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RESEARCH ARTICLE

POWERING THE MOUNTAINS WITH THE SUN A TECHNO-ECONOMIC CASE STUDY OF ROOFTOP SOLAR FOR A 70-ROOM HILL HOTEL IN MASHOBRA, SHIMLA

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Abstract

Hotels in the Himalayan foothills pay commercial tariffs for grid electricity and run diesel generators when supply fails, yet published proof on rooftop solar for such hotels seldom uses a hotel's own bills. This paper assesses a proposed 200.4 kWp rooftop plant at Welcomhot el by ITC Hotels, Mashobra, Shimla, a hotel of approximately 70 rooms, using 17 months of HPSEBL bills (April 2025 to August 2026), diesel generator records, monthly occupancy and two vendor recomme ndations. In the twelve months that ended in March 2026, the hotel used 562,852 kWh. It was charged for 566,338 kVAh. The average cost was ?7.93 for each kVAh. The amount of energy used each month was closely linked to hotel occupancy. The Pearson correlation was 0.88. The Spearman correlation was 0.85, with 17 months of data. When the hotel was only 14 to 20 per cent full, the energy use was still 60 per cent or more of the average month. The borderline cost of a grid unit is about ?8.15 under the levies printed on the August 2026 bill. The vendor's estimate of 249,000 kWh a year would equal 44% of 2025?26 grid consumption. At the mediated Ekam price of ?66 lakh plus ?9 lakh of other costs, simple payback is 5.6 years if only the energy charge is saved and 4.1 years if duty and cesses are also avoided (8.7 and 5.5 years when discounted at 10%). The generators cost ?29?32 per unit to run, but possible diesel savings are small next to grid conservation and depend on a design decision not yet made. All rupee figures are nominal. The paper lists the items still to be confirmed before purchase.

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Introduction:-

Background:-

In the foothills of the Himalayas, electricity is more than light for a hotel. It also heats the guest rooms and the water. During the cold months, the kitchens, laundry and ventilation systems are powered by electricity. The diesel generators kick in when the main power source is disrupted. That is at a significantly higher cost per unit of energy. In fact, the reliance on energy systems is a fundamental part of how hotel firms work, as research on climate and energy risks in the lodging industry shows (Mota et al., 2024). Energy efficiency is another concern highlighted by

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research on hotel sustainability (Blanco-Moreno et al., 2025).The easiest approach for a hotel to lower the amount of electricity it buys from the grid is to install rooftop photovoltaic (PV) systems. But the real-world examples of this aren?t as good as the hype around it. Most studies on hotels enforcing power conversations discusses the reasons for and barriers to that, in a broad approach (Haider et al., 2026) or look at just one hotel in a particularly favourable position (Barbara et al., 2024). Few of the studies reviewed here combine a hotel's own metered consumption, its actual tariff, its diesel generator records and a live vendor quotation. That combination is what an owner needs before placing a purchase order, and this paper provides it for one property.

The case and the research gap:-

The property under study is Welcomhotel by ITC Hotels, located in Mashobra, Shimla. It is a hotel with around 70 rooms. The hotel is owned by Zed Infrastructure Pvt. Ltd.. Managed by ITC Hotels. It gets its power supply from Himachal Pradesh State Electricity Board Limited, known as HPSEBL. The electricity is provided under a two-part tariff. The hotel has received quotes for a solar plant with a capacity of about 200 kW. The hotel wants to know if the investment in solar power makes sense. It is also interested in finding out the size of the solar plant. Additionally, the hotel is curious about how much of the benefit depends on assumptions that have not yet been confirmed. The literature reviewed in Chapter 2 does not report utility-bill-based economics for a mid-sized, chain-managed hill hotel, and the hotels around this property have no solar installations that could serve as a local reference.

Objectives:-

The study has four objectives:-

1. to describe the hotel's electricity use, tariff, maximum demand and diesel generator operation from 17 months of utility bills and operating records;
2. to test how monthly consumption links to occupancy and what that means for the load when occupancy is low;
3. to evaluate the roof?s capacity, technical limits and vendor proposals, for a rooftop PV plant;
4. to calculate the financial return of the plant based on the given assumptions highlighting diesel savings separately since those depend on a technical choice that has not been made yet.

Scope:-

The paper is a single-site case study supported by a literature review. It uses no survey or interview data. Every number about the hotel comes from its HPSEBL bills (consumption months April 2025 to August 2026), its diesel generator log (April 2025 to September 2026), its occupancy record (April 2025 to September 2026) or the hotel's written brief. Figures for the solar proposals come from the vendors' quotations as communicated to the author. Where a figure is calculated rather than reported, the text says so.

Literature Review:-

Sustainable energy consumption in hotels:-

Hotels offer services 24/7. Their energy needs depend on how many people are staying. The research on sustainability in hospitality has shown that energy performance, usage of resources and managing the environment are main areas of focus (Blanco-Moreno et al. 2025). The situation in mountain or hill places has an additional layer. Mota et al. (2024) studied the influence of climate change on hotels. Noted such regions are very reliant on energy-intensive systems. The expense increases when these systems fail. Service quality falls. So, controlling the energy use at a constant level is crucial not only for the environment but also for seamless functioning.

