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A Design and study of Solar Net Energy Metering System in Prospective of INDIA

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Abstract € *In The main purpose of our study is to investigate the effects of Net Energy Metering on client's engagement. Detail discussions about Net Metering , its purpose, its problems and its advantages , are included in our work . we conclude the net-metering rules and regulations policies in the India . The Net Energy Metering are not similar in all states.*

we identifies the impacts of Net Metering on power providers and PV owners in particular. same time a solution has been proposed for Net Metering challenges, which includes a case study on residential net-metered client's.
On the basis of the results of this research, it can be concluded that Net Energy Metering is good for everyone, and could affect on economic and environmental point of view .
Keywords: **Power Quality, Power System, Fuzzy Logic, Fuzzy-PI Controllers, Voltage**

I. INTRODUCTION

All Also known as Net energy metering (NEM), a net metering system is a metering and billing system designed to monitor and record the flow of power between a solar energy system and the government, and to further increase private investments on the renewable energy resources. The net metering solar arrangement allows you to send unused surplus power to the grid instead of letting it get wasted The Net Energy Metering is used to read and record the amount of electricity that transfer from and to the power grid, and it is typically implemented by using a single bi-directional meter or by two meters at client's site. Indeed, the excess generations emerge when client's DERs generate more electricity than is needed, which is precious and would be transferred to the power grid for use there about where it is needed . For example, the meter will run backwards to give a credit to the customer for any excess generation that have been delivered to the power grid by the client's photovoltaic solar at daylight hours in order to offset any using of electricity from the power grid at other times such as night hours.

Figure 1: Net Energy Metering

Consequently, and over the applicable billing period, the policy of Net Energy Metering is used to offset client's• consumption of electricity that comes from the power grid by using earned credits from delivering excess generation to the power grid, which in turn would reduce client's electricity payments. However, the customer could be paid rather than paying bills to the electrical department if the client's net excess generation exceeds the client's consumption of the electrical department•s electricity.

To clarify more, net-metered client's will receive Net Energy Metering bill credits when they produce more electricity than their needs. As well, when they need more power than their production of electricity, they can lower their electricity bills by using those credits. Indeed, this modest billing configuration can create a serious influence on the economic viability of exploitation renewable energy .

The following figures explain how Net Energy Metering works in a simplified manner.

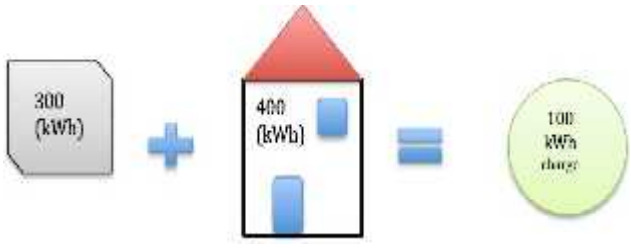

Figure 2: If a customer consumed electricity more than the generated electricity

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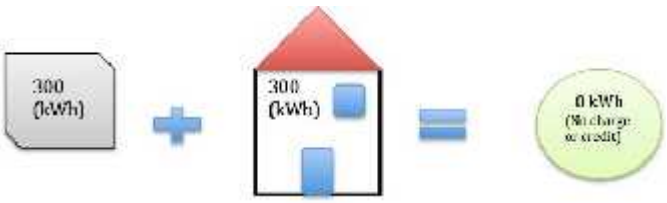

Figure 3: If generated electricity is equal to the client's consumption

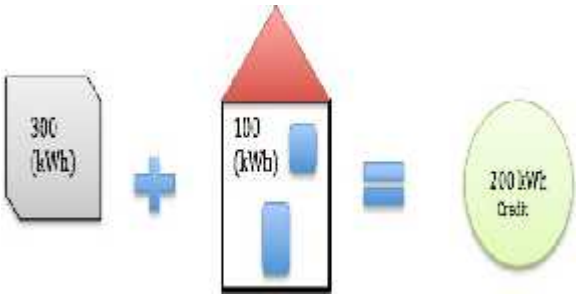

Figure 4: If the customer generates more electricity than is needed

A customer produced 300 kWh and consumed 400 kWh in Figure 2, so the customer would be charged by the electrical department just for 100 kWh, which is the result of subtracting client's consumption of client's generation. In Figure 3, a customer produced 300 kWh and consumed 300 kWh, so the customer would not be charged or credited since the client's consumption is equal to the client's generation. In Figure 4, a customer produced 300 kWh and consumed 100 kWh, so the customer would be credited by the electrical department for 200 kWh, which is the result of subtracting client's consumption of client's generation.

The rules and standards for how Net Energy Metering will be credited and for which kind of renewable energy systems can obtain Net Energy Metering credit are mostly set by electrical department regulators and state law makers . Mostly states of India uses Net Metering , but the policies of each state are different .

