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RESEARCH ARTICLE

USING AGGREGATOR-BASED PLATFORM FOR ACCELERATING SOLAR ROOF TOP POWER PLANT BASED ON DECISION-BASED MODELING

[1*]Kamran Quddus and [2]Aayush Anand

[1]Accounting and Finance, Indian Institute of Management Ranchi, Jharkhand, India
[2]PGEXP Student (2021-23), Indian Institute of Management, Ranchi

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**Corresponding Author:*
Kamran Quddus

ABSTRACT

Despite India witnessing an 88% decadal drop in the weighted price of solar installation, which is among the highest in the world, the share of Solar Roof Top installation has not grown proportionately compared to ground-mounted solar rooftop projects. As per Ministry of New and Renewable Energy (MNRE) data, the overall installed capacity as of November 2021 was 6 GW, and it is likely to miss the target of 40GW set by the Government Of India by December 2022. One of the major areas for increasing the rooftop installation is the residential segment, given the incentives given by MNRE. The government has tried to do course correction by simplifying the solar installation process in January 2022. However, as previous studies have suggested, this is only one of the problem areas for the slow uptake of Residential Solar Power Plant. In our study, we focus on addressing the financing gap, which is one of the major hurdles in the adoption of solar through decision-based modelling with distribution companies as an aggregator.

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INTRODUCTION

Electricity in India appears in the concurrent list of The Constitution. This implies that both the Central and State governments have the authority to legislate on the issue. The Electricity Act of 2003 has been one of the important legislative initiatives taken by the Central Government. One of the key provisions of this Act was to unbundle the vertically integrated state electricity boards into generation, distribution and transmission. Further, to introduce competition licensing requirement on generation was removed, and open access to transmission and distribution was provided. An independent regulator in the form of the State Electricity Regulatory Commission and Central Electricity Regulatory Commission at the State and Central levels was also envisaged through the Act. One of the main aims of the state regulators is to regulate electricity tariffs from time to time to ensure commercial viability. Though it is pertinent to have tariff revision from time to time, in practice, hikes are overshadowed by populous politics. Past experience shows that if some political parties have tried raising tariffs in order to turnaround DISCOM, they were voted out of office in the election (Verma et al., 2020). As a result, different states have different tariff rates and structures.

One common thing, though, is that tariffs for agriculture and domestic groups are much lower than the average cost of supply (Jain & Nandan, 2019). This is one of the reasons for the dismal revenue condition of most of the Distribution Companies [DISCOM] in India. As per the latest data available on the Ministry of Power's Uday Portal, the all-India difference between the average cost of supply and average revenue realized is 0.32 Rs/kWh, which implies that for every unit of electricity sold there is a loss of 32 paise, this is inclusive of subsidy received to the DISCOM in the form of UDAY grant and regulatory income. The revenue gap for the DISCOM without the Uday grant and regulatory income has varied from 0.53 Rs/kWh to 0.72 Rs/kWh over different years. Details of the Average cost of supply and Average Revenue Received with and without subsidy, in Rs/kWh, for the period 2015-16 to 2019-20 are shown in figure 1.

Details of Revenue Gap with and without subsidy, in Rs/kWh, for the period 2015-16 to 2019-20 is shown in Figure 2. Due to poor financial conditions, the DISCOMs are not able to pay back to the generating companies. As a result, there is a huge backlog of dues of DISCOM to Generating Companies (GENCOs).

