



# Techno-Economic Feasibility Study of Net-metering Implementation in Rooftop Solar PV in Nepal

Hardik Pokhrel

*WindPower Nepal, Lalitpur, Nepal*

Corresponding E-mail: pokhrel.hardik27@gmail.com

## **Abstract:**

While a plethora of new hydro generation capacity are, being constructed, other forms of energy like solar is still undeveloped in Nepal. As of May 2018, the total installed capacity of Nepal stands at 1060 MW, among which mere 0.68 MW (0.06%) is solar. Solar Rooftop holds potential for development of solar and recognizing this, AEPC had urban solar program with capital subsidy element. In addition, NEA announced Alternative Electricity Connected to Grid 2018, with Feed in Tariff of NRs 7.30 for 3 years paving way for net metering in solar rooftop. This paper discusses the techno-economic feasibility of solar net metering across domestic (both individual and high-rise apartments), commercial and institutional consumers with the FiT offered. The analysis is done in both scenarios; where there is no export to grid and where there is export to the grid possible. Sample data on LCOE and kWh demand for each segment are collected and system size and solar production is calculated using Helioscope. Along with this, rate of return and payback years is calculated with current benchmark pricing and industry wide assumptions. The results of these analyses show higher payback period (6-9 years) and unattractive return (<15%) in the BOOT model for rooftops. Even in segments like high-rise apartments and commercial consumers with minimum 500 kW size where returns are higher (>20%), limitations as rooftop space makes net metering an un-attractive proposition. This paper also provides current policy landscape and envisages addressing policy gaps, and learnings from international arena on success of net-metering including financial incentives and regulations provided to drive the net-metering growth in Nepal.

**Keywords:** Solar, Net-metering, Distributed Grid Integrated System, Feed-in Tariff, Renewable Energy

## **1 Introduction**

Despite a huge resource potential for energy, Nepal as a country has continued to face energy deficit and has a strong dependence on traditional forms of energy. The per capita annual electricity consumption in Nepal stood at 140 kWh in 2015 and projected to reach only 270 kWh in 2020 [1]. The situation is certainly improving for the grid areas since the load shedding is over. However, this was only possible because of energy import of 2,581.80 GWh from India in 2018 alone. This number increased by 18.7% from 2,175.04 GWh compared to 2017 [2]. This import worth 19 billion rupees last year itself is certainly putting a burden on our country economy. Also, as per the GoN's new vision for the economic development target with 7.2 % GDP growth, a large national demand for electricity (approximately 18 GW peak) can be expected by the year 2040 [1].

Similarly, another concern is Nepal's overly dependence in a single source of power. As of May 2018, the total installed capacity of Nepal is 1060.78 MW, among which hydropower contributes 1006.78 MW power, 53.4 MW by Multi-fuel and a mere 0.6 MW by solar power

[3]. Given the concerns regarding the seismic nature of Nepal and frequent disaster, there is a need for energy portfolio diversification into other sources, which will eventually work as a complementary source to hydropower. Solar PV plants have less than 5 percent of civil structures, making these systems less vulnerable to natural disaster [4].

This is a concern shared by other countries with a very similar energy portfolio like Brazil where in 2011, 81% of the total energy was sourced from Hydropower, but have increased their focus on achieving a generation mix and is in a path where only 62% will be from Hydropower in 2035 with increased share in Wind and Solar [4]. Hence, Nepal also needs to explore increasing their share of Solar.

Recognizing this, Nepal Electricity Authority came up with the 7.30 Feed in Tariff for Grid Connected Solar plant and as of August 2018, 22 MW was already in post- PPA stage while more than additional 50 MW in the pipeline to hook up in the national grid. While this is certainly a directional improvement, the land use pattern of Nepal along with transmission constraints limits the development of utility scale solar. About 29% of the land

are agricultural use while about 26% is forest cover [5]. Therefore, development of utility scale solar plant poses these challenges.

Hence, it is imperative that we move to a decentralized system of energy. Solar rooftops with net-metering provision provides a win-win solution, where the energy is generated and consumed locally as fed into the grid when not in use. Since, the system uses the grid as a form of storage, the cost of solar rooftop with net metering is lower compared to stand alone systems.

