

Technical Proposal for the Installation of Solar Photovoltaic and Solar Water Heating Systems in 62 Households of Kerung Village, Solukhumbu District

Prepared For :

Solar Shower Help Nepal

Prepared By :

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ABSTRACT

This proposal presents a plan to install solar photovoltaic (PV) systems and solar water heating (SWH) units for 62 households in Kerung, Dudhkunda Municipality – Ward No. 6, Solukhumbu District. Based on an assessment of five housing typologies, customized designs have been developed to meet varying energy needs efficiently and sustainably. The project will provide reliable electricity and hot water, reduce firewood dependency, improve health and living standards, and benefit over 300 residents. With a clear implementation, cost, and maintenance strategy, the initiative supports both community well-being and Nepal's renewable energy goals.

ACKNOWLEDGEMENT

We would like to express our sincere gratitude to Solar Shower Help Nepal for entrusting Brick International Pvt Ltd with the responsibility of preparing the technical proposal for the installation of solar photovoltaic (PV) systems and solar water heating (SWH) units in Kerung Village, Dudhkunda Municipality – Ward No. 6, Solukhumbu District. Their commitment to improving the lives of rural communities through sustainable energy solutions has been the driving inspiration behind this work.

We also extend our appreciation to the local community members of Kerung Village for their cooperation and valuable insights during the preliminary assessments. Their support and participation are vital for ensuring the long-term success and sustainability of the project.

Finally, we acknowledge the dedication of our technical and field teams who contributed their expertise, time, and effort in developing this proposal. Their commitment to innovation and quality ensures that the project will not only meet immediate energy needs but also contribute to broader goals of environmental conservation and rural development in Nepal.

DECLARATION

I, the undersigned, on behalf of Brick International Pvt. Ltd., hereby declare that the information, analysis, and recommendations presented in this Technical Proposal Report titled “Technical Proposal for the Installation of Solar Photovoltaic and Solar Water Heating Systems in 62 Households of Merangdi Village, Solukhumbu District” have been prepared with the utmost care and technical accuracy.

The field data and baseline information used for this report were obtained from secondary sources provided by Solar Shower Help Nepal, the initiating INGO of this project. Our company has analyzed and structured these data to develop suitable system designs, technical recommendations, and implementation strategies tailored to the project’s objectives.

It is important to note that this report does not include administrative costs, financial institution charges, or costs related to administrative human resources. The financial sections focus solely on technical system components, transportation, logistics, and installation.

This proposal is prepared exclusively for submission to Solar Shower Help Nepal and is intended for project planning, budgeting, and implementation purposes.

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The image shows a handwritten signature in black ink that reads "Utsav Adhikari". To the right of the signature is the logo for "BRICK INTERNATIONAL". The word "BRICK" is in a large, bold, blue, sans-serif font, and "INTERNATIONAL" is in a smaller, blue, sans-serif font below it.

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1. EXECUTIVE SUMMARY

1.1. Project Background

The proposed initiative focuses on providing sustainable energy access to 62 households in Kerung Village, Dudhkunda Municipality – Ward No. 6, Solukhumbu District. These households face significant challenges in meeting their daily energy needs, relying heavily on firewood, kerosene, and limited grid supply. To address this, Solar Shower Help Nepal has initiated a project to install solar photovoltaic (PV) systems and solar water heating (SWH) units across the community. Brick International Pvt Ltd has been assigned to prepare the technical proposal and ensure that the system designs are efficient, reliable, and suited to the unique local conditions.

1.2. Objectives of the Study

This proposal has been developed to align with the project's long-term sustainability goals. The main objectives can be summarized as follows:

- i. Assess the different housing typologies in Kerung Village and analyze their specific energy requirements.
- ii. Propose suitable solar PV and SWH system designs tailored to each typology.
- iii. Provide a comprehensive technical solution that is cost-effective, durable, and sustainable in the rural Himalayan context.
- iv. Outline a feasible implementation plan, including installation methodology, operation and maintenance (O&M), and community training.
- v. Demonstrate the project's contribution to improving livelihoods, reducing environmental impact, and supporting Nepal's renewable energy goals.

1.3. Scope of Work

The scope of work defines the technical and managerial tasks to be undertaken by Brick International Pvt Ltd to ensure successful implementation. The activities include:

- i. Conducting technical assessments of the 62 houses and classifying them into 5 typologies.
- ii. Designing and sizing solar PV systems for reliable household electrification.
- iii. Designing and sizing solar water heating systems to meet hot water needs in cold climatic conditions.
- iv. Preparing system layouts, technical specifications, and cost estimate for each typology.
- v. Developing an implementation and logistics plan tailored to Solukhumbu's remote terrain.
- vi. Providing an operation, maintenance, and training framework for long-term sustainability.

1.4.Key Outcomes and Benefits

The proposed intervention is expected to deliver multiple social, environmental, and economic benefits for the community. The major anticipated outcomes are:

- i. Reliable access to clean electricity and hot water for all 62 households.
- ii. Direct improvement in the living standards of over 300 residents of Kerung Village.
- iii. Reduction in firewood dependency, leading to improved health, reduced indoor air pollution, and protection of local forests.
- iv. Contribution to greenhouse gas (GHG) reduction and Nepal's renewable energy transition.
- v. Creation of local capacity through training for installation, operation, and maintenance.
- vi. Enhanced community resilience, with long-term social, environmental, and economic benefits.

2. PROJECT BACKGROUND AND CONTEXT

2.1.Background

Energy demand and its profound economic and environmental implications has become a pivotal concern for policymakers worldwide. Among all sectors, buildings are one of the primary contributors, accounting for approximately 40% of global primary energy consumption and about 36% of greenhouse gas (GHG) emissions (Luis Pérez-Lombard, 2008) (Hai-xiang Zhao, 2012). Within this sector, residential buildings account for over 60% of the total building energy use, while commercial buildings contribute the remainder. If current trends continue, building-related energy demand is projected to rise steadily in the coming decades, further straining energy resources, supply systems, and the environment (Hai-xiang Zhao, 2012).

