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INTEGRATION OF GRID TIE SOLAR ENERGY USING BIDIRECTIONAL METER FOR ELECTRICAL POWER AND TO THE UTILITY POWER GRID

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Abstract—Energy is beneficial to the human kind when it is available in the necessary form. For example, here the supposed form of energy is electricity. There are several stand-alone power systems throughout the globe depends on fossil fuels to generate electricity. These applications incur high electric generating costs due to the price of fossil fuels. It is expected that our fossil fuels may be exhausted with in a century by observing the present rate of consumption. Periodic price hike of crude oil has made that form of energy most economical. To meet energy crisis we have to integrate or coupling renewable energy sources (RES) such as solar (PV), wind, biomass, tidal, wave, geothermal energies can lower the cost of producing electricity. Integration of renewable energy sources like solar and wind energy to utility grid like APEPDCL in India for electrical power. Andhra Pradesh is the one of the highest solar power producing state in India. In top of residential buildings and some educational institutions there is a Rooftop solar system installations integrated with APEPDCL. Electrical power what we are generated during day time is may be sufficient or may not be sufficient, it is based on not only utility point of view. RES are intermittent and variable in nature. Net meter is a single and bidirectional meter, which can measure the flow of current in both the directions.Net energy metering, provides an alternative solution to sell excess energy to the utility company or purchase/buy from utility grid. Net metering consumer uses more power for residential building. Net metering (or net energy metering, NEM) allows customer to use electrical power produced from rooftop solar system during day time. This paper presents the Electrical power consumption in units from various energy sources, Average units per day, Revenue generation and CO_2 savings and reduction for last five years, Electricity bill monthly saving, Return on Investment of percentage per annum from FDs

Keywords—Variable renewable energy, Rooftop solar system, Net energy metering, Electrical power consumption, CO_2 savings.

I. INTRODUCTION

Grid tie solar rooftop system [1] defiantly is easy way and lowers price to produce electrical power and it has some pros and cons. Solar panels generate electricity moves to inverter. The DC to AC grid tied inverter converts variable direct current from the solar panels to alternating 240 volts. The inverter uploads power to the utility grid and distributed to the consumers. The consumer is not using the much generated power it supplies electricity to bi-directional meter. The bidirectional meter rotates backwards supply electricity to the utility grid. If the sun is not shine the system does not produce any power then the meter rotates forward direction and consumes

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power from the grid. When measuring voltage in high resistance circuits digital meters accurate than Analog meters. Digital meters more impedance than analog meters.

II. ENERGY METERS

A. *Types of energy meters*

After going through the text book written by A.K.Sawhney [2] a few points are taken into consideration to write about the types of energy meters. In domestic and industrial a.c.circuits energy can be measured by induction type instrument. There are two fluxes produced by currents flowing in the windings of the instrument. These fluxes are alternating in nature and so they produce emf in a metallic disc. Fig. 2.1 shows thin circular aluminium disc free to rotate about an axis throughout its centre. There are two poles P_1 and P_2 producing alternating fluxes $\varnothing_1$ and $\varnothing_2$ which cut the disc, annular motion of the disc with centre on the axis P_1.

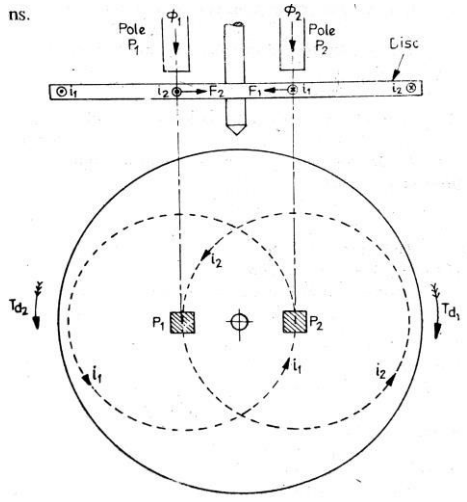

Fig. 2.1. Principle of working of an induction type instrument

In induction type instrument [2] any annular portion of the disc with centre on the axis P_1 will be linked by alternating flux $\varnothing_1$, hence it will have an induced emf and this induced electro motive force will produce an eddy current i_1.Similarly flux $\varnothing_2$ will produce an eddy current i_2.Single phase induction type energy meter and its construction varies in details from one manufactures product to the next. However the differences are very minor in nature.

