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DIESEL STUDY REPORT

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ABBREVIATIONS

ADB	Asian Development Bank
CERC	Central Electricity Regulatory Commission
CGIAR	Consortium of International Agricultural Research Centers
CMPDI	Central Mine Planning and Design Institute
CSE	Centre for Science and Environment
DGPV	Diesel Generator Photo Voltaic
DG Sets	Diesel Generator Sets
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmBH
GW	Giga Watt
IGSP	Indo-German Solar Partnership
IWMI	International Water Management Institute
LCOE	Levelised Cost of Electricity
MW	Mega Watt
PM KUSUM	Pradhan Mantri Kisan Urja Suraksha Evem Utthan Mahabhiyan
POISED	Preparing Outer Islands for Sustainable Energy Development
PPAC	Petroleum Planning and Analysis Cell
PV	Photo Voltaic
PVRT	Photo Voltaic Rooftop

BACKGROUND

In India there are challenges like scheduled or unscheduled power cut throughout the country excluding a few states and cities. In those situations, most of the establishments prefer to have a back-up power as an alternative to meet their energy needs. Diesel gensets and battery banks are two major sources to provide this back-up. Levelised Cost of Electricity (LCOE) generated through diesel is quite high in comparison to the grid power or the solar power. However, power from the grid and from solar resources also have their limitations. Another prevailing problem in India is the need for standalone application especially in rural areas.

Across India, diesel generators, commonly known as DG sets, are used by factories, commercial establishments, residential societies, and individual households for power backup. According to estimates given by the Central Electricity Regulatory Commission (CERC), in 2014, DG sets installed across India had a cumulative capacity of 90,000 MW, which was greater than the total installed power capacity of the United Kingdom (85 GW) as of 2014 and has been growing at a rate of 5,000 MW to 8,000 MW every year. Such a large installed capacity of DG sets is due mainly to power deficits and erratic power supply across India. Considering the incremental diesel tariff it has become essential to think of replacing diesel power generator with Solar PV or integrating Solar PV with DG sets.

As per the report "All India Study on Sectoral Demand of Diesel & Petrol" by the Petroleum Planning and Analysis Cell (PPAC), the diesel consumption for electricity is around 5 per cent of the total consumption of diesel. The shortage of electricity is a problem in states such as Delhi, Uttar Pradesh, Bihar, Tamil Nadu and Karnataka etc., the country faced a huge power deficit during the peak hours in the last financial year, but it is somehow interesting to note that for some states this gap is significantly less compared to other states. This provides an interesting fact to carry out the study across India to identify the potential of this kind of solution and their commercial viability. Further, this study is proposed to understand the issues related to market potential, the proper sizing of solar PV, diesel and battery to get the most optimum LCOE.

On behalf of the Federal Ministry for Economic Cooperation and Development, the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH in partnership with the Ministry of New and Renewable Energy (MNRE) implements the Indo-German Solar partnership (IGSP). As part of the project activities, a study on "How to replace the diesel genset with Solar Rooftop and Storage" has been undertaken. The key objective was to support the installation of the solar rooftop PV systems. The option of replacing diesel gensets with solar and storage offers a huge opportunity for the industry. This study was intended to bring attention of the industry, create awareness towards such systems and to determine an optimal size of the diesel gensets.

DG PV SWOT ANALYSIS

STRENGTH

1. DG with synchronisation of Solar PV gives the provision of backup power.
2. Operates at a very low operation and maintenance cost.
3. Reduction in fuel emission which impacts environment.
4. DG-PV can provide lower cost power generation at remote location.
5. Uninterrupted power supply possible in high power cut zones.
6. Most of the developments of solar PV plants is backed by Government.
7. India is blessed with high solar irradiance with more than 300 days of sunshine.
8. Solar PV can be easily connected with DG set through proper synchronisation.

WEAKNESS

1. Proper synchronisation between DG set and Solar PV system is required to avoid islanding effect.
2. Requirement of electricity shall not be fulfilled at night as the connection will be with Solar PV.
3. Requirement of electricity shall not be fulfilled during rainy season or snowfall as the generation will be solely dependent on the availability of clear sunny days.
4. Solar cannot fully replace DG set.

