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Grid-Connected Rooftop Solar Systems in the Residential Sector: An Analysis of Vendor Perceptions

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Abstract
Growing concerns of climate change, energy security, and environmental sustainability have accelerated the global transition towards renewable energy sources. International initiatives and agreements such as the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol, the Paris Agreement (COP21), and subsequent Conference of Parties (COP) summits have emphasized the need to reduce greenhouse gas emissions and increase the share of clean energy in national energy basket. In response to these global commitments, India has undertaken significant efforts to promote renewable energy, particularly solar energy, through various policy initiatives and schemes. Among these, the Grid-Connected Rooftop Solar Scheme has emerged as an important initiative to encourage decentralized electricity generation and increase the adoption of solar energy at the household level.
The present study examines the implementation of the Grid-Connected Rooftop Solar Scheme in the Rohtak Division of Haryana, covering the districts of Rohtak, Sonipat, Jhajjar, and Bhiwani. The study is based on primary data collected from twenty empanelled solar vendors through the schedule method. The objectives were to assess the types of solar panels used, installation timelines, net meter installation process, implementation challenges, vendor satisfaction with government policies, perceptions regarding upfront costs, subsidy disbursement efficiency, and barriers to household adoption of rooftop solar systems.
The study concludes that the Grid-Connected Rooftop Solar Scheme has contributed positively to the promotion of solar energy in Haryana. However, improvements in net meter installation timelines, workforce skill development, affordability measures, consumer awareness, and administrative efficiency are essential to accelerate rooftop solar adoption and support India's renewable energy and sustainability goals.
Keywords: *Solar Energy, Grid-Connected Rooftop Solar Scheme, Renewable Energy, Haryana, Vendors, Net Metering, Subsidy Disbursement, Sustainable Development.*

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I. Introduction

Climate change and energy are closely interconnected, as the production and consumption of energy are among the largest sources of greenhouse gas emissions worldwide. India's growing economy and increasing energy demand have traditionally relied heavily on fossil fuels such as coal, oil, and natural gas, which contribute significantly to environmental degradation and global warming. Rising carbon emissions from power generation, transportation, and industrial activities have intensified concerns regarding climate change and energy security. To address these challenges, India has undertaken various initiatives to promote renewable energy sources such as solar, wind, biomass, and hydropower, ethanol blending, etc. The expansion of clean energy is essential not only for reducing greenhouse gas emissions but also for ensuring sustainable economic growth and energy independence. Government programmes such as the National Solar Mission, PM Surya Ghar Yojana, and the National Action Plan on Climate Change reflect India's commitment to a low-carbon development pathway. Furthermore, the country's targets for increasing renewable energy capacity and improving energy efficiency align with the United Nations Sustainable Development Goal 7, which seeks to ensure access to affordable, reliable, sustainable, and modern energy for all. Thus, the transition towards clean and renewable energy is a critical strategy for mitigating climate change while meeting the nation's growing energy requirements.

Recognizing the growing importance of renewable energy in addressing climate change and energy security, Government of Haryana has introduced progressive policies to promote solar energy development across the state. The Haryana Solar Power Policy 2023 aims to accelerate the adoption of solar energy through large-scale solar parks, distributed solar projects, and grid-connected rooftop solar systems. Given Haryana's favourable solar radiation and limited potential for wind and hydropower, the state has prioritized rooftop solar installations

in residential, commercial, industrial, and institutional sectors. The policy promotes both CAPEX and RESCO models, along with net metering and gross metering mechanisms, to encourage consumer participation. Haryana has set a target of adding 1,600 MW of rooftop solar capacity and supports farmers through schemes such as PM-KUSUM. The policy also emphasizes research and development, manufacturing of solar equipment, employment generation, and public-private partnerships. By encouraging clean energy generation and reducing dependence on conventional fuels, Haryana's solar initiatives contribute to environmental sustainability, fulfillment of Renewable Purchase Obligations (RPOs), and the achievement of national renewable energy and climate goals.

