EAI
Energy Alternatives India

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Replacing Diesel with Solar

A Comprehensive Guide for Indian Businesses

This e-book provides representative sample content to assist a reader in evaluating the Replacing Diesel with Solar Report

Preface

With its economy growing at a fast clip, the Indian industry is in a time of unprecedented opportunities for growth. Along with this growth comes the need for higher energy consumption, as energy demand / consumption are highly correlated to economic growth.

Until recently, India's energy demand has been met to a large extent by non-renewable resources, mainly coal and oil. Recently, natural gas has started playing an important role as well. But with the global concerns over climate change and the depleting nature of fossil fuels, not to mention the geopolitical risks attached with depending on foreign countries for these fuels, have made it imperative for the Indian industry to look at renewable sources of energy.

As a result of the nature of fossil fuels, their costs have been on the increase. Use of diesel in this regard should merit special mention, especially as a fuel for backup power for diesel gensets. While large factories and industrial set ups have their own captive power plants (usually powered by coal), tens of thousands of small and medium plants use diesel for a significant portion of their power needs. With the consequent increase in the cost of both grid power and that of diesel used as a fuel for backup power, businesses are looking for alternative and more sustainable sources for power production. It is well known that India has abundant sunlight that could support robust solar-based power production. Solar photovoltaic (PV) based power production could thus be an effective alternative.

The Replacing Diesel with Solar PV report has been developed for those companies and institutions keen on installing a solar PV based captive power production facility, especially as a replacement for their diesel use. The focus of the report is to facilitate a much deeper and more comprehensive understanding of the captive solar PV segment, specifically in the context of costs and technology aspects.

The report is developed by Energy Alternatives India (EAI), leading business intelligence and market research firm from India focused on the renewable energy and cleantech industries. This report was last updated in the first week of January 2014.

What Will You Know after Reading This Report?

- ✓ Why should I go for solar based captive power?
- ✓ How much solar PV capacity do I need?
- ✓ How much will it cost to install a solar PV captive system?
- ✓ How much maintenance does a solar PV system require?
- ✓ What are the key things I should look out for before installing a solar PV system?
- ✓ What are the mistakes I should avoid?
- ✓ How much space will I need for the captive PV installation?
- ✓ Should I use solar as a backup power or as a mainstream power source?
- ✓ Will I be able to depend completely on solar energy for my day time operations?
- ✓ If I operate night shifts, will I need a storage system (battery) for my energy needs?
- ✓ Can I sell my excess energy to the grid?
- ✓ What are the components of the solar PV system?
- ✓ What is the lifetime of the system?
- ✓ Am I eligible for availing government incentives?
- ✓ Can I install a hybrid captive system (mix of solar and wind OR solar and diesel)?
- ✓ When should I consider using a generator with my solar PV system?

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CHAPTER-1

Captive Power in India

Compared to the hectic growth in electricity demand, India has seen only a modest pace of growth in the supply of electricity. Power shortages have had a significant impact on companies and industries, especially manufacturing industries. As a result, quite a few businesses have started generating their own power, using conventional sources (usually diesel for small backup power and relatively larger coal based power plants) and in later periods wind based captive power plants were also set up. For these companies, in recent times, solar is emerging to be an attractive option. This chapter gives an overview of conventional captive power plant status and explains the advantages of using solar for captive power generation.

Key Sections

Sample Topic

Captive Power Plants in India

Solar Power vs. Diesel Generator

Uncertainty in Weather: The design of a solar power generation system involves either the use of historical weather data or weather forecast methods to predict the future temporal evolution of the solar energy system. Despite the use of such methods, the behaviour of weather conditions always involves high uncertainty. Unless such uncertainty is accounted for during the system design, the performance of the solar-based system will only be optimum within the range of the considered weather conditions. Potentially unpredictable weather fluctuations will result in suboptimal system operation.

Solar Irradiance: Solar irradiance is one of the most important factors in the operation of the PV systems and it can have a significant impact on the efficiency and power quality response of the whole system. The variable power flow due to the fluctuation of solar irradiance and temperature are some of the parameters that affect the power quality of photovoltaic systems. With high connection densities of photovoltaics in the distribution grid, low irradiance can lead to undesirable variations of power and supply quality (voltage and current) at the connection point which might even exceed acceptable limits. The system injects a highly distorted current (with respect to the fundamental frequency current) to the distribution network during low solar irradiance conditions. It has been found that low solar irradiance has a significant impact on the power quality of the output of the PV system.

