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Research Article

# Solar Energy Policies for Commercial Buildings in India: Experiences of Building Owners and Managers

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**Abstract:** To fulfill the demands of a country that is fast developing and heavily reliant on fossil fuels, India's energy sector has expanded rapidly. Since renewable energy sources are plentiful, limitless, and ecologically beneficial, they provide an alluring answer to the world's mounting energy problems. Numerous initiatives have been taken in the direction of developing solar energy in all fields by the national and state-level governments in India. This study evaluates the various government initiatives for off-grid solar photovoltaic (SPV)/solar water heating (SWH) systems from the viewpoint of building owners and managers of commercial establishments in India. Building owners and managers rated environmental consciousness as the most important accelerator for installing SPV/SWH system. Limited financial and fiscal incentives from the government, limited sources of information with unclear, technical, and incomplete content, and government websites not being updated regularly were reported as the barriers hindering the installation of SPV/SWH systems in commercial establishments. The study thus identified gaps in the implementation of government initiatives and recommended improvements. The recommendations will go a long way in bringing all the stakeholders on the same page for the better functioning of the policy regime.

***Keywords*:** building owners and managers, commercial establishments, government policies, policy framework, SPV, SWH

## 1. Introduction

Energy is essential for development, enhancing the standard of living, and catalyzing economic growth. A consistent source of energy is essential for contemporary economies to thrive because it is a necessity for human life [1, 2]. However, in the 21st century, it has proven to be extremely difficult to provide everyone with enough clean energy. The world's expanding population and economic growth place tremendous strain on the available resources. This is anticipated to lead to a three- to five-fold rise in global economic production by 2050 and a further 10- to 15-fold increase by 2100 [3].

The long-term availability of energy from sources that are inexpensive, reachable, and ecologically friendly is vital for future economic growth [4]. Between 1990 and 2040, there will be an estimated 48% rise in global energy use. In the absence of targeted policies, the increase in global population and gross domestic product (GDP) will result in a constant increase in energy demand [5].

For its energy needs, India has been reliant on fossil resources. The nation relies on imports because India's


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reserves are insufficient and prevent it from being self-sufficient. Due to rising demand, the world's fossil fuel supplies are under increasing pressure as they are depleting quickly. The environment is directly impacted by climate change caused by human activity, particularly the release of greenhouse gases. The energy industry is important in this context since it produces damaging compounds for the environment throughout its production, delivery, and consumption [6]. The efforts made to accommodate the growing demand for energy have grown along with it over time. India's total installed capacity has increased from 42,585 MW at the conclusion of the Sixth Five-Year Plan in 1985 to 388,849 MW in 2021 [7, 8].

India's potential for renewable energy from commercially viable sources is projected to be around 147,615 MW. India's total installed renewable energy capacity expanded dramatically between 2013 and 2021, rising from 28,067 MW to 147,096 MW [8, 9]. Renewable energy, especially solar energy, has gained momentum in the past decade, with the Government of India taking concerted efforts towards its promotion for a long time. With increased targets for renewable energy, India is set to take multi-fold initiatives towards this end. Further, the imbalance between demand and supply with the growing population, a sizable untapped potential, environmental concerns, the necessity to improve India's energy supply, and practical solutions for rural electrification are some of the key drivers for renewable energy. If India wants to keep its promises to lower its emissions, it must accelerate its renewable energy capacity. India might establish globally competitive enterprises and technology that could present fresh prospects for growth and leadership by investing in renewable energy. It can guarantee a steady supply of electricity to support domestic industrial expansion, draw in new investors, and thus serve as a key driver of employment creation and additional revenue [10].

India's average yearly temperature ranges from 25 °C to 27.5 °C due to its geographic location between the Tropic of Cancer and the Equator, thus leading to massive solar potential in the country. India currently has a total installed solar energy capacity of around 42 GW. About 6,762 MW of this comes from grid-connected systems, and the remaining comes from off-grid systems. By 2030, 280 GW of installed solar capacity is anticipated in the country [11]. Table 1 throws light on the expansion of solar energy installed in India over the last decade [8].