This paper discusses the technical feasibility and financial viability of installing solar rooftop net metering in Nepal.

## **2 Status of Solar Rooftop and Net-metering**

Global solar investments topped US\$160.8 billion in 2017, an 18% increase over the previous year, despite capital costs declining around 25% [6]. Similarly, the global solar market installed 98.9 GW of new capacity in 2017 [7], increasing by 29.3%, in comparison to the 76.5 gigawatts (GW) and 49% recorded in 2016. While this solar revolution is happening all over the globe, leading this exponential growth are our neighbours – India and China. China and India together accounted for 63% of total solar demand in 2017 [7]. Even in the case of Rooftop PV, in China, rooftop solar installation is expected to surge to 24 gigawatts in 2018 [8] and in India, 715 MW Rooftop PV was installed in FY 2017 with a 117% growth rate since April 2013 [8].

However, Nepal has not been able to replicate the solar revolution happening globally. While there are no official figures on total installed capacity of solar rooftop, there is a rough estimate that Kathmandu has 20MW to 30 MW of solar rooftop installed. Owners installed the system during the energy crisis that are now stranded. Even in the case of net metering, there has not been mainstream adoption of the system and has been limited to few pilots in a few areas like CIAA office (514 kWp), ICIMOD (92 kWp) and a few others handful areas.

From Nepal Electricity Authority perspective, in 2018, as has been in the past, the domestic consumer category with 3.33 million consumers remained the largest category with 93.83% share of the entire electricity consumers [2]. Domestic and Industrial consumer category contributed 43.50 % and 37.53 % to the gross electricity sales revenue respectively [2]. Hence, development of solar rooftop in these two sections of

consumers will hold a key to growth of the solar rooftop and through net metering contribute towards energy independence in the entire country.

### **2.1 Business Model for Solar Rooftop Installations**

(a) Owned by the customer (CAPEX model): The rooftop owner owns the solar PV system generates electricity for self-consumption. The surplus electricity is sold to the grid through net metering. Alternatively, system can also be built for total grid export under gross metering. (b) Third party owned (RESCO model) with Rooftop leasing: In this model, a developer leases the roof from the property owner and pays a rooftop lease. Electricity generated is sold to the grid at the feed-in-tariff determined by the regulator. The ownership of the system lies with the developer. (c) Third party owned (RESCO) with solar power purchase agreement: Rooftop owner signs a PPA with a third-party developer and enters a net metering arrangement with the utility. The ownership of the system lies with the developer. The major benefit is no upfront capital burden to the consumer [9].

### **2.2 Policy snapshot of solar net metering in Nepal**

The policy landscape of solar rooftop net metering in Nepal is at a nascent stage and is conflicting in nature. The Ministry of Energy has declared the decade 2016-2026 as the National Energy Crisis Reduction and Electricity Development Decade. In this regard, the MOF has issued a Concept Paper on Elimination of Energy Emergency and Electricity Development Decade, 2015 (2072) to ensure energy security within the next decade [10]. In June 2015, Alternate Energy Promotion Centre (AEPC) stated that net metering will be done in 2 phases. In first phase, objective is to replace/reduce existing charging source from NEA to solar and in the second phase, sell excess energy to national grid at an agreed tariff rate [11]. With this foundation, a capital subsidy of Nrs.20,000 for greater than 200 Wp for domestic and greater than 1500 Wp for Commercial was provided under “Urban Solar Programme”. An additional Subsidy in interest was also in the program, a 75% for Domestic and 50% for commercial at 9% interest rate. Based on the circular by AEPC dated March 2018 the subsidy has been discontinued citing overflow of applications.

On February 8, 2018, Ministry of Energy launched “Guidelines for Alternative Electricity Connected to Grid 2018”. The features of the guidelines were (a) Only 15%

of the capacity can be contracted for buy-out by the NEA (b) The agreed feed-in tariff rate for excess rate is NRs 7.30 for next 3 years (c) Classification of Classification of consumers provided (i) Domestic : 500 W to 10 KW (ii) Institutional:>10 KW (iii) Commercial: > 500 KW.