II. Research Methodology

The present study is based on primary data collected from vendors associated with the Grid-Connected Rooftop Solar (GCRT) Scheme in the Rohtak Division of Haryana, comprising the districts of Rohtak, Sonipat, Jhajjar, and Bhiwani. A descriptive research design was adopted to examine the perceptions, experiences, opportunities, and challenges faced by solar vendors in the implementation of rooftop solar systems. Specifically, the study aims to identify the types of solar cells commonly used in rooftop solar systems, assess the average time taken by vendors to complete installations, evaluate the time required by DISCOMs for net-meter installation, analyse the difficulties faced by vendors during project implementation and measure vendor satisfaction with existing government policies. Primary data was collected through the schedule method, wherein a structured schedule containing both closed-ended and open-ended questions was personally administered to the respondents. The survey covered aspects such as vendor profile, awareness of government policies and incentives, installation trends, customer preferences, net-metering procedures, financial and technical constraints, and future prospects of rooftop solar energy. The total number of vendors engaged in the survey are twenty using census method within the study area. The data obtained was subsequently classified, tabulated, and analyzed using descriptive statistical tools such as frequencies and percentages to assess the overall perception of vendors regarding the effectiveness and implementation of the Grid-Connected Rooftop Solar Scheme in the study area.

Types of Panels used in Household

Table No. 1
Descriptive Statistics of Types of Solar Cells/Panels Widely Used

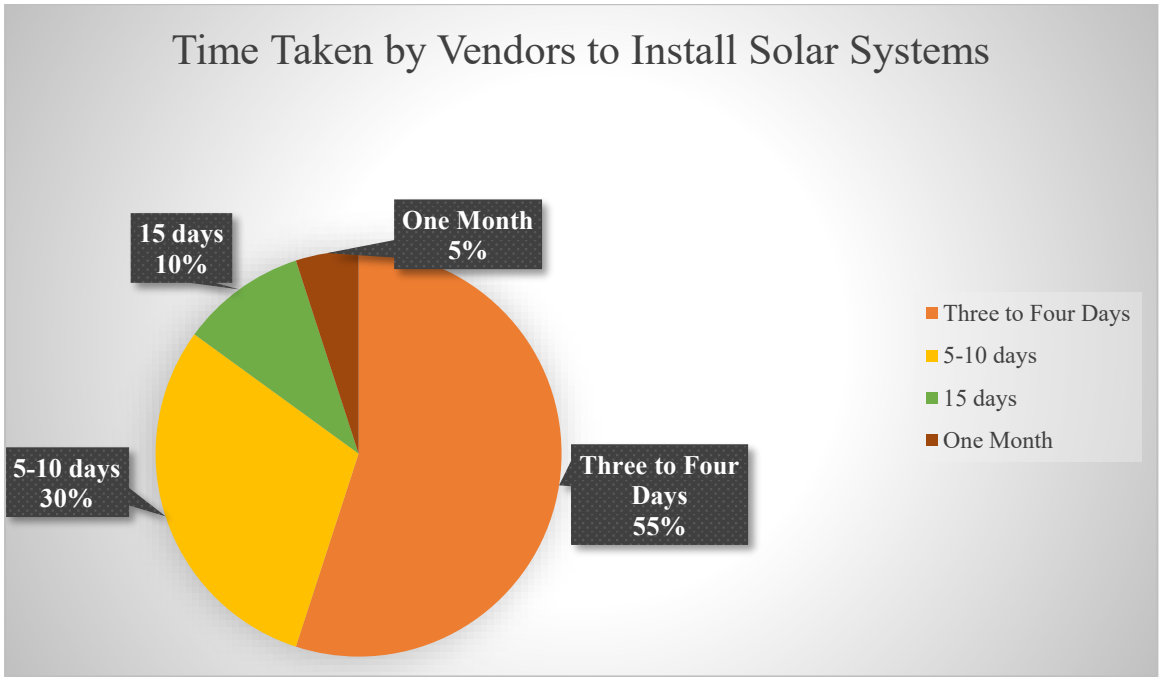
Which type of solar cells/panel is widely used in this scheme?					
Name of Solar Cells		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Top Con	10	50.0	50.0	50.0
	Bifacial	05	25.0	25.0	75.0
	Mono perc Half Cut	03	15.0	15.0	90.0
	Other	02	10.0	10.0	100.0
	Total	20	100.0	100.0	

Source: Primary Data

Table no. 1 depicts the types of solar cells/panels most widely used under the scheme, as reported by vendors. The data shows that TopCon solar panels are the most widely used, reported by 50.0% of the vendors. The figurep indicates a clear preference for TopCon technology, likely due to its higher efficiency and better performance compared to conventional options. The second most commonly used type is bifacial solar panels, accounting for 25.0% of responses. Their ability to generate electricity from both sides makes them an attractive option, especially where installation conditions permit enhanced reflectivity. This is followed by mono PERC half-cut panels, used by 15.0% of vendors. Although efficient, their relatively lower adoption suggests that newer technologies may be gradually replacing them under the scheme. The findings highlight a strong shift toward advanced solar technologies, with TopCon panels clearly dominating installations under the scheme, followed by bifacial and mono PERC panels.