Solar PV on hotel roofs:-

Haider et al. (2026) explored the determinants of hotel rooftop panel installation. They identified four primary factors that influence the decision: money, technology, the way the hotel is run and government laws. Hotels are being driven to solar by saving money, caring about the environment, obtaining advice, and feeling confident in the solar firms. High upfront expenses, technical limitations, and uncertain or unstable policies are more difficult. The authors also note that few studies have focused on hotels. Barbara et al. (2024) analysed a motel that installed panels and changed to LED lighting. They discovered it saved money and cut pollutants. The findings relied on how much of the solar power the hotel consumed directly, and the cost of electricity in the area. These two elements are the basis of the analysis: self-consumption and the avoided fee. These are discussed in detail below.

Storage. Diesel. Resilience:-
Luo and Cao (2025) proposed a model of a zero-emission hotel building and found that storage combined with energy management enhanced the durability of the facility during power outages. The structure they were looking at was not in the Himalayas, but the essential point still holds. Solar power is only useful during an outage if the system is set up to work when it is needed. Grid-connected standard inverters stop working when the power goes out. The decision to save power from a hotel?s diesel generator during outages has to be considered separately as done in Section 7.4 of this article.

Energy management and monitoring:-
Khatter (2025) states that technology helps to make the hospitality business more environmentally friendly through the use of energy management systems and building technologies, while Yolcu et al. (2025) point out that digitalisation and efficiency are related subjects in research on hotel technology. In a tourist example, Valett et al. (2026) demonstrate that digital energy management can change the decision from focusing on costs to additionally considering carbon and performance. For a hotel with no building management system, the true concern is more limited: whether the existing sub-meters and the inverters' own monitoring offer sufficient data to assess the plant's output, versus the load, which Section 6.4 discusses.

Guests and credibility:-
Singh and Mittal (2026) found that online reviews and how guests feel about practices affect whether they decide to book a green hotel in India. Still, a positive view does not always mean a guest will actually make a booking. Park et al. (2024) say that if green practices are not designed well, they can actually make a guest?s stay less enjoyable. The study by Thongmun and colleagues in 2025 found that when hotels include elements that support sustainability along with messages about it, guests are more inclined to behave in ways that are good for the environment. Another study by Singh and Mishra in 2026 showed that when the people involved with hotels are dedicated to sustainability, the hotel does a good job with sustainability efforts. Taken together, these studies suggest a point: guests are more likely to trust a plant if its energy production is measured and made public.

Solar yield in Himachal Pradesh:-
Vendor claims about generation should be checked against independent data. Sharma and Singh (2026) simulated a 14.82 kWp solar system at twelve district headquarters across Himachal Pradesh. These sites ranged in elevation from 360 meters to 3,025 meters above sea level. They used PVsyst and Meteonorm data to model the system. The results showed that specific yield increased from 1,345 kWh/kWp per year at the lowest elevations to 1,798 kWh/kWp per year at the highest points. That?s 138 more kWh per kWp each year for every 1,000 meters of elevation gained. This study was published outside the five publisher platforms used in the review, so it is included only as a local reference. It is a model of one system design, not a measurement, from an actual hotel solar plant.

Conceptual Framework:-
Two well?known frameworks shape the analysis. I notice that the Technology?Organisation?Environment framework (Tornatzky & Fleischer, 1990) separates the forces that push a firm to adopt a technology into the technology itself, the organisation?s resources and the external environment. The triple bottom line (Elkington, 1997) looks at the outcome by considering environmental and social outcomes. Rogers (2003) diffusion theory points out that adoption is easier when potential adopters can see the innovation working nearby. The hotels around this property have no installations, so the demonstration effect is absent here.Figure 1 applies these ideas to the case. Rooftop generation and metering feed the hotel's energy system. Organisational factors include capital, engineering capacity and management support. Environmental factors include tariffs and levies, utility rules and climate. These factors affect the system. The outcomes that are measured are the cost of electricity, supply resilience and environmental performance.Figure 1. Conceptual framework of the case study: rooftop generation and metering interact with the hotel's energy system, under organisational and environmental influences, to determine the outcomes assessed (adapted from Tornatzky & Fleischer, 1990, and Elkington, 1997).

Research Methodology:-
Design:-
The research is done using a single-case study methodology and approach. The article opens with a literature review for context and comparison. Then data is gathered for the case by looking into utility bills and operating records. The assumptions are applied in a discounted cash-flow model to assess the proposed plant. Chapter 2 draws on peer-reviewed articles from Taylor & Francis, Emerald, Elsevier, Wiley and Springer Nature, found by searching the

publishers' platforms for combinations of terms on solar energy, hotels, digital energy management and mountain tourism, and screened for relevance to hotel or commercial-building energy. One regional benchmark outside these platforms is identified in Section 2.6.

Case data:-

Table 1. Data sources and how they were used

Source	Content	Use
HPSEBL electricity bills (17)	Bills dated May 2025 to September 2026, covering consumption from April 2025 to August 2026	Consumption, demand, tariff, charges
Diesel generator log (Excel)	Monthly diesel litres, generator units and running hours, April 2025 to September 2026	Diesel cost and generator use
Hotel occupancy record	Monthly occupancy, April 2025 to September 2026	Association between occupancy and consumption
Hotel engineering brief	Rooms, connected load, roof, equipment, diesel price, project assumptions	System description and assumptions
Vendor quotations	Ekam Energy and Powermore proposals and negotiated prices	Capacity, price, generation estimate

Consumer, installation and bill identifiers appearing on the bills were not used.