However, Nepal Electricity Authority floated a circular dated July 1st, 2018 contradicted MoE's guidelines stating that no net payment from NEA to the consumer will be done if more energy is fed in the grid than consumed. In addition, the solar energy will not exceed 90% of the annual energy consumed by the consumer through the national grid.

### 2.3 Building standards

Building design plays an essential role in the feasibility of solar rooftops. Since all the buildings in urban areas are not suitable for rooftop solar PV system installation due to the shadows from the surrounding buildings, it is crucial to evaluate and determine which building is suitable for rooftop solar PV system installation (i.e., rooftop solar PV suitability) within certain urban boundaries. Nepal's National Building Code (NBC) formulated back in 1994 [12] had no mention of the word. The standard guidelines developed in 2015 post-earthquake discussed solar power [13] (esp. on health and public guidelines) briefly but focused more on the solar water heater. However, National Reconstruction Authority (NRA) as a part of Earthquake Housing Reconstruction Project (EHRP) provided additional NRs 25,000 [14] as part of housing grant to promote sanitations and renewable energy. In addition, the regulation developed by the Ministry of Federal Affairs and Local Development in December, 2015, mandated all commercial, institution and private houses with plots larger than 3422.5 sq ft and roofs larger than 2,500 sq ft to install solar power plant to generate 25% of their total energy requirement. [15] However, the implementation of this regulation has not been effective partly because homeowners do not return to receive completion certificate and in this post load-shedding era, the authorities have not focused in its strict implementation.

## 3 Methodology

The overall intent of this study is to help ascertain viability of solar rooftop systems with net metering provision and activities carried out included the following: (a) Primary data collection the current electricity consumption and charge paid per annum to account for seasonal variation. (b) Design of potential

rooftop size based on the observations on available rooftop area, optimum placement of solar panels and shading analysis assessment using Helioscope Tool and corroborating the solar yield data from PVGIS. (c) Mapping existing policy schemes and building design norms along for implementation of solar rooftop systems through secondary research and consultation with NEA officials and solar vendors (d) sensitivity analysis for techno-commercial assessment for various scenarios like net payment facility and across various segments of consumers. Based on the data on grid tariffs and guidelines on grid connected solar along with ground level data on electricity consumption, a detailed financial modelling for each site is carried out. For each case, IRR and payback period is derived to assess the viability and attractiveness of the solar rooftop implementation option.

## 4 Analysis and Results

As discussed in the method, a technical assessment using the Helioscope tool for three different areas in Kathmandu city was done to calculate solar output; similarly, PVGIS tool was also used to cross verify the data and a conservative output out of them were considered. Similarly, a financial analysis was done for five different consumer segments to make a broader point on them.

### 4.1 Technical Analysis

Solar Resource Assessment (SRA) refers to the analysis of a prospective solar energy production site with the end goal being an accurate estimate of that facility's annual energy production (AEP). The main goal of Solar Resource Assessment in reference to site-specific measurement is to collect "ground truth" meteorological data for lowering the uncertainty of the Annual Energy Production. During design of solar system, optimized Slope angle is calculated at 31 degrees and DC to AC ratio is kept at 1.25.

#### 4.1.1 Shading Analysis

Detailed analysis of any shading of the system will give reasonable estimates of the available solar irradiation for that site and therefore, the reduction in expected energy.

A detailed shading analysis is done for an optimized PV output providing actual on-ground conditions.

