

# **Size Selection in Accordance with Economic Feasibility of Solar PV System for a LT-VII A Consumer in Kerala**

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**ABSTRACT:** Solar PV plants have attained greater acceptance in the present world. This paper proposes a study in size selection and economic feasibility analysis of a LT VII customer in Kerala in reference with 'Solar Connect - Distributed generation Programme'. From this paper a LT VII three phase commercial customer will be able to select the size of the plant required according to his average daily consumption.

**KEYWORDS:** LT VII A, solar connect programme, IRR, Payback

## **I. INTRODUCTION**

Solar pv is emerging as one of the most promising technology for electrical energy generation. Central and state governments are promoting their use in a wide range by providing financial subsidies. The development in renewable energy sources in India has been recently accelerated by government policy initiatives.

The performance of solar pv systems may vary according to difference in climate, type of solar cell used, level of irradiance, inverter efficiency. Expected efficiency will be obtained from PV plants only in STC.

Performance evaluation of 3.9kW grid connected photovoltaic system is given in [3]. The paper concentrates on the use of on-grid solar PV systems by industrial consumers in LT VII [A, B,C] tariff of the state of Kerala. Failure in pv systems will result in economic losses [1]. On behalf of both utility companies and customers, reliability of grid connected pv systems have been of great concern.[2].

The paper focuses on the study where a commercial customer will be able to choose the power rating if solar panel feasible. The main factors to be looked at are feasible design options that will result in minimum payback period and high rates of return.[3] Fed in tariff is also considered for IRR and payback period calculations.

## **II. SOLAR PV SYSTEM**

Two major classifications of solar systems are: grid-tied or on grid and off grid systems.[4]

### **A. Grid-tied systems**

Photovoltaic systems are designed to make use of an existing electric grid. Block diagram for a grid tied system is shown in fig.1. In a grid tied system there is no need for a battery system to store the energy that the solar panels generate. Instead the power grid itself acts in a sense as a giant battery uses any excess electricity that solar panels may generate and which you can draw from on cloudy days when there is insufficient sunlight to fully power your needs.

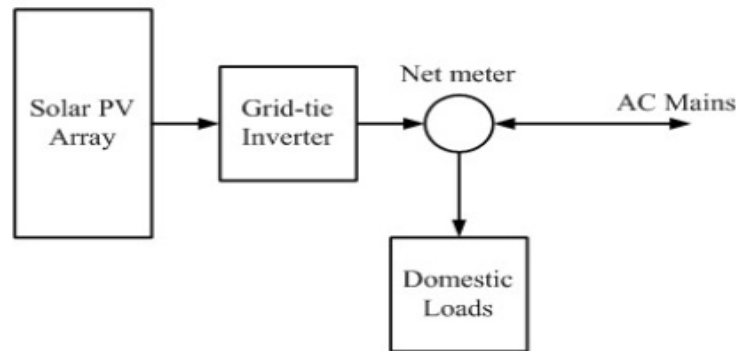


Figure 1: Grid-Tied System

**B. Off Grid Systems**

The figure 2 shows the basic block diagram of off grid system. It is possible to install a solar system that is independent of the electrical grid. This is called an off-grid system, and it requires that the solar panels are able to produce enough electricity to cover 100% of the energy needs of the building. Most homes have higher electricity demand in the evening or at night, so off-grid systems usually incorporate either a battery (to store energy produced during the day), a backup source of energy (like a generator), or both. Off-grid systems are more complex and less flexible than grid-tied systems. An off-grid solar system must be large enough to produce enough electricity to cover 100% of the energy needs of the building. In all off-grid scenarios, electrical usage must be monitored and kept below the maximum output of the panels and batteries as there is no grid-source to supply excess power.