The most significant environmental impact of building energy consumption is the release of GHGs, particularly carbon dioxide (CO₂), largely generated from electricity production based on fossil fuels and biomass. This makes the building sector a central focus of global mitigation strategies requiring immediate attention and effective action.

Numerous studies highlight that energy-efficient building design and sustainable land-use practices can substantially reduce GHG emissions while lowering operational costs (Perez-Lombard et al., 2008). The energy performance of a building is defined as the actual or estimated energy needed to meet typical requirements, such as space heating and cooling, lighting, and hot water production. An energy-efficient building ensures thermal and visual comfort with the least possible energy demand by employing an optimized mix of passive solar design strategies, efficient mechanical systems, and renewable energy sources.

Currently, socio-cultural, economic, and ecological aspects are considered during the design process, but energy performance is often overlooked. Critical determinants of building energy use such as orientation, spatial configuration, material selection, and construction methods are established during the design phase but are not always optimized for efficiency. This highlights the need to integrate energy considerations early in the design process.

Reducing building energy demand can be achieved through bioclimatic design principles and the application of simple yet effective techniques. Over time, these strategies not only reduce maintenance and operational costs but also minimize the environmental footprint of buildings (Hai-xiang Zhao, 2012).

2.2. Energy Consumption Trend in Nepal

According to the energy sector synopsis report 2024 published by Water and Energy Commission, Government of Nepal, the residential sector dominates energy consumption with 60.75% of total national energy consumption. (Water and Energy Commission, Government of Nepal, 2024)

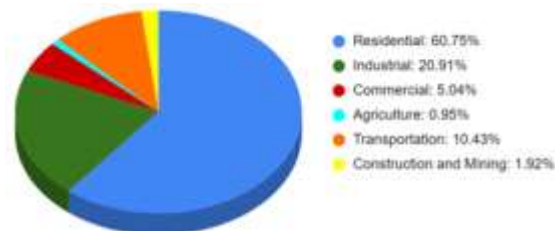


Fig 1.1: Sectoral energy consumption shares for FY 2079/80 (source: http://weecs.gov.np/source/ESR_2024)

In the residential sector, the energy mix of Nepal totals 323.46 PJ (Figure 3.24). The largest share is from fuelwood, accounting for 79.52%. Other significant contributions include LPG at 5.62%, electricity at 4.99%, and biogas at 3.31%. Smaller contributions come from agricultural residue (2.75%), animal dung (2.93%), solar (0.68%), micro/pico hydro (0.14%), wind (0.0053%), kerosene (0.03%), and coal (0.01%). (Water and Energy Commission, Government of Nepal, 2024)

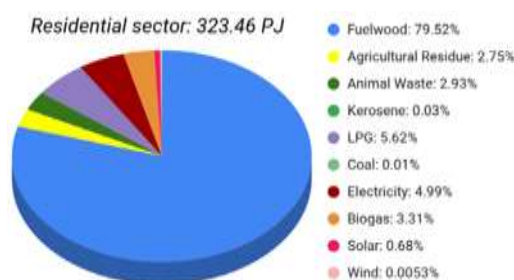


Fig 1.2: Energy consumption of residential sector for FY 2079/80 (source: http://weecs.gov.np/source/ESR_2024)

The increasing usage of electricity, however, has led to the increase in the per capita electricity consumption value and subsequently increased the residential electricity consumption per household. The overall electricity consumption of Nepal reached about 370 kWh per capita and is observed to have an increasing trend, likely due to the increasing dependence and utilization of electricity. (Water and Energy Commission, Government of Nepal, 2024)

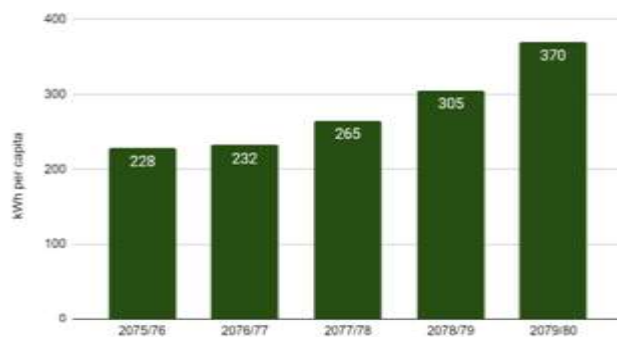


Fig 1.3: Electricity consumption trend (kWh per capita)
(source: http://weecs.gov.np/source/ESR_2024)

2.3.Introduction to the Project Area (Solukhumbu District)

Solukhumbu District, located in Province No. 1 of eastern Nepal, is a mountainous region renowned for its rugged terrain, harsh climatic conditions, and limited infrastructure facilities. The district is home to diverse communities that often live in scattered settlements with difficult access to basic services. Kerung Village, Dudhkunda Municipality – Ward No. 6, is one such settlement where households face significant energy challenges due to its remoteness and lack of reliable grid connectivity. The community primarily depends on traditional energy sources such as firewood and kerosene, which not only strain the local environment but also compromise health and quality of life.



Fig 2.1: Ariel View of Kerung Village

2.4. Energy Access Challenges in the Community

The households of Kerung Village experience limited access to clean, reliable, and affordable energy. Most families depend on firewood for cooking and heating, which contributes to deforestation, indoor smoke, and respiratory health issues. Kerosene lamps are commonly used for lighting, posing fire hazards and high recurring costs. While some households may have limited or irregular access to electricity, the supply is insufficient to meet their daily needs, especially for lighting, water heating, and small appliances. The absence of reliable energy also restricts opportunities for children's education, economic activities, and improved living conditions.

2.5. SSHN's Project Vision and Goals

Recognizing these challenges, Solar Shower Help Nepal has initiated a project to improve the energy situation in Kerung Village through the installation of solar photovoltaic (PV) systems and solar water heating (SWH) units. The vision of this project is to ensure sustainable energy access that enhances the quality of life, promotes environmental protection, and supports community resilience. The key goals include:

- i. Providing reliable electricity and hot water to all 62 households.
- ii. Reducing dependency on traditional fuels and lowering environmental degradation.
- iii. Supporting health and education outcomes by ensuring clean energy access.
- iv. Building community capacity for the long-term operation and maintenance of the systems.