Time Taken by Vendors to Install Solar Systems

It helps in understanding the efficiency and responsiveness of vendors involved in the implementation of solar energy systems. Installation time directly affects customer satisfaction, trust, and the overall adoption of solar technology.



Primary Data

Figure No. 1 Time Taken by Vendors to Install Solar Systems

The data given in figure no. 1 indicate that majority of vendors complete installation within three to four days, as reported by 55.0% of respondents. This indicates that, in most cases, the installation process is completed quickly. This is followed by installations taking 5 to 10 days, reported by 30.0% of vendors. These cases involve slightly larger systems, logistical delays, or site inspection requirements. A smaller proportion of vendors, 10.0%, indicated that installation takes around 15 days, suggesting occasional delays due to procedural, technical, or coordination-related issues. Only 5% of respondents reported that installation takes one month, showing that few customers did face problem in installation. Overall, the data clearly indicates that solar system installation is largely completed within a short timeframe, with more than four-fifths of installations finished within ten days, reflecting operational efficiency among vendors under the scheme.

Time Taken by Electricity Department Officials to Install Net Meters

Net meter installation is essential for connecting rooftop solar systems to the grid and enabling consumers to benefit from net metering policies. The time taken by electricity department officials to install net meters directly influences the operationalization of solar systems and the realization of financial benefits by consumers.

Table No. 2
Descriptive Statistics of Time Taken by Electricity Department Officials to Install Net Meters

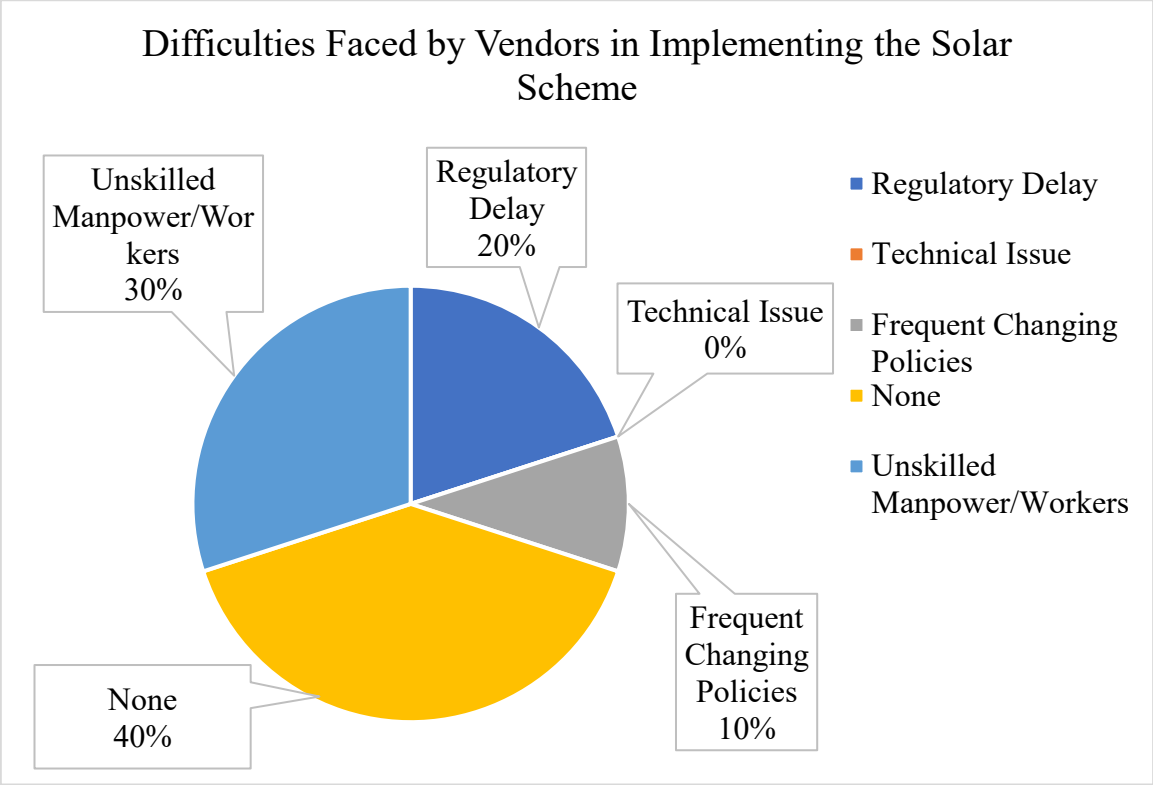
Time taken by electricity dept officials to install net meter?					
Time Range		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Zero to Three Days	00	00	00	00
	Three to Six Days	00	00	00	0
	10 Days	02	10.0	10.0	10.0
	15 Days	12	60.0	60.0	70.0
	One Month	6	30.0	30.0	100.0
	Total	20	100.0	100.0	