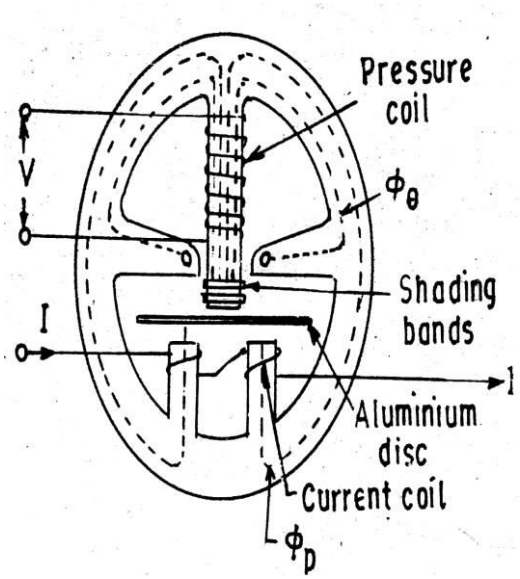

Fig. 2.2. Single phase induction type energy meter

Polyphase energy meter circuits can be measured by a group of single phase energy meter [2]. It is connected as required by Blondels theorem. The total energy is the sum of the readings of all energy meters.

B. *Two element energy meter*

Two element energy meters [2] which is used for 3 phase 3 wire systems. The meter shown in the diagram is provided with two discs one for each element. Power passing through each element can be exactly equal and producing same amount of driving torque. In addition to the device an adjustable shunt magnet is provided on both the elements to balance the torques of the two. The necessary adjustment is made with the coils energized from a single phase supply. The current and pressure coils are connected in series, parallel but the torques generated by the two elements opposes each other. When torques generated by two elements is exactly equal and opposite then the rotation of disc stopped. The shunt magnet is adjusted to a position. This way the two elements are rendered exactly similar.

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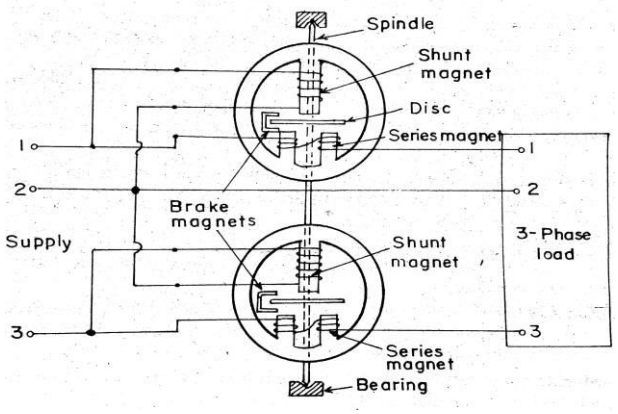

Fig. 2.3. Two element energy meter

c. Net meter or bidirectional meter

Energy meter [3] measures excess energy and energy used. The excess energy from solar panels that is not used it goes back to the grid. What is the energy producing from the photovoltaic panel is not enough to run the house then it is taken from grid. Energy=power x time

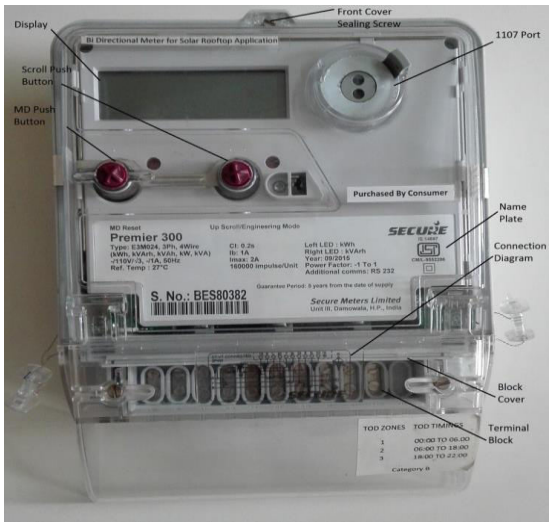

Fig. 2.3. Bi directional meter for solar rooftop

Electrical information of the bi-directional meter [3] is displayed on the Name Plate such as the type of connection, voltage, current, frequency, etc. Apart from the electrical information, they exhibit the company name, serial number, warranty etc on the nameplate. The huge LCD displays, which show altered electric parameters recorded by the said meter. This LCD display has various segments for showing exact information. In the bi-directional meter [3], two push buttons are observed such as MD push button and Scroll push button. By using scroll push button, we can scroll and change the display. Different parameter of the system is displayed by energy meter. An optically isolated sealable port button is enabled to transfer data from the meter through an optical cable. Input and Output terminals are there in the meter. On the left side, we can see a communication terminal as well.