2.6. Role of Brick International Pvt Ltd

Brick International Pvt. Ltd. has been selected as the technical partner to prepare and deliver the proposal for this project. The company's role is to design suitable solar PV and SWH systems tailored to the five distinct housing typologies identified in the community. Responsibilities include conducting energy demand assessments, preparing technical system designs, specifying required equipment, and developing a practical implementation and maintenance plan. By leveraging its expertise in renewable energy and sustainable building solutions, the company aims to deliver a proposal that aligns with the vision of Solar Shower Help Nepal and addresses the real needs of Kerung Village.

3. HOUSING TYPOLOGY ASSESSMENT

3.1. Overview of 62 Houses

Kerung Village consists of 62 households that vary in size, structure, and construction materials. Most houses are traditional Himalayan-style dwellings built with stone, wood, and tin or slate roofing. The community is dispersed across hilly terrain, with limited access to grid electricity and modern energy infrastructure.

Preliminary site visits revealed variations in household size, number of rooms, and energy usage patterns, which directly influence the design of solar PV and solar water heating systems.

3.2. Classification into 5 Typologies

Based on structural characteristics, household size, and roof type, the 62 houses have been classified into five distinct typologies:

Typology	Description	No. of Houses	Roof Type	Floor Area (approx.) in sq ft	Notes
T1	Small single-story stone house	11	Sloped tin	400	Lesse energy demand
T2	Medium single-story stone/brick house	22	Sloped tin/metal	650	Moderate household energy demand
T3	Large single-story stone house	9	Sloped slate	750-800	High electricity demand
T4	Two-story house	8	Tin/metal	900	Can accommodate larger PV and SWH units
T5	Two-story house with attached kitchen	12	Tin/metal	1200	Highest energy consumption

Note: Exact floor areas will be filled after detailed field survey.



Fig. Residential Building in Kerung Village T2



Fig. Residential Building in Kerung Village T4



Fig. Residential Building in Kerung Village T2.1



Fig. Residential Building in Kerung Village T5

3.3. Energy Demand Analysis by Typology

Each housing typology has been analyzed to estimate its daily and seasonal energy requirements:

- i. Electricity demand: lighting, phone/laptop charging, small appliances, and fans.
- ii. Hot water demand: primarily for bathing and kitchen use.
- iii. Peak load assessment: identifies system sizing requirements for solar PV and SWH units.

Preliminary analysis indicates that smaller households (T1, T2, T3) require 1–2 kWp PV systems, while larger and two-story households (T4, T5) may require 3–4 kWp PV systems and appropriately sized solar water heating units to meet hot water needs.

3.4. Site Assessment and Roof/Orientation Suitability

A thorough site assessment was conducted to evaluate roof orientation, tilt, and shading conditions, which are critical for solar system performance:

- i. Roof orientation: Most houses face south or southeast, ideal for solar exposure.
- ii. Roof tilt and structure: Sloped roofs with sufficient load-bearing capacity are suitable for mounting solar PV panels and SWH collectors. 18 among 62 houses have comparatively weaker roof structure to withstand the load of SWH but can withstand load of solar PV units.
- iii. Shading analysis: Minimal obstruction from trees or neighboring structures ensures optimal solar radiation.
- iv. Accessibility: Hilly terrain requires careful planning for transportation and installation of solar equipment.
- v. 49 among 62 houses have separate temporary structure for sanitary purpose and are not in condition to withstand loads of SWH units or solar PV cells.

The assessment confirms that the majority of houses are suitable for the proposed solar PV and SWH installations, with minor adjustments in mounting and placement to maximize efficiency and safety.

4. PROPOSED TECHNICAL SOLUTIONS

4.1. Solar Photovoltaic System (Solar PV)

The proposed solar PV systems aim to provide reliable, off-grid electricity to all 62 households in Kerung Village. Systems are designed to meet varying energy demands based on the five housing typologies while ensuring efficiency, durability, and minimal maintenance in the Himalayan environment.

4.1.1. System Design and Sizing

The PV systems are designed to supply household electricity needs including lighting, phone/laptop charging, fans, and small appliances. System sizing is based on typology-specific energy demand:

Typology	Estimated Daily Energy Use (kWh)	Recommended PV System Size (kWp)	Battery Storage (Ah)
T1	2–4	1–2	100–150
T2	2–4	2	150–200
T3	3–4	2–3	200–250
T4	5–6	3	250–300
T5	6–8	3–4	300–400

The design ensures sufficient solar generation during peak hours, reliable battery backup during cloudy days, and scalability for future energy needs.

4.1.2. Component Specifications (Panels, Inverters, Batteries, Wiring)

Key components for the PV systems include:

- i. Solar Panels: High-efficiency monocrystalline modules, 330–400 Wp per panel, with corrosion-resistant frames suitable for high-altitude environments.
- ii. Inverters: Pure sine-wave inverters, 1–4 kVA depending on typology, ensuring stable AC output for household appliances.
- iii. Batteries: Deep-cycle lithium-ion or high-quality lead-acid batteries, sized according to household energy needs for 1–2 days of backup.
- iv. Charge Controllers: MPPT controllers for optimal energy conversion and battery protection.
- v. Wiring & Accessories: UV-resistant DC/AC wiring, connectors, junction boxes, and proper grounding for safety.

4.1.3. Layout and Installation Considerations

Proper system layout and installation are critical to maximize energy production and ensure safety:

- i. Roof Mounting: Panels mounted at an optimal tilt (25–35°) to maximize solar exposure; south-facing orientation preferred.
- ii. Structural Safety: Roof inspection and reinforcement where necessary to support panel and SWH weight.
- iii. Shading Avoidance: Panels positioned to avoid shading from nearby trees or structures.
- iv. Wiring & Safety: Proper cable routing, lightning protection, and grounding systems.
- v. Maintenance Access: Ensure easy access to panels, inverters, and batteries for routine cleaning and service.

The PV system design ensures that households will receive reliable, sustainable electricity, with minimal operational challenges and maximum energy efficiency, even in Merangdi’s remote and challenging terrain.