II COMMUNITY NET ENERGY METERING

Community Net Energy Metering system is claimed as an alternate development of the Net Energy Metering system proposing a whole community of users to be treated as a single purchaser. In this issued design, one collective generation facility is developed rather than client's owning individual solar panels. It further allows a feedback system connected throughout the community where excess energy can be offset among the purchasers themselves. Furthermore, a excess of the generated renewable energy is sent back to the grid and the purchasers can have access to this policy onsite or offsite. Purchasers can possess multiple meters with different tariff rates. For the billing procedure, the net consumption units of all the purchasers combined are computed.

To disclose the advantages, this system offers to achieve economies of scale. The cost and labor of installation of panels, operating and maintenance of individual generation sites, ordering applications, etc. can be avoided as this system proposes only one collective generation site. Furthermore, smaller purchasers with insufficient spaces to install individual

solar panels can benefit equally from this project thus encouraging a larger audience to invest in renewable energy. The benefit of installing a generation panel in an optimal location can be realized in terms of absorbing sufficient heat and radiation from the sun avoiding the shading to produce energy. In figure 1, the community Net Energy Metering system has been depicted as containing a community of multiple users with a single onsite or offsite generation site .

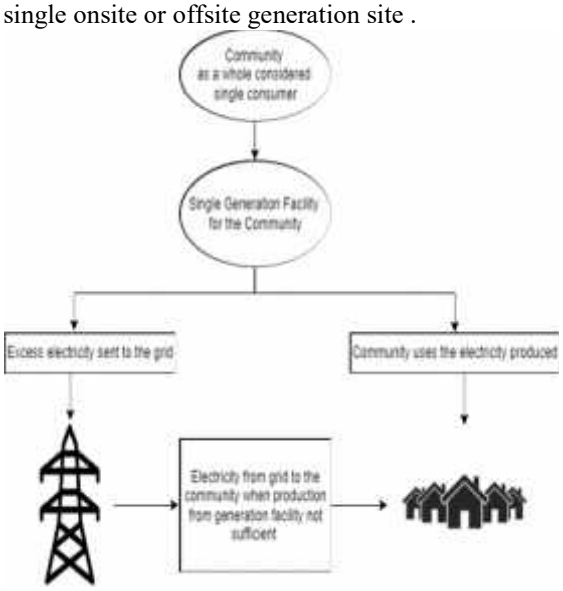

Fig. 5 Flowchart of aggregate net energy system

IV. METHOD

The India, along with the rest of the world is undergoing an energy transition with an impetus on use of renewable energy technologies. Like other nations, India•s Solar Photovoltaic (SPV) program was perceived in 1970s in response to the oil crisis. In 2010, the Jawaharlal Nehru National Solar Mission (JNNSM) was introduced as part of the National Action Plan on Climate Change 2008, and a target was set to install 20 gigawatt (GW) solar capacity by 2022. In 2014, the government increased this target to 100 GW, and set a sub-target of 40 GW of grid connected rooftop solar systems, or rooftop solar photovoltaic (RTSPV), which allow purchasers to generate electrical energy at their premises using a net-metering system.

Net Metering

Net Energy Metering is an energy accounting system that helps purchasers with grid connected rooftop solar systems reduce their energy bills. Globally, it has been a key instrument in promotion of rooftop PV deployment. Under a Net Energy Metering arrangement, purchasers who install solar rooftop system on their premises have their energy bill offset against the PV generation. Net Energy Metering works with metering at two points, a bi-directional energy meter which records both import and export of energy and a generation meter that accounts the solar generation as shown in Figure 6.

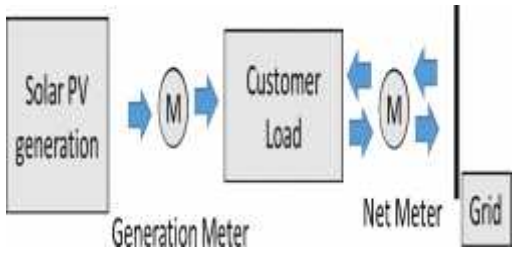

Fig 6: Schematic Representation of Net Energy Metering Arrangement

Challenges of Net Metering

Despite the applicability of incentivized metering arrangements, India has only achieved about 1.1 GW of grid connected solar rooftop as on March 2018. This is due to a variety of reasons, ranging from poor implementation in some states, and reluctance or slow execution by coms. From the point of view of the purchaser, the challenge of Net Energy Metering is that it only appeals to a small cross-section of purchasers who have high-tariffs, adequate rooftop space and a sufficient load at a single location. Net-metering system presents challenges in promotion of rooftop solar among several classes of purchasers. Some such classes are as follows.

