Comparative Analysis of Net Metering and Feed in Tariff Schemes for 50kw Solar Photovoltaic Distributed Generation System at Mahad

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Abstract: Solar Photovoltaic (PV) system compared to its scenario a decade ago has made a great impact in energy production. Government provides several benefits to the customers in terms of subsidies, benefits in income-taxes and many other such benefits. Tariff by Net metering schemeregulated by the Government provides benefits to the consumer applicable for various distributed generation system. In this paper, a new scheme of Feed in Tariff (FiT) for metering the total amount of energy generated has been discussed. A case study on 50 kW Laxmi Ice factory at Mahad, Maharashtra is considered in this paper. A MATLAB/Simulink model consisting 50 kW solar PV system, FiT& Net metering, solar radiance value is simulated. This model gives cost and energy analysis in terms of savings in a monthly bill, thus improving the rate of investment of solar PV system. Both methodology have their own merits and demerits. The results presented in the paper show that theFiT metering is more economical in terms of cost effectiveness and energy saving.

Keywords: *Feed in Tariff, Net Metering, Distributed Generation, Solar PV*

IV. INTRODUCTION

The fact that there is a considerable fall in the price of solar products increases its applications. Government of India under Ministry of Renewable Energy (MNRE) has been promoting various programmes for the use of renewable energy. It has also planned to widen the area of distributed generation not only to urban areas but also to rural applications, small business, government schools etc. The application solar as roof top PV system with or without grid connectivity is of main type of distributed generation system in a country like India where abundant amount of solar energy is available maximum time of the year. MNRE has set up various incentive program for upbringing and promoting distribution generation (here solar roof top PV application) by giving tax benefits, incentives etc.

Net metering and Feed in Tariff (FiT) are among the tariff schemes proposed by the Government. Net metering monitors the record between export and import of electrical energy; where the excess solar energy generated available for export and input of electrical energy from distribution company as an import. This method applies the tariff in a way that it credits the customers based on excess electricity generated; which takes place through grid. Feed in tariff (FiT) or renewable energy payment method is applied to those distributed energy systems producing electricity by their own. FiT has two tariffs i.e. for its generation and its own consumption.Both methods i.e. Net metering and FiT prove to be cost and energy effective and provide reduction in CO2 emission. However, the latter provides more effective result in terms of cost and energy.

This paper provides the statistical analysis between Net metering and Feed in Tariff applied on a 50kWp solar roof top PV application. This is applied at Laxmi Ice Factory in Mahad, Maharashtra at an altitude 11m and latitude 18.1N and 73.4E respectively. The analysis is tested by implementing MATLAB/Simulink model where data is analysed using solar radiance, energy generated by roof top solar implementation, net metering and FiT. This model provides the necessary statistical analysis proving which tariff is better in terms of cost and energy analysis for a period of one month. Both method also helps in reduction of CO2 emission significantly. Also, rate of investment is also calculated using the two tariff methods. This paper is organised as follows: Section 2 introduces single cell model of PV system and its mathematical modelling. Section 3 gives information of various types of tariff schemes and its calculation methods and is followed by specification details of solar panels and its typical solar grid-tied representation in section 4. Section 5 explains MATLAB/Simulink model wherein results are discussed. Section 6 concludes the paper.

V. MATHEMATICAL MODEL OF PHOTOVOLTAIC SYSTEM.

Figure 2.1 shows basic representation of PV system. It also shows equivalent circuit diagram which is called as “four parameters model” consisting of diode, current source, series and parallel resistance; where, Photo-Diode represents – Light generated current of the solar cell, Diode represents – Non-linear impedance of P-N junction, Series resistance represents – Internal electrical losses and Shunt resistance represents – Leakage current to ground.

The light generated current source and diode connected in anti-parallel represents ideal model of solar cell (theoretically). Direct current is generated when solar radiation falls on solar panel, and this current is inversely proportional to solar radiation.

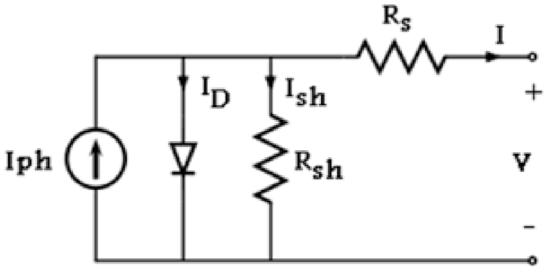

Fig. 1: Mathematical model of PV system

Considering the circuit diagram of Fig.1, following characteristics equation is developed.