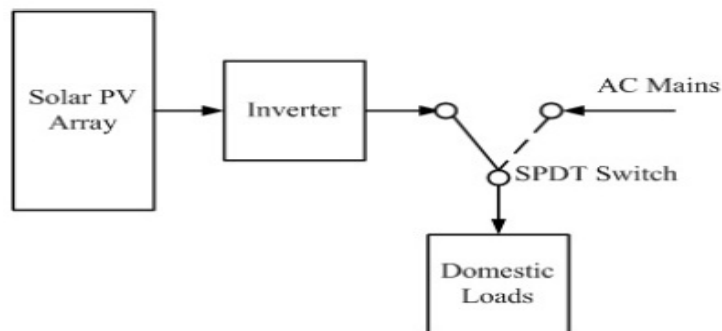


Figure 2: Off Grid System

**III. SOLAR CONNECT PROGRAM**

The scheme aims at the installation of rooftop solar PV grid connected power plants of 2kW to 50kW in Kerala. It is open to all type of beneficiaries, but here we concentrate only in analysing the economic feasibility of commercial consumer. ANERT provides the list of empanelled agencies associated with this scheme. Installation of Roof-top Solar PV grid connected power plants, of 2kW to 50 kW capacities in Kerala, open to all types of beneficiaries limiting the total installed capacity to 50kW in a single location. Central and state Govt. Subsidy will be made available to the beneficiary if and when available.

**A. Minimum Requirements for the installation of power plant & General Information**

Minimum 10square meters hade free area is required for installing 1kW Solar panel array. The availability of area for installing the required plant has to be assured while submitting the application. The area required can be estimated by multiplying the Capacity of plant in kW with 10sq.m (ie. Capacity in kWp X 10 Sq.m) [5].

The system will be in the grid connected mode without battery backup. The electricity generated will be utilized directly and excess electricity could be fed to the grid of Distribution licensee through energy meter with net metering facility. There will be no generation & backup while grid electricity is not available. The electricity generated will be based on the solar insolation available and capacity of system installed and availability of grid power. The system will generate only if grid power from Distribution licensee is available in the prescribed voltage level and frequency. (Voltage of the grid should be between 184VAC and 253VAC (for Single Phase) and 332VAC to 456VAC (for Three Phase). Frequency should be between 47.5Hz and 50.5 Hz). Average daily electricity generation on a sunny day will be 4units/kW of solar modules installed. But this will vary according to the availability of solar insolation and presence of grid. The Government/ ANERT reserve the right to modify the terms and conditions and eligibility criteria if required.

**B. System cost and Subsidy/ Financial incentive available:**

Approximate cost of the system is about 0.8lakh/kW. This may vary according to the pricing received during expression of interest. Charges and fees related to connectivity levied by Distribution licensee is not included in this estimation. State financial assistance of Rs.10, 000/- per kW is available. Govt. of Kerala sanctioned a project of 12MW aggregated capacity. Central financial assistance available is Rs.24000/- per kW or 30% of the cost of system ( Whichever is less) ( For systems with cost lower than the Bench mark cost fixed by MNRE Subsidy will be limited to 30% of Total cost).This will available for an aggregated capacity of 5MW. This will made available based on the priority of registration number allotted. System Sizing is based on the availability of shade free area, requirement by the beneficiary and the connectivity permission from the Distribution licensee. Minimum capacity should be 2kW and maximum allowable is 50kW for single system. Capacity up to 5kW should be single phase. Systems of capacity 5kW and higher must be of 3phase. If the Distribution licensee connection to the beneficiary is single phase wishes to install solar power plant of capacity 5kW and above has to convert the consumer connection to 3phase before proceeding for installation. The configuration of systems available is as listed below. If any of the beneficiary requires configuration other than in this list, he can opt combination of the systems listed below. Maximum capacity allowable is 50kW under this programme.

**IV. LT VII TARRIF**

Tariff for commercial consumers such as shops, other commercial establishments for trading, showrooms, display outlets, business houses, hotels and restaurants (having connected load exceeding 1000W) private lodges, private hostels, private guest houses, private rest houses, private travellers bungalows, freezing plants, cold storages, milk chilling plants, bakeries (without manufacturing process), petrol/diesel/LPG/CNG bunks, automobile service stations, computerized wheel alignment centres, marble and granite cutting units, LPG bottling plants, house boats, units carrying out filtering and packing and other associated activities using extracted oil brought from outside, share broking firms, marketing firms. The trend during the past few years have been to increase the electricity tariff rates on a yearly basis, as decided by the Kerala State Electricity Regulatory Commission. Tariff details for LT VII A is shown in Table I

**Table 1: LT VII A TARIFF DETAILS**

<b>LT VII (A) COMMERCIAL</b>	
<b>Fixed Charge</b>	<b>(Rs./KW per Month)</b>
Single Phase	60
Three Phase	120
<b>Energy Charge</b>	<b>Paise per Unit</b>
Upto 100 units per month	600 Non-telescopic
Upto 200 units per month	670 Non-telescopic
Upto 300 units per month	740 Non-telescopic
Upto 500 units per month	800 Non-telescopic
Above 500 units per month	930 Non-telescopic

## V. FINANCIAL ANALYSIS TOOLS

The financial assessment done in this paper based on calculating the Internal Rate of Return (IRR) and Payback period after considering certain assumptions, which are given below.