4.2. System Design and Sizing

The proposed solar water heating systems aim to provide households in Merangdi Village with reliable access to hot water for bathing and kitchen use. The systems are designed to be durable, energy-efficient, and suitable for high-altitude, cold-climate conditions.

4.2.1. System Design and Sizing

A uniform system is recommended for all households to simplify implementation and maintenance. The proposed system includes:

- Collector: 20-tube evacuated solar collector
- Storage Tank: 200 L insulated tank

This configuration provides sufficient hot water for average household use, ensuring availability even during winter months with minimal auxiliary heating.

4.2.2. Component Specifications (Collectors, Tanks, Piping, Insulation)

- i. Solar Collector: 20 evacuated tubes, high thermal efficiency, anti-freeze capability for cold climates
- ii. Storage Tank: 200 L, well-insulated, corrosion-resistant
- iii. Piping: Insulated PEX or copper pipes to minimize heat loss
- iv. Insulation: Mineral wool or polyurethane foam for pipes and tank
- v. Accessories: Temperature/pressure relief valves, expansion tank, and optional circulation pump

4.2.3. Layout and Installation Considerations

- i. Collector Placement: South-facing orientation, tilted at 30–45° for optimal solar gain
- ii. Separate sanitary units with roof area 8' x 10' adjacent to the house need to be built to withstand the load of SWH unit.
- iii. Roof/Wall Mounting: Securely installed on sloped roofs or reinforced walls with easy access for cleaning
- iv. Piping & Insulation: Minimize pipe lengths and bends; ensure full insulation to prevent heat loss or freezing
- v. Safety Measures: Proper anchoring, pressure relief mechanisms, and routine maintenance
- vi. Integration: Optionally integrate with PV-powered circulation pump for enhanced efficiency

This uniform SWH design ensures consistent hot water supply across all households, improving health, hygiene, and comfort while reducing dependence on firewood or kerosene.

4.2.4. Separate Sanitary Block Design

Due to weaker and unfavorable roof conditions in the existing houses, a separate sanitary block closer to the house is proposed. The newly built block shall have plinth area, floor area and roof area of 120 sq ft, 80 sq ft and 120 sq ft respectively.

i. Construction Technology

The structure is built on a 10 ft × 12 ft plinth and accommodates a toilet and bathing zone, separated into distinct spaces. It is designed as a load-bearing building with seasoned stone masonry walls of 12-inch thickness, providing both durability and thermal comfort.

The building has a floor-to-ceiling height of 8 ft 11 in and is topped with a reinforced cement concrete (RCC) roof slab of 5-inch thickness. The roof supports a solar water heating system, including a 200-liter solar water heater tank and an additional 500-liter water storage tank.

ii. Sustainability

The stone masonry walls are built with locally available, seasoned stones, ensuring durability and natural thermal regulation of indoor spaces. The mud tile flooring further reflects vernacular techniques, offering a breathable and eco-friendly surface that maintains indoor comfort. Cement plaster finishes provide protection and durability while keeping maintenance simple. By using regional materials, the construction supports local supply chains and minimizes embodied energy.

iii. Employment and Community Involvement

The construction process engaged local masons and artisans, preserving indigenous craftsmanship and creating employment opportunities within the community. The reliance on traditional building practices not only ensures knowledge transfer across generations but also empowers local workers with fair wages. By sourcing both materials and labor locally, the project demonstrates a socially responsible approach, contributing directly to the local economy while promoting sustainable construction practices.

4.3. Integration of PV & SWH Systems

To maximize efficiency, sustainability, and ease of operation, the solar photovoltaic (PV) systems and solar water heating (SWH) units are designed to work in a complementary and integrated manner. The integration ensures that both electricity generation and hot water supply are reliable, safe, and suitable for the unique needs of Merangdi Village.

4.4. System Performance and Reliability

The combined solar photovoltaic (PV) and solar water heating (SWH) systems are designed to deliver consistent performance and long-term reliability in the specific climatic and geographical context of Merangdi Village, Solukhumbu District. Considering the high-altitude environment, cold winters, and seasonal variations in solar insolation, the systems have been engineered to ensure stable outputs throughout the year.

The PV systems will provide sufficient electricity to meet daily household demands such as lighting, charging, and small appliances. High-efficiency panels with

durable mounting structures will ensure reliable energy generation even under partially cloudy conditions. Battery banks with adequate storage capacity will allow households to maintain electricity supply during the night and in periods of reduced sunlight, while modern charge controllers and inverters will safeguard system components and enhance reliability.

Similarly, the SWH units, designed with 20 evacuated tubes and a 200-liter insulated storage tank, will consistently provide hot water for bathing and kitchen use. The evacuated tube technology ensures excellent performance in cold climates, while high-quality insulation minimizes heat loss, enabling households to access warm water even during winter mornings. Pressure-relief valves and corrosion-resistant materials further improve system reliability and safety.

Routine maintenance requirements are minimal, and the systems have been selected for their robustness and low-maintenance characteristics. By aligning maintenance of both PV and SWH units, operational efficiency is maximized, and long-term functionality is assured. Overall, the integrated systems are expected to achieve over 90% availability, ensuring households in Merangdi Village benefit from reliable and sustainable energy services for many years.

5. TECHNICAL DESIGN PER HOUSING TYPOLOGY

For 5 different housing typologies, 2 different load of solar PV cells are proposed as follows.

