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Impact on Demand Side Management with Renewable Energy Integration

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ABSTRACT: The rapid increase in urbanization has led to a significant rise in domestic, commercial, and industrial electricity demand. To ensure reliable power supply from the grid, there is a growing need for system enhancement along with extensive research on renewable energy sources and advanced energy management technologies. These developments must consider key factors such as high effectiveness, low cost, and environmental sustainability. One of the most critical aspects of renewable energy integration is the energy management system and overall system reliability. In demand side management (DSM), consumer participation plays a vital role. Consumers are directly involved through practices such as peak-time tariff evaluation, time-of-day tariffs, and regulated energy usage aimed at reducing consumption. The cumulative effect of these savings and load reductions constitutes demand side management. This work focuses on the integration of solar energy in the agricultural sector and its impact on the electrical grid. A case study from an Indian state is considered to analyze both the technical and financial implications of this approach. Additionally, demand side management challenges and demand response calculations are discussed in detail in this paper.

KEYWORDS: Demand side management DSM, Agricultural DSM AgDSM, Distribution Companies Discom, Central Finance Assistance CFA, PMKUSUM, Pradhan Mantri Kisan Urja Suraksha evam Utthan Mahabhiyan.

I. INTRODUCTION

Demand Side Management (DSM) is a strategy employed by utilities and energy providers to actively influence and manage the consumption patterns of electricity by end-users. The primary goal of DSM is to optimize the utilization of electricity resources, enhance grid reliability, and minimize overall energy costs. This approach involves implementing various techniques such as time-of-use pricing, demand response programs, and energy efficiency initiatives to encourage consumers to shift their electricity usage to off-peak hours or reduce consumption during periods of high demand. By actively engaging consumers in the management of their electricity demand, DSM not only helps in balancing the load on the grid but also contributes to environmental sustainability by reducing the need for additional power generation capacity. DSM initiatives often leverage advanced technologies, such as smart meters and home automation systems, to provide real-time information to consumers about their energy usage. This enables end-users to make informed decisions about when and how they use electricity, leading to a more efficient and sustainable energy ecosystem. Additionally, DSM plays a crucial role in supporting the integration of renewable energy sources into the grid by aligning electricity demand with the intermittent nature of renewables. Overall, Demand Side Management represents a proactive and holistic approach to addressing the challenges of modern energy systems by promoting energy conservation, grid stability, and environmental responsibility. [1]

As per the energy scenario we can see that power demand increasing every year and within next few years it will increase in a large manner and in several lakhs of Megawatts and to fulfil all this requirement power generation will also increase and due to the use of excess fossil fuels increase in the level of carbon monoxide and other toxic gases will also increase and affect the environment badly. So A clean energy and green energy schemes should be increased by increasing the power generation capacity by renewable sources like solar and wind energy.