### A. IRR

The internal rate of return of a project is the discount rate which will make the net present value of the project equal to zero where  $CF_n$  is the cash flow at the end of year  $n$ ;  $r$  is the discount rate and  $n$  is the life of the project. The calculations done in this paper are done by taking  $r = 8\%$  and  $n = 10$ . The project period is not usually considered to be more than 10 years since the waiting period will be very high for the project to be financially feasible. The project with a higher IRR is always preferred over a project with lesser IRR.

$$NPV = \sum_{n=0}^N \frac{C_n}{(1+r)^n} = 0$$

$NPV$  = the net present value

$n$  = Period

$N$  = total number of periods

$C_n$  = cash flow

$r$  = Internal Rate of Return

### B. Payback Period

The payback period is calculated by considering the annual discounted cash flow and the period at which the net present value becomes equal to zero is taken as the break-even period or the payback period. Here payback period is constrained to a limit of less than or equal to 10.

## V. ECONOMIC FEASIBILITY STUDY

### A. Consumer Selected

Consumer selected for the financial analysis of the solar connect programme is LT VII A commercial consumer. The main reason for this due to the fact that the average daily consumption greater than 20kWh is mostly for this type of consumers. The plant capacities considered are 10kW, 15kW, 20kW, 25kW, 30kW & 40kW.

### B. Assumptions Taken

- 4kWh is generated per day for every 1 kWp solar PV system installed [5].
- The inverter efficiency is 90% and is taken to be constant, although in practice it will depend on the power being transferred to the grid.
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### C. Analysis

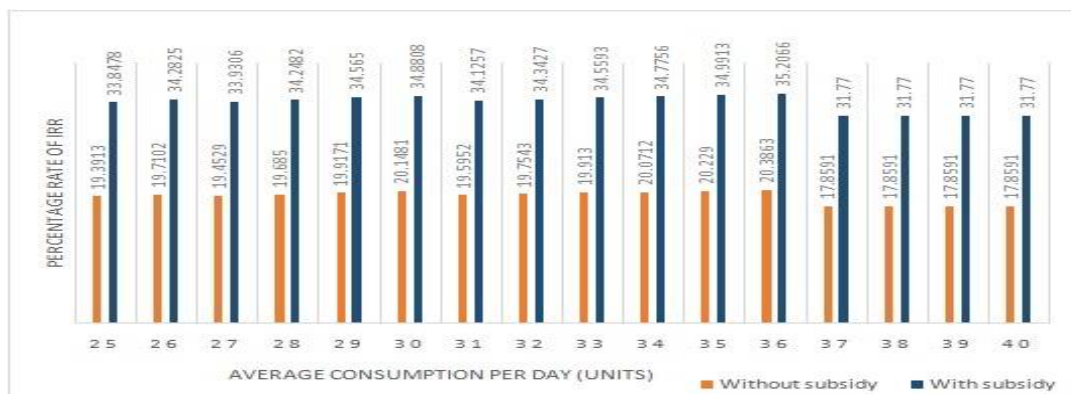
The analysis is done by considering the daily average consumption of the consumer as the basis, starting with 25 units per day. The upper limit of average daily consumption is taken as 40 units due to the fact that commercial consumers which consumes over 40 units per day is comparatively rare in the state of Kerala. The analysis is further divided by considering a system with subsidy and the same system without subsidy. The benchmark price and the subsidy rates are given in Table II

**Table 2: CATEGORY WISE SUBSIDY AND SYSTEM PRIZE**

SI No:	Configuration	Without Subsidy	With Subsidy
1	5 kW Three phase	430599	260599
2	10 kW Three phase	800000	460000
3	15 kW Three phase	1175089	672562
4	20 kW Three phase	1482366	837656
5	25kW Three phase	1890000	1073000
6	30kW Three phase	2211369	1247958
7	40kW Three phase	2946130	1662291
8	50kW Three Phase	3675134	2072594