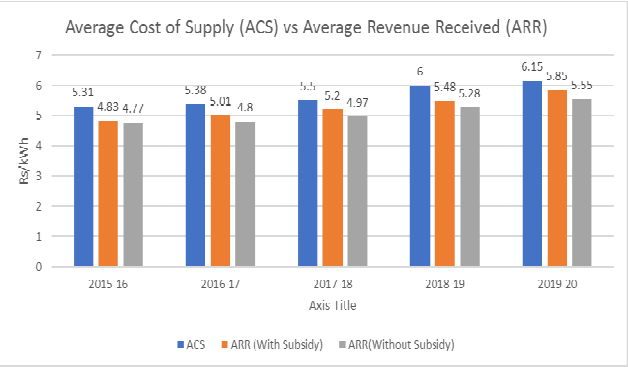

Figure 1. Average Cost of Supply (ACS) vs Average Revenue Received (ARR), Source of Data [PFC Annual Report]

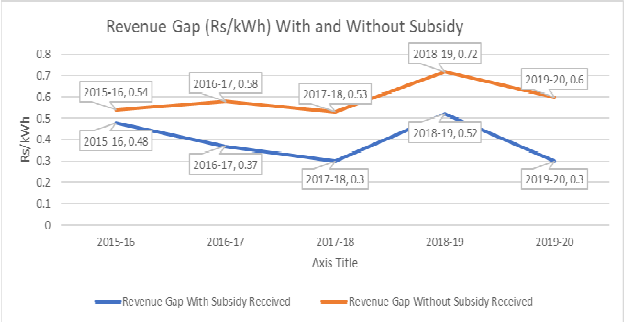

Figure 2- Revenue Gap With and Without Subsidy, Source of Data [PFC Annual Report]

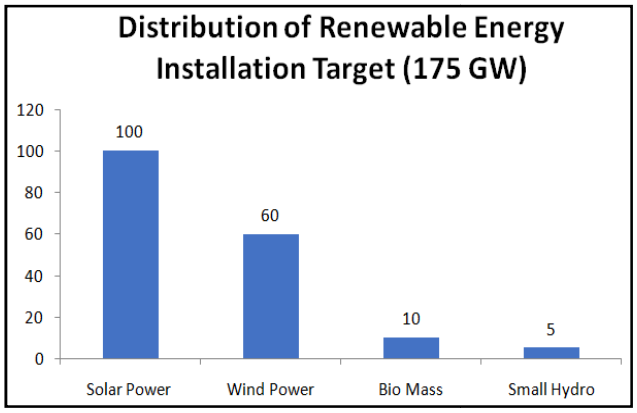

Figure 3: Distribution of Renewable Energy Installation Target (175GW)

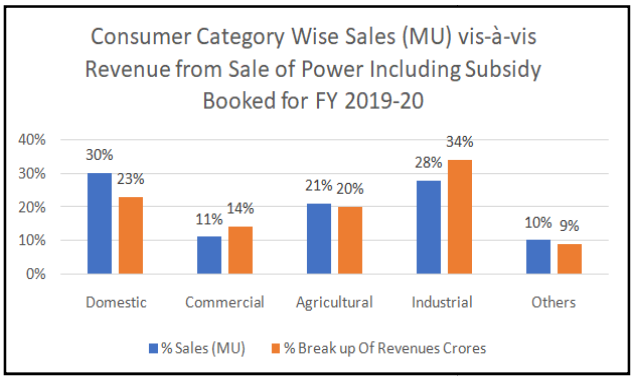

Figure 4: Consumer Category Wise Sales (MU) vis-à-vis Revenue from Sale of Power Including Subsidy Booked for FY 2019-20 (Data Source: Reports on Performance of Powe Utilities 2019-20-PFC)