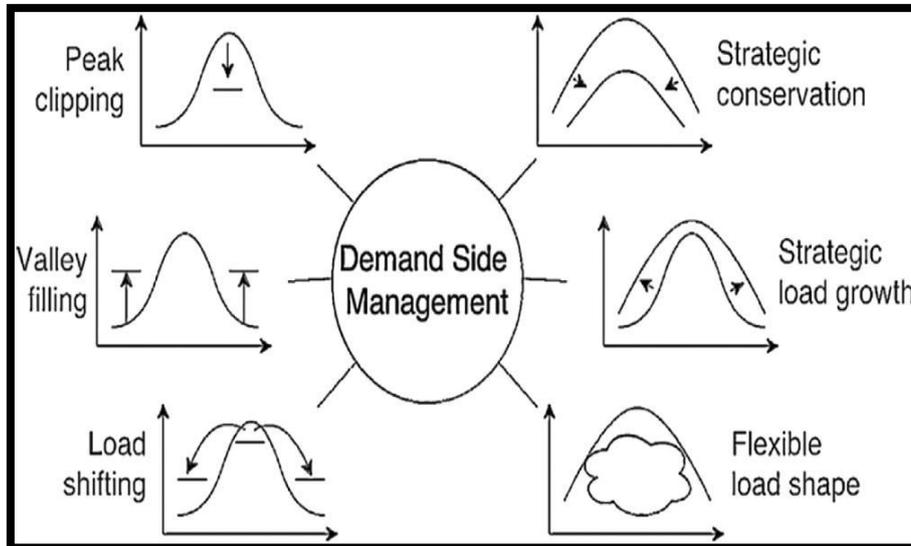


Fig -1: Demand Side Management Functions

II. SOLAR FARM CONNECTED WITH GRID

Grid connected solar farms on agricultural land also known as solar farming. In this case the landowners can use the generated electricity and the surplus generation can be transported to the grid via net metering. This measure can reduce the electricity bill, provides the income stream through power sales and practice sustainability. In this measure the panels are elevated to allow the crop grazing and potentially improving crop yields due to reduce water stress. Excess power production makes farmer enables for extra income through power export and also fixed rental income of the land. There are two system types on grid in which the power export to the grid through net metering most common practice in India. Next is hybrid mode in which combines grid connectivity with battery storage for energy independence.



Fig. 2 Solar Farm in agricultural land

The government has initiated many schemes like PM KUSUM Scheme (Pradhan Mantri Kisan Urja Suraksha evam Utthan Mahabhiyan). In this scheme the government enables the farmers to install grid connected solar power plants on

barren lands in component A or solarise existing grid connected agricultural pumps component C to sell surplus power to discoms. It offers upto 50% subsidy, provide daytime income and increase sustainable practices.

In this work a state discom has been selected like Rajasthan and accordingly as per the government rates and subsidies we have tried to find out the implementation cost.

III. IMPLEMENTATION COST MODULE

Table 1 Implementation Cost

S. No.	Component	UoM	Cost	Reference / Remarks
1	Total module cost	Rs. Cr / MW	2.90	DCR module @ Rs. 29 per Watt
2	BoP and Civil cost	Rs. Cr / MW	1.11	Thumb rule of 26% of total cost
3	Grid connectivity charges	Rs. Cr / MW	0.03	Rs. 2.5 lakhs per MW
4	Other (Legal, Contingency, Liason, land development)	Rs. Cr / MW	0.05	Assumption of Rs. 5 lakh per MW
5	Cost of connecting line (5 KM)	Rs. Cr	0.17 (11kV) 0.60 (33kV)	11kV @Rs. 3.05 lakh per KM 33kV @Rs. 10.5 lakh per KM
6	Cost of metering - Plant level (main, check, standby)	Rs. Cr	0.05	Rs. 1.5 lakh per metering system
7	Breakers (both side of feeder)	Rs. Cr	0.11 (11kV) 0.23 (33kV)	11kV @Rs. 11 lakh per system 33kV @Rs. 23 lakh per system
	TOTAL	Rs. Cr / MW	4.42 (11kV) 4.96 (33kV)	

Table 2 Levelled Trarrif break up

S. No.	Particulars	UoM	Levelized Tariff * 1 MW SPV Plant (11kV Connecting line)	Levelized Tariff * 2.56 MW SPV Plant (33kV Connecting line)
1	O&M Cost	Rs. Per Unit	0.411	0.410
2	Interest on loan	Rs. Per Unit	0.728	0.715
3	Interest on working capital	Rs. Per Unit	0.055	0.055
4	Depreciation	Rs. Per Unit	0.857	0.844
5	Return on Equity (RoE)	Rs. Per Unit	1.311	1.296
	Levelized Tariff (excl. lease rent)	Rs. Per Unit	3.361	3.320