Applying KCL, the output current of the cell is:

$$I = I_{ph} - I_d - I_{sh} \quad (1)$$

The light generated current or photo current varies with irradiance and temperature is given by these mathematical equations:

$$I = I_{ph} - I_s [\{\exp (V+IR_s) q / aKTN_s\} - 1] - \{(V+IR_s) / R_{sh}\} \quad (2)$$

Where,

$I_{ph} = I_r (I_{sc} / I_{ro})$,

$Is = I_{sc} / [\{\exp (V_{oc} / aV_t)\} - 1]$,

$I_d = I_s / [\{\exp (V+IR_s) / aV_t\} - 1]$,

$I_{sh} = (V + I_{rs}) / R_{sh,}$

and $V_t = (KTN_s) / q$.

The above equation represents relation between current and voltage of solar photovoltaic module. The mathematical equation is a nonlinear equation where

N_s represent series connected cells, I_{ph} is the light generated current, $I_s$is the reverse saturation current, R_s andR_{sh} represent the series and parallel inherent resistances of the cell, q is the electron charge 1.60217646×10−19 C, k is Boltzmann's constant 1.3806503 ×10 −23 J/Kanda is ideality factor modified.

VI. TARIFF SCHEMES IN INDIA

3.1 Feed in Tariff scheme (FiT)

Feed in tariff monitors the cost and generated energy from renewable source of energy which is distributed to the grid. Here, the ice factory does not consume any energy from the PV system. This signifies that the amount of energy drawn from the utility grid remains and the generated renewable energy from solar PV roof top system is sold back to the utility. The utilities rate is Rs. 2.65 per kWh given in equation (3),

$$FiT = REkwh \times FiTrate \quad (3)$$

3.2 Net Metering Scheme

This method computes the net energy after utilizing generated energy by PV system. This system generates maximum output during the day time when the solar radiation is maximum.The net energy consumption where kWh is the energy consumption and REkwhis renewable energy generated.

$$Netkwh = kWh - Rekwh \quad (4)$$

With net metering scheme, the maximum power demand can be shaved off by the PV generated power as defined in equation (5) where MD(T is the peak power occurred at a given time which can be identified from the load profile and PVout(T) is PV generated power at a giventime when peak power occurs.

$$MDshaved = MD(T) - Pvout(T) \quad (5)$$

$$Usage = (Netkwh \times 2.64) + (MDshaved \times 170) \quad (6)$$

The net energy and maximum demand usage is defined in (6) and the total bill can be computed as follows

$$Bill = (Usage - ICPT) \times GST + KWTBB \quad (7)$$

where,

ICPT = Imbalance Cost Pass-Thro Tariff Rebate

= kWh x 0.1

KWTBB = Usage x 1.6%

IV. . MATLAB IMPLEMENTATION

For 50 kWp project, technical specifications are given in Table I and Table II.

Table I: Specifications of Solar Panel Array

Sr.No.	Technical specification	
1	Capacity of PV Module	325Wp
2	Voltage at P_{max}	36.7V
3	Current at P_{max}	8.86A
4	Open Circuit Voltage	45.2V
5	Short Circuit Current	9,.33A
6	Module Efficiency	16.74%

Table II: Technical Specifications of String Inverter

Sr. No.	Technical Specification of Module Mounting Structure	
1	Max. PV generator power	25000 kVA
2	No-Load Voltage	1000V
3	Max. Input Current	38A
4	No. of MPP Trackers	1
5	Max. Power/Tracker	25kW
7	Number of Strings	4
8	Rated output	25000kVA

The MATLAB/Simulink model is designed to monitor three conditions of the ice factory:

Case 1. Factory campus without PV installation

Case 2. Factory campus with Feed in metering scheme

Case 3. Factory campus with Net metering scheme

Figure2 shows graph load profile of the factory campus before and after shaving the PV system. Maximum demand of connected load is 83kW. The graph is very consistent considering energy consumption.