Typology	Recommended PV System Size (kWp)
T1, T2, T3	2
T4, T5	3

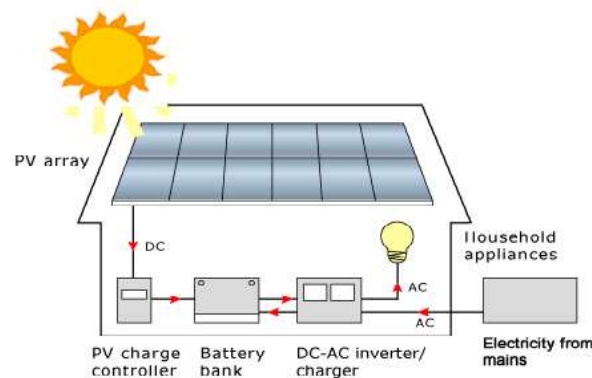


Fig 5.1: Typical Rooftop PV System

(Source: <https://www.linkedin.com/pulse/design-solar-pv-system-homeutilities-ajmal-jamal->)

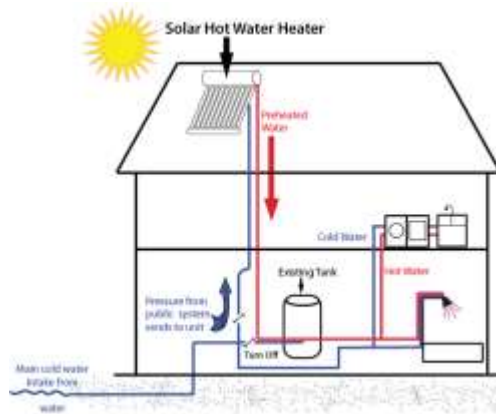


Fig 5.2: Typical Rooftop PV System

(source: <https://lifetheexperience.wordpress.com/2015/12/10/solar-water-heating-system/>)

A uniform system is recommended for all households to simplify implementation and maintenance. The proposed system includes:

- Collector: 20-tube evacuated solar collector
- Storage Tank: 200 L insulated tank

5.1. Typology 1, 2 & 3- Description and Proposed PV System Design

For this typology we propose 2 kWp solar PV System. System description are as follows:

- a. System capacity (DC): 2.0–2.2 kWp (oversizing recommended for better inverter loading)
- b. Configuration: Grid-tied (net-meter ready) with option to upgrade to hybrid (battery-ready)
- c. Primary goal: Reduce grid consumption and electricity bills and enable hot-water preheat synergy with existing SWH; provide clean power.
- d. Roof type: RCC flat slab or south facing slope with clear area available ~12–14 m² (shade-free 9 AM–3 PM).
- e. Electrical service: Single-phase, 230 V, 50 Hz.
- f. Array tilt: 20–30° (fixed), south-facing (±15° acceptable).
- g. Wind/structural: Mounting rated for local wind speeds; anchors to RCC with stainless steel fasteners; maintain roof waterproofing.
- h. Modules: 4 × 550 Wp mono-PERC, half-cut
- i. Array size: 2.2 kWp
- j. Typical module specs (per panel):
 - i. Dimensions: ~2278 × 1134 mm (≈2.6 m²)
 - ii. Weight: 28–32 kg
 - iii. $V_{mp} \approx 41\text{--}42\text{ V}$, $I_{mp} \approx 13\text{ A}$; $V_{oc} \approx 49\text{--}50\text{ V}$
- k. Stringing: 1 series string of 4 (1S4P)

- i. String V_{mp} : ~165–168 V
- ii. String V_{oc} (25 °C): ~196–200 V (verify max at lowest temp; stays well below typical inverter limits)

5.1.1. Inverter and DC/AC Ratio

For this system, a 2.0–3.0 kW single-phase string inverter is recommended, with preference for models that have dual MPPT inputs to allow flexibility and future expansion. When paired with a 2.2 kWp array, the inverter can be sized at 2.0 kW, which gives a DC/AC ratio of about 1.1, or alternatively with a 2.5 kW inverter, yielding a ratio of 0.88. Both configurations fall within acceptable performance ranges. The inverter should operate with a wide MPPT voltage range of approximately 120–500 V, comfortably accommodating both stringing options of 4×550 Wp or 5×400 Wp modules. High efficiency levels are expected, with at least 97% Euro efficiency and 98% peak efficiency. Integrated protections such as DC reverse polarity, ground fault monitoring, anti-islanding, and arc fault circuit interruption (AFCI, if available) are crucial to ensure safety and compliance with modern standards.

5.1.2. Balance of System

The system will use galvanized steel or aluminum mounting structures at 20–30° tilt. DC cables (4–6 mm², UV-resistant) and AC cables (2.5–4 mm²) ensure safe power flow with voltage drops below 1.5%. Safety equipment includes DC isolators, surge protection, AC MCBs, RCCBs, and proper earthing with resistance below 5 Ω. A Wi-Fi monitoring system and safety labels will also be provided.

5.1.3. Expected Energy Yield

The 2.0–2.2 kWp system is expected to produce 8.5–11 kWh/day or 3,100–4,000 kWh annually, depending on site conditions. The performance ratio will be around 0.75–0.82, enough to offset a major part of household daytime use.

5.1.4. Structural and Loading Notes

The array load is about 20–23 kg/m², adding ~220–250 kg over 11 m². The RCC roof can support this easily when anchored with stainless fasteners. A 0.6 m service gap will be kept, and shading from tanks or parapets will be avoided.

5.1.5. Technical Compliance

Standards (typical): IEC 61215/61730 (modules), IEC 62109 (inverter safety), IEC 61683 (inverter efficiency), IEC 60364-7-712 (PV

installations), IEC 62305 (lightning), local utility interconnection rules (net-metering/anti-islanding).

5.2. Typology 4 and 5- Description and Proposed PV System Design

- a. System capacity (DC): 3.0–3.3 kWp (slight oversizing recommended for better inverter performance)
- b. Configuration: Grid-tied (net-meter ready) with option to upgrade to hybrid (battery-ready)
- c. Primary goal: Reduce grid electricity consumption and bills, support clean energy generation, and allow future integration with battery storage for backup.
- d. Roof type: RCC flat slab or south-facing slope with clear area available ~16–18 m² (shade-free 9 AM–3 PM).
- e. Electrical service: Single-phase, 230 V, 50 Hz.
- f. Array tilt: 20–30° fixed, oriented due south ($\pm 15^\circ$ acceptable).
- g. Wind/structural: Mounting designed for local wind speeds, with RCC anchoring using stainless steel fasteners and roof waterproofing maintained.
- h. Modules: 6 × 550 Wp mono-PERC, half-cut type
- i. Array size: 3.3 kWp
- j. Typical module specs (per panel):
 - i. Dimensions: ~2278 × 1134 mm (≈ 2.6 m²)
 - ii. Weight: 28–32 kg
 - iii. $V_{mp} \approx 41$ –42 V, $I_{mp} \approx 13$ A; $V_{oc} \approx 49$ –50 V
- k. Stringing: 1 series string of 6 (1S6P)
 - i. String V_{mp} : ~247–252 V
 - ii. String V_{oc} (25 °C): ~294–300 V (verify max at lowest temp; within inverter limits)

5.2.1. Inverter and DC/AC Ratio

For a 3.3 kWp system, a 3.0–3.5 kW single-phase string inverter is recommended. A 3.0 kW inverter gives a DC/AC ratio of about 1.1, while a 3.5 kW inverter lowers it to 0.94, both acceptable for stable operation. The inverter should have a wide MPPT range of 120–500 V, which comfortably accommodates the 6-module series string. Efficiency should be at least 97% Euro and 98% peak, with protections such as DC reverse polarity, ground fault monitoring, anti-islanding, and AFCI (if available) to meet safety and utility requirements.