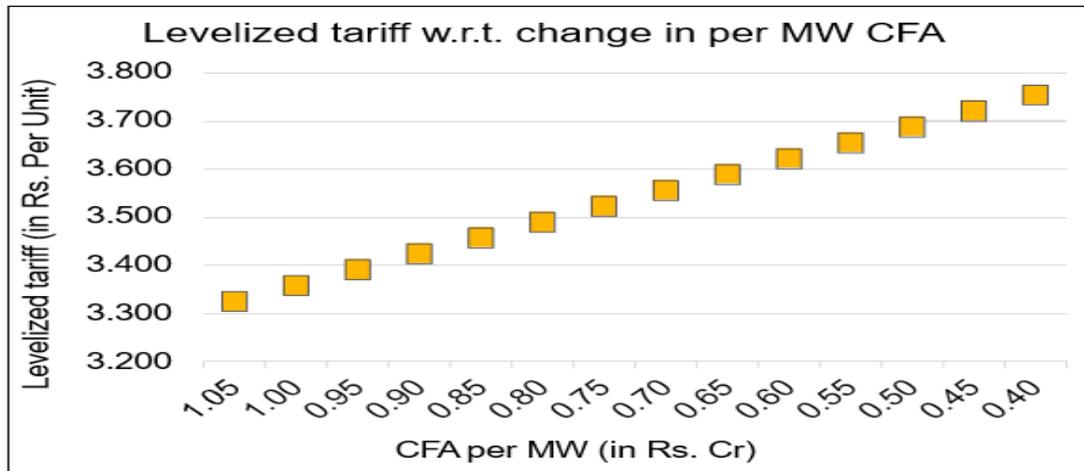


Fig. 3 Negative correlation between levelised tariff and CFA per MW

The figure 3 illustrates the relationship between CFA per MW and the levelized tariff, showing a clear inverse and nearly linear trend. As the CFA per MW decreases from about ₹1.05 crore to ₹0.40 crore, the levelized tariff increases from roughly ₹3.3 per unit to around ₹3.75 per unit. This indicates that higher CFA support reduces the effective capital cost of the project, resulting in a lower levelized tariff, while a reduction in CFA increases the financial burden on the developer and leads to higher tariffs to recover costs. Overall, the graph highlights the strong sensitivity of levelized tariff to changes in CFA, emphasizing the importance of capital subsidies in maintaining affordable electricity tariffs.

IV. RESULT AND DISCUSSION

In this work, the importance of demand side management (DSM) measures is analyzed, building on previous studies that identify solar-based domestic, industrial, and agricultural projects as the major DSM approaches, supported by various government subsidies. The primary objective is to conduct an in-depth technical and financial analysis of post-implementation scenarios and to assess their impacts on both the electricity grid and consumers. A target of 460 MW capacity is assumed for a particular DISCOM, and the corresponding implications in terms of CFA requirements, grid load reduction, and the total subsidy amount to be disbursed by the government are evaluated. The analysis considers the complete system cost, including solar panel costs and integration up to the 11 kV and 33 kV distribution levels, along with other variable costs. In addition, a rooftop solar scenario for domestic consumers is examined, where a collective installation of 100 kW capacity within a DISCOM area is assessed to understand its impact on grid performance and the associated subsidy disbursement.

Calculation for 460 MW solarization of agricultural feeders		Units
Total kWp potential	4,60,000	Kw
Solar PV Panel Efficiency	16%	
Annual Energy Generation	72,22,32,200	Kw
Cost per MW or 100 KW for 11 KV	4.42	Cr
Cost per MW or 100 KW for 33 KV	4.96	Cr
Cost for 460 MW for 11 KV	2,033	Cr

Cost for 460 MW for 33 KV	2,282	Cr
CFA per MW	1.05	Cr
CFA for 460 MW	483	Cr
Payback Period considering all factors calculated by DISCOM	12.0	Years
Internal Rate of Return	17.7	%

Fig. 4 Overall calculation for 460MW

Calculation for 100Kwp Solar Roof Top Savings		Units
Total kWp potential	100	Kw
Solar PV Panel Efficiency	16%	
Annual Energy Generation	1,57,007	Kw
Cost per kWp	50,000	Cr
Total capital cost for proposed Solar PV plant	50,00,000	Cr
CFA amount for 10Kwp	1,21,284	Cr
CFA amount for 100 Kwp	12,12,840	Cr
Total capital cost for proposed Solar PV plant after adjusted with CFA	37,87,160	Cr
Electricity cost per kWh	7.95	Cr
Total cost saving	12,48,205.7	Years
Payback period	3.03	%

Fig. 5 Overall calculation for 100 KW Roof top solar

V. CONCLUSION

The conclusion will finally comes after the measurement and valuation after the implementation and calculation done at that time. Theoritically we can see the payback period is very less and the peak load can be reduced at the day time after this bulk installation in any of the discom.



Fig. 6 Measurement and valuation

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