Source: Primary Data

The data of table no. 2 indicate that the majority of respondents, 60.0%, reported that net meter installation takes about 15 days. This indicates that a two-week period is the most common timeline followed by electricity department officials for completing net metering after solar installation. This is followed by 30.0% of respondents who stated that net meter installation takes up to one month, suggesting notable delays in a substantial number of cases. Only 10.0% of vendors reported that the process is completed within 10 days, indicating that faster installations are relatively rare. Importantly, no respondents (0.0%) reported net meter installation within zero to three days or three to six days, highlighting that immediate or short-term installation is largely absent. Overall, the findings suggest that there is non availability of net-meter and significant delay in installation of net-meter in particular and thereby roof top solar system in general.

Difficulties Faced by Vendors in Implementing the Solar Scheme

Vendors play a central role in the successful implementation of solar schemes, from procurement and installation to coordination with government departments and consumers. Identifying the difficulties faced by vendors helps in understanding the practical and operational challenges encountered at the ground level during scheme execution.

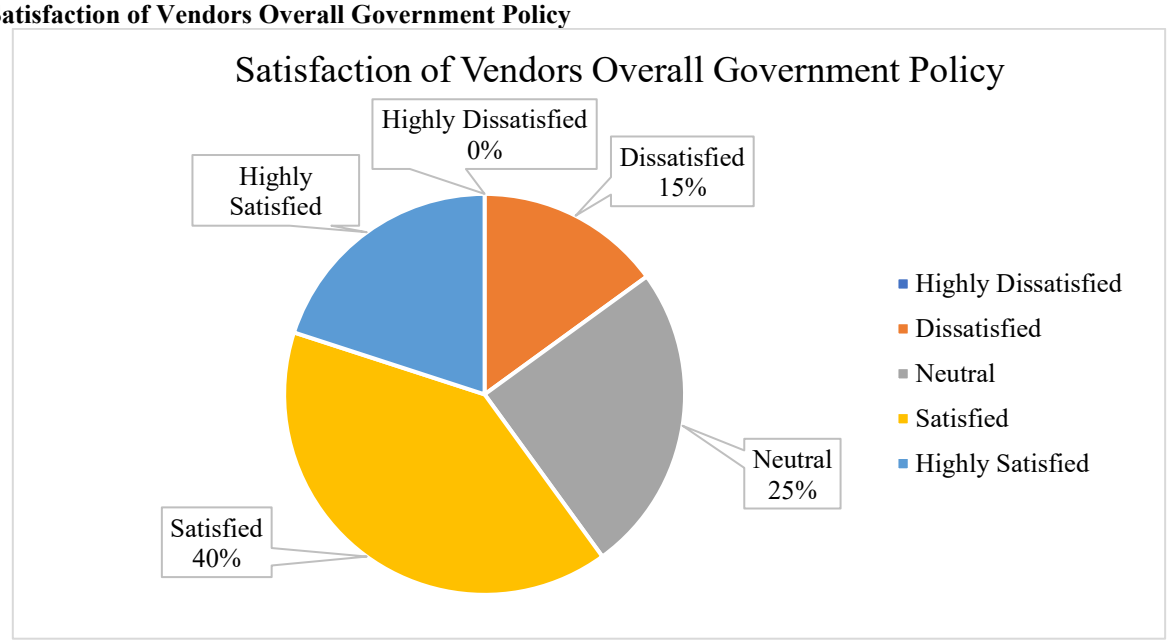


Primary Data

Figure No. 2 Difficulties Faced by Vendors in Implementing the Solar Scheme

The presented data of figure no. 2 show that the largest proportion of vendors, 40.0%, reported no difficulties in implementing the solar scheme. This indicates that a significant section of vendors finds the implementation process smooth and manageable. This is followed by 30.0% of vendors who identified unskilled manpower/workers as the major difficulty. This highlights a clear skill gap in the workforce involved in solar system installation and related activities. Next, 20.0% of respondents pointed to regulatory delays as a challenge, suggesting that administrative or procedural approvals can slow down project execution. A smaller proportion, 10.0%, reported frequent changes