5.2.2. Balance of System

The mounting system will use galvanized steel or aluminum structures tilted 20–30°, fixed securely to the RCC slab. DC cables (4–6 mm² UV-resistant) and AC cables (4 mm²) will be installed to keep voltage drop below 1.5%. Key protections include DC isolators, DC SPDs, AC MCBs, AC SPDs, and

RCCBs. Proper earthing with resistance below 5 Ω will be ensured, bonding the array, inverter, and building ground together. The system will also include Wi-Fi-based monitoring for performance tracking and fault alerts.

5.2.3. Expected Energy Yield

The 3.0–3.3 kWp system is expected to generate 12.5–16.5 kWh/day under good site conditions, translating to an annual output of 4,600–6,000 kWh. The performance ratio will remain in the range of 0.75–0.82, enabling the system to cover a substantial portion of a household’s electricity needs, particularly during daytime.

5.2.4. Structural and Loading Notes

The array imposes a distributed load of about 20–23 kg/m². Over an area of ~16 m², the total added weight is 320–360 kg, which is easily supported by a typical RCC roof. Mounting structures will be anchored with stainless steel fasteners to resist wind uplift. A 0.6 m maintenance gap will be kept, and careful placement will avoid shading from parapets, tanks, or nearby obstructions.

5.2.5. Technical Compliance

The system will comply with international and local standards, including IEC 61215/61730 (modules), IEC 62109 (inverter safety), IEC 61683 (inverter efficiency), IEC 60364-7-712 (PV installations), and IEC 62305 (lightning protection). Interconnection will follow local utility regulations for grid-tied net-metering and anti-islanding.

5.3. Comparative Analysis of 2kWp and 3kWp PV System

Parameter	2 kWp System	3 kWp System
System Capacity (DC)	2.0–2.2 kWp	3.0–3.3 kWp
Configuration	Grid-tied, net-meter ready; hybrid (battery) optional	Grid-tied, net-meter ready; hybrid (battery) optional
Roof Area Required (existing building roof can be used)	~12–14 m ²	~16–18 m ²
Electrical Service	Single-phase, 230 V, 50 Hz	Single-phase, 230 V, 50 Hz
Array Tilt & Orientation	20–30°, south-facing ($\pm 15^\circ$)	20–30°, south-facing ($\pm 15^\circ$)
Modules	4 × 550 Wp mono-PERC	6 × 550 Wp mono-PERC
Total Array Size	2.2 kWp	3.3 kWp
Module Specs (each)	~2278 × 1134 mm, 28–32 kg, Vmp 41–42 V, Voc 49–50 V	Same as 2 kWp

Stringing	1S4P (4 modules in series)	1S6P (6 modules in series)
String Voltage (Vmp/Voc)	Vmp ~165–168 V, Voc ~196–200 V	Vmp ~247–252 V, Voc ~294–300 V
Recommended Inverter	2.0–2.5 kW single-phase, dual MPPT	3.0–3.5 kW single-phase, dual MPPT
DC/AC Ratio	1.1 (with 2 kW inverter) or 0.88 (with 2.5 kW inverter)	1.1 (with 3 kW inverter) or 0.94 (with 3.5 kW inverter)
Efficiency (Inverter)	≥97% Euro, ≥98% peak	≥97% Euro, ≥98% peak
Balance of System	Galvanized/aluminum mounting, 4–6 mm ² DC cables, 2.5–4 mm ² AC cables, DC & AC isolators, SPDs, RCCB, Wi-Fi monitoring	Same as 2 kWp, with AC cables ~4 mm ²
Earthing Requirement	<5 Ω, copper/aluminum bonding of PV, inverter & building	Same as 2 kWp
Structural Load	~20–23 kg/m ² (≈220–250 kg total)	~20–23 kg/m ² (≈320–360 kg total)
Expected Generation (Daily)	8.5–11 kWh/day	12.5–16.5 kWh/day
Expected Generation (Annual)	3,100–4,000 kWh	4,600–6,000 kWh
Performance Ratio (PR)	0.75–0.82	0.75–0.82
Compliance Standards	IEC 61215/61730, IEC 62109, IEC 61683, IEC 60364-7-712, IEC 62305, local net-metering rules	Same as 2 kWp
No of Beneficiary Houses	42	20

6. IMPLEMENTATION PLAN

The successful implementation of the solar PV and SWH systems in Kerung Village requires careful planning and a structured approach. This section outlines the methodology, timeline, resources, and risk mitigation strategies to ensure efficient and safe installation of all systems.

6.1. Installation Methodology

The installation process will be carried out in a phased and systematic manner to ensure quality and safety:

- i. **Site Preparation and Assessment:** Conduct detailed inspection of roofs and structures, ensuring they can safely support PV panels and SWH collectors. Identify optimal panel and collector placement to avoid shading.
- ii. **SWH Installation:** Install 62 solar water heating units (20-tube collectors with 200 L tanks) on suitable roof locations, ensuring proper tilt and orientation for maximum solar exposure. Insulated piping, safety valves, and tanks will be securely installed.
- iii. **Solar PV Installation:**
 - Install 42 units of 2 kWp PV systems on smaller households (T1–T3) based on energy demand.
 - Install 20 units of 3 kWp PV systems on larger households (T4–T5) to meet higher electricity requirements.