**1. 5 kW system.**

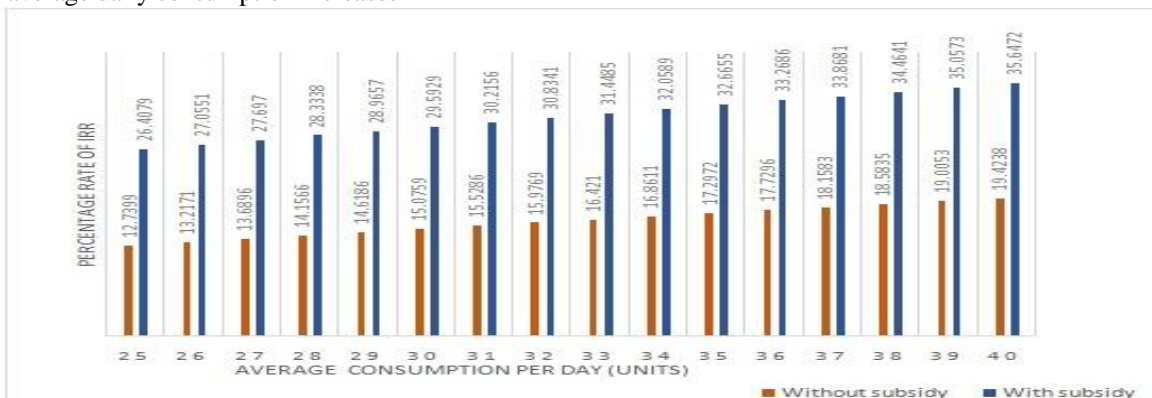
It is clear from figure (3) that the project implemented facilitating subsidy has a higher IRR and is the suitable choice for implementation, whatever be the daily average consumption of the user. Here it can be observed that IRR varies abnormally as the daily average consumption of the consumer increases and so we cannot say that the IRR increases corresponds to average daily consumption. But it is clear that the IRR rates are feasible for with subsidy rates than without subsidy rates.



**Figure 3: IRR of 5 kW system**

**2. 10 kW system.**

It is evident from the fig(4) that the project implemented is favourable for with subsidy rates than without subsidy rates; having higher IRR and is the suitable choice for implementation. It is also observable that IRR rates increases gradually as the average daily consumption increases



**Figure 4: IRR of 10 kW system**

**3. 15 kW system.**

The IRR of 15 kW is given in fig 3. It can be observed that IRR rates of with subsidy rate are far higher than without



subsidy rate. The IRR rates vary from 8.9227% to 13.9897% and 21.4234% to 28.2442 % for without subsidy and with subsidy rate respectively; in reference with 25 units/day to 40 units/day.



Figure 5: IRR of 15 kW system

4. **20 kW system.**

The IRR of 20 kW is given in fig 6. The figure shows slight increment in IRR for both with subsidy and without subsidy rate. IRR of without subsidy rate varies from 7.6210 % to 11.8266% and IRR of with subsidy rate varies from 20.0259% to 25.6661%.

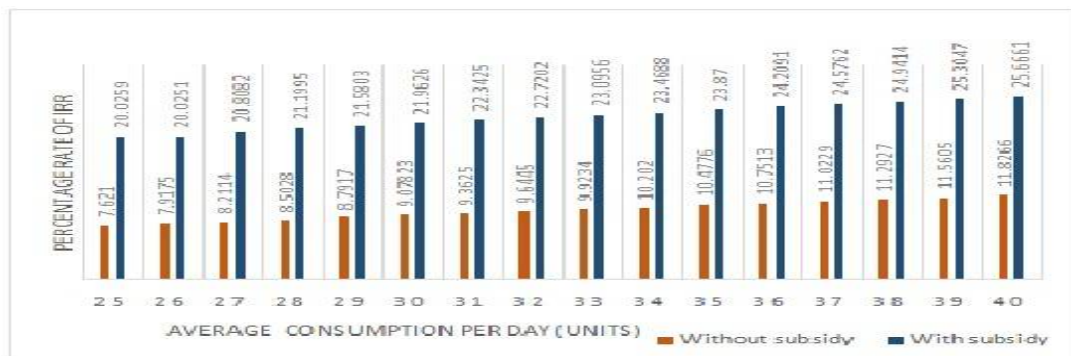


Figure 6: IRR of 20 kW system

5. **25 kW system**

The IRR of 25 kW is given in fig 7. Here also the IRR varies in a slow slope. For with subsidy rate IRR varies from 17.4376 % to 22.0743% and for without subsidy rate IRR varies from 5.7363% to 9.2536%. It is also notable that for 30 units consumption per day, the IRR of both with subsidy and without subsidy rates are slightly less than that of others.