in policies as a difficulty, indicating some level of uncertainty affecting planning and implementation. Notably, 0.0% of vendors reported technical issues, implying that technology-related problems are not a significant concern in the implementation of the solar scheme. Overall, while many vendors do not face major obstacles, manpower-related issues and regulatory delays emerge as the key challenges in effective implementation of the scheme.

Satisfaction of Vendors Overall Government Policy



Primary Data

Figure No. 3 Satisfaction of Vendors Overall Government Policy

Data presented in figure no. 3 presents the highest proportion of respondents, 40.0%, reported being satisfied with the overall government policy, indicating a generally positive perception among vendors. This is followed by 25.0% of vendors who expressed a neutral opinion, suggesting that a significant section neither strongly approves nor disapproves of the policy framework. Next, 20.0% of vendors reported being highly satisfied, reinforcing the view that a substantial proportion holds a favorable opinion of government policies related to the scheme. On the other hand, 15.0% of vendors were dissatisfied, reflecting some level of concern or unmet expectations. Overall, the findings suggest that a clear majority of vendors (60.0%, combining satisfied and highly satisfied) view the government policy positively, while dissatisfaction remains limited. This indicates broad acceptance of the policy, though there is scope for improvement to address the concerns of dissatisfied and neutral respondents.

Upfront Cost of Solar Systems

Upfront cost is one of the most critical factors influencing a household's decision to adopt rooftop solar systems. Despite long-term financial and environmental benefits, a high initial investment can act as a major barrier, especially for middle- and lower-income households.

Table No. 3
Descriptive Statistics of Perceived Upfront Cost of Solar Systems

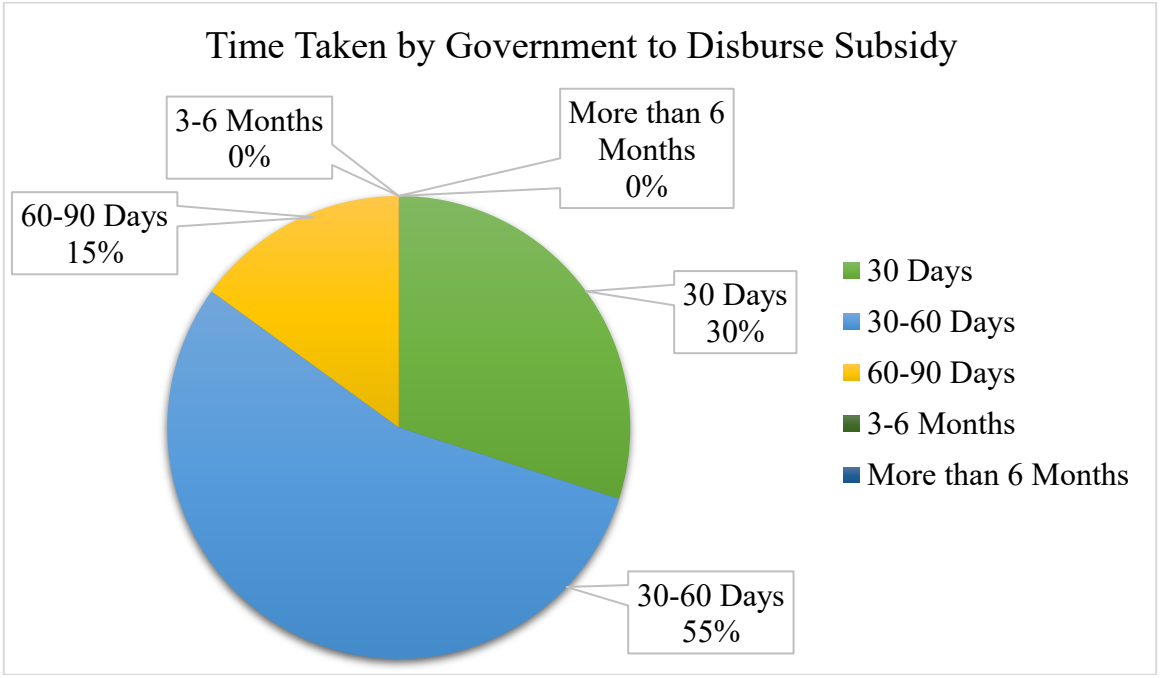
Do you believe upfront cost of solar system is high?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	12	60.0	60.0	60.0
	No	08	40.0	40.0	100.0
	Maybe	00	00	00	100.0
	Total	20	100.0	100.0	