**Table 1: Shading Analysis for Solar Rooftop**

PV Output	4.14	4.28	4.56

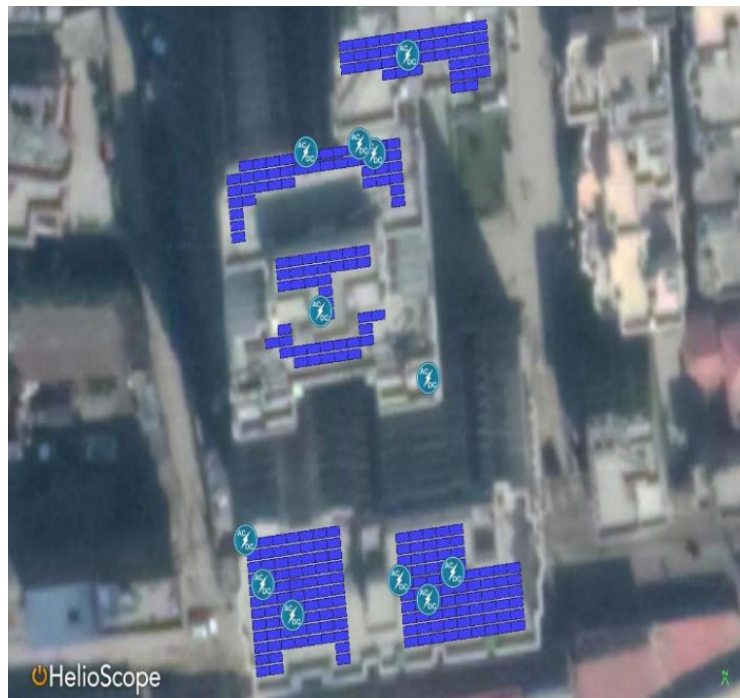


Figure 1: HeliScope tool showing overview of Solar Rooftop

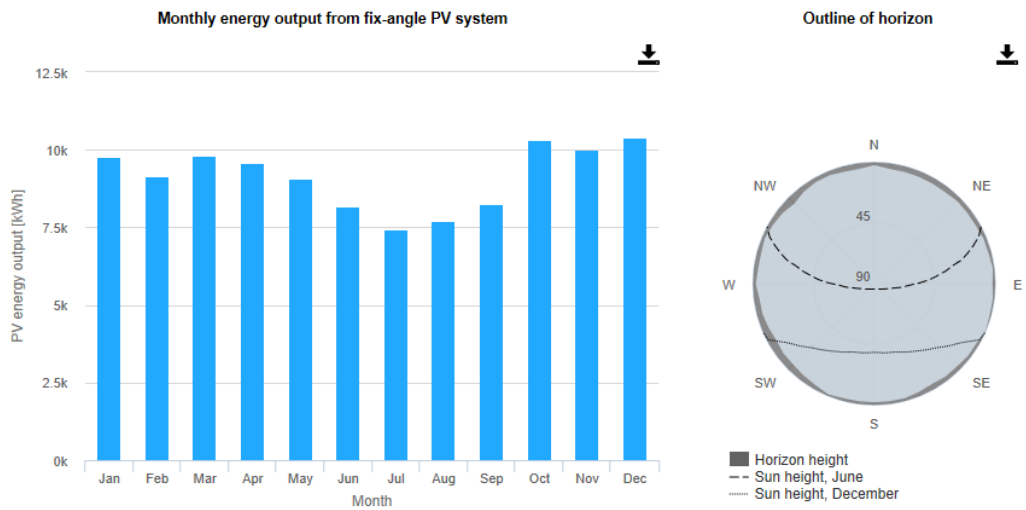


Figure 2: PVGIS showing result of the analysis on PV output





Figure 3: Shading Analysis for Solar Rooftop

### 4.2 Financial Analysis

The cost and the assumptions considered for the analysis are as follows:

Table 2: Capital Expenditure of Solar PV

Components	NRs/Wp
Solar Module (Trina/250 Wp)	60.0
Inverter	28.0
Structure and components	9.0
Cable, Junction boxes, Electrical accessories, etc.	2.4
Protection Equipment	0.9
Civil and Electrical Work	6.0
<b>Total</b>	<b>106.3</b>

Given all three sites are in the Kathmandu city, due to local conditions like temperatures and other losses, a slight variation in the solar yield results in the LCOE (Levelized cost of electricity) of ~NRs 0.9/kWh as shown in Figure 4. Hence, in order to make a broad view of these individual sites to an entire segment of consumers and to have a standardization of analysis across segments, we take 4.14 as a solar yield and a LCOE of NRs 10.03/kWh. This is done because feasibility needs to be assessed at the lowest condition set and not limited by geographies or local conditions.

Consumers that pay very low tariff like the Rural industry, irrigation, Water Supply and temple are not considered analysis since given their low grid tariff (as low as NPR 4.3), as solar can't compete to that rate. On the other hand, while there are consumers that pay one of the highest tariffs the entertainment segment (Cinema

Hall, Fun Park, Theatre) or temporary supply, as discussed in Section 2, their contribution on a macro scale is very low, hence not considered in the analysis.