f Purchasers who are forced to install rooftop systems of lower capacity due to small connected loads, despite having large rooftop space and the financial capability, e.g., warehouses, domestic purchasers in semi urban areas, etc. This leads to sub optimal usage of rooftop space and loss of benefit from potential „economies of scale•.

f Purchasers with a portfolio of buildings, e.g. large commercial establishments and institutions such as the Indian Railways. Such purchasers with large rooftop space at several premises, may have significant loads at different locations. These client's are unable to avail Net Energy Metering benefits under the current approach. The same is applicable for purchasers who have sufficient aggregated load and adequate rooftop space at multiple locations.

f Urban residential purchasers living in multi-story house without any roof rights are unable to invest in solar rooftop generation and derive benefits under conventional Net Energy Metering schemes.

f Typical residential purchasers in housing societies with adequate shared space within the premises have no incentive to adopt rooftop solar, as they cannot avail Net Energy Metering benefits because Net Energy Metering schemes map one purchaser to one point of generation.

To facilitate such categories of purchasers to set up rooftop solar, a new metering arrangement such as virtual Net Energy Metering (VNM) is required. The concept and its applications are discussed in the following sections.

Technical and Non-technical consideration and constraint in design process

Technical Constraints

…To ensure efficient supply of excess PV to the grid, the grid tied inverter must be capable to not only keep the voltage slightly higher than the grid voltage at all times but also match the phase of the grid.

…The grid tied inverter must have the quality to ensure unity power factor so as to avoid any penalty charges resulting from it.

…Segments of the grid receiving a good amount of power from renewable sources such as solar would result in the rise of voltage levels especially during peak production intervals; thus it is paramount that our system has the capability to deliver reactive power to the grid if and when necessary to prevent the aforementioned problem.

…Our system must be able to quickly disconnect itself from the grid when the national grid seems to be down; so as to prevent the harming of any potential workers fixing the national grid.

Non-technical constraints

…Purchaser type - In INDIA, not all purchasers are eligible to use Net Energy Metering due to the guidelines set by the INDIA Energy Regulatory Commission.

…Capacity restriction - Output AC capacity of the renewable energy converter must not exceed a maximum of 70% with respect to the purchaser•s sanctioned load

but also be less than 3 MW according to INDIA's Net Energy Metering guidelines.
…Location constraint - Solar panel installation requires ideal sites, which have more potential for solar energy harvesting. In terms of optimal radiation from the sun, reduced shading can be an ideal location to install solar panels. But these sites are hard to find and harder to come to an agreement to install the solar panel.
…Installation cost - Solar panel requires a lot of manpower and budget to be installed.

IV. RESULT

Thus, all the multiple design approaches for the project are analyzed. Similarly, in our project to determine the best way among all the approaches of Net Energy Metering was only selected after software simulation for all the designs were accomplished. The results obtained from different designs were analyzed and compared thoroughly in order to deduce the optimal design for our project. After doing an adequate amount of research we selected simulation softwares: MATLAB, MATLAB Simulink, for designing our multiple approaches, in order to determine the optimum design amongst all the optimized multiple designs for our project.

Load Analysis:
Analysis of loads while determining the solar generation system is extremely important, it could be the deciding factor of whether the project is going to be profitable or not. Attached below is a detailed discussion of how we did our load analysis while performing software simulation through MATLAB.
For the calculation of the load profile, the monthly average electricity consumption rate (kWh/month) for different types of houses has been surveyed . The electricity consumption of a house is determined by a variety of factors, including the number and type of electrical appliances, as well as the number of people living in the house. We have chosen five such houses for our project that best suits the average household in a typical locality in our country.

Table 1 Households monthly electricity consumption and their corresponding typical appliances

Household	Family Members	Number of Refrigerators	Number of Machine	Electricity Consumption (kWh/month)
1	5	1	0	215
2	4	2	0	310
3	1	1	0	155
4	4	1	1	260
5	3	1	1	188

For the third month of the year we used the data from the table immediately above as during this month the electricity consumption remains very close to the yearly average as shown by the graph attached below. Electricity consumption is lesser in the earlier months of the year compared to the medial months, thus we predicted values accordingly. It is also seen that electricity consumption is at its highest during the month of August and at the end of the year consumption begins to diminish which we have represented in our load profile data. All our assumptions were made using the help of the figure below where the graphical representation of energy consumption for a year was provided by means of definite inspection.