OPPORTUNITY

1. India has a high percentage of power cut hence there is necessity of installing DG sets. More DG sets means more diesel consumption and greenhouse gas emission. To reduce the fuel consumption solar PV has ample scope to either synchronization with DG sets or replacing the DG sets.
2. As oil prices increase, the solar power generators help reduce operational costs.
3. Diesel generation tariff is high whereas solar generation tariff is quite low and still decreasing.
4. Government of India's inclination towards solar energy is a big motivating factor for solar PV plant developers.
5. Ever increasing demand for power provides an opportunity for solar energy to fill the void.

THREATS

1. Entry of foreign players in solar market may lead to decline in the cost which may eventually lead to compromise in quality as the benchmark cost will reduce.
2. The remote location of the plants may lead to theft of the solar components.

BUSINESS MODELS

In recent years, PV system and batteries storage costs have steeply dropped making it an affordable energy source for companies in remote areas. Using only a PV system and solely relying on the solar irradiation (even if there is plenty of it and it is free), is not a safe option for an industrial consumer as PV production can be inconsistent. This is why the Industrials are resorting to PV Diesel hybrid system. As energy reliability if crucial for industrial customers and solar irradiation is inconsistent, solely relying on solar PV is not optimal for them. This is why industrials consumers are resorting to PV Diesel hybrid systems.

As diesel generator market set is expected to grow at a rate of 10 per cent the coming years this marks the potential of adopting the DGPV model. This operation can be carried out in three models:

1. Solar PV with DG
2. Solar PV with DG and Storage
3. Solar PV replacing DG

A comparative analysis of the models is shown below which will provide insights into the different model's advantages and disadvantages over each other.

Models	Advantages	Disadvantages
Solar PV with DG	1. Increased PV penetration 2. No wasted Energy 3. Uninterrupted Power 4. Hybrid Systems can be programmed. 5. Environment-friendly	1. Mostly beneficial in remote areas 2. Complicated and highly skilled 3. High maintenance cost
Solar PV with DG and Storage	1. Storage capacity helps in using the system during night-time without diesel. 2. Useful for critical loads mainly in industrial and commercial setup. 3. Constantly evolving storage technologies help in more storage of generated electricity.	1. Costly setup as battery system for the required capacity is quite expensive. 2. Battery replacement in every five years make the overall maintenance system costly.
Solar PV replacing DG	1. Completely eco-friendly 2. Less space utilisation 3. Full grid integration possible 4. Easy system design 5. Cheap power output	1. Not available during night-time or cloudy days. 2. Efficiency less than a hybrid system.

Table 1: Comparative Analysis of Different Business Model

Revenue Model for all three listed business models is shown below in figure 1 –

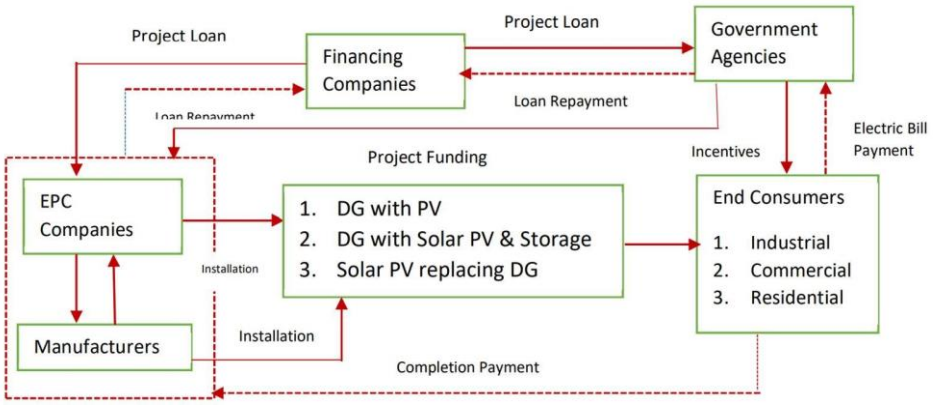

Figure 1: Revenue Model

The decision to replace the DG power is based on various factors like reliability, cost, accessibility, and quality of power. In the study, various business models are developed by using the combination of DG, PV and energy storage and a detailed financial model is developed to understand the impact of each input parameter on the financial viability of each business model. The financial modelling is based on actual consumption value, contract load and the roof space available for installing solar PV system. The average runtime for a DG set is considered as four hours and storage is two hours. The Solar PV system is taken as 55 kW. The summary of the results of financial modelling is shown in table 2–