Treatment of the bills:-

Each bill is labelled with the month in which it was issued but covers the meter-reading period that ended on the first day of that month. The bill labelled May 2025, for example, covers 1 April to 1 May 2025 and is treated as April 2025 consumption. The data support this mapping: the lowest consumption appears in the bill covering August 2025, which is also the month of lowest occupancy (13.86%).Two energy units appear in the bills. Active energy (kWh) is the energy actually used. Apparent energy (kVAh) is the quantity HPSEBL meters and bills; it is slightly larger than kWh because of reactive power, and the ratio of the two is the power factor. This paper uses kWh for physical comparisons, namely the association with occupancy and the match with solar output, which is also measured in kWh. It uses kVAh for anything tied to the tariff, such as the cost per unit.

Figures were copied from each bill by hand, so every bill's own arithmetic was recomputed as a check on copying errors. The peak, normal and night readings must add up to the total kVAh. The energy charge plus the demand charge and any fuel and power purchase adjustment (FPPAS) must equal the net charge. The FPPAS is a variable charge that the utility adds to the bill when its cost of fuel & purchased power differs from the cost assumed in the approved tariff. The net charge plus electricity duty, cesses and municipal tax must equal the amount payable. All 17 bills reconcile. In one bill, for March 2026 consumption, the printed energy charge is ?512.62 higher than the units multiplied by the printed rate of ?6.20. The difference equals about 51,262 units at ?6.21 and 1,711 units at ?6.20, which suggests the bill was prorated across the tariff change. The printed amount is used. Late payment surcharges and deposit-interest adjustments are excluded because they depend on when the hotel paid.

Analysis:-

We measured the association between consumption and occupancy with two coefficients on the 17 monthly pairs. Pearson?s r shows how closely the points follow a line. Spearman?s ? ranks the months by occupancy and by consumption. Checks whether the two rankings agree, so it does not need a straight line and is less affected by one or two extreme months. We calculated two?sided p?values for both. We obtained a 95?% confidence interval for r using Fisher?s z transformation. With 17 months and strong seasonality, the coefficients describe the association; they do not prove that occupancy causes the consumption.

Diesel cost was calculated at the stated purchase price of ?87 per litre applied to both reporting periods. The financial model projects 25 years of savings net of operation and maintenance costs. Reports simple payback, discounted payback, internal rate of return (IRR) and net present value (NPV). Its inputs are listed in Table 10.

Every input that was not supplied by the hotel or a vendor is labelled as an assumption. Tested in the sensitivity analysis.

All rupee amounts are nominal, meaning they are stated in the rupees of the month in which they were billed or quoted. No inflation adjustment has been applied to the bills, so a comparison between 2025 and 2026, such as the cost per unit, combines real tariff changes with general price changes. Rupee amounts use the Indian digit?grouping convention (1 lakh = 100,000); physical quantities use grouping.

Energy Profile of the Hotel:-

Property and supply:-

Table 2 summarises the supply arrangement as recorded on the bills and in the hotel's brief. Guest rooms are heated by Samsung and Daikin VRV systems and hot water is produced by AO Smith heat pumps, all electric. The rated capacities (kW) of these systems were not available for this study, so their share of the connected load cannot be stated. The area-wise meters already installed in the hotel could provide it. The hotel has no central building management system, since at about 70 rooms the owner judged that one would not pay for itself, and no neighbouring hotel has installed solar.

Table 2. Electricity supply and installed generation

Item

Value

Property

Welcomhotel by ITC Hotels, Mashobra, Shimla; approximately 70 rooms; owned by Zed Infrastructure Pvt. Ltd., managed by ITC Hotels

Utility and tariff category

HPSEBL; CS-Two Part

Supply voltage

Availed 22 kV; standard 11 kV; metering at 22 kV

Sanctioned and billing contract demand

250 kVA (application made to raise it to 350 kVA)

Highest recorded demand, 17 months

221 kVA (May 2026)

Connected load

461 kW as printed on the bills; the hotel brief gives approximately 611 kW

Diesel generators

Two sets, 320 kVA and 250 kVA

Sources: HPSEBL bills; hotel engineering brief. The connected load differs between the two sources and should be reconciled with the utility's records.

Consumption and occupancy:-

From April 2025 to March 2026, the hotel used 562,852 kWh of electricity from the grid. HPSEBL billed the hotel for 566,338 kVAh. This shows that the hotel used 46,900 kWh each month on average. The hotel’s monthly electricity use varied, with usage at 28,074 kWh in August 2025 and the highest at 60,052 kWh in June 2025. Across all 17 months, the highest amount was 68,924 kWh in June 2026. The average occupancy was 44.7% in the twelve months and 50.2% in April to August 2026. Figure 2 shows both sets of data, and Table 3 contains the numbers. Figure 2 shows both sets of data, and Table 3 contains the numbers.Figure 2. Monthly grid consumption (billed kVAh) and hotel occupancy, April 2025 to August 2026. Source: HPSEBL bills; hotel occupancy records.

Table 3. Monthly grid consumption, demand and charges

Consumption month

Occupancy (%)

Active energy (kWh)

Billed energy (kVAh)

Max demand (kVA)

Power factor

Charges payable (?)

