राप्त विद्युत मात्र Net Metering बिधिबाट आपूर्ति लिइने छ ।

दफा१२ सौर्य ऊर्जा सम्वन्धि लेखांकन, भुक्तानी र समायोजन	ग्राहकले ने.वि.प्रा. को प्रणालीबाट प्राप्त गर्ने ऊर्जाको यूनिट र ने.वि.प्रा. को प्रणालीमा सप्लाई गर्ने ऊर्जा युनिट हरेक महिना हिसाव गर्दा ग्राहकबाट कुनै महिनामा वढी ऊर्जा प्राप्त हुन आएमा सोही महिनामा समायोजन गरिने छ। फोटो भोल्टेक सौर्य ऊर्जा प्रणालिबाट प्राप्त हुने ऊर्जाको खरिद दर प्रति युनिट रु ७.३० हुनेछ । मूल्य समायोजन गर्ने विधि अनुसूची-२ मा उल्लेख भए बमोजिम हुनेछ।	ग्राहकले ने.वि.प्रा. को प्रणालीबाट प्राप्त गर्ने ऊर्जाको यूनिट र ने.वि.प्रा. को प्रणालीमा सप्लाई गर्ने ऊर्जा युनिट हरेक महिना हिसाव गर्दा ग्राहकबाट कुनै महिनामा वढी ऊर्जा प्राप्त हुन आएमा सोही महिनामा समायोजन गरिनेछ। यसरी समायोजन गरिने विलमा ने.वि.प्रा. को तर्फबाट सम्बन्धित कार्यालय प्रमुख वा इन्जिनियर मध्ये कुनै एकको दस्तखत र ग्राहकको तर्फबाट निजले तोकेको आधिकारिक प्रतिनिधि कुनै दुई जना मध्ये एकको दस्तखत गरी प्रमाणित गरिनेछ । यसरी समायोजन गर्दा ग्राहकलाई भुक्तानी दिनु पर्ने देखिएमा प्रत्येक महिना मिटर रिडिङ्ग भएको मितिले सात दिन भित्र सम्बन्धित प्रादेशिक कार्यालयलाई भुक्तानीको लागी पत्राचार गर्ने र सम्बन्धित प्रादेशिक कार्यालयले पैंतालिस दिन भित्र भुक्तानी गरिदिने छ । फोटो भोल्टेक सौर्य ऊर्जा प्रणालीबाट प्राप्त हुने ऊर्जाको खरिद दर प्रति युनिट रु ७.३० हुनेछ। मुल्य समायोजन गर्ने विधि अनुसुची २ मा उल्लेख भए बमोजिम हुनेछ।

A.19 Contract template for CAPEX and OPEX model

Model Agreement

Between

Applicant and the vendor for installation of rooftop solar system in residential house/commercial property/factory of the applicant under simplified CAPEX model of Rooftop Solar PV System Programme

This agreement is executed on …… *[Day]*……*[Month]* …… *[Year]* for design, supply, installation, testing, commissioning and *[……]* years comprehensive maintenance of rooftop solar system to be installed undersimplified **CAPEX/OPEX model** of rooftop solar programme.

Between

…………………………………………… *[Name of applicant]* having residential/commercial/factory electricity connection with consumer number……………… from ……………………….. at ……………………………………………………………….. (Hereinafter referred to as applicant).

And

…………………………………………………………*[Name of vendor]* is registered with the (hereinafter referred to as Vendor) and is having registered/functional office at ……………………………………………. [hereinafter referred to as vendor].

Both the applicant and the vendor are jointly referred to as Parties.

Whereas

- The applicant intends to install a rooftop solar system under the simplified CAPEX/OPEX model of the rooftop solar programme.
- The vendor is a qualified registered solar company for the supply and installation of rooftop solar systems. The vendor satisfies all the existing regulations pertaining to electrical safety and license in the respective state and it is not debarred or blacklisted from undertaking any such installations by any government agency.
- Both parties mutually agreed and understand their roles and responsibilities and have no liability to any other agency/firm/stakeholder.

GENERAL TERMS

- The applicant hereby represents and warrants that the applicant has the sole legal capacity toenter into this agreement and authorise the construction, installation and commissioning of the rooftop solar system which is inclusive of the balance of system ("**BOS**")on the applicant's premises ("**Applicant site**"). The vendor reserves its right to verify ownership of the applicant site and the applicant covenants to cooperate and provide all information and documentation required by the vendor for the same.

- The vendor may propose changes to the scope, nature and or schedule of the services being performed under this agreement. All proposed changes must be mutually agreed between the parties. If parties fail to agree on the variation proposed, either Party may terminate this agreement by serving notice.
- The applicant understands and agrees that future changes in load, electricity usage patterns and/or electricity tariffs may affect the economics of the system and these factors have not been and cannot be considered in any analysis or quotation provided by the vendor or its authorized persons (*defined below*).

SYSTEM DETAILS

- The total capacity of the system will be a minimum ……. kW_P.
- The solar modules, inverters and BOS will confirm to minimum specifications and other requirements of NEPQA.
- Solar modules of make, ……. model, ……. W_P capacity each and ……. % efficiency will be procured and installed by the vendor.
- The solar inverter of ……. make, ……. model, ……. kW rated output capacity will be procured and installed by the vendor.
- Module mounting structure has to withstand minimum wind load pressure as specified by guidelines.
- Other BOS installations shall be as per best industry practice with all safety and protection gears installed by the vendor.

PRICE AND PAYMENT TERMS

The cost of the system will be Rs.__________(to be decided mutually). The applicant shall pay the total cost to the vendor as under:

i. *[XX%]* as an advance on confirmation of the order;

ii. *[XX%]* against Proforma Invoice (PI) before dispatch of solar panels, inverters and other BOS items to be delivered;

iii. *[XX%]* after installation and commissioning of the system.

The order value and payment terms are fixed and will not be subject to any adjustment except as approved in writing by the vendor. The payment shall be made only through the bankers' cheque / online payment portal as intimated by the vendor. No cash payments shall be accepted by the vendor or its authorized person.