III. WORKING PROCEDURE

By operating or scroll push button in fig.2.4, see the display and read the required values like time, date, serial number, voltage, current, input power, output power, imported power, exported power. We can observe the readings on the display and by pushing button it can see change the display. Read secure bi-directional meter [3] class 0.5 accuracy based secure bi-directional meter you see I_{max} 10 Amps CT operated secured meter there is a serial number XC441940 on the meter there is a display. By using scroll push button, we can scroll the display .Each display shows different parameters and we will see different readings after you restart screen of the meter so here time, date and year shown of the particular meter. Serial number same was mentioned on the outside body of this meter, here there is net reading in KWH i.e. imported unit (consumed from the grid side) next exported unit towards grid. There is a reactive power imported it is in KVAh and there is exported reactive power after this in the display we can see last month import unit bill ,last month export unit bill in KWH ,last month reactive import bill , last month reactive export bill it is in KVAh and frequency of the device.

Step 1

Fig. 3.1.First push button

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Step 2

Fig. 3.2.Time

Step 3

Fig. 3.3. Date, month, year

Step 4

Fig. 3.4. Serial number

Step 5

Fig. 3.5. Imported unit power

Step 6

Fig. 3.6. Reactive power imported

Step 7

Fig. 3.7. Reactive power exported

Step 8

Fig. 3.8. Lost month exported bill

Step 9

Fig. 3.9. Frequency

From the Fig. 3.10 Electrical Power from the distribution network (Descom grid) coming to the bi directional meter (Net meter) going towards the relay operated automatic disconnect switch (bus bar) connected to the consumer distribution panel. The bus bar also connected to the load that is the house supply then neutral wire from the bus bar connected to the solar meter which will show the solar readings and this wire connected to the DC to AC grid tied inverter.

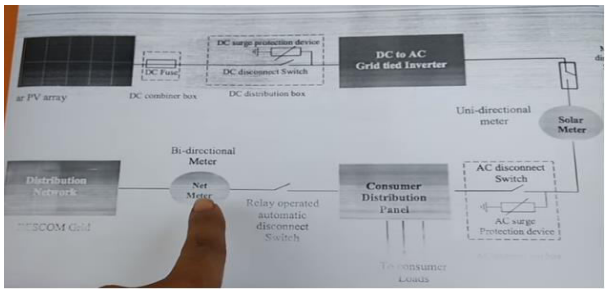

Fig. 3.10. Single line diagram for solar rooftop photovoltaic net metering interconnection

IV. Results and Discussions

The below statistics indicate Electrical power consumption in Unit's from various energy sources, total number of units used, average units per day and the amount of revenue being generated (in₹) and CO_2 emission savings (Ton) by solar Power plant during Jan 2014 to Dec 2018 and with the use of solar Rooftop system we could able to save 60, 84,904 rupees per annum.There are different slabs rates in APEPDCL discom. According to electrical power consumption if units greater than 2700 it will come under category of Group – C. From 1-04-2017 APEPDCL tariffs in Andhrapradesh has changed. In our institution almost the monthly consumption is greater than 2700 units. The monthly consumption is greater than 2700 units, the unit rate RS 9.06/- , for calculating final electricity bill for house hold and institutes for educational

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purpose. Every month one employer from Electrical department used to visit our institute has taken reading from net meter handover the electricity bill to consumer. In the electricity bill in addition to the consumption charges they will added R.M.D charges, customer charges, electricity duty, fuel charges, surcharges for late payment, interest on electricity duty, others (+),fuel surcharges interests, bill adjustments (+ / -) ,bill amount, I.S.D, previous arrears, current arrears these all are added to the final bill amount .Due to the above charges electricity bill costlier for consumers.