Initial Cost: The high initial cost of solar PV systems is one of the most significant barriers to PV adoption. However, the recent results of MNRE's bidding under JNNSM phase 1 batch 2 process show that the cost of solar system have fallen significantly. As the initial cost of PV system decreases and the cost of diesel fuel increases, these systems will become more economically competitive. It is important to note that solar has already achieved grid parity when compared with diesel based power generation.

CHAPTER-2

Technology Options

Selecting the best system design for a particular application is more important. Often a combination of techniques can dramatically reduce costs and improve the reliability of a system, or provide the design flexibility to cover a wide range of applications. This chapter explains three different types of solar PV systems

- Stand-alone PV System
- Grid-tied PV System
  - Grid-Interactive Without Battery Backup
  - Grid-Interactive With Battery Backup
- Hybrid Solar PV System

Designing and implementation of each of these categories is different, and would need to be treated accordingly.

Key Sections

Sample Topic

Solar Photovoltaic-Diesel Generator Hybrid System

Beneficial in terms of improved reliability, energy services, operational life and energy efficiency, the hybrid system has brought forth the highest form of perfection in electricity generation. This system combines two energy sources; the sun and a diesel generator (genset), where the genset supplies excess load and recharge the battery during overcasts.

The hybrid system is meant for backup power in case of a power shortage, say during the peak demands. It also reduces downtime during maintenance or repairs since the system on its own, ensures that all the components are used efficiently at an optimum rate. For example, during the day, the solar modules will generate energy in the form of Direct Current (DC) and is stored in the battery or straight away put to use by converting it into AC through the inverter. So, when night time falls and the solar modules do not generate energy, the DC stored in the battery is put into use.

However, the DC stored in the battery is not necessarily enough to support the energy demand throughout the night since during day time, it may rain or the sunlight might be blocked by thick clouds, reducing the energy production. This will maximize the discharge level of the battery, causing its operational life to decrease, in other words, exhausting the battery. Here is where the genset comes in. The genset produces AC and can be immediately used and simultaneously rectified to produce DC to recharge the battery. The mechanism can also happen during peak loads or when a prolonged period of overcast occurs.

In addition, due to this alternate operation, the overall system has prolonged life proven by the discharge level of the battery is being kept optimum. The hybrid system adopts an environment-friendly technology whereby the diesel generator is used discontinuously and the whole operation itself is much quieter. All this is governed by a micro-processor-based controller unit.

The first installation may take up a high cost, but the maintenance cost afterwards is very low. In addition, we can save fuel consumption of the genset because the solar photovoltaic (PV) modules support the base electricity load while the genset provides additional energy should there be a sudden peak in the energy demand.

CHAPTER-3

Setting up Solar CPP in India

Once an entrepreneur has decided to set up a solar based captive power plant, there are seven steps involved in designing a successful captive solar PV installation. Whether the solar electric system is going to be small or large, and whether it is going to be off the shelf lighting kit or designing something from scratch, it is worth following these steps to ensure one gets the best from the system.

Key Sections

Sample Topic

Steps Involved in Setting a Captive PV Power Plant

Sizing for a Diesel-Solar Hybrid System with Batteries

Integrating solar power with diesel generator sets without affecting the daily operations has proved to be more challenging than originally thought. A whole host of issues related to frequency synchronisation, reverse current flows, and efficiency losses have contributed to solar system sizing limitations which have a direct bearing on the savings possible and consequently, the economics of the investment.

Frequency & Power Quality: As the loading factor of the diesel generator varies (as a result of introducing an intermittent solar power source into the mix), the frequency of the output AC power can vary beyond acceptable levels reducing the quality of power. Some modern day devices require high quality power to operate.

Reverse Current Flow: When the output of the solar power exceeds that of the load demand, some reverse current will flow in the diesel generator. Normally, there are acceptable levels to which this can happen beyond which the diesel generator trips cutting off the reference voltage for the solar and the system breaks down.

Efficiency and Minimum Loading: Diesel generators operate in various modes. Running a generator at loads below the minimum load factor[1] for prolonged periods affects the efficiency of operations which in turn has a bearing on fuel consumption, maintenance costs and useful life. Operating below the minimum load is possible if a sizeable solar system is integrated into the supply and results in decreased lifecycle savings of the solar-diesel generator system.