REPRESENTATIONS MADE BY THE APPLICANT

The applicant acknowledges and agrees that:

Any timeline or schedule shared by the vendor for the provision of services and delivery of the system is only an estimate and the vendor will not be liable for any delay that is not attributable to the vendor; all information disclosed by the applicant to the vendor in connection with the supply of the system (or any part thereof), services and generation estimation (including, without limitation,the load profile and power bill) are true and accurate, and acknowledges that vendor has reliedon the information produced by the applicant to customize the system layout and BOS design for the purposes of this agreement;

All descriptive specifications, illustrations, drawings, data, dimensions, quotations, fact sheets, price lists and any advertising material circulated/published/provided by the vendor are approximate only;

Any drawings, pre-feasibility report, specifications and plans composed by the vendor shall require the applicant's approval within 5 (five) days of its receipt by electronic mail to the vendor and if the applicant does not respond within this period, the drawings, specifications or plans shall be final and deemed to have been approved by the applicant;

The applicant shall not use the system or any part thereof, other than in accordance withthe product manufacturer's specifications, and covenants that any risk arising from misuse or/and misappropriate use shall be to the account of the applicant alone.

The Applicant represents, warrants and covenants that:

i. All electrical and plumbing infrastructure at the applicant site conform with applicable laws;

ii. The applicant has the legal capacity to permit unfettered access to the vendor and its authorized persons for the execution and performance of this agreement;

iii. The applicant has and will provide requisite power, water and other requisite resources and storage facilities for the construction, installation, operation and maintenance of the system;

iv. The applicant will provide support for site fabrication of structure, assembly and fitting of module mounting structure at the applicant site;

v. The applicant will ensure that the applicant site is shadow-free and free of all encumbrances during the lifetime of the system;

vi. Applicant should ensure that the applicant regularly cleans and ensures accessibility and safety to the system, as required by the vendor and dusting frequency in the premises.

vii. The vendor is entitled to permit geo-tagging of the applicant site as a vendor installation site;

viii. Unless otherwise intimated by the applicant in writing, the vendor is entitled to take photographs, videos and testimonials of the applicant and the applicant's site, and to create content which will become the property of the vendor and the same can be freely used by vendoras part of its promotional and marketing activities across all platforms as it deems fit;

ix. The applicant validates the stability of the applicant site for the installation of the system.

MAINTENANCE

Vendor shall provide .... years of free workmanship maintenance. The vendor shall visit the Applicant's premises at least once every quarter after the commissioning of the system for maintenance purposes.

During such maintenance visits, the vendor shall check all nuts and bolts, fuses, earth resistance and other consumables in respect of the System to ensure that it is in good working condition.

Cleaning requirement/expectation from the applicant side – applicant responsibility, minimum expectation from the applicant that it will be cleaned regularly as per the dusting frequency.

ACCESS AND RIGHT OF ENTRY

The applicant hereby grants permission to the vendor and its authorized personnel, representatives, associates, officers, employees, financing agents, and subcontractors ("**Authorized persons**") to enter the applicant site for:

i. Conducting feasibility study;

ii. Storing the system/any part thereof;

iii. Installing the system;

iv. Inspecting the system;

v. Conducting repairs and maintenance to the system;

vi. Removing the system (or any part thereof), if necessary for any reason whatsoever;

vii. Such other matters are as necessary to execute and perform its rights and obligations underthis agreement.

The applicant shall ensure that third-party consents necessary for the authorized persons to access the applicant site are obtained before the commencement of services under this agreement.

WARRANTIES

Product warranty: The applicant shall be entitled to the manufacturer's warranty. Any warranty concerning the system supplied to the applicant by the vendor under this agreement is limitedto the warranty given by the manufacturer of the system (or any part thereof) to the vendor.

Installation warranty: The vendor warrants that all installations shall be free from workmanship defects or BOS defects for five years from the date of installation of the system. The warranty is limited to Vendor rectifying the Workmanship or BOS defects at vendor's expense in respect of those defects reported by the Applicant, in writing. The Applicant is obliged and liable to report such defects within 15 (fifteen) days of the occurrence of such defects.

Subject to manufacturer warranty, the vendor warrants that the solar modules supplied herein shall have tolerance within a five percentage range (+/-5%). The peak-power point voltage and the peak-power point current of any supplied solar module and/or any module string (series connected modules) shall not vary by more than 5% (five percent) from the respective arithmetic means for all modules and/or for all module strings, as the case may be, provided the system is properly maintained and the applicant site is free from shadow at the timeof operation of the system.

Exceptions for warranty:

i. Any attempt by any person other than the vendor or its authorised persons to adjust, modify, repair or provide maintenance to the system, shall disentitle the applicantof the warranty provided by the vendor hereunder.

ii. The vendor shall not be liable for any degeneration or damage to the system due to any action or inaction on the part of the applicant.

iii. The vendor shall not be bound or liable to remedy any damage, fault, failure or malfunctionof the system owing to external causes, including but not limited to accidents, misuse, neglect, if usage and/or storage and/or installation are non-confirming toproduct instructions, modifications by the applicant leading to shading or accessibilityissues, failure to perform required maintenance, normal wear and tear, Force Majeure Event, or negligence or default attributable to the applicant.

iv. Vendor shall not be liable to repair or remedy any accessories or system added to the existing system that was not originally sourced by vendor to the applicant.

PERFORMANCE GUARANTEE

The vendor guarantees a minimum system performance ratio of 75% as per the performance ratio test carried out in adherence to IEC 61724 or equivalent BIS for five years.

INSURANCE

Vendor may, at its sole discretion, obtain insurance covering risks of loss/damage to the system (any part thereof) during transit from Vendor's warehouse until delivery to the applicant site and until installation and commissioning.

Thereafter, all risk shall pass on to the applicant and the applicant may accordingly procure relevant insurance.

CANCELLATION

The applicant may cancel the order placed on the vendor within 7 (seven) days from thedate of remittance of advance money or the date of order acceptance, whichever is earlier ("**Order Confirmation**") by serving notice.

If the applicant cancels the order after the expiry of 7 (seven) days from the date of the order form, the applicant shall be liable to pay vendor, a cancellation fee of xx% of the total order value *plus* costs and expenses incurred by the vendor, including, costs for labour, design, return of products, administrative costs, subvention costs.

Notwithstanding the aforesaid, the applicant shall not be entitled to cancel the orderform after vendor has dispatched the system (or any part thereof, including BOS) to theapplicant site. If applicant chooses to terminate the order form after dispatch, the entire amount paid by the applicant to date shall be forfeited by vendor.

LIMITATION OF LIABILITY AND INDEMNITY

To the extent that terms implied by law apply to the system and the servicesrendered under this agreement, vendor's liability for any breach of those terms is limited to:

i. Repairing or replacing the system/any part thereof, as applicable; or

ii. Refund of the money paid by the applicant to vendor, if vendor cannot fulfil the order.

SUSPENSION AND TERMINATION

If the applicant fails to pay any sum due under this agreement on the due date, vendor may, in addition to its other rights under this agreement, suspend its obligations under this agreement until all outstanding amounts (including interest due) are paid.