Table 4.1. Electrical power consumption in Unit's from various energy sources April-2018 to March 2019

S. no	Month	Apepdcl	Generators	Solar power	Total Units	Avg.units/Day
1	Apr-18	377400	6887	60961	445248	14842
2	May-18	240460	8567	61820	313847	10124
3	Jun-18	330930	13766	50862	394294	13143
4	Jul-18	454285	10344	48025	512654	16537
5	Aug-18	441720	10550	47003	499274	16106
6	Sep-18	444862	56859	9078	510799	17027
7	Oct-18	404662	62966	4077	471705	15216
8	Nov-18	347865	52112	7107	407084	13569
9	Dec-18	354555	46692	1569	402816	12994
10	Jan-19	275572	58012	4487	339171	10941
11	Feb-19	355236	62379	3026	415915	14342
12	Mar-19	449290	60932	3262	513483	17706
	Total	44,76,837	83820	671623	5232280	14335

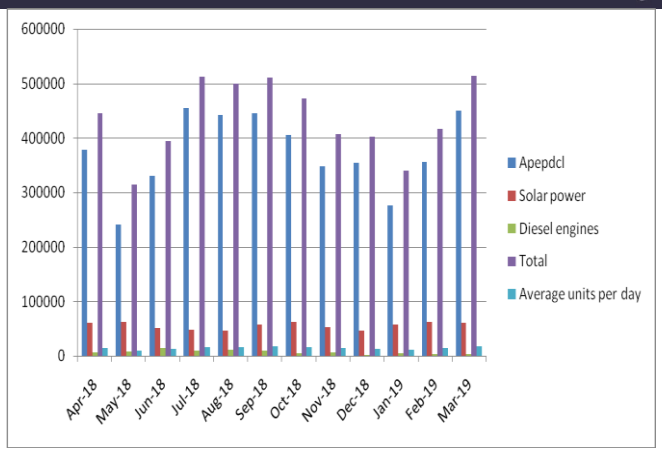

Fig. 4.1 Electrical power consumption in Unit's from various energy sources April-2018 to March 2019

Table 4.2. Revenue generation and CO_2 savings

Revenue generation and CO_2 savings		
Year	*Revenue*	*CO_2 savings (Ton)*
2014	₹ 23,29,459.00	219.24
2015	₹ 26,48,002.00	244.47
2016	₹ 25,59,726.00	229.68
2017	₹ 25,45,984.00	235.77
2018	₹ 25,62,444.00	241.16

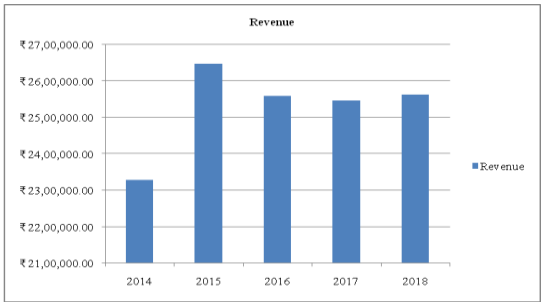

Fig. 4.2 Revenue generation during Jan 2014 to Dec 2018

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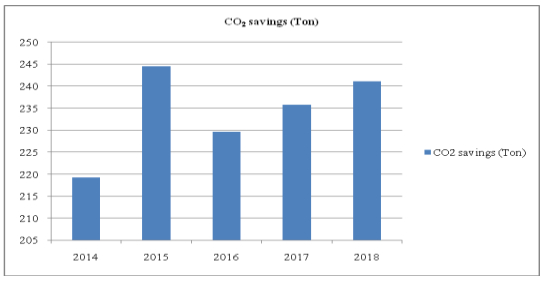

Fig. 4.2 CO_2 savings during Jan 2014 to Dec 2018

V. CONCLUSIONS

It is clear that there is a necessity and strong reason to integrate renewable energy sources into the electrical network (on grid) in the present and the future electricity needs. To meet energy crisis due to population, maximum utilization and Periodic price hike of crude oil. It is necessary to integrate or coupling renewable energy sources such as solar (PV), wind. Electrical power what we are generated during day time is may not be sufficient from the above results. If enough power we required erect or install more rooftops solar systems on the buildings. It can also reduce the cost of generating electricity by decreasing the usage of conventional energy sources. Solar Rooftop systems can be installed within a short period of time when compared to fossil fuel power plants. By burning fossil fuels a number of air pollutants (CO_2, CH_4, N_2O) that are harmful to both the environment and public health. The cost of generation of solar power is costlier compared with conventional sources of energy but it set to be fall within a decade.

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