**Table 1.** Growth of solar installations in India

| Year | Solar power installed capacity (MW) |
|---|---|
| 2022 | 54 |
| 2021 | 40.1 |
| 2020 | 34.6 |
| 2019 | 28.2 |
| 2018 | 21.7 |
| 2017 | 12.2 |
| 2016 | 6.7 |
| 2015 | 3.7 |
| 2014 | 2.6 |
| 2013 | 2.3 |
| 2012 | 1.2 |
| 2011 | 0.5 |
| 2010 | 0.2 |

Decentralized off-grid solar solutions can be used effectively to provide electricity for individual buildings. As a result, solar photovoltaic (SPV) and solar thermal off-grid technologies can be used to convert solar radiation into heat and power, greatly enhancing the viability of solar in India [12]. Yet, off-grid solar installations are limited in the country [13, 14]. Thus, impetus needs to be given to the benefits of off-grid solar applications. The Government of India's decision to increase its goal for renewable energy to 500 GW by 2030—280 GW of which will come from solar power—is the most notable action taken in this respect [15].

Since the early 1970s, renewable energy has played a significant role in India's energy planning process. The Ministry of New and Renewable Energy (MNRE) has been working on a number of projects for the implementation of programs to harness renewable energy [16-18]. In addition to MNRE, many states and Union Territories (UTs) have been taking measures to promote solar energy in their respective states and UTs because electricity is a topic of the state, UT, and central government's legislative and regulatory power [19]. Figure 1 illustrates the policy framework at the central and state levels in India.

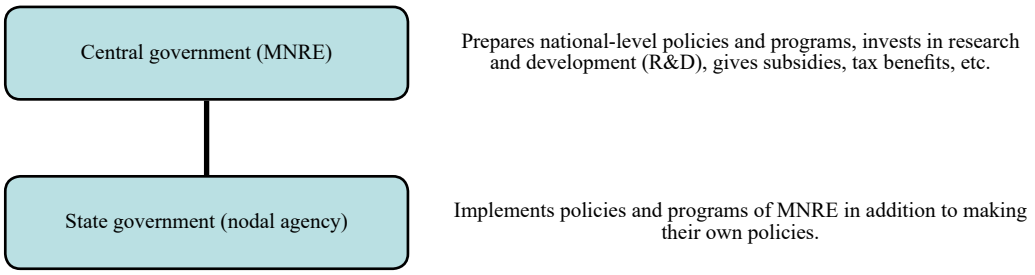


**Figure 1.** Policy framework for renewable energy in India

### 1.1 *Scope and significance*

Commercial buildings, particularly institutional and industrial ones, are frequently seen as energy hogs. In India, the commercial building industry consumes around 8.04% of all electricity and is expanding significantly and more quickly than other sectors [20]. It is important to concentrate on this sector, as it has the means to invest in solar energy. The continuous use of fossil fuels will also confront a number of difficulties, including the depletion of fossil fuel reserves, worries about global warming and other environmental issues, as well as the recent, persistent, and large rise in fuel prices. Given that it is infinite and limitless, renewable energy seems like a good choice in this situation. Due to its geographical location, India receives between 300 and 330 sunny days a year, which presents a significant possibility for utilizing solar energy. In order to attain energy security in a sustainable way, the government is encouraging the use of solar energy in the country.

The study was carried out in six Indian states and UTs, which were chosen based on their total installed solar capacity under different government programs. According to their total installed solar capacity, states and UTs were listed and divided into high, medium, and low categories. Two states and UTs from each of the three categories (high, medium, and low) were selected. Additionally, SPV and solar water heating (SWH) are most frequently employed in the commercial sector to meet the demands for electricity and hot water, and were thus chosen for the study.