NOTICES

Any notice or other communication under this agreement to vendor and or to the applicant shall be in writing, in the English language and shall be delivered or sent: (a) by electronicmail and/or (b) by hand delivery or registered post/courier, at the registered address of applicant/vendor.

FORCE MAJEURE EVENT

Neither party shall be in default due to any delay or failure to perform its/his/her/theirobligations under this agreement which arises from or is a consequence of the occurrence of an event which is beyond the reasonable control of such party, and which makes the performance of its/his/her/their obligations under this agreement impossible or so impractical as reasonably to be considered impossible in the circumstances and includes, but is not limited to, war, riot, civil disorder, earthquake, fire, explosion, storm, flood or other adverse weatherconditions, pandemic, epidemic, embargo, strikes, lockouts, labour difficulties, other industrial action, acts of government, unavailability of equipment from a vendor, changes requested by the applicant ("**Force majeure event**").

GOVERNING LAW AND DISPUTE RESOLUTION

The interpretation and enforcement of this agreement shall be governed by the laws of Nepal. In the event of any dispute, controversy or difference between the parties arising out of, or relating to this agreement ("**Dispute**"), both parties shall make an effort to resolve thedispute in good faith, failing which, any party to the dispute shall be entitled to refer the dispute to arbitration to resolve the dispute in the manner set out in this Clause. The rights and obligations of the Parties under this agreement shall remain in full force and effect pending the award in such arbitration proceeding.

The arbitration proceeding shall be governed by the provisions of the Arbitration Act, 1999 (2055 B.S.) and shall be settled by a sole arbitrator mutually appointed by the Parties.

Applicant

Name: ....

Designation: ....

Organization: ....

Signature: ....

Vendor

Name: ....

Designation: ....

Organization: ....

Signature: ....

Witness 1

Name: ....

Designation: ....

Organization: ....

Signature: ....

Witness 2

Name: ....

Designation: ....

Organization: ....

Signature: ....

A.20 Bill of materials • Sample

Bill of materials (non-exhaustive)

Materials	Number	Unit (No.)	Total (No.)
Solar panels – xxx W_P			
Inverters – xxx kW			
DC cable (twin) OR red and black/blue – xx mm^2			
AC cable – xx mm^2			
Earthing cable – xx mm^2		Number of panels in meter plus array to inverter distance and inverter to MSB	
DC isolators		1 per string	
String fusing		2 per string (if more than 2 strings are combined)	
Like-to-like connectors		1 male and 1 female per string	
Rails		(2 x Total number of panels (portrait) x 1.05)	
Rail splice		Approx. 1 pert rail	
Tilted leg set – front and back)		1+ number of panels per array	
Mid clamps		[2 x (number of panels)-2] per array	
End clamps		4 x number of arrays	
DC main switch		1 per inverter	
AC isolator		1 per inverter	
AC main switch		1 per DB	
DC/AC SPD		1 per board	
DC/AC MCB, MCCB		1 per board	
Cable tray with lid			
Conduits			

Penetrations		2 per tilted leg set	
MC4 connector (pair)		For connecting modules	
MC4 Y connector (pair)		For connecting modules	
Cable tie XX mm (pkt)			
Metal- tie XX mm			
Screw, PVC grip, metal grip			
Power cable (Cu/Al)		As per the requirement	
Multistrand flexible cable XX sq. mm			
Copper strip (3x25/xx…) XX kg			
Lightning arrestor			
Earthing rod			
Earthing chemical			
Cable trays			
PVC conduits			
Insulators, connectors etc.			
DB boxes, various sizes (Indoor/Outdoor)			
Tools (if any)			
Others….			
…			

A.21 Technical specifications, non-exhaustive list

1. Solar photovoltaic (PV) module

The PV module intended for use in a solar grid-connected system in Nepal must adhere to the NEPQA (Nepal Quality Assurance) standard and receive approval from RETS (Renewable Energy Test Station).

⇒ **Module type:** Monocrystalline, Polycrystalline, Bifacial, PERC or Thin-film.

⇒ **Power output:** Minimum power rating of the module 400W_P in STC.

⇒ **Tolerance:** Power tolerance of - 0 to +5% of the rated power output.

⇒ **Efficiency:** Module's efficiency of at least 18% in STC.

⇒ **Power degradation:** Not more than 3% in the first year and less than 7% from the 2nd to the 25th year.

⇒ **Dimensions:** With the least physical footprint under similar power rating capacity (economics to be considered while making decisions) with either 40mm or 35mm frame thickness.

⇒ **Weight:** The gross weight of the selected panels shall be approx. 9 - 10kg/m2.

⇒ **Operating temperature:** PV module operates optimally -40°C - +85°C

⇒ **Voltage characteristics:** Suitable either to design for residential systems or non-residential systems.

⇒ **Max. system voltage:** 1,500VDC

⇒ **Certifications:** Approved by RETS to be used in Nepal. Follows NEPQA and guidelines. IEC 61215-1 :2016, IEC 61215-2 :2016, IEC61730-1 :2016, IEC61730 -2 :2016

⇒ **Durability test certificates:**

- Snow load, front: 5,400PA and Wind load, back: 2,400PA;
- PID (IEC TS 62804 – 1:2015): 1,500V / 85°C / 85% Relative humidity.
- Hail impact: at least 25mm ice ball at 83km/h

⇒ **Warranty:** Mechanical warranty of at least 15 years and linear production warranty of at least 25 years.

⇒ **Manufacturing standards:** The manufacturer shall have ISO 9001 for quality management and ISO 14001 for environmental management.

⇒ **Frame:** Silver or black (Anodized aluminium)

⇒ **Junction box:** IP 68

⇒ **Bypass diodes:** at least 3

⇒ **Anti-reflective coating:** The proposed module shall have an anti-reflective coating to enhance light absorption and improve efficiency while reducing induced glare.

⇒ **Cell technology:** Specify the cell technology shall be mono PERC (Passivated Emitter Rear Contact),or multi PERC, or other advanced cell technologies.

⇒ **Mechanical load (ML):** at least 2,400Pa

2. Grid-connected inverter

The general requirement of the PV inverter or grid-tie inverter shall match the voltage, frequency, phase angle and phase sequences of the national grid system of Nepal. The PV inverter shall also house the maximum power point tracker (MPPT). The inverter-generated harmonics, flicker, DC injection limits, voltage range, frequency range, power factor range and anti-Islanding measures at the point of connection to the utility services should follow the latest grid code of the Nepal Electricity Authority (NEA).