As per the latest data made available by the Parliamentary Consultative Committee attached to the Ministry of Power in February 2022, the outstanding dues of DISCOMs to GENCOs is Rs 1600 billion [PIB][1]. This constraint on financial resources severely impacts the whole power sector value chain. The transmission and distribution losses of power in India are more than 20% which is more than double the world average [Economic Survey 2020-21]. The coal-fired thermal power plant efficiency of the Indian Power plant is an abysmal 29.7 percent (Ganesan & Narayanaswamy, 2021), and since more than 70 percent of electricity is generated by these coal-fired plants (Das & Srikanth, 2020), the carbon intensity of electricity generation is higher than the world average. As per calculation done by IEA, India's carbon intensity of electricity generation in 2018 was 709gCO2/kWh against the world's average of 476 gCO2/kWh [IEA][2]. To reduce its electricity intensity, India is also looking to tap into the vast renewable energy sources that it is endowed with. The Electricity Act legislation envisages renewable energy generation by the government at different levels. The Indian Government in 2015 had set renewable energy capacity target of 175 gigawatts (GW) to be achieved by 2022 [Figure 3]. Out of this, 100 GW was earmarked for solar-powered power plant with 40 GW (40%) expected to be achieved through Grid Connected Rooftop Solar Power Plant (GCRTV) and 60 GW (60%) scheduled to be completed through Ground Mounted Rooftop Solar Power Plant. The thrust on solar was given because of a) The vast solar potential that India has. As per estimates India's solar potential is about 748 GW b) The cost of installation of solar has seen the highest decadal drop of 88% and the levelized cost of electricity [LCOE] production through solar is amongst the cheapest in the world.

Since cost of power procurement constitutes more than 80 percent of total expenditure of DISCOM (Das & Srikanth, 2020) switching part of energy mix to cheaper power alternatives, will help in not only achieving India's international commitment to combat climate change but will also help in improving the financial condition of DISCOMs as average cost of power procurement would be better than what is the cost of procurement of electricity now. While India had made a notable progress in the deployment of utility scale ground mounted solar power plant, the deployment of roof top solar power plant has not been along expected lines. With the country estimated to have a significant solar roof top potential of 1.7 petawatt-hour per year combined with the lowest cost of attaining the potential ($66 per Mega Watt -hour) (Joshi et al., 2021) the actual progress in deployment of solar plant does not match to its potential. As of end of March 2022, the cumulative installation of roof top solar power plant in India was approximately 6.64GW [MNRE][3]. Studies have found that the poor adoption of roof top power plant in the residential segment is a significant factor responsible for this situation (Dutt & Ranjan, 2022) and the major barriers to adoption are lack of financing schemes, lack of wide network of suppliers and service providers and lack of awareness among consumers [TERI]. To address the aforementioned issues, this study

[1]Meeting of Parliamentary Consultative Committee attached to Ministry of Power-Press Information Bureau, Government of India, Ministry of Power-17-February-2022: ttps://pib.gov.in/PressReleaseIframePage.aspx?PRID=1799074
[2]International Energy Agency (2020). Tracking Power 2020. https://www.iea.org/reports/tracking-power-2020
[3]Ministry of New & Renewable Energy. Cumulative Physical Progress .https://mnre.gov.in/the-ministry/physical-progress

proposes using an aggregator-based platform based on a decision-making framework.

Theoretical Framework and Concept: The theoretical framework proposed involves the concepts described as follows:

Residential roof tops in India though having huge potential, are small in size. As a result, solar installation becomes a challenge due to diseconomies of scale. Moreover, though government provides subsidies to residential customers for roof top solar, the upfront cost for solar installation is another hindrance factor that has prevented adoption of solar in residential sector.

The supplier and installers are more inclined towards the installation of utility-scale project than residential ones because of greater aggregate demand and work concentration in single location. The Distribution Companies provide electricity to residential sector at a subsidized cost whereby the selling price of electricity is lesser than the cost price at which electricity is purchased from generation companies [Figure 4] Given the context, DISCOM can play role of aggregator, they will act as a combination of demand, production and load aggregators. As explained in the figure.