Table 3: Assumptions considered for analysis

Components	Value
Solar Output and Size	Based on actual simulation PVGIS & Helioscope
Inverter Efficiency	97% (Equipment Rating)
Subsidy	0% (As per AEPC circular of March 2018)
Discount Rate	10%
Price escalation in grid tariffs	3%/ annum
Cost escalation in O&M	2%
Life of asset	25 years with Inverter replacement at 8th year
Degradation in production	1.00%/annum
O&M overheads	2% of the capex

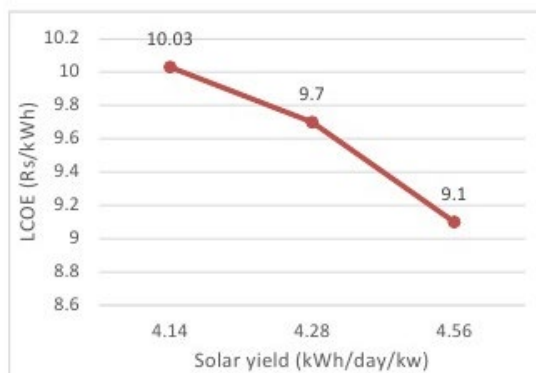


Figure 4: LCOE against solar yield



**Table 4: Nepal Electricity Authority Tariff Rate**

Domestic	Single Phase						Three Phase	
	21-30	31-50	51-150	151-250	251-400	Above 400	Up to 400	Above 400
	7.00	8.50	10.00	11.00	12.00	13.00	12.50	13.50
	Low Voltage (230/400 V)				Medium Voltage (33 kV)			
Commercial	11.20				10.80			
Non-Domestic	13.00				12.55			
Industrial Time (5.00 -17.00)	High Voltage (66 kV or above)			Medium Voltage (33 kV)		Medium Voltage (11 kV)		
	7.50			8.40		8.55		

Based on these data points, Internal Rate of Return (IRR) and Payback period is calculated for the segments in discussion:

**Table 5: Result of Financial Analysis with IRR and Payback**

		No Export to Grid	Export to Grid
Individual	Size	10 kW	10 kW*
	IRR	12.64%	14.00%
	Payback	9 years	8 years
High-Rise	Size	10 kW	10 kW
	IRR	18.15%	19.54%
	Payback	6 years	6 years
Commercial	Size	20 kW	20 kW
	IRR	14.68%	16.05%
	Payback	8	7
Non-domestic	Size	20 kW	20 kW
	IRR	17.41%	18.79%
	Payback	6	6
Industrial	Size	500 kW	500 kW
	IRR	10.4	11.78%
	Payback	10	9 years

\*Assuming demand is 15% less than of the capacity enabling 15% export to the grid

## 5 Discussion on Findings

a) Marginal Solar yield plays an important role in overall feasibility of the solar rooftop. As shown above, a mere 0.28 drop in yield result increases the LCOE by NRs 0.60/unit. Hence, geography is a major factor for feasibility of solar net metering with all parameters constant; causing a system result feasible in Mustang but not in Eastern Terai where irradiation is lower.

- b) In the case of single-phase domestic consumers, solar rooftop metering in Kathmandu area is not attractive for households consuming lower than 150 units monthly consumption given that the analysis is done at a grid tariff at NRs 10/unit, which is charge for 51-150 units slab.
- c) For high-rise apartments that is billed through a blended tariff of grid and backup, solar is feasible, but due to limitation in rooftop area, the overall savings are minimal. Also, in reality since welfare society act as a bulk buyer and sells electricity, the effective tariff paid by consumers will be as high as NRs 16.5/unit for high rises as shown in Figure, but given the limitation of 10 kWp for domestic segment, the system overall becomes unattractive for the owners.
- d) For industrial consumers, space is not an issue, however, TOD tariff is very low during the solar hours and solar cannot compete with that tariff, even though the tariff is higher in non-solar hours, addition of storage of the cost will result in the solar rooftop non- viable.
- e) For commercial consumers, the PV rooftop is attractive, however with the size stipulated to 500 kW, space could be an issue and hence the minimal savings do not act as an incentive for consumers to set up net metering.