⇒ **Inverter type:** String inverter, microinverter, or power optimizer system.

⇒ **Power capacity:** Rated power capacity of the inverter in kilowatts (kW) or megawatts (MW).

⇒ **Maximum DC input voltage and current:** The maximum DC input voltage [xx]volts and the maximum DC input voltage [xx]volts.

⇒ **Maximum DC input power:** The maximum DC input power [xx]kW.

⇒ **Maximum AC output power:** The maximum alternating current (AC) power output capacity of the inverter. The inverter shall have NEA grid supply compatible AC output and comply with NEA directives and technical specifications.

⇒ **Functioning: number of MPPTs:** At least 2 but if the design permits, a single MPPT for a better payback period, can be considered.

⇒ **Technology of proposed inverter:** Transformer less technology.

⇒ **Efficiency:** Peak efficiency at least 98% and Euro efficiency at least 97%.

⇒ **Voltage range:** Grid supply compatible AC output shall be either 400±10% Vac (L-L) for three phases or 230 ±10% Vac (L-N) for a single phase.

⇒ **Frequency:** Output electricity frequency shall be 50HZ ± 2.5%.

⇒ **Power factor:** The power factor shall be 0.9 leading to 0.8 lagging.

⇒ **Protection features:** IP ratings of at least IP65 according to IEC 60529 and anti-islanding provisions in accordance with UL 1741 and IEEE 1547.

⇒ **Communication and monitoring:** Modbus, Ethernet LAN, WiFi or Modbus RS232 or RS485. The inverter must communicate with other equipment and monitoring systems and must have data logging and web server features and also preferably with front side LCD screen.

⇒ **Environmental conditions:** The operating temperature range -40°C - +60°C.

⇒ **Certifications and compliance:** Necessary certificates for the inverter: IEC 61727: 2004, IEC 62116: 2014, IEC 62109-1: 2010 and IEC 62109-2: 2011, IEC 61683: 1999 and IEC 60068. Also, the inverter must be certified by the Certification Body Testing Laboratory (CBTL) or Renewable Energy Testing Laboratory (RETL) or National Certification Body (NCB) or Renewable Energy Certification Body (RECB) enlisted in the IECEE website or IECRE website. The enlisted CBTL or RETL or NCB or RECB must have the scope of PV inverter testing.

⇒ **Warranty**: Manufacturer’s warranty: at least 10 years and possible extension options.

⇒ **Mounting and installation:** Inverters shall be compatible with outdoor installation and shall be with wall mount features.

3. **Support structure for PV modules:**

Support and installation structure shall comply with the local building and structural codes and standards.

⇒ **Certification:** Framing shall be certified by the relevant equivalent body if not custom-designed or certified. The structure shall be approved by the relevant organization to be used in the region/locality.

⇒ **Wind loading:** The wind speed to be assumed for customized design is 47m/sec.

⇒ **Structure material:** The structure shall be made of aluminium or stainless steel (SS 304) or MS hot dip galvanized suitable sections.

⇒ **Spacing of poles:** For ground mount system, horizontal spacing between 2 vertical legs must be between 2.5 to 3.5 meters as per load conditions.

⇒ **Resistivity quality:** The support structure and its accessories shall be able to resist at least 20 years of outdoor exposure without suffering damage or corrosion.

⇒ **Flat-on-roof installation:** There should be 20 cm gap (or minimum 15 cm) between the modules' back sheet and roof for air circulation if installed flat on the roof.

⇒ **Comply with:** PV racking and structures must comply with NEPQA and guidelines.

4. **Electrical Accessories** (DC combiner box (if applicable))

⇒ **Certification:** ISO 9001:2015, ISO 14001:2015, OHSAS 18001: 2017/ISO 45001: 2018 Certificates.

⇒ **System voltage:** System maximum DC voltage 1,000V-1,500V (depending on the configuration of the PV array).

⇒ **Environmental conditions:** The operating temperature range -25°C - +55°C. and permissible relative humidity 0-95%, No condensation.

⇒ **Degree of protection:** At least IP65 according to IEC 60529. The enclosure must be UV resistance. If PV string fuses are installed in the combiner box, they must be in accordance with IEC 60947-3. Fuses must be cylindrical type mounted on appropriately sized non-exposed type DC fuse blocks or DC fuse holders. The fuse holders/block must be DIN rail adapted and should comply with IEC 60947.

⇒ The DC combiner box must have DC isolation switch and comply with IEC 60947 and must be provided with IEC 62208 hinged door with EPDM rubber gasket to prevent water and moisture ingress.

⇒ **Degree of protection for the fuse:** At least IP20 according to IEC 60529. The fuse must be designed for at least DC system nominal voltage of 1,000V – 1,500 V (depending on the configuration of the PV arrays).

⇒ **The manufacturer shall have:** ISO 9001:2015, ISO 14001:2015 OHSAS 18001: 2017/ISO 45001: 20 18 certificates.

5. **Lightning Arrestor**

⇒ **Type/Class:** Type 1 (Class I) or Type 2 (Class II) lightning arrestor based on the risk of lightning strikes in the area. Type 1 is typically used at the main service entrance, while Type 2 is used at the sub-distribution level.

⇒ **Maximum discharge current (Imax):** Select a lightning arrestor with an Imax rating that matches the expected lightning current in the area. Common Imax values range from 10 kA to 100 kA or more.

⇒ **Voltage protection level (Up):** The Up rating indicates the maximum voltage that the lightning arrestor allows during a surge event. Common up values range from 1.2 kV to 2.5 kV.

⇒ **Number of poles**: Determine whether a single-pole or multi-pole lightning arrestor is required based on the configuration of your solar rooftop system.

⇒ **Connection type:** Select the appropriate connection type (e.g., screw terminal, bolted connection) for your system's wiring and grounding.

⇒ **Material and enclosure:** Ensure that the lightning arrestor is made of durable and corrosion-resistant materials suitable for outdoor installation. It should also have weatherproofed and UV-resistant enclosures.

⇒ **Operating temperature range:** Verify that the lightning arrestor's operating temperature range is compatible with the local climate conditions.

⇒ **Mounting method:** Choose a mounting method suitable for your rooftop, such as pole-mounted or surface-mounted lightning arrestors.

⇒ **Compliance with standards:** Ensure that the lightning arrestor complies with relevant international standards, such as IEC 61643-11, UL 1449, or local standards applicable in your region.

⇒ **Remote signalling:** Consider whether you need remote signalling capabilities to monitor the status of the lightning arrestor and identify when it needs replacement or maintenance.