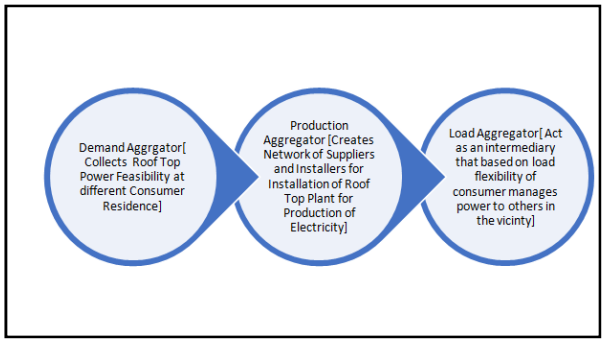

Figure: Discom as combination of Aggregators

Model: The DISCOMs can aggregate all demands from residential sector through a web-based platform and or a mobile -based app. The detail collected shall also include the detail of the cost structure of project. Based on the inputs and technical feasibility of site the capacity of power plant shall be determined. Based on the cost structure chosen by the customer the Weighted Average Capital Cost [WACC] shall be chosen. Using the calculated WACC the LCOE shall be calculated and compared with the cost of supply. In case the LCOE is less than the supply cost then the project passes the feasibility check. Based on passing of feasibility the capacity of power plant that can be installed shall be decided. On collection of a pre-decided number the information shall be pushed to the supply aggregators and the solar plant shall be installed. The part subsidy now being given to the end users can be given as payment to installer post commissioning of the plant. The tariff of solar generated can be charged based on tariff which shall be determined based on below decision making factors

Case 1 : If LCOE < Tariff : The generation charge to customer for generation of electricity through solar shall be slightly less than the tariff but greater than LCOE. In case of export of power not used by consumer the rate shall be equal to the consumer tariff.

Case 2 : If LCOE => Tariff : The generation charge to customer for generation of electricity through solar shall be equal to the consumer tariff. In case of export of power not used by consumer the rate shall be equal to the consumer tariff. The tariff collected from consumer through generation of solar power can be shared among the DISCOM and the EPC company based on the predetermined agreement. The excess power generated can be used as net export and depending on the equity ownership of customers a part of it can be used to extend the ownership of the home owner and part of it can be used to adjust the electricity bill. The percentage share and their division there of in equity ownership and paying of electricity bill shall be determine based on the customer choice of equity ownership chosen at the beginning. The remaining part of revenue generated which is not part of share of customer can be divided shared by discom and installers.

Benefits

The benefits for different stake holders are as follows:

EPC/ Suppliers: The aggregation of supply helps in reaching out to untapped potential and unmet demands which earlier were not approachable due to non-willingness to pay and dis-economies of scale. Further it shall ensure a revenue assurance and cash flow for a long period of time.

Customers: The residential customers shall get quality power supply and also an increasing percentage of ownership of a solar power plant at an affordable price. The export of electricity shall help in further paying of their bills thus leading to reduction in energy expenditure.

Distribution Companies: The electricity tariff to residential sector is highly subsidized and is one of the reason for the bad shape of DISCOM finances as the cost of supply is more than the cost of revenue through sale of electricity. Through adoption of lower cost of solar power for supplying electricity the losses can be minimized and gap between the economies of supply and demand can be reduced.

Generation Companies: Sometimes due to unmet seasonal demands particularly during day time, many thermal power plants have to be operated at low plant load factor which further reduces the over efficiencies of these power plants leading to more intake of coal for lesser electricity production. If renewable energy generation is increased then some of the unmet seasonal demands can be met through solar power.

Government: The model can help government in achieving the international commitments that it has pledged for as the model will help in increasing the solar power share which is a non-fossil based power in the electricity mix. It will also help in reducing the carbon intensity of electricity produced thus reducing our emission.

CONCLUSION

In this study, we show how the decision based framework can help in wider adoption of solar power plant by mitigating the financial challenges faced by consumer in terms of willingness of pay and the higher cost faced by EPCs due to diseconomies of scale.

Research Implication

Our paper makes theoretical contribution in the interference of distributed energy resources, sharing economy and improving finances for different stakeholders in the power sector. The study is one of first few attempts where decision-based modelling in power sector has been studied. We also believe that it is the first of its kind model in the Indian context, where solar power plant installation with DISCOM as an aggregator and financier is used, and revenue sharing between different stakeholders is based on a decision-based model.

Limitations and future research: Our study has certain limitations. First, this study takes on a holistic view of the power sector. As electricity is a concurrent subject and each state has different policies and geographies, further study and models based on similarly placed states may be carried out for better outcomes.

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