Source: Primary Data

The table no. 3 presents the vendors' perception regarding the upfront cost of solar systems. A majority of respondents, 60.0%, believe that the upfront cost of a solar system is high, indicating that initial investment remains a significant concern. This is followed by 40.0% of respondents who do not consider the upfront cost to be high, suggesting that a sizeable proportion perceives solar systems as financially manageable, possibly due to subsidies or long-term cost savings. Overall, the findings highlight that while perceptions are somewhat divided, a dominant majority views the upfront cost as high, emphasizing the importance of financial support mechanisms, subsidies, and awareness about long-term economic benefits to encourage wider adoption of solar systems.

Time Taken by Government to Disburse Subsidy

Assessing the time taken by the government to disburse subsidies helps in evaluating the administrative efficiency of the scheme and identifying procedural bottlenecks. Prolonged delays may affect cash flows for households and vendors, slow down installations, and negatively impact the momentum of renewable energy adoption.



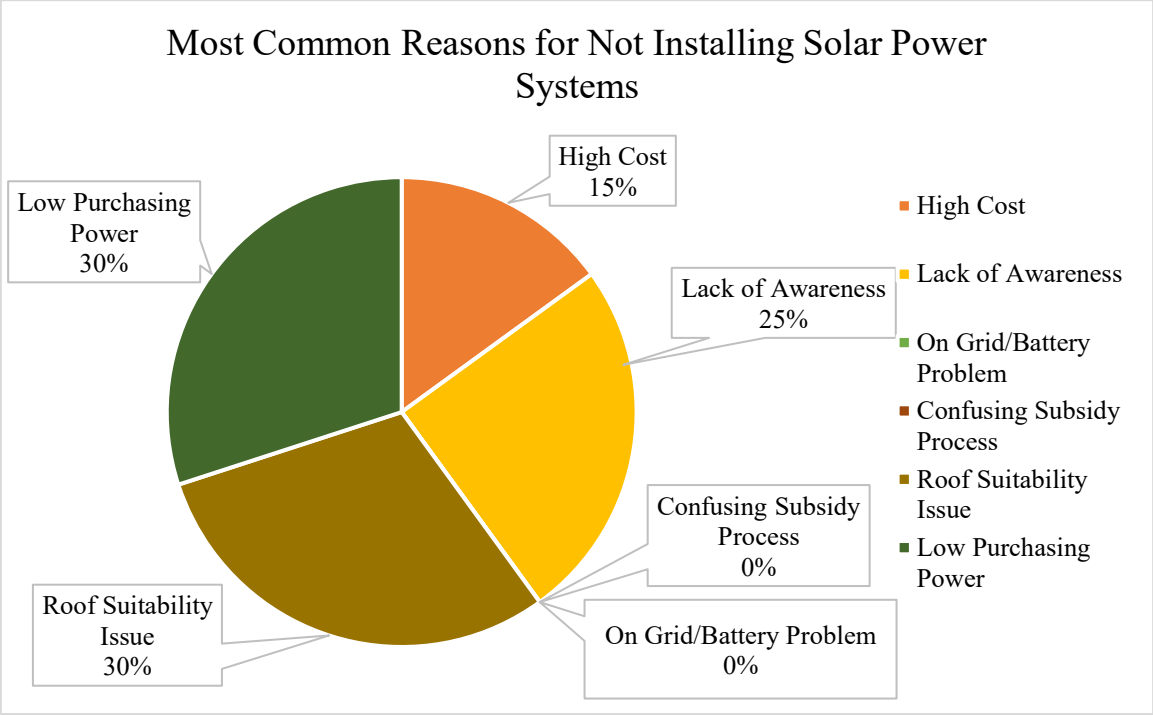
Primary Data

Figure No. 4 Time Taken by Government to Disburse Subsidy

Inserted data in figure no. 4 depicts the time taken by the Government to disburse subsidy as perceived by the vendors. The largest proportion of respondents, 55.0%, reported that subsidy disbursement takes 30–60 days, indicating that this is the most common time frame experienced by beneficiaries. This is followed by 30.0% of respondents who stated that the subsidy is disbursed within 30 days, reflecting relatively prompt processing in a substantial number of cases. Further, 15.0% of respondents indicated that the subsidy takes 60–90 days, showing that delays beyond two months are experienced by a smaller segment. Overall, the data indicate that subsidy disbursement is generally completed within 60 days for the majority of beneficiaries, highlighting a moderately efficient subsidy delivery mechanism with limited instances of extended delays.

Most Common Reasons for Not Installing Solar Power Systems

Identify the key barriers that prevent households from adopting solar power systems, despite the availability of government schemes and incentives. Understanding why potential users choose not to install solar systems provides critical insights into gaps in policy design, awareness, affordability, and infrastructure readiness. Analysing these reasons might allow researchers and policymakers to distinguish between financial constraints, such as high upfront costs or low purchasing power, and non-financial barriers, including lack of awareness, roof suitability issues, or technical concerns.



Primary Data

Figure No. 5 Most Common Reasons for Not Installing Solar Power Systems

Data presented in figure 5. reveal that the most prominent reasons reported were roof suitability issues and low purchasing power. This indicates that both fear of roof utilisation and financial limitations are the leading barriers to the adoption of solar power systems. This is followed by lack of awareness, reported by 25.0% of respondents, highlighting that insufficient information and understanding about solar power systems remains a significant challenge. Further, high cost was identified as a reason by 15.0% of respondents, suggesting that upfront expenses continue to influence adoption decisions, though to a lesser extent compared to roof availability and income-related factors. Notably none of respondents reported on-grid or battery problems and a confusing subsidy process as reasons for non-installation, indicating that these factors are not perceived as major barriers by the respondents. Overall, the findings reveal that physical suitability of rooftops and economic capacity are the primary obstacles, while awareness and cost also play a meaningful role in limiting the installation of solar power systems.