⇒ **Coordination with surge protection devices (SPDs):** Ensure that the lightning arrestor is coordinated with other SPDs in your solar system to provide comprehensive protection against surges.

⇒ **Grounding system:** A properly designed and installed grounding system ensures the lightning arrestor's effectiveness. Grounding is a critical component of lightning protection.

⇒ **Manufacturer and warranty:** Choose a reputable manufacturer with a history of producing reliable lightning arrestors and ensure that the product comes with a warranty.

⇒ **Compliance with local codes and regulations:** Verify that the lightning arrestor installation and grounding system comply with local building codes and regulations related to lightning protection.

A.22 List of IEC standards, non-exhaustive list

International standards (IEC)

Standards	Brief description
IEC 61215	IEC 61215 sets requirements for the design and qualification of terrestrial photovoltaic (PV) modules. It focuses on ensuring the safety, performance, and durability of PV modules through testing and characterization. This standard serves as a global benchmark for PV module manufacturers, providing a common set of criteria to follow. It covers various aspects of module design and testing, including mechanical and electrical characteristics, performance in different environmental conditions, and reliability. IEC 61215 specifies specific tests and requirements for PV modules, including mechanical load tests, thermal cycling tests, damp heat tests, UV exposure tests, and electrical performance tests. These tests evaluate factors such as structural integrity, durability, resistance to moisture and UV degradation, and electrical performance.
IEC 61730	IEC 61730 is an international standard for PV module safety. It ensures the safety of users, installers, and system operators by providing guidelines and tests for PV module operation and installation. It complements IEC 61215, which focuses on performance and durability. Key safety requirements and tests in IEC 61730 include electrical insulation, fire, mechanical load, termination robustness, and resistance to environmental stress.
IEC 62548	IEC 62548 establishes design requirements for PV arrays, covering DC array wiring, electrical protection devices, switching, and earthing. It excludes energy storage, power conversion, and loads, except for DC safety. The standard addresses interconnecting small DC conditioning units to PV modules. Its main aim is to address the specific design safety requirements of photovoltaic systems, considering their unique hazards such as electrical arcs. Adhering to IEC 62548:2016 ensures safe PV array design, mitigating additional risks of DC systems and PV arrays. For detailed requirements, please refer to the complete document.
IEC 60529 (IP Code)	IEC 60529 standard for "Degrees of protection provided by enclosures (IP Code)," specifies the levels of protection provided by enclosures against the ingress of foreign objects (such as dust and water) and the level of protection offered to people against contact with hazardous parts inside the enclosure. The IP (Ingress Protection) Code, defined in IEC 60529, consists of two digits. The first digit indicates the degree of protection against solid objects, and the second digit indicates the degree of protection against water.
IEC 62852	IEC 62852 sets design requirements for PV arrays, focusing on safety aspects. It covers DC array wiring, electrical protection devices, switching, and earthing provisions. Energy storage, power conversion, and loads are excluded. Provisions for power conversion equipment are included only if they relate to DC safety. The standard addresses small DC conditioning units for PV modules. It aims to ensure safe design for PV systems, which have unique hazards like electrical arcs. Compliance with IEC 62109-1 and IEC 62109-2 for PV array inverters is vital for grid-connected systems' safety.

Bloomberg tier1	"Bloomberg Tier 1" is a ranking system by Bloomberg New Energy Finance (BNEF) used in the renewable energy industry to evaluate the financial stability and bankability of solar module manufacturers. It assists investors and project developers in assessing risk and supplier reliability. Criteria considered include financial health, production capacity, market longevity, and project experience. However, being Tier 1 does not guarantee module quality or performance. Other factors such as certifications and independent testing should also be considered. The Bloomberg Tier 1 ranking complements industry standards like IEC certifications and UL listings.
NBC 104:1994 and IS 875:1987 and IS 800:1984:	All PV racking shall be designed and /or certified as per the Indian standard IS 875 (part 3)1987. The Dead Load and Live load are taken from IS 875 (part 1)1987 and IS 875 (part 2)1987. The code used for designing the steel member is NBC 111:1994 and IS 800:1984.
IEC 62109	IEC 62109 focuses on safety requirements for inverters, converters, and similar power electronic devices in PV systems. It ensures their safe design, installation, and operation, addressing hazards like electrical shock and fire risks. The standard provides guidelines for electrical safety, fire prevention, mechanical strength, and environmental considerations. Manufacturers seek compliance with IEC 62109 to demonstrate their products meet PV industry safety requirements. It covers aspects such as electrical safety, fire protection, mechanical safety, and environmental considerations.
IEC 61140	IEC 61140 focuses on electrical shock protection in installations and systems. It provides guidelines for electrical safety measures to prevent shock hazards in various applications. The standard addresses electrical insulation, protective earthing, and equipment bonding to minimize the risk of electric shock. Its primary goal is to ensure individual safety and create safer environments. It covers areas such as protective measures, safety signalling, touch voltage, and protective measures for equipment.
IEC 61643-11	IEC 61643-11 is an international standard for surge protective devices (SPDs) in low-voltage power systems. It guides the selection, installation, operation, and maintenance of SPDs to safeguard electrical equipment from voltage surges. Compliance ensures adherence to performance and safety standards through standardized testing and evaluation. It covers aspects such as classification, performance testing, coordination with other protective devices, and installation and maintenance related to surge protection.
IEC 60947-2	IEC 60947-2 focuses on the safety of low-voltage switchgear and controlgear assemblies used in electrical distribution systems. It provides guidelines and requirements for their design, construction, and testing. Compliance with this standard is crucial to ensure the safety and reliability of such assemblies. Manufacturers, designers, and users refer to IEC 60947-2 to ensure proper practices are followed, minimizing the risk of electrical hazards and ensuring the safe operation of electrical distribution systems.

A.23 Pre-installation task plan

Project activities

1. Preparation

⇒ *Onsite inspection:*

It is important to verify if there are any on-site discrepancies as compared to the DFS) report. If such discrepancies are found, the plan should be revised if necessary; otherwise, the installation work should proceed according to the original DFS plan. Site preparation activities, such as land levelling and clearing the allocated installation area, will be carried out as per the plan.

⇒ *Setting up of lifting equipment (if any):*

Arrange a time for the lifting equipment and acquire permission from the consumers. Conduct a safety inspection of the equipment and complete the checklist to ensure safety.

⇒ *Setting up roof/land access:*

Ensure that the roof access points are secured and easily reachable. If external equipment is required, ensure that it is installed securely and meets safety standards. Determine the access points to reach the designated land site for installation.

Make sure that the land is levelled, and the area is clear to operate an elevated work platform/ladder for a ground mount system.