? per kVAh

Apr-25

69.43
49,895
50,112
162
0.996
3,95,188
7.89
May-25
49.89
47,270
47,433
138
0.997
3,75,992
7.93
Jun-25
81.35
60,052
60,302
180
0.996
4,68,201
7.76
Jul-25
19.70
36,759
36,897
116
0.996
3,00,499
8.14
Aug-25
13.86
28,074
28,260
132
0.993
2,38,614
8.44
Sep-25
18.65
28,321
28,537
118
0.992
2,40,598
8.43
Oct-25
47.22
46,071
46,357
137
0.994
3,68,282
7.94
Nov-25
46.52

50,907
51,210
178
0.994
4,03,055
7.87
Dec-25
53.26
58,997
59,304
191
0.995
4,61,050
7.77
Jan-26
38.78
54,747
55,014
172
0.995
4,30,311
7.82
Feb-26
40.12
49,665
49,939
164
0.995
3,93,948
7.89
Mar-26
57.52
52,094
52,973
205
0.983
4,15,668
7.85
Apr-26
67.16
63,056
63,982
205
0.986
5,00,444
7.82
May-26
66.66
67,502
68,480
221
0.986
6,00,607
8.77
Jun-26
74.00
68,924

69,800
196
0.987
6,05,274
8.67
Jul-26
21.55
38,904
39,878
121
0.976
3,61,290
9.06
Aug-26
21.69
40,008
41,194
162
0.971
3,72,021
9.03

Source: HPSEBL bills. Charges payable = net energy and demand charges + electricity duty and cesses + municipal tax; they exclude late payment surcharge and deposit-interest adjustments.

Consumption and occupancy move together. Table 4 shows a Pearson correlation of 0.88 (95% confidence interval 0.70 to 0.96, $p < 0.001$). A Spearman correlation of 0.85 ($p < 0.001$) exists between occupancy and monthly kWh, and the coefficients for kVAh are almost identical. Both indicate a positive association. Months with more guests use electricity. Figure 3 shows the 17 months.

Table 4. Correlation between monthly occupancy and grid consumption (n = 17 months)

Measure	**Coefficient**	**p-value**	**95% confidence interval**
Pearson r, kWh	0.88	< 0.001	0.70 to 0.96
Spearman ?, kWh	0.85	< 0.001	not calculated
Pearson r, kVAh	0.88	< 0.001	0.68 to 0.96
Spearman ?, kVAh	0.85	< 0.001	not calculated

Source: author's calculation from the bills and the occupancy record. The Spearman coefficient is identical for kWh and kVAh because both rank the months in the same order.

Figure 3. Monthly grid consumption against occupancy, with Pearson and Spearman correlation coefficients (17 months).

The association is strong but far from proportional. In the three months with occupancy (13.9%, 18.7% and 19.7%), the occupancy was only 31% to 44% of the twelve-month average of 44.7%, but the energy use was 28,074, 28,321 and 36,759 kWh. That is 60%, 60% and 78% of the month. A large part of the energy use continues when there are few guests in the house. This matters for the plant because it means that the energy use during the day does not go away in the off-season.The cold months show a pattern. January 2026 had an occupancy of 38.8%, which's lower than April 2025 (69.4%) and October 2025 (47.2%). However, the hotel used 54,747 kWh in January compared to 49,895 kWh in April 2025 and 46,071 kWh in October 2025. December 2025, with 53.3% occupancy, 58,997 kWh were used. This is what electric room heating and heat-pump water heating would use in this weather. However, the electricity bills alone cannot tell the difference between heating and other energy uses. The area-wise meters could.A comparison of the same months in the two years, in Table 5, shows a rise in 2026 that occupancy does not explain. Consumption was higher in all five months. In April and June, it rose by 26% and 15%, although occupancy was lower, by 2.3 and 7.4 percentage points. The data supplied do not show the reason. New equipment, a different mix of guests and services, or changes in operation are all possible, and the hotel's engineering team is best placed to say which.

Table 5. Same-month comparison of occupancy and grid consumption, 2025 and 2026

Month	Occupancy 2025 (%)	Occupancy 2026 (%)	kWh 2025	kWh 2026	Change in kWh
April	69.43	67.16	49,895	63,056	+26.4%
May	49.89	66.66	47,270	67,502	+42.8%
June	81.35	74.00	60,052	68,924	+14.8%
July	19.70	21.55	36,759	38,904	+5.8%
August	13.86	21.69	28,074	40,008	+42.5%

Source: calculated from HPSEBL bills and the occupancy record.

Table 6. Comparison of the two reporting periods

Indicator	**Apr 2025 ? Mar 2026 (12 months)**	**Apr ? Aug 2026 (5 months)**
Grid consumption (kWh)	562,852	278,394
Billed consumption (kVAh)	566,338	283,334
Average monthly consumption (kWh)	46,904	55,679
Average occupancy (simple mean of months)	44.7%	50.2%
Charges payable (?)	44,91,406	24,39,636
Average charge per kVAh (?)	7.93	8.61
Highest recorded demand (kVA)	205	221
Average power factor (kWh ' kVAh)	0.994	0.983

Source: calculated from HPSEBL bills. Nominal rupees; no inflation adjustment.

The average charge per kVAh rose from ?7.93 to ?8.61 between the two periods although the energy rate did not rise, as the next section explains.

Tariff and cost structure:-

The bills show an energy charge of rupees 6.21 per kVAh for consumption up to February 2026. Then the rate changes to rupees 6.20 for consumption starting in April 2026. The bill for March 2026 has a mix of both rates. This is mentioned in Section 4.3. The rate is the same for peak hours, normal hours and night hours. So the tariff does not encourage moving energy use from one time band to another. Peak hours accounted for 17.4% of consumption and night hours for 24.0% in the first twelve months (Figure 4). The demand charge is ?170 per kVA per month. Electricity duty is 12% of the energy charge, and milk and environment cesses are 10 paise per unit each. A fuel and power purchase adjustment (FPPAS) appears only in the bills for April and May 2026 consumption, at ?6,591.95 and ?17,904.87. Energy charges made up 78.3% of the payable amount in the first twelve months, the demand charge 9.7% and duty and cesses 11.9%.