PV panels will be mounted on reinforced roof structures with proper tilt (25–35°) and orientation, ensuring secure wiring, grounding, and inverter/battery placement.
- iv. **System Integration and Testing:** Connect PV and SWH systems, check performance, and ensure proper functioning. Conduct load testing and temperature verification for hot water.
- v. **Training and Handover:** Provide community training on routine maintenance, basic troubleshooting, and safe operation of PV and SWH systems.

6.2. Timeline and Phasing

Once the funding gets approved, The project will be implemented over an estimated 28-week period, divided into the following phases:

Phase	Activities	Duration
Phase 1	Site assessment, structural verification, logistics preparation	4 weeks
Phase 2	Installation of SWH units (all 62 households)	8 weeks
Phase 3	Installation of PV systems (42 × 2 kWp + 20 × 3 kWp)	8 weeks
Phase 4	System integration, testing, and commissioning	4 weeks
Phase 5	Community training, handover, and documentation	4 week

6.3. Risk Identification and Mitigation

Several risks are anticipated due to the remote location and high-altitude terrain. Key risks and mitigation measures include:

- i. **Weather Delays:** Plan installation during favorable weather months; maintain buffer in timeline.

- ii. Structural Constraints: Conduct detailed roof inspections and reinforce structures where needed.
- iii. Transportation Challenges: Use local labor and pack equipment in smaller loads suitable for hilly terrain.
- iv. System Malfunction: Procure high-quality components; perform thorough testing before handover.
- v. Community Engagement: Conduct awareness sessions to ensure proper operation and maintenance of systems post-installation.

Through careful planning, phased execution, and risk mitigation, this implementation plan ensures that all 62 SWH units, 42 × 2 kWp PV systems, and 20 × 3 kWp PV systems are installed efficiently, safely, and sustainably, providing long-term benefits to the Kerung Village community in Solukhumbu.

7. Financial Proposal and Cost Estimate

The financial proposal outlines the estimated costs for the installation of 62 solar water heating (SWH) units, 42 × 2 kWp PV systems, and 20 × 3 kWp PV systems in Merangdi Village. It provides a detailed breakdown by housing typology, system components, logistics, and overall project cost, along with a preliminary cost-benefit analysis.

7.1. Cost Estimate for Separate Sanitary Block (for single unit)

SN	Description of Works	Qt	Rate (NRs)	Amount (NRs)	Amount (Euro)
1	Site clearing and Excavation	1	50000.00	50000.00	
2	Construction of Stone Masonry Building (foundation and structure)	120 sq ft	3000.00 per sq ft	3,60,000.00	
3	RCC Slab	120 sq ft	1500.00 per sq ft	1,80,000.00	
4	Finishing (Plastering, flooring and fixtures)	120 sq ft	1000.00 per sq ft	1,20,000.00	
Total				7,10,000.00	
Electrical works 5% of Total				35,500.00	
Sanitary Works 10% of Total				71,000.00	
Total (A)				8,16,500.00	€ 4,966.77

7.2. Cost Estimate for SWH unit

SN	Description of Works	Qt	Rate (NRs)	Amount (NRs)	Amount (Euro)
1	20 Tube 200 litre SWH	1 set	65,000.00	65,000.00	€ 396.5
2	Delivery Charges from Kathmandu to Solukhumbu	1set	7,000.00	7,000.00	€ 42.7
3	Fitting Charges	1 set	14,000.00	14,000.00	€ 85.4
Total (B)				86,000.00	€ 524.6

7.3. Cost Estimate for 2kWp Solar PV System

SN	Description of Works	Qt	Rate (NRs)	Amount (NRs)	Amount (Euro)
1	6×350W monocrystalline panels (total 2.1 kWp)	1 set	180000	180000	€1098
2	Inverter: 1 × 2 kW hybrid inverter (supports both solar and battery)	1set	50000	50000	€305
3	Batteries: 2 × 12V 200Ah deep-cycle gel batteries	1 set	60000	60000	€366
4	Charge Controller: 1 × MPPT charge controller	1 set	15000	15000	€91.5
5	Mounting Structure: Aluminum frame for rooftop installation		10000	10000	€61
5	Cabling & Accessories: MC4 connectors, fuses, cables, and junction boxes	1 set	10000	10000	€61
6	Transportation	1 set	8000	8000	€48.8
7	Installation	1 set	14000	14000	€85.4
Total (C1)				3,47,000.00	€ 2116.7

7.4. Cost Estimate for 3kWp Solar PV System

SN	Description of Works	Qt	Rate (NRs)	Amount (NRs)	Amount (Euro)
1	6×500W monocrystalline panels (total 3.0 kWp)	1 set	378000	378000	2305.8
2	Inverter: 1 × 3 kW hybrid inverter (supports both solar and battery)	1set	50000	50000	305
3	Batteries: 2 × 12V 250Ah deep-cycle gel batteries	1 set	120000	120000	732
4	Charge Controller: 1 × MPPT charge controller	1 set	15000	15000	91.5
5	Mounting Structure: Aluminum frame for rooftop installation		10000	10000	61
5	Cabling & Accessories: MC4 connectors, fuses, cables, and junction boxes	1 set	10000	10000	61
6	Transportation	1 set	8000	8000	48.8

7	Installation	1 set	14000	14000	85.4
Total (C2)				605000.00	€ 3690.5

7.5.Total cost per typologies (in NRs)

SN	Cost heading	T1	T2	T3	T4	T5
1	Sanitary Block	816500	816500	816500	816500	816500
2	SWH Unit	86000	86000	86000	86000	86000
3	Solar PV Unit	347000	347000	347000	605000	605000
D	Sub-Total per unit (D)	1249500	1249500	1249500	1507500	1507500
	No of Units	11	22	9	8	12
E	Sub-Total per Typology E	13744500	27489000	11245500	12060000	18090000
F	Contingencies & workcharge establishment 4% of E	549780	1099560	449820	482400	723600
G	Physical Contingencies 10% of E	1374450	2748900	1124550	1206000	1809000
H	SUM with Contingency (E+F+G)	15668730	31337460	12819870	13748400	20622600
I	VAT 13% OF E	1786785	3573570	1461915	1567800	2351700
	GRAND TOTAL PER TYPOLOGY (H + I)	17455515	34911030	14281785	15316200	22974300