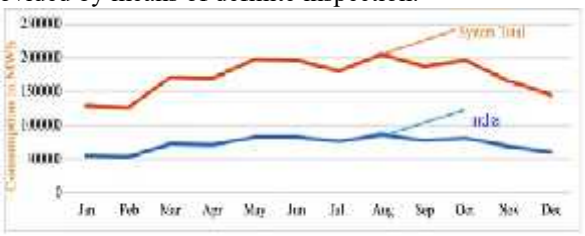

Fig. 7 Monthly energy consumption of the year 2022

Using the monthly energy consumption trend of the year 2022, we predicted the household electricity consumption for all of the months of the year from the average monthly electricity consumption value and acquired data for the load profile of our system.

Table 2 Electricity consumption rate throughout the year of our five households

	Monthly average electricity consumption rate (kWh/month)				
Month	Household 1	Household 2	Household 3	Household 4	Household 5
January	190.0	280.0	130.0	242.0	170.0
February	198.0	284.0	128.0	240.0	168.0
March	210.0	320.0	145.0	280.0	194.0
April	212.0	318.0	148.0	284.0	192.0
May	220.0	330.0	154.0	292.0	208.0
June	224.0	338.0	158.0	298.0	212.0
July	218.0	335.0	150.0	290.0	205.0
August	230.0	350.0	162.0	310.0	218.0
September	212.0	328.0	158.0	300.0	204.0
October	218.0	332.0	160.0	308.0	208.0

November	202.0	295.0	138.0	254.0	198.0
December	195.0	282.0	132.0	246.0	174.0

Identify optimal design approach Analysis: MATLAB Simulink

The issued multiple Net Energy Metering systems have been further formulated in MATLAB Simulink and with corresponding code providing the required data. The detailed explanation of the designs formulation are discussed below:

I. Community Net Energy Metering system

In the MATLAB design of the community Net Energy Metering system, the custom solar PV output block which results in the total energy generated (kWh) represents the solar PV generation site. The monthly and yearly total generated amount is shown in the output blocks. The extracted energy from the generation panel is further distributed among five different

house holds according to their preallocated share through a distribution block. Sequentially, the Net Energy Metering block representing each of the households takes the PV generated energy as input, subtracts the consumed amount depending on each of their provided load profiles and accumulates the excess energy as outputs. The output power is basically the excess amount of energy supplied or taken from the grid. The negative output values stand for the amount supplied to the electrical department grid and positive values stand for the amount extracted from the grid. The excess amounts for each of the households are represented in the output blocks in the far-right for each month. The annual excess energy supplied or extracted from the electrical department grid summing the monthly outputs and the yearly consumed amounts for the houses are further availed and demonstrated.

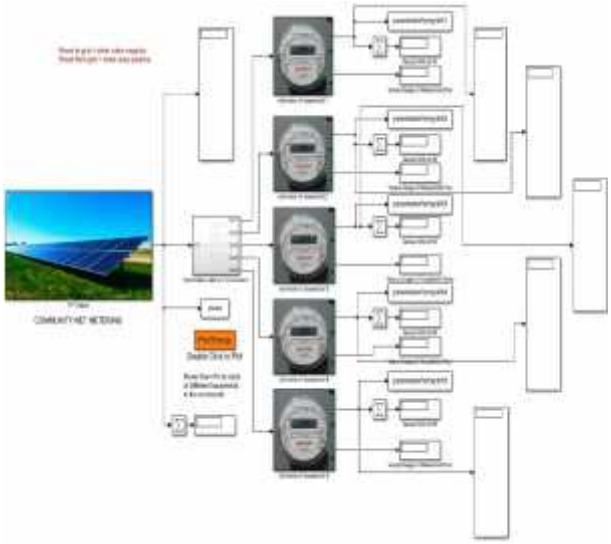

Fig. 8 Community Net Energy Metering software implementation

V. CONCLUSION

Our project is designed in such a way that we emphasize on the new concept of Net Energy Metering that is incorporated with an easily utilizable renewable energy form called solar energy. The main motive behind our idea included conserving natural energy resources and increasing the dependency on renewable energy resources to meet up with the ever-increasing energy demands. Simultaneously, keeping a track of energy flow of households to reduce the electricity bill of purchasers in the future

Through our research work we got to learn that there are multiple ways of implementing a Net Energy Metering system, community Net Energy Metering being one of them. In community Net Metering , the whole community is treated as a single customer and sets up a single generating site. The aggregate load demand consumed by all the participants is critical in determining the size of the generating facility. A number of purchasers will come together to form a single facility, hence the hassles of filing application, operation and maintenance of the plant would be reduced. Smaller purchasers can be served more effectively. The client's who do not have place for installation of solar panels can be benefited most by such policy, thereby reducing inequities. Another method of Net Energy Metering is aggregate Net Metering , where the single purchaser with a single generation system offsets power from multiple meters accumulating all the benefits under a single purchaser. In this type of metering a single investor tends to use multiple meters in multiple locations all under the investor and enjoys the benefits of it.

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