Figure 4. Time-band split of billed consumption and composition of charges, April 2025 to March 2026. Source: HPSEBL bills.A further levy of ?1 per unit first appears on the bill for May 2026 consumption, charged for ?55,225.81, which is 25 of the 31 days' units, and on every unit from June 2026. It increased duty and cesses from ?0.94 per kVAh to ?1.94 per kVAh. Explains most of the rise in the cost per unit shown in Figure 5. Under the structure printed on the August 2026 bill, each additional unit drawn from the grid carries ?6.20 of energy charge, ?0.74 of electricity duty, ?0.20 of two cesses, ?1.00 of the levy and ?0.01 of municipal tax, about ?8.15, in all. Before the new levy, the same sum was about ?7.17. This marginal cost is the value used for the savings in Chapter 7.

Figure 5. Charge per kVAh by component, April 2025 to August 2026 (nominal rupees). Source: calculated from HPSEBL bills.

Demand and power factor:-

Maximum recorded demand stayed between 116 and 221 kVA, below the sanctioned 250 kVA in every month (Figure 6). The bills charge demand at the higher of recorded demand and 85% of contract demand, which is 212.5

kVA. This floor applied in 16 of the 17 months, and the only month billed on recorded demand was May 2026, at 221 kVA. Demand charges are therefore close to fixed at ?36,125 a month, and solar generation cannot be expected to reduce them. Nor can it be assumed to reduce maximum demand, since the peak could occur in the evening or in winter when the plant produces little.Figure 6. Maximum recorded demand and demand billed against the sanctioned contract demand, April 2025 to August 2026. Source: HPSEBL bills.

An application has been made to raise contract demand to 350 kVA. If the same 85% floor applies at the new level, billed demand would be at least 297.5 kVA, which at ?170 per kVA raises the demand charge by ?14,450 a month, or about ?1.73 lakh a year, whatever the actual use. This is a calculation from the bill rules, not a utility statement, and the hotel may expect load growth that the bills do not yet show. It matters to the solar decision only because it changes the hotel's fixed cost, not the plant's savings.Power factor declined over the period. It was 0.99 or above in most months of 2025 and fell to 0.976 and 0.971 in July and August 2026. Because the utility bills in kVAh, a lower power factor raises billed units for the same real energy. The cause is not identified in the data. It also matters for solar: the plant reduces real power drawn from the grid, while the reactive component remains, so the reduction in billed kVAh may be slightly smaller than the energy generated.

Diesel generator operation:-

The 250 kVA set ran for 324.5 hours between April 2025 and March 2026. It produced 20,956 units of electricity using 7,079 litres of diesel. This means it generated 2.96 units per litre. At a cost of ?87 per litre, the total fuel cost came to ?6,15,873. That works out to ?29.4 per unit generated.From April to September 2026, the 250 kVA set ran for 70.3 hours. The 320 kVA set ran for 30.7 hours. Together, they produced 6,105.7 units using 2,258.5 litres of diesel. This gives a production rate of 2.70 units per litre. The cost per unit was ?32.2. (See Table 7 for details.)Diesel power ended up costing four times the marginal grid cost during the same period. Up to March 2026, the grid cost was ?7.17 per unit. Later, in August 2026, the grid bill showed a cost of ?8.15 per unit. So, using diesel was more expensive than grid power, especially in the earlier period.

Table 7. Diesel generator operation

Indicator	**Apr 2025 ? Mar 2026**	**Apr ? Sep 2026**
Diesel consumed (litres)	7,079	2,258.5
Units generated	20,956	6,105.7
Running hours, 250 kVA set	324.5	70.3
Running hours, 320 kVA set	not recorded	30.65
Diesel cost at ?87 per litre (?)	6,15,873	1,96,490
Fuel cost per unit generated (?)	29.4	32.2
Units per litre	2.96	2.70

Source: hotel diesel log; price from hotel brief, applied to both periods. Generator units are as recorded in the log.Figure 7. Monthly diesel consumption of the generators, April 2025 to September 2026. Source: hotel diesel log.Diesel use is concentrated in a few months. January and March 2026 together account for 3,832 litres, 54% of the twelve-month total. The log does not give reasons for generator operation, so this paper does not attribute the use to grid outages or to any other cause. Generator output was about 3.7% of the energy drawn from the grid over the twelve months.

The Proposed Solar Installation:-

Roof and capacity:-

The plant is proposed on the GI sheet roofs of the hotel. Their structural condition is reported as good, and the roofs face south. The vendor has asked for a load allowance of approximately 20?25 kg per square metre. The hotel's engineering assessment of the available capacity is 200 kW, which falls to 160 kW if safety rails are installed. Larger panels from Avaada could raise the capacity to 238 kW on the same roof area. Table 8 shows what each option would generate if it matched the yield implied by the Ekam proposal.

Table 8. Roof capacity options

Option
Capacity
Indicative annual output at Ekam's specific yield (kWh)
With safety rails, Tata TOPCon bifacial
160 kW
about 198,800
Base case, Tata TOPCon bifacial (Ekam)
200.4 kWp
249,000 (vendor estimate)
Avaada panels, larger module size
238 kW
about 295,700

Capacity and vendor estimate from the hotel brief. The 160 kW and 238 kW outputs are scaled by the author at 1,242.5 kWh per kWp and are not vendor figures. Whether the 238 kW layout passes the structural check has not been assessed.

Snow stays on the roofs for about 6 to 8 days a year at most and clears by itself because of the south-facing slope. If the plant produced nothing on all 8 days, the loss would be 2.2% of days. Winter days produce less than average, so the loss of annual energy would be smaller than that.