Business Model	Tariff (Rs./kWh)	Project IRR (%)	Equity IRR (%)	Project NPV (in Cr.)	Payback Period (Yr.)
DG with Solar PV	6.50	15.55	36.76	0.13	1.72
DG with Solar PV and Storage	6.50	13.25	31.04	0.09	1.75
Solar PV replacing DG	6.50	18.86	45.44	0.17	1.68
Replacing DG with Solar PV and Storage	6.50	16.09	38.25	0.13	1.71

Table 2: Financial Model Summary

Based on the business model and their scenario analysis it has been proposed that the most economically viable model is replacing DG with solar PV. However, the business model of integrating Solar PV with DG with proper safety check can also be applied as it is also viable on varying the DG running time. This integration will offset the grid tariff and diesel tariff which will give a high earning benefit. Although Solar PV itself is the most commercially feasible option but certain places like hospitals, schools, etc, require DG which cannot be completely replaced. Hence, in such cases, the requirement of DG integrated with Solar PV is high and its application feasible.

CASE STUDY

As part of the study, few sites were identified in the Delhi/National Capital Region and Ranchi where surveys have been conducted. The primary aim of the research team was to collect the actual first-hand data of the consumption of power i.e. grid and DG both, site feasibility and the solution that can be provided for each site. The primary data collected from the actual site surveys were then extrapolated and mapped with the information collected from the secondary research to propose the best suitable standardised models.

The commercial office Ranchi was identified under CMPDI. The CMPDI complex has three DG sets available: two DG set of capacity 250 kVA each and one of capacity 500 kVA. The DG log of 30 days' time from 21 January 2020 to 19 February 2020 has been taken for analysis. Based on the DG set usage it is evident the usage of DG is quite low. Only 1.3% time the DG set has been used. Among the DG sets it is found that the primary generation has been catered by DG set of capacity 500 kVA, almost 89% of the DG usage. Other two DG sets has been kept as backup ones. Figure 2 and Figure 3 show a schematic of the working principle of the PVDG.

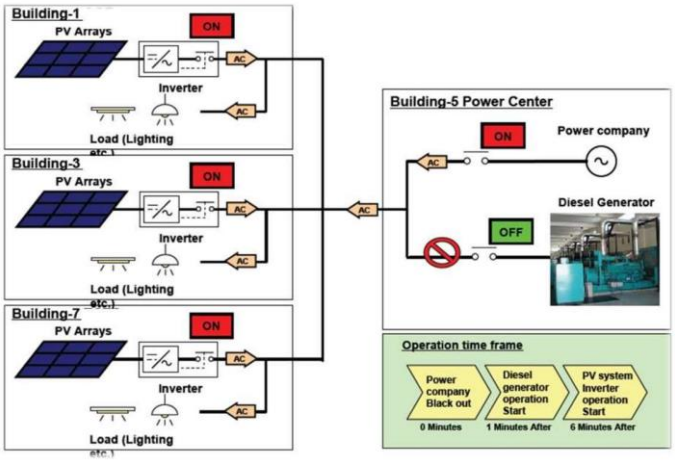

Figure 2: PVDG when grid supply is ON

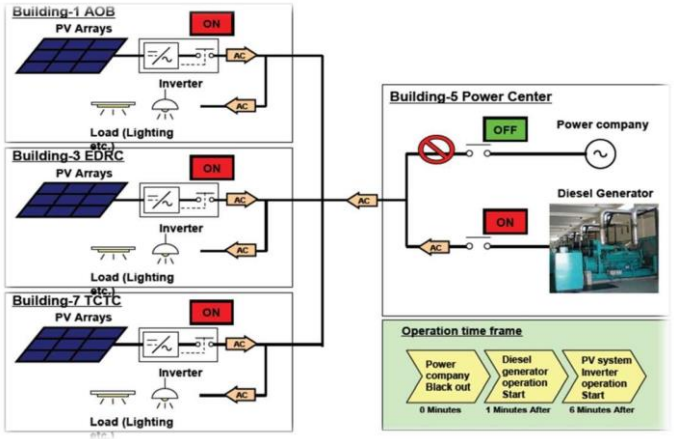

Figure 3: PVDG when grid supply is OFF

The CMPDI complex had a total capacity of 190 kW rooftop solar power plant installed which are generating electricity. Based on the generation of the working solar plant, it is evident that solar power generation is sufficient to replace the DG sets. However,since the DG sets are connected with critical load complete replacement might not be technically feasible. Integration of solar PV with DG is the more feasible option in this case. Also, suitable storage options can be implemented with a solar PV system.