⇒ *Elimination of hazards in and around the working space:*

Eliminate any potential hazards such as nails, metal structures, and cover or mark skylights on the roof or land space.

⇒ *Safety marking and safety labelling:*

Prepare the site to create a safe working environment. Label and mark areas with high risks. Ensure that posters and stickers are displayed clearly, marking exits and hazardous areas for easy visibility.

2. Setups

⇒ *Setting up roof edge protection, anchor points and walkways:*

Prior to starting any work on the roof, it is necessary to install roof edge protection and anchor points for harnesses. In case the surface is slippery, uneven or unsafe, walkways should be installed.

⇒ *Measurements:*

Prior to commencing any installation work, it is crucial to carry out a comprehensive measurement in accordance with the DFS document and mark the roof fixtures/mounting structures, including the positioning of posts, purlins, etc.

⇒ *Setting out and markings:*

Establishing the panel layout and marking the solar structure according to the provided plan, along with a plan for the roof fixtures/ground mounting structure and its accessories, is essential.

⇒ *Lifting of PV racking and panels:*

To minimize costs, it is recommended to lift the PV racking and panels simultaneously, while ensuring compliance with lifting safety standards to prevent any injuries. Proper care must be taken to handle or hoist panels to avoid any panel cracks.

⇒ *Finalisation of locations:*

Location and trenching for cable runs, earthing pits, and power evacuation points are to be finalised before starting the installation work and record them on the as-built diagram if the installation is ground mounted.

3. Installation

⇒ *Roof fixtures shall be installed using penetrating or non-penetrating methods:* The DFS report shall mention it.

During the installation of PV racking and panels, it is important to minimize penetrating the roof by utilizing existing holes in the roofing material. Additionally, dissimilar metals must be separated properly. Any penetrations that are made should be sealed with outdoor (radiation) grade silicone gel. If the solar panels are being installed on the ground, posts must be installed according to the design specified in the DFS report.

⇒ *Run all DC cable from the array location to the DC combiner box:*

During the installation process on the roof or land, the DC cable designed for the array location must be installed in the combiner box. The number and size of DC cable runs must be determined during the DFS. All cables should be placed in a metal cable tray, and internal cable runs should be in a hard conduit. It's important to note that DC, AC, and communication cables should not be installed in the same cable tray or conduits until they are mechanically separated.

In addition, Type 2 SPDs should be installed on the AC and DC sides of the wiring. Earthing cables on the DC side should be grounded using an appropriately sized earthing cable and terminated to the MEN. Finally, a lightning arrester should be installed to protect the system and property.

⇒ *Installation and connection of panels:*

As PV panel installation proceeds, the panel's cable lead must also be connected. The wiring loop should avoid conductive wiring regardless of the panel's connection method. The connectors used on the cables should match the connectors on the panel lead cable. The drawing of the best cable wiring practice as an example has been presented in annex 27.

While installing the panels, all necessary DC isolators, fuses, and disconnectors should be installed on the rails using an outdoor combiner box. The switch gears should be placed in UV and IP67-rated enclosures.

⇒ *Installation of DC combiner box connection of DC cable:*

The DC combiner box, either pre-fabricated or made on-site, will be installed near the inverter, and all DC string cables from the roof will be directed into the box through suitable cable glands.

⇒ *Installation of inverter and cable run between combiner box and inverter:*

The inverters will be installed at the designated location according to the DFS plan. The installation of the inverter should not be too high or too low from the ground, and the inverter display should be at eye level. If the inverter is to be installed outdoors, ensure that the manufacturer permits it and is installed with an awning. While selecting an outdoor installation, it is recommended to avoid south and west-facing walls.

⇒ *AC cable run from inverter to MSB/DB:*

The AC cable/cables shall be installed from the inverter to the DB or MSB busbar based on the inverter's output. The connection of the inverter to the AC supply should be carried out according to the schedule and approval for switching off the grid supply in the property.

⇒ *Labelling:*

Proper labelling is necessary to indicate the designations of components and their respective termination points. The solar PV system components, including DB/MSB/meter/supply points, must be appropriately marked and labelled.

4. Testing and commissioning:

⇒ *Cable connection, testing and commissioning of the system:*

Once the interconnection of the panels and strings is complete, it is necessary to conduct testing of the strings and earth cable. All activities and readings related to the testing shall be recorded in the testing and commissioning framework/checklist provided in Annex 8. The interconnection of the solar system to the grid supply shall be carried out and tested in the presence of a certified electrician. In the case of a pure grid-tied net-metered solar PV system, the entire solar system shall be turned off again after commissioning.

⇒ *Site cleaning and wrap-up;*

After completing the commissioning, the site should be thoroughly cleaned up, and all waste materials should be disposed of in accordance with environmental protocols.

5. Application and connection and net metering:

⇒ *Apply for RETS inspection and certification:*

After completion of installation, testing and commissioning of the system, an application for system inspection and certification by RETS should be initiated.

⇒ *Apply for net metering connection with NEA if the system is RETS certified:*

After receiving RETS observation certification, NEA application should be moved forward.

6. Approval and connection:

Only after signing of net metering contract with NEA the system should be turned on for net metering purposes.