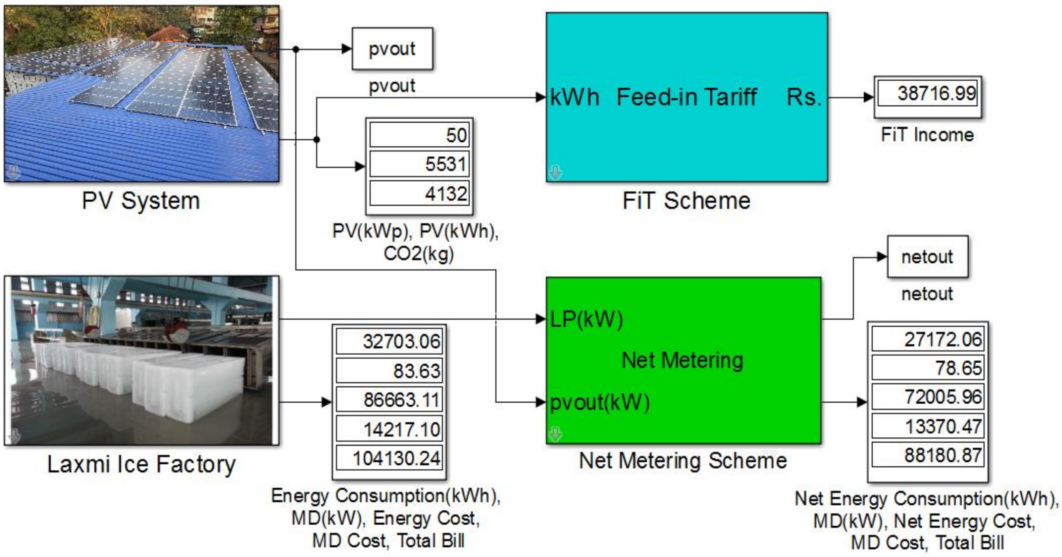

Fig. 2: MATLAB System Overview

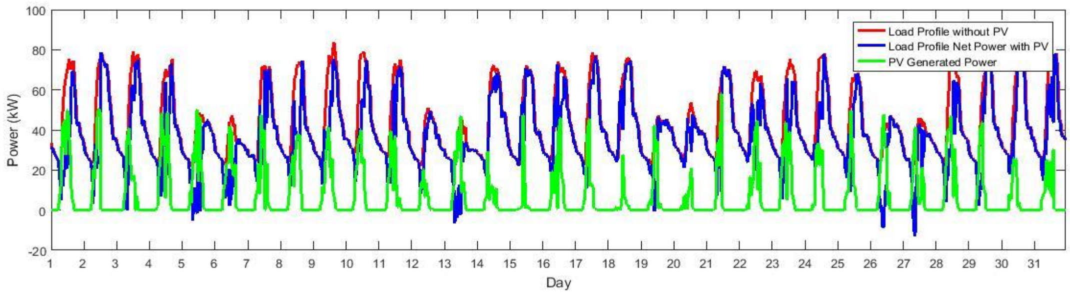

Fig. 3: Graph of load profile without PV, with PV net energy and PV generated power

Table III: Energy consumption, maximum demand, PV generated energy and CO2 emission for all three cases

	Without PV system	Feed in Metering	Net Metering
Energy consumption(kWh)	32703	32703	27172
Maximum demand(kW)	83	83	78
PV generated energy(kWh)	0	5531	5531
CO2 emission avoidance (Kg)	0	4132	4132

The installation cost is Rs.70 per kW; which cost Rs. 3500000 for 50 kWp installation. These details with the available readings in table III, monthly saving is calculated. Important parameter of rate of investment (ROI) is calculated considering total investment and saving over a period of time. Fit saving and Net saving is calculated using formula:

FiT saving = Total Bill (without PV) – Total Bill (FiT) (8)

Net Metering saving = Total Bill (without PV) – Total Bill (Net metering) (9)

ROI = (Total Investment Cost) / (Monthly saving x 12) (10)

Table IV gives details of cost saving, energy analysis and return of investment for all three cases using the above formulae. The monthly saving using FiT scheme is Rs. 38717 and ROI is 9.3 years. The monthly saving using Net metering scheme is Rs. 15494and ROI is 18.3 years.

Table IV: Energy Consumption tariff, MD, FiT income, monthly saving, ROI, profit/saving in Rupees

	Without PV system	Feed in Metering	Net Metering
Energy consumption tariff charge	86663.11	86663.11	72005.96
Maximum demand charge	14217.10	14217.10	13370.47
Income	0	38716.99	0
Total Bill	104130.24	104130.24	88180.87
Monthly Saving	0	38716.99	15949.37
Return of Investment (Yrs)	0	9.3	18.2

V. CONCLUSION

The detail study of 50kWp roof top solar installation and complete comparison between Feed in tariff and Net Metering schemes is explained in this paper using a MATLAB/Simulink model. FromTable IV, it is clear that FiT tariff is better compared to Net metering considering its cost efficacy and rate of return of investment. Net metering is beneficial and effective for the strong values of solar irradiance during maximum demand of the month. Both methods not only prove beneficial in reducing the overall load demand and load consumption of the factory campus; but the CO2 emission has also been reduced significantly. FiTand Net metering schemes save approximately 37.8% and 18% respectively in the monthly bill and also avoid 4132 kg of CO2. The MATLAB/Simulink model created can also be used to monitor and analyse different ratings of solar PV installations.

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