Figure 4: Generation (kWh)

EVALUATION

Over the project period (2018-2023), the need and advantages of replacing diesel with Solar PV has penetrated the solar rooftop market. Various customer segments have been introduced to this system and this business model has encouraged PVRT installations in the segments where PV installations were not accepted due to the requirements.

One such segment is Residential Societies.[1] Many of the residential societies in India are equipped with the Diesel Generator (DG) sets to supply electricity during power outages. However, the use of diesel-based power generation in societies is not only costly but also causes damage to environment and health. Studies conducted by various think tanks like the Centre for Science and Environment (CSEs)[2] reveal the success, effectiveness and acceptance of the DGPV business model for residential societies. Additionally, a huge capacity of DG can also be solarised for government buildings and offices.

Solar PV with DG and the battery business model is also highly effective and successful in case of energy access challenges. For example, Places where the reliable grid infrastructure is a challenge, just like remote locations or islands which rely on diesel-based energy mini grids. The Asian Development Bank's Preparing Outer Islands for Sustainable Energy Development (POISED) [3] is one such project which focuses on this business model in islands.

"The POISED project will introduce sustainable energy in the outer islands as well as help reduce the cost of energy, minimise CO2 emissions, achieve considerable fuel savings, and reduce the burden on the government budget," said the Director of ADB's Energy Division for South Asia, Mr. Priyantha Wijayatunga. Similar projects have been implemented in Lakshadweep and Andaman and Nicobar Islands in India.

Another area of successful implementation of Solar PV replacing the DG business model is under Kisan Urja Suraksha Evem Utthan Mahabhiyan (KUSUM) scheme where diesel-based irrigation pumps are replaced with solar pumps. Under the PM-KUSUM scheme it is targeted to achieve 10,000 MW capacity through installation of grid-connected solar power plants each of capacity up to two MW under Component A and solarisation of 35 lakh agriculture pumps under Component-B and Component-C. Around the solar powered pumps, various other cost sharing business models have been developed and implemented. One such example is an initiative by the International Water Management Institute (IWMI), a CGIAR Research Center, to trial solar-powered water pumps for irrigation and household water. The community covered 50% of the costs, with the other 50% subsidised by IWMI.[3]

New business models developed by IWMI are turning farmers into solar irrigation providers, with the option to pay for a part of the infrastructure in instalments, and to form cooperatives with other farmers to sell their surplus energy to major utilities, thereby creating an incentive to use water and energy sparingly.

A new solar-powered pump on farmer's land, connected to an underground pipeline of more than 30 kilometres, is now providing a steady water supply for his farm and household, as well as those of 110 other farmers. "The new technology has brought irrigation costs down by 50%, and because of the guaranteed supply, has given farmers confidence to cultivate crops in all seasons, thereby doubling their incomes", stated one of the farmers.

The experiences shared above on all three case studies, suggests a huge potential market for the implementation of these business models, with the promise of profit for private companies, including small and local businesses. It will also drastically cut carbon emissions, contributing to global efforts to tackle climate change.

[1] Centre for Science and Environment, Solar Rooftop- Replacing Diesel Generators in Residential Societies: https://www.cseindia.org/solar-rooftop-replacing-diesel-generators-in-residential-societies6702

[2] Centre for Science and Environment, Solar Rooftop- Replacing Diesel Generators in Residential Societies: https://www.cseindia.org/solar-rooftop-replacing-diesel-generators-in-residential-societies-6702 [3] Asia Development Bank, ADB Inaugurates Project to Replace Diesel Systems with Solar Hybrid Across Maldives: https://www.adb.org/news/adb-inaugurates-project-replace-diesel-systems-solarhybrid-across-maldives

[3] CGIAR, Solar power replacing diesel for farmers in India: https://www.cgiar.org/food-securityimpact/photo_stories/solar-power-replacing-diesel-for-farmers-in-india/

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