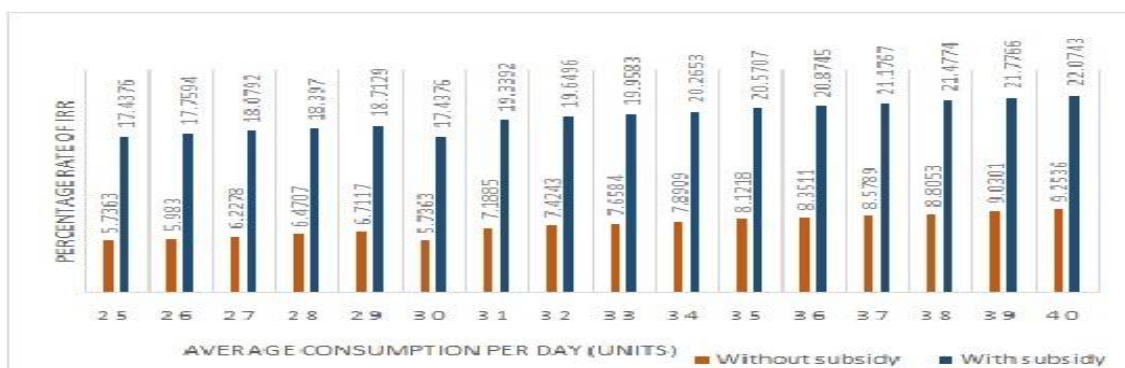


Figure 7: IRR of 25 kW system

**6. 30 kW system**

The IRR of 30 kW is given in fig 8. It is clear that as the average units per day increases IRR values also increases. The project is feasible for plants provided with subsidy. IRR vary for with subsidy rate is 16.7971% to 20.85205%.



Figure 8: IRR of 30kW system

**7. 40kW system**

The IRR of 30 kW is given in fig 9. From the fig it is observable that the IRR values of both with subsidy and without subsidy rates are comparatively smaller than other plant sizes. The IRR of without subsidy rate varies from 3.77% to 6.2124% and 15.0287% to 18.2075% for with subsidy rate.



Figure 9: IRR of 40 kW system

**D. Choice of selection of installation**

For a 5 kW system, while considering the unit consumption/day from 25 to 36, with subsidy IRR rates are far higher than that of all other systems, but while considering the units from 37 to 40, the with subsidy IRR rates for a 5kw system are less than that of with subsidy IRR rates of a 10 kW system. Higher rates of IRR is always more feasible for a consumer. So in short for a consumer consumes electrical energy/day from 25 kWh to 40 kWh; 5kW system is favourable for them. For unit consumption/day 37 to 40; 10 kW system is favourable because of high rates of its with subsidy IRR rates. The matter very important is that the payback period is confined to a year less than or equal to 10. But the calculations of payback period of 40 kW system shows that the project will not be feasible as their payback period is beyond the limits. Also it can be inferred that 30 kW system is feasible only for units consumed/day greater than 39kWh/day. 25 kW system is feasible only for units/day greater than 35.

**VI. CONCLUSION**

The financial analysis of the plant sizes from 5kW to 40 kW systems are done using IRR and fixed payback period (less than or equal to 10 years) as reference. It can be inferred that the 5 kW system is found to be a better choice than all

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other systems, with assumptions under consideration. If we consider the salvage value of the plant after 10 years the payback period will reduce further and IRR rates in turn increases. The impact of inflation is not considered here.

The projects are found to be feasible in the sense that they provide less payback period and higher rates of IRR. As the average daily consumption of electrical energy is higher, the payback period will reduce gradually and IRR increases to maximum value. This can be also treated as the promotion of renewable energy in spite of other options.

The authors of this paper are in the course of measuring actual plant outputs at various sites in Kerala. This will help in giving a better input about the energy generated per kW of installed plant. This will give accurate data which makes the project more feasible in the real sense.

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