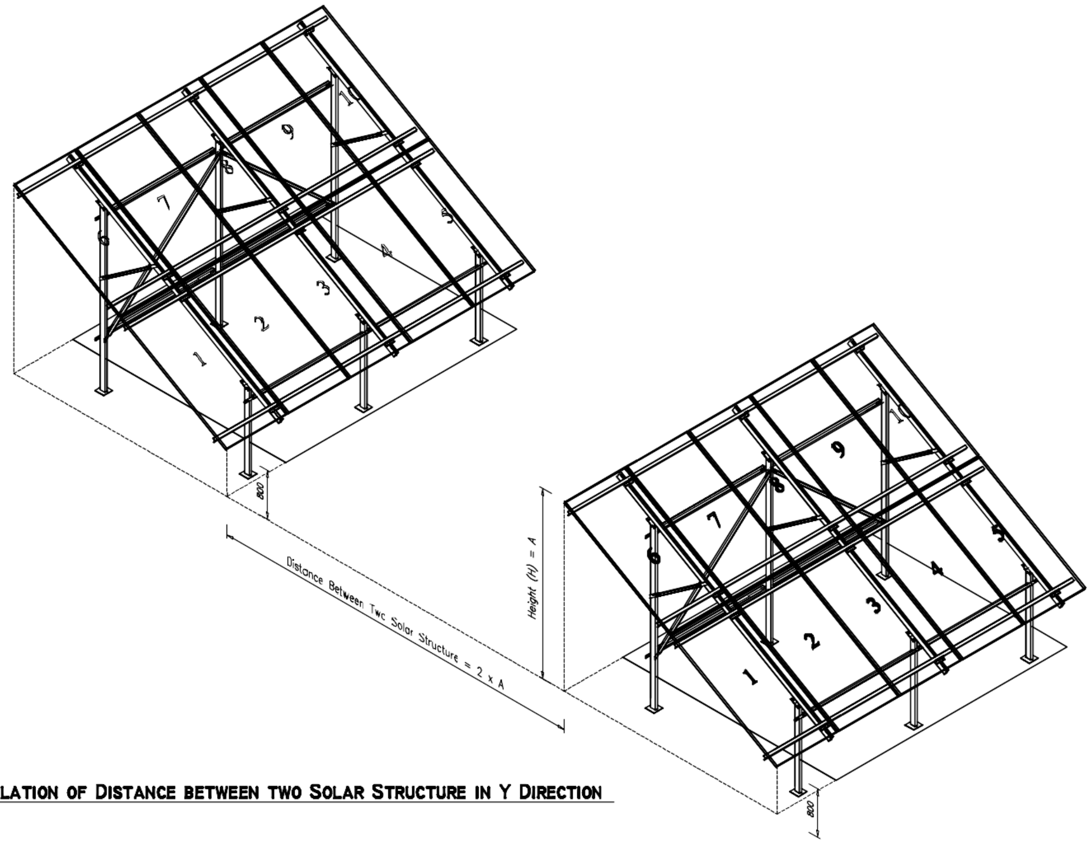
A.24 Solar support structure details and references

Specification and considerations of solar support structures

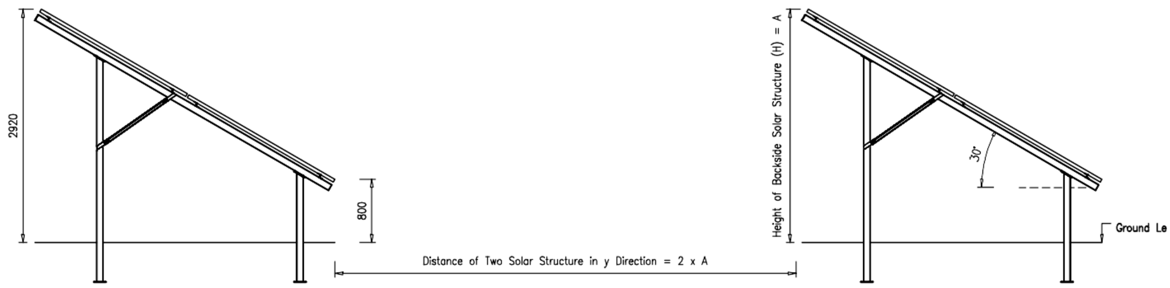
Consideration	Nepal standard	International practice	Software	Reference
Wind load	47m/s or 55 m/s	55m/s	Risa-3D or any other structural analysis program	Design code: NBC 105:2020 IS 875 (part-3): 2015
Dead load	Dead load apart from the self-weight of a structure is taken as per technical data sheet from the manufacturer or IS 875 Part-1 or it varies from (25kg-30kg) manufacture of solar panel. i.e. 10.447kg/sq. m.	264.6 KN	Risa-3D or any other structural analysis program	Design code: NBC 105:2020 IS 875 (part-1): 2015
Placement and shading	The inclination of solar panels depends on the site condition of the roof and place where maximum sunlight obtains solar energy.	The slope of the panel as per site condition and generation analysis	Sketchup	
Economic	Solar panels with the provision of attaching the panel with selected clamps to avoid screws, which avoids drilling on solar panels and solar structures which reduce time for installation, easy and fast.	Maximize safety and maximize returns	Excel	
Monthly Inspection	Check: Rusting Loosen off nut and bolt Damages Power losses	Checklist		
Maintenance	Remove any dust particles Remove debris Remove any obstructions	Checklist		
Clamps vs Screw	Depends on the type of solar panel (Manufacturer) used. If the panel have an internal screw hole, then the screwing method is used. If not, clamps are used to attach the panel. A clamp system is easier and faster to installation also it gives more protection than a screw-based system.	Screws and clamps are used but the clamp is preferred		

Penetrative vs non penetrative	Used as per site and consumer demand Penetrative: Ground base mount, Flat Terrace base mount, corrugated roof sheets Non- Penetration: HSPAN roof sheets etc	Penetration as well as non-penetration used		
Concrete roof	Anchor bolts are drilled on the concrete slab with epoxy penetration. Or RCC column pedestal is casted for each leg to ensure overturning from wind.	Both drilling and adhesive-based structures are used.		
Concrete roof	Anchor bolts are drilled on the concrete slab with epoxy penetration. Or RCC column pedestal is casted for each leg to ensure overturning from wind.	Both drilling and adhesive-based structures are used.		