S.N.	Particular	Unit/Rate	Amount	Rate
1	Electrical Unit			
	Current Meter Reading			
	Previous Meter Reading			
	8424	182	16.5	3003
2	Fixed Demand Charge by NEA			315
3	Water Supply charge			250
4	Back Up			250
5	Monthly Service Charge	1120	2	2240
6	Previous Pending Due			
7	Additional Expenses			1000
	Dashain Bonus			0
	Grand Total			7058

**Figure 5: Actual bill of a consumer of high-rise apartment showing rate of NRs. 16.5/unit**

- f) For non-domestic consumers that include Embassy, Foreign Mission, INGO, Private Campus, Star Hotel and Shopping Mall, solar rooftop is a very attractive proposition.
- i) The individual consumption for these consumers is calculated at 5.88 MWh per month for the 1364 consumers in Kathmandu alone.
  - ii) As per the revenue received by NEA against the units consumed in FY 2074/75, per unit cost is upwards of NRs 15/kWh. Hence, consumers are paying much more than the tariff and demand charges stipulated by NEA.

## 6 Learnings from the international scenario: Case study of India

India can be a good learning benchmark for net-metering policy and execution learnings. Generation based incentive: GBI is an incentive based on units generated by the system. In Delhi, 2.00/kWh of gross solar generated for systems generating minimum 1000 kWh/annum used to be provided and is capped at 1500 kWh per kWp.

**Accelerated Depreciation Benefits:** Currently, 76% of rooftop in India are from Capex model. The reason for such a high share of capex model is due to accelerated depreciation benefit that allowed an investor to claim 80% asset depreciation in the first year of installation. This benefit however is capped at 40% at present.

**Building Mandates:** Haryana Urban Development Authority- All residential building build on 500 Sq. yards and above Minimum of 1 kWp or 5% of the connected load, whichever is higher. In Uttar Pradesh, All such residential building with area 5,000 sq.mt or larger. Solar PV is implemented utilizing at least 25% of the available plinth area.

**Government institution leading the way:** More than 1GW rooftop PV projects were auctioned by various government bodies in the first nine months of 2017. Government institutions prefer signing PPAs under RESCO model as it helps them avoid making upfront investments while receiving the benefits of rooftop PV. Developers also prefer government-owned off-takers as they offer PPA tenors covering the project lifetime carry lower default risk and are less likely to break away from the signed contracts.

**Other incentives:** Most states have exempted banking charges (facility to inject excess energy in the grid which can be claimed later for a fee), wheeling charges (using the discom assets to transfer power

from point of generation to point of use), cross-subsidy charges, electricity duty and other surcharges, thereby incentivizing rooftop projects.

## 7 Conclusion and Recommendation

As discussed, with how parameters stand in terms of guidelines, technical feasibility and financial viability, solar rooftop with net-metering stands feasible only under limited circumstances and for a limited customer segment. Therefore, some recommendations based on this and the learnings discussion are:

- a) **Enabling Net payment:** As it stands currently, there is no provision of customers getting paid from NEA if solar produces more than the customer consume from the grid. As shown in the Table 5, this provision will result in higher rate of return and more interest from the customer to install solar rooftop.
- b) **Innovative financing:** Financing is key in growth of the sector. With innovative financing, other models like RESCO and Rooftop/PV leasing can be explored. Along with this also comes incentives, rather than capital subsidy we could focus on incentive like the GBI and Accelerated Depreciation Benefits.
- c) **More clarity in the process:** There is lack of clarity from the process side and from the policy side from Nepal Electricity Authority. A clarity with Step by step process, documents required, and ease of application will certainly interest more consumers to be part of this.
- d) **Building design mandates:** Relevant authorities can mandate or at least have mechanism in place for buildings over a certain area to source their partial electricity within the compound.
- e) **Lead by government institutions and non-domestic consumers:** As pointed out in 5(f), non-domestic consumers as well as government institution can certainly take a lead on developing solar rooftop and bear the burden of early movers in the sectors. This will allow the market to mature when it reaches other competitive segments.

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