Vendor proposals:-

Table 9. Proposals received

Item
Ekam Energy (Tata Power Solar channel partner)
Powermore
Plant size reviewed
About 200.4 kWp panels, 150 kW inverter capacity
254.88 kWp (earlier proposal)
Estimated annual generation
About 2.49 lakh units (249,000 kWh)
Not provided
Quoted amount
?66.65 lakh including stated GST
Not provided
Final negotiated price
?66 lakh
?61 lakh (capacity basis to be confirmed)
O&M
?0.75 per watt per year (Tata); 5% annual increase; coverage and GST to be confirmed
Not provided
Module degradation stated
1% in the first year, 0.5% a year thereafter
Not provided

Source: vendor proposals as communicated by the hotel. The degradation figures should be checked against the manufacturer's warranty.

Two details need confirmation before the proposals can be compared fairly. The Powermore price of ?61 lakh was negotiated against an earlier proposal for 254.88 kWp, and the capacity it now covers is not stated. The selected capacity is 200 kW. If Powermore's price is for an equivalent 200 kWp system with the same yield, the project cost

would be ?5 lakh lower, and Chapter 7 shows that case. If it is for a different size or panel type, the comparison is not valid.The Ekam estimate of 249,000 kWh corresponds to a specific yield of 1,242.5 kWh per kWp per year. This is below the 1,345 to 1,798 kWh per kWp range simulated for Himachal Pradesh by Sharma and Singh (2026). Their figures are for a different panel type and are simulated, so they are not a guarantee, but the vendor's estimate does not appear optimistic. The analysis uses the vendor figure as the central case and tests a 10% shortfall.

Matching generation to load:-

The plant would produce about 20,750 kWh a month on average. In the twelve months to March 2026, the hotel drew between 28,074 and 60,052 kWh a month, so average solar output is at most 74% of the lowest monthly draw, and annual output equals 44% of annual grid consumption (Figure 8). The three lowest-occupancy months, which still used 60% or more of the average month (Section 5.2), also exceed average solar output. On these totals, little energy should be exported. Monthly totals do not prove this hour by hour. On a clear day in a low-occupancy month, midday output could exceed the instantaneous load. Hourly load data from the area-wise meters would settle the question and should be obtained before the plant size is fixed.Figure 8. Monthly grid consumption (kWh) against the average monthly output of the proposed 200.4 kWp plant. Source: HPSEBL bills; vendor generation estimate.

Generator interaction and monitoring:-

Standard grid-tied inverters disconnect when grid supply fails, which is a safety requirement. The proposed plant will therefore stop when the hotel switches to diesel unless it is designed to operate with the generator. Whether the quoted scope includes equipment that allows this has not been confirmed. The base case therefore assumes no diesel savings, and Section 7.4 shows possible savings separately.For monitoring, area-wise energy meters are installed, and an internet connection is fixed on the wall below the roof at the proposed inverter locations. This is enough to use the inverters' own monitoring portals, so the hotel's engineers can compare plant output with the area meters' readings without any new building-wide system. Commissioning has not been scheduled.

Financial Evaluation:-

Assumptions:-

Table 10. Model inputs

Input
Value
Basis
Plant size
200.4 kWp
Ekam proposal
Year-1 generation
249,000 kWh
Vendor estimate
Degradation
1% after year 1, then 0.5% a year
Vendor statement; to be checked against warranty
Project cost, Ekam
?66 lakh negotiated + ?9 lakh other costs = ?75 lakh
Negotiated price; other costs are the mid-point of ?8?10 lakh
Project cost, Powermore
?61 lakh + ?9 lakh = ?70 lakh
As above; capacity basis unconfirmed
O&M
?0.75 per watt per year on 200,400 W = ?1,50,300 in year 1; +5% a year; GST excluded
Tata rate and escalation from the hotel brief
Value of each unit generated, Case A
?6.20 (energy charge only)
Current bill
Value of each unit generated, Case B
?8.15 (energy charge, electricity duty, cesses, municipal tax)
Calculated from the August 2026 bill; ?7.17 before the new ?1 levy
Tariff change over time
None in the base case (nominal)

Rate was ?6.21 and then ?6.20 during the 17 months
Share of generation used on site
100%
Assumption; tested in Table 12
Project life
25 years
Assumption; to be matched with warranty
Discount rate for NPV
10% (nominal)
Illustrative; replace with the company's hurdle rate
Income tax and depreciation
Not included (pre-tax analysis)
Rate and eligibility to be confirmed by the accounts team
Inverter replacement
Not included
No cost quoted

Cases A and B bracket the value of a unit saved. Case A assumes that only the energy charge is avoided. Case B assumes that duty and cesses fall in proportion to the units drawn, as they are calculated on the bills, and reflects levies in force since mid-2026, which can change. Whether duty and cesses apply to solar energy used on site should be confirmed with HPSEBL. The demand charge is not reduced in either case.All rupee figures in the model are nominal. Holding the tariff in nominal terms is conservative. Why? Because if inflation is near the 4% target set by the Reserve Bank of India in 2025, then each unit saved loses 4% of its real value every year. At the same time, O&M costs are expected to go up by 5% each year. So a rupee saved in year 15 is worth less than a rupee spent today.That?s why the evaluation reports use NPV and discounted payback along with payback. It doesn?t rely on lifetime totals. The sensitivity analysis also includes a case where the value of a unit increases by 4% each year. This keeps the value of each unit steady in terms.