III. Findings & Conclusion

The findings of the study reveal that TopCon solar panels are the most widely used technology under the Grid-Connected Rooftop Solar Scheme, indicating a preference for high-efficiency solar solutions among vendors. Most vendors complete solar system installations within three to four days, reflecting operational efficiency; however, the installation of net meters by electricity department officials generally takes 15 days to one month, causing delays in system operationalization. While 40 percent of vendors reported facing no major difficulties during implementation, the shortage of skilled manpower and regulatory delays emerged as the most significant challenges. The majority of vendors expressed satisfaction with the overall government policy, suggesting a generally positive perception of the scheme. At the same time, 60 percent of respondents considered the upfront cost of solar systems to be high, highlighting affordability as an important concern. Subsidy disbursement was found to be moderately efficient, with most vendors reporting that beneficiaries receive subsidies within 30–60 days. The study further revealed that roof suitability issues and low purchasing power are the primary reasons preventing households from adopting rooftop solar systems, while lack of awareness and high initial costs also contribute to lower adoption levels. Overall, the findings indicate that although the scheme has been successful in promoting rooftop solar installations, improvements in net meter installation timelines, workforce skill development, affordability, and consumer awareness are necessary to enhance its effectiveness and expand adoption.

The study examined the perceptions and experiences of vendors associated with the Grid-Connected Rooftop Solar Scheme in the Rohtak Division of Haryana. The findings indicate that the scheme has made considerable progress in promoting rooftop solar adoption and encouraging the use of modern solar technologies such as Topcon and bifacial panels. Vendors generally demonstrated operational efficiency by completing

installations within a short period, reflecting their capability to support the expansion of solar energy systems. Despite these positive developments, certain challenges continue to affect the smooth implementation of the scheme. The electricity department should focus on timely availability of net-meter and disbursement. Although vendors expressed overall satisfaction with government policies, the high upfront cost of solar systems remains a major barrier for many potential consumers. Furthermore government should focus more on awareness campaign. Though Grid-Connected Rooftop Solar Scheme has achieved encouraging results, but greater attention to affordability, workforce development, consumer awareness, and faster procedural clearances are important for accelerating rooftop solar deployment and achieving renewable energy targets in Rohtak division in particular and Haryana in general.

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