The primary objective of the study was to study the government's initiatives in terms of their framework and scope in promoting selected off-grid solar technologies in commercial establishments and identify the barriers associated with the same. The study aimed at compiling the framework of government initiatives for the promotion of selected off-grid solar technologies in the commercial sector and the awareness level of selected stakeholders regarding these initiatives. The study also looked into the accelerators and barriers faced by selected stakeholders with respect to these government initiatives. For the present paper, however, emphasis has been laid on the perspective of building owners and managers as important stakeholders in the implementation of these government initiatives. A review of the literature highlighted the concerted efforts initiated by the Indian government at the national, state, and UT levels to promote decentralized solar technologies, namely SPV and solar thermal, but the uptake of these technologies in commercial establishments is still limited. Therefore, it felt imperative to understand the initiatives from the stakeholders' perspective.

## 2. Materials and methods

Six Indian states and UTs were selected as the locales of the study. Based on their total solar installed capacity

under different government projects, the states and UTs were chosen. Gujarat and Rajasthan were chosen as high performers, Punjab and Haryana as medium performers, and Delhi and Chandigarh as low performers. In the commercial building sector, both government and private buildings were included. In the six selected states and UTs, a comprehensive list of the commercial establishments (both government and private) using off-grid SPV/SWH systems was made with the help of the central government and state nodal agencies. Out of these, the buildings meeting the inclusion criteria, as stated above, were listed. From this list, random selection was done to take four buildings from each state and UT (two each for SPV and SWH from the government and private sector), making a total of 24 buildings from six states and UTs.

Owners and managers of the selected commercial establishments using selected solar technologies were selected as stakeholders. Since owners and managers are the prime decision-makers regarding the installation of off-grid SPV/SWH systems in their buildings, it was considered significant to understand their perspective. These stakeholders play an important role and create a demand-side pull for taking the solar momentum forward. Three respondents were selected from each building, making a total of 72 building owners and managers. The owners and managers of the selected commercial establishments were included in the sample to understand their awareness level regarding government initiatives for SPV/SWH systems and to get their perspectives on the accelerators, barriers, and suggestions regarding these initiatives.

The framework of the government initiatives was studied in terms of the national and state-level policies and incentives offered under these policies. Further, for availing of these incentives, the process was studied in detail to find out the barriers at each of the stages of the process from stakeholders' perspectives. For the study, both primary and secondary sources were used as study tools. Questionnaires were used to study the awareness, accelerators, barriers, and suggestions of the selected stakeholders regarding government initiatives for SPV/SWH systems. Two separate questionnaires, one for SPV and the other for SWH, were designed for building owners and managers from the two categories of selected off-grid solar technologies, namely SPV and SWH. Each questionnaire was divided into three parts, focusing on the background details of the building and SPV/SWH systems, their awareness regarding government initiatives and accelerators, and barriers to the policies and programs. They were also asked to give suggestions to improve the adoption of SPV/SWH systems. Both open-ended and closed-ended questions were included in the tools. Apart from these, rating scales and checklists were used for acquiring important information.

In order to understand the national framework of policies and programs for solar energy, multiple trips to MNRE, the Government of India, were made during the initial stages of data gathering. Secondary data was also gathered during these sessions. Meetings were scheduled over the phone or via email with representatives of the state nodal agencies. The owners and managers of the chosen buildings were contacted by phone or email. Some of the respondents indicated that they would be open to an interview, while others chose to keep the questionnaires. Later, the researcher collected the completed surveys from them.

Since the majority of the stakeholders who were chosen for the study did not want their names or the names of their organizations to be disclosed, the researcher ensured the confidentiality of the data at every stage of the data gathering and presentation. Interviews provided a chance to speak with them directly and gain a comprehensive understanding of the obstacles that had to be overcome in order to install SPV/SWH systems in the building. Additionally, informally speaking with the stakeholders was done