Results:-

Table 11 gives the results for the Ekam price and for the Powermore price, each with ?9 lakh of other costs. Year-1 savings from avoided grid purchases are ?15.44 lakh in Case A and ?20.30 lakh in Case B, before O&M of ?1.50 lakh. On Ekam's pricing, simple payback is 5.6 years in Case A and 4.1 years in Case B; discounted at 10%, the figures are 8.7 and 5.5 years. Varying other costs between ?8 and ?10 lakh moves simple payback by only about 0.1 year.

Table 11. Results by vendor price and value of a unit saved
Case
Year-1 net saving (? lakh)
Simple payback (years)
Discounted payback at 10% (years)
IRR, 25 years
NPV at 10% (? lakh)
Ekam, ?75 lakh, Case A (?6.20)
13.94
5.6
8.7
16.9%
38.8
Ekam, ?75 lakh, Case B (?8.15)
18.80
4.1
5.5
23.8%
81.2
Powermore, ?70 lakh, Case A
13.94
5.2

7.8
18.3%
43.8
Powermore, ?70 lakh, Case B
18.80
3.8
5.0
25.6%
86.2
Source: author's model using the inputs in Table 10. Nominal rupees; pre-tax.
Figure 9. Cumulative net cash flow over 25 years by vendor price and value of a unit saved (Case A solid, Case B dashed; nominal, undiscounted).Over 25 years the plant would generate about 5.84 million kWh. The cost per kWh, taking the project cost plus 25 years of O&M and discounting both costs and output at 10%, is ?4.41, below the ?6.20 energy charge the plant displaces today.

Sensitivity:-
Table 12. Sensitivity of the Ekam case (?75 lakh)
Change from base
Case A net saving (? lakh)
Case A payback (years)
Case A IRR
Case B payback (years)
Case B IRR
Base case
13.94
5.6
16.9%
4.1
23.8%
Generation 10% lower
12.39
6.3
14.6%
4.6
21.0%
Only 80% of output used on site
10.85
7.2
12.2%
5.2
18.1%
Project cost 10% higher
13.94
6.1
15.1%
4.5
21.5%
Value of a unit rises 4% a year
13.94
5.1
21.5%
3.8
28.2%
18% GST added to O&M
13.66
5.7
16.3%

4.1
23.3%
Project cost at Powermore price (?70 lakh)
13.94
5.2
18.3%
3.8
25.6%
Source: author's model. Payback is simple payback. Using 80% of output on site means 20% of generation brings no savings, for example because it is exported without credit.

The result depends a lot on how much of the generation the hotel uses on its own and on how much each unit is worth. If 80 per cent of the output is used at the location, the simple payback period becomes 7.3 years in Case A. That's why hourly load data is important. A 10 per cent increase in project cost has a greater effect than a 20 per cent decrease in self-consumption. Adding 18% GST to the O&M charge changes payback by less than 0.15 years. If the value of a unit rises with inflation at 4% a year, payback falls to 5.1 years in Case A.

Generator-related savings, shown separately:-
The base case assumes no savings on diesel, because they depend on whether the plant is designed to work alongside the generators, which has not been decided. Table 13 shows what different shares of the generators' fuel use in the twelve months to March 2026 would be worth if solar could displace them. These are scenarios, not forecasts. They exclude the cost of any equipment needed to let solar operate with the generators, as no price is available.

Table 13. Possible diesel savings if solar can operate with the generators (April 2025 ? March 2026 fuel use, ?87 per litre)
Share of generator fuel displaced
Diesel saved (litres a year)
Value (?)
Compared with Case A year-1 saving
0% (base case)
0
0
0%
10%
708
61,587
4.0%
25%
1,770
1,53,968
10.0%
50%
3,540
3,07,937
19.9%
Source: author's calculation from the diesel log and the stated price. Savings would be higher in a year with more generator use.
Even with half of the generators' fuel displaced, the saving is about one-fifth of the grid savings in Case A. The decision to buy the plant therefore rests on grid savings, and diesel savings are an extra to be pursued if the engineering proves practicable.

Items awaiting confirmation:-
1. income-tax rate and depreciation eligibility (accounts team);
2. whether electricity duty and cesses apply to solar energy used on site, and how self-consumed solar is accounted for in a kVAh-based bill (HPSEBL);
3. what the Powermore price of ?61 lakh covers;

4. what the O&M rate covers, whether GST is added and for how long;
5. the manufacturer's warranty terms for degradation;
6. whether the structural assessment accepts 20?25 kg per square metre across the full 200 kW layout;
7. inverter replacement cost and timing.

Discussion:-

The case supports the general finding in the literature that hotel solar can be economically sound when the hotel uses most of what it generates (Barbara et al., 2024). Here the condition appears to be met on monthly totals, because a large part of the hotel's load continues at low occupancy. The remaining uncertainty is hourly self-consumption and the value of each unit saved, the same two factors the literature flags.The barriers and enablers described by Haider et al. (2026) appear in this case in concrete form (Table 14). The financial barrier is modest relative to the savings. The technical constraint that matters most is the roof: safety rails would cut capacity from 200 kW to 160 kW, about a fifth of the output. Organisational capacity is a strength, since the property has a chief engineer, a managing company and area-wise meters, which smaller hotels would usually lack.

Table 14. Barriers and enablers observed in this case

Barriers	Enablers
Roof load limit of 20?25 kg per square metre; safety rails reduce capacity to 160 kW	Roofs in good condition, south-facing, with snow clearing by itself
Other costs of ?8?10 lakh are not final	Two competing quotations; negotiated prices ?66 lakh and ?61 lakh
Tax rate and depreciation not yet confirmed	Load that continues at low occupancy (60% or more of the average month)
Solar?generator operation unresolved	Marginal grid cost about ?8.15 per unit against diesel at ?29?32 per unit
Billing basis for solar in a kVAh tariff and treatment of duty unconfirmed	Area-wise meters and internet at the inverter locations
No nearby solar hotels to learn from; commissioning date not set	Management by an established hotel operator with a chief engineer

Source: author's synthesis from the hotel brief, bills and Chapters 5 to 7.