CHAPTER-4

Policies, Regulations & Incentives

For setting up an enabling environment for solar technology penetration in the country both at a centralized and decentralized level, in June 2010, government of India announced the guidelines for solar off-grid and decentralized power, under the National Solar Mission. Under this scheme, the Ministry of New and Renewable Energy (MNRE) provided central financial assistance for setting up of solar power projects for captive use. This chapter gives details on the financial assistance, eligibility criteria, and process involved in obtaining this assistance.

Key Sections

Sample Topic

Captive SPV and the NSM

Wind-Solar Hybrid Systems

a) The MNRE support for wind solar hybrid/ aerogenerator systems will be provided on per kW basis. The support will be provided on the basis of type of users. Following two slabs of CFA will be available:

Government/ public/charitable, R&D, academic and other non-profit making institutions.	Rs. 1.50 lakh per kW
Other beneficiaries not covered in the above given category (individuals and private/corporate sector will come under this category)	Rs. 1.00 lakh per kW
For 25 demo projects in North-Eastern states including Sikkim & J&K including Leh-Laddakh	Rs. 2.25 lakh per kW

b) The remaining cost of the system and all other expenditure related to packing & forwarding, transportation, installation and commissioning of the system will be a part of the system and will be met by the beneficiary of the system.

c) In case of installation of systems to be done through SNAs, an administrative charge @ 2% of CFA will be provided to SNAs at the time of final release.

CHAPTER-5

Economics of Captive Power Plants

The costs involved in setting up and running solar PV power plants are significantly different from those for coal based or natural gas power plants. Solar power systems are much higher in capital costs and much lower in operating costs. This chapter explains in detail the capital and operating expenses of captive PV systems and provides a comprehensive comparison of a captive solar system with a diesel genset system.

Key Sections

Sample Topic

Capital Costs and Breakups

Cost break up of a 100 kW solar captive system – without batteries

Items	Cost range
PV modules	31.5 - 33.8 Lakhs
Inverters (grid tie)	7.7 - 8.3 Lakhs
Balance of System (transformers, cables and wires, tracking devices, etc.)	23.8 - 25.5 Lakhs
Installation (civil & general works)	6.3 - 6.8 Lakhs
Total	**70.0 – 75.0**

As can be seen from the above table, the capex of a 100 kW system without batteries (i.e. a grid tie system) will be approximately 70.0-75.0 lakhs

Note: The cost range is given here because different manufacturers price their products differently.

CHAPTER-6

Financing of Solar CPPs

One of the key challenges in installing a Solar CPP is the financing aspect. This being a nascent industry, project developers would be keen to know how to finance the projects, especially when banks and other financial industries do not have much exposure in this area. This chapter describes various financing options available in the country for setting up captive power plants.

Key Sections

Sample Topic

Project Finance

Project Debt Financing for Renewable Energy – Highlights

Parameter	Value
Debt: Equity	70:30
Loan Tenure	6-8 years (including 1 year moratorium)
Interest	11-11.5%

Note: All details provided are only indicative in nature;

The table above provides the highlights of renewable energy financing in India. A similar pattern is expected for solar PV captive financing as well.

Financial Institutions that Fund RE Projects in India:

The primary debt providers in renewable energy project financing are commercial banks. Prominent domestic banks that currently fund renewable projects are: Industrial Development Bank of India (IDBI), Export-Import Bank of India, ICICI Bank, the Industrial Finance Corporation of India (IFCI), State Bank of India, Yes Bank, and PNB.