7.6.Total Cost per Typology in Euro (for 1 Nrs = € 0.0061)

SN	Cost heading	T1	T2	T3	T4	T5
1	Sanitary Block	4980.65	4980.65	4980.65	4980.65	4980.65
2	SWH Unit	524.60	524.60	524.60	524.60	524.60
3	Solar PV Unit	2116.70	2116.70	2116.70	3690.50	3690.50
D	Sub-Total per unit (D)	7621.95	7621.95	7621.95	9195.75	9195.75
	No of Units	11.00	22.00	9.00	8.00	12.00
E	Sub-Total per Typology E	83841.45	167682.90	68597.55	73566.00	110349.00
F	Contingencies & workcharge establishment 4% of E	3353.66	6707.32	2743.90	2942.64	4413.96
G	Physical Contingencies 10% of E	8384.15	16768.29	6859.76	7356.60	11034.90
H	SUM with Contingency (E+F+G)	95579.25	191158.51	78201.21	83865.24	125797.86

I	VAT 13% OF E	10899.39	21798.78	8917.68	9563.58	14345.37
	GRAND TOTAL PER TYPOLOGY (H + I)	€106478.64	€212957.28	€87118.89	€93428.82	€140143.23

7.7.Total Project Cost

SN	Typology	Cost in NRs	Cost in Euro
1	T1	1,74,55,515.00	€106,478.64
2	T2	3,49,11,030.00	€212,957.28
3	T3	1,42,81,785.00	€87,118.89
4	T4	1,53,16,200.00	€93,428.82
5	T5	2,29,74,300.00	€140,143.23
Total Project Cost		10,49,38,830.00	€640,126.86

The total project is estimated to be ten crore forty nine lakhs thirty eight thousand eight hundred and thirty Nepali rupees which is equivalent to six hundred and forty thousand one hundred twenty six euro and eighty six cents only.

7.8.Consulting and Report Preparation Charges

SN	Description of Works	Cost in NRs	Cost in Euro
1	Data Review and Analysis (secondary data from Solar Shower Help Nepal)	100,000.00	€ 609.10
2	System Design & Technical Drawings	80,000.00	€ 487.28
3	Report Writing, Editing & Documentation	50,000.00	€ 304.55
4	Communication, Printing & Miscellaneous	30,000.00	€ 182.73
Sub-Total		2,80,000.00	€ 1705.47
VAT 13%		36,400.00	€ 221.71
Total Consulting Fee		3,16,400.00	€ 1927.18

8. ENVIRONMENTAL AND SOCIAL IMPACT

The installation of solar PV systems and solar water heating (SWH) units in Merangdi Village will have significant environmental and social benefits. The project not only promotes clean energy adoption but also improves the overall quality of life for the community.

8.1.Environmental Benefits

The proposed solar systems will substantially reduce the community's dependence on traditional fuels, particularly firewood and kerosene, which are major sources of indoor air pollution and deforestation. By replacing these fuels with solar energy,

the project will reduce greenhouse gas (GHG) emissions, contributing to climate change mitigation. Additionally, less reliance on firewood helps preserve local forests, improves soil stability, and maintains biodiversity in the Solukhumbu region. Over the lifespan of the systems (15–20 years), the cumulative reduction in CO₂ emissions is expected to be significant, supporting Nepal’s national renewable energy and sustainability goals.

8.2.Social Benefits

The project will have a direct positive impact on health, education, and social development:

- i. **Health:** Reduced indoor smoke from firewood use lowers respiratory problems and other health risks, particularly among women and children.
- ii. **Education:** Reliable electricity enables evening study and access to digital resources, improving learning outcomes for children.
- iii. **Women Empowerment:** Reduced time spent on fuel collection allows women to engage in productive activities, education, and community development.
- iv. **Quality of Life:** Consistent access to hot water improves hygiene and sanitation, supporting better overall health and comfort for households.

8.3.Community Participation and Ownership

Active involvement of the community is critical for the long-term sustainability of the project. Local residents will be trained in basic operation and maintenance of PV and SWH systems, ensuring they have the knowledge and skills to manage the systems effectively. The project will encourage community ownership, fostering responsibility and pride in maintaining the installed systems. Additionally, local labor will be employed during installation, providing temporary employment and enhancing skill development in renewable energy technologies.

9. Conclusion and Way Forward

The proposed installation of 62 solar water heating units and 62 solar photovoltaic (PV) systems in Kerung (Local Name: Merangdi) Village, Solukhumbu District, represents a transformative initiative to enhance energy access, improve living conditions, and promote environmental sustainability. By adopting renewable energy solutions, the project addresses key challenges faced by the community, including limited electricity access, high dependence on firewood, and associated health and environmental risks.

The technical solutions recommended in this proposal—including 2 kWp and 3 kWp PV systems and 20-tube, 200-liter SWH units—are tailored to the specific needs and housing typologies of the 62 households. These systems are designed for reliable performance, minimal maintenance, and long-term sustainability, ensuring that the community benefits for many years.

Way Forward:

- i. **Phased Implementation:** Begin with detailed site preparation, followed by the installation of SWH units and PV systems in a structured, phased approach.
- ii. **Capacity Building:** Conduct training sessions for residents to ensure proper operation, maintenance, and ownership of the systems.
- iii. **Monitoring and Evaluation:** Establish a framework to monitor system performance, troubleshoot issues, and ensure the longevity of installations.
- iv. **Community Engagement:** Continue active participation of local stakeholders to foster responsibility, skill development, and sustainability.

By combining technological solutions with community involvement and environmental stewardship, this project sets a precedent for sustainable rural energy development in Solukhumbu District. With effective implementation, it will improve the quality of life, health, and socio-economic opportunities for residents, while contributing to Nepal's broader goals of renewable energy adoption and climate resilience.

The image shows a handwritten signature in blue ink that reads "Ar. Utsav". To the right of the signature is the logo for "BRICK INTERNATIONAL". The word "BRICK" is in a large, bold, blue, sans-serif font, and "INTERNATIONAL" is in a smaller, blue, sans-serif font below it.

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ANNEX