Samples of various types of support structures

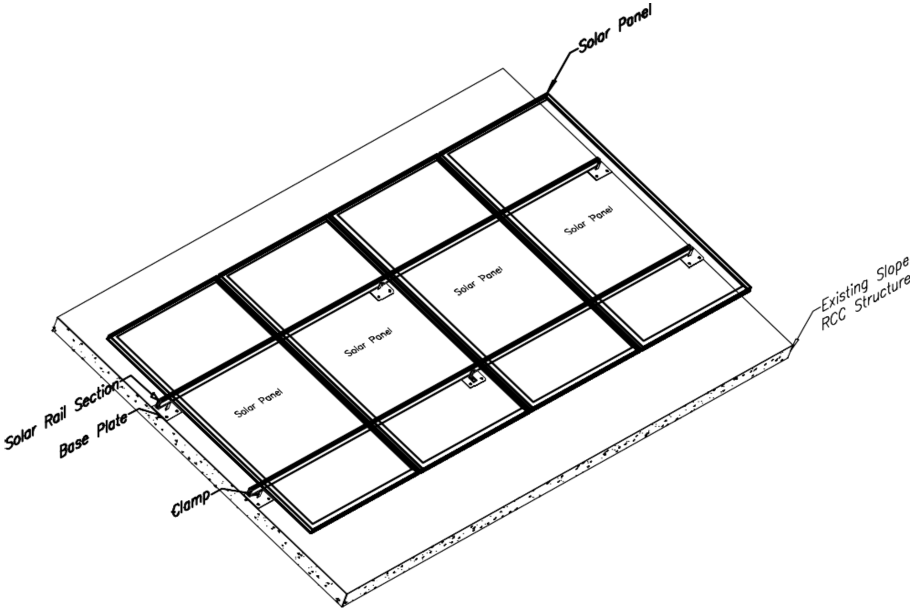


CALCULATION OF DISTANCE BETWEEN TWO SOLAR STRUCTURE IN Y DIRECTION

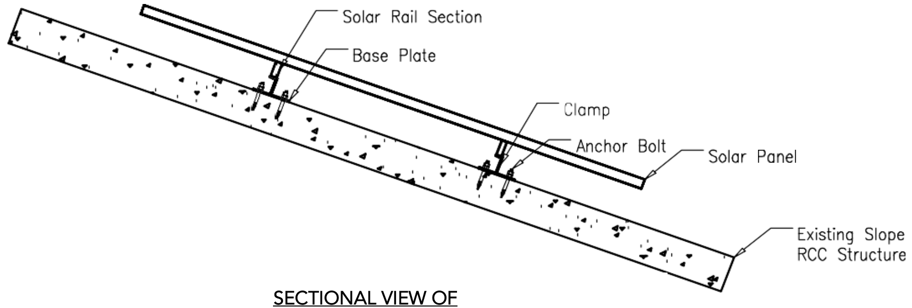


SECTIONAL VIEW OF SOLAR SUPPORTING STRUCTURE

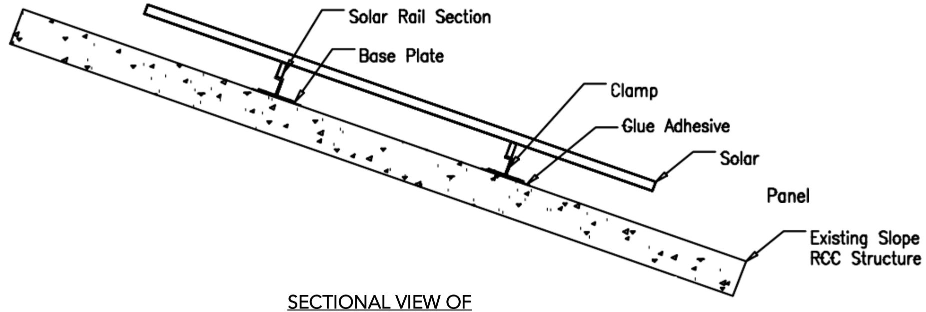
Figure 10: Ground mount type installation



SOLAR SUPPORTING STEEL STRUCTURE AT RCC SLOPE ROOF



SECTIONAL VIEW OF
SOLAR SUPPORTING STEEL STRUCTURE AT RCC SLOPE ROOF
(BY USING ANCHOR BOLT)



SECTIONAL VIEW OF
SOLAR SUPPORTING STEEL STRUCTURE AT RCC SLOPE ROOF
(BY USING GLUE ADHESIVE

Figure 11: RCC - Slope type installation

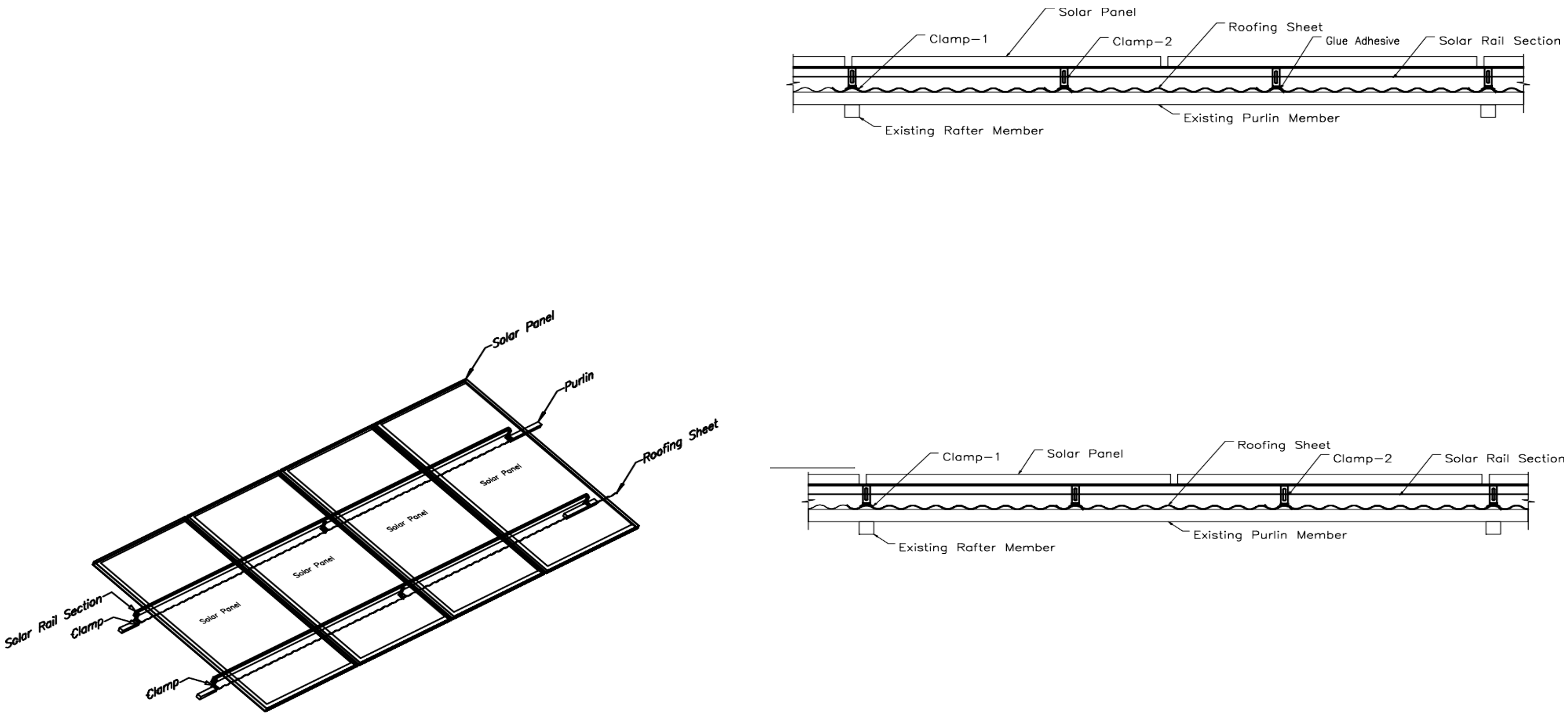


Figure 12: CGI sheet - Slope type installation

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