CHAPTER-7

Next Steps to be taken by a Solar PV Captive Power Developer

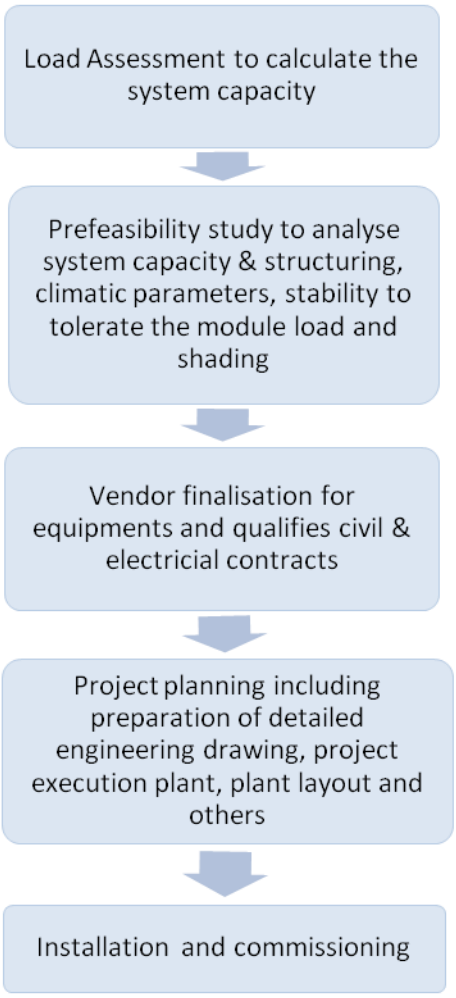
Solar PV captive power developers need to undertake a series of steps before they can start the implementation of the solar PV power system. These steps include efforts for both analyses (technical and economic feasibility) as well as interactions with government departments and prospective suppliers. This chapter provides detailed inputs on how institutions and entrepreneurs can undertake each of these activities.

Key Sections

Sample Topic

Next Steps to be taken by a Solar PV Captive Power Developer

Next Steps to be taken by a Solar PV Captive Power Developer



CHAPTER-8

Solar PV in India – Industry Status and Trends

India presents an attractive opportunity for captive solar PV developers and investors. Apart from PV (especially polycrystalline technology) based captive solar, standalone solar power plants can also be set up using other technologies. The objective of this chapter is to provide an introduction to alternative energy sources and discuss in detail about the status and trends of the Solar PV technology in India.

Key Sections

Sample Topic		
Solar Photovoltaic in India – A Snapshot	Total available potential	India lies in a sunny tropical belt (High insolation) Total theoretical potential – annually over 5,000 trillion kWh
	Exploited potential (production/installed capacity)	Exploited potential (production/installed capacity) is very little; total installed capacity (grid and off grid) is approximately about 2,220 MW, and of that about 2,080 MW is grid-connected (as of Oct 2013)
	Future expected production/installed capacity	For solar CSP and PV together, National Solar Mission attempts to reach an installed capacity of • By 2013: 1-2 GW • By 2017: 4-10 GW • By 2020: 20 GW Moreover, large areas of the Thar Desert has been set aside for solar power projects, sufficient to generate 700 to 2,100 GW
	Specific government incentives	National Solar Mission and other Generation Based Incentives (GBI) are available through Ministry of New and Renewable Energy
	Amount of investments happening in this now, expected in future	Government is expected to spend $19 billion until 2022.
	Key bottlenecks and barriers	• Cost of solar PV • High population density (land scarcity) • Technology obsolescence
	Cost of power generation - and trends in the same over years	Current cost of production (after bidding) – Rs. 7/kWh (weighted average). This includes O&M, amortized/depreciated capital costs, loan repayment costs, and other expenses such as insurance. Costs of production expected of Solar PV power plants in the near future - Rs/kWh: By 2015 – 6 By 2020 – 5

CHAPTER-9

Case studies of Indian Use of Captive Solar PV

This section of the report presents the performance, impacts and lessons learnt from planning, implementing and monitoring of solar based captive power plants. Case studies of companies and organizations in India are provided here. The chapter also provides a comprehensive list of system integrators.

Key Sections

Sample Topic

Stand-alone Solar PV Installation in India

Provided below is the sample list of SPV captive Power Installations in India.

Name of Customer	Location	Project capacity	System Type	Impact
Tata BP Solar				
Karnataka Public Works Department	VikasaSoudha - Bangalore	100 kWp	Roof-top Grid Connect Solar Power Plant	The 100 kW Peak Solar Array provides power to satisfy the energy requirements of the building and the housing facilities of the government offices.
Oil & Natural Gas Corporation Limited	Mumbai High Field		Standalone solar PV mounted on helideck of 9WPP	The solar power generation system used on the ONGC wellhead offshore platforms powers telemetry, gas detection, lighting and navigational aid systems.
Executive Ship Management Pte Ltd	Samudra Institute of Maritime Studies, Mumbai.	90kWp	BIPV Systems	BIPV installation in India, SIMS successfully satisfies most of the institute's power requirements internally
West Bengal Renewable Energy Development Agency (WBREDA)	Indrapur, West Bengal	110 kWp	Standalone Solar Power Plant	The solar power generated, is utilized to provide power to every household for basic lighting, commercial utilization and for water pumping system

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