On monitoring, the decision not to install a central building management system looks reasonable at this size. The inverter portals and the existing area meters are enough to measure output against load, which is the information Valett et al. (2026) and Khatter (2025) identify as the useful part of digital energy management. Reporting measured output to guests would also respond to the credibility concerns raised by Singh and Mittal (2026) and Park et al. (2024), but this study has no guest data and cannot say whether it would improve bookings.

Conclusions and Recommendations:-

Conclusions:-

Seventeen months of bills show a hotel that draws about 46,900 kWh a month, pays about ?8.15 for each additional unit under the latest levies, and keeps using 60% or more of an average month's energy even when occupancy is 14?20%. A 200.4 kWp plant producing 249,000 kWh a year would offset about 44% of the grid energy drawn in 2025?26. On the negotiated Ekam price of ?66 lakh plus ?9 lakh of other costs, simple payback is 5.6 years if only the energy charge is saved and 4.1 years if duty and cesses are also avoided; discounted at 10%, the paybacks are 8.7 and 5.5 years. The generators cost about ?29 to ?32 per unit to run, but the possible diesel saving from solar is small besides the grid savings and depends on an engineering decision that has not been made.

Recommendations:-

1. Proceed with a plant of about 200 kW, subject to a written structural assessment of the roof, and obtain a quotation for the 160 kW safety-rail configuration so that the cost of the rails is known.
2. Obtain hourly load data from the area-wise meters for a low-occupancy month and a high-occupancy month to confirm full self-consumption.
3. Resolve the items in Section 7.5 in writing before the purchase order, in particular the treatment of solar under the kVAh tariff and the Powermore scope.
4. Treat solar operation with the generators as a separate engineering study and cost it before counting any diesel savings.

5. Review the application for 350 kVA contract demand against the recorded maximum of 221 kVA, because it would raise fixed charges if the 85% billing floor applies.
6. Once installed, report monthly generation, grid consumption and savings against this study's estimates.

Limitations and further research:-

This is a single-site study, and the results apply to this property's tariff, load, and roof. The solar generation figure is a vendor estimate, not a measurement. Hourly load data, equipment ratings, tax treatment, inverter replacement, and the Powermore scope were not available. Correlation over 17 months shows association only. Carbon savings were not quantified. Future work should compare measured plant output with this study's estimates after a full year of operation and extend the approach to other hill hotels.

Appendix A. Detailed Bill Data:-

Table A1. Monthly figures transcribed from the HPSEBL bills (nominal rupees)

Month
kWh
kVAh
Normal kVAh
Peak kVAh
Night kVAh
Rate (?)
Energy charge (?)
Demand + FPPAS (?)
Duty & cesses (?)
Payable (?)
Apr-25
49,895
50,112
30,302
8,277
11,533
6.21
3,11,196
36,125
47,366
3,95,188
May-25
47,270
47,433
29,042
7,692
10,699
6.21
2,94,559
36,125
44,834
3,75,992
Jun-25
60,052
60,302
37,332
10,333
12,637
6.21
3,74,475
36,125
56,997
4,68,201

Jul-25
36,759
36,897
22,447
5,840
8,610
6.21
2,29,130
36,125
34,875
3,00,499
Aug-25
28,074
28,260
17,315
4,544
6,401
6.21
1,75,495
36,125
26,711
2,38,614
Sep-25
28,321
28,537
17,340
4,704
6,493
6.21
1,77,215
36,125
26,973
2,40,598
Oct-25
46,071
46,357
27,556
7,643
11,158
6.21
2,87,877
36,125
43,817
3,68,282
Nov-25
50,907
51,210
29,045
9,405
12,760
6.21
3,18,014
36,125
48,404
4,03,055
Dec-25
58,997

59,304
33,788
11,099
14,417
6.21
3,68,278
36,125
56,054
4,61,050
Jan-26
54,747
55,014
30,644
9,890
14,480
6.21
3,41,637
36,125
51,999
4,30,311
Feb-26
49,665
49,939
27,467
9,153
13,319
6.21
3,10,121
36,125
47,202
3,93,948
Mar-26
52,094
52,973
29,667
9,888
13,418
6.21/6.20
3,28,945
36,125
50,068
4,15,668
Apr-26
63,056
63,982
36,421
10,823
16,738
6.20
3,96,688
42,717
60,399
5,00,444
May-26
67,502
68,480
39,819

11,344
17,317
6.20
4,24,576
55,475
1,19,871
6,00,607
Jun-26
68,924
69,800
41,399
10,931
17,470
6.20
4,32,760
36,125
1,35,691
6,05,274
Jul-26
38,904
39,878
22,879
6,182
10,817
6.20
2,47,244
36,125
77,523
3,61,290
Aug-26
40,008
41,194
23,973
6,618
10,603
6.20
2,55,403
36,125
80,081
3,72,021

Source: HPSEBL bills. Municipal tax (1 paisa per unit) is included in Payable but not shown separately. Demand + FPPAS is the demand charge plus any fuel and power purchase adjustment. The March 2026 bill prints ?6.20, but its energy charge equals a mix of ?6.21 and ?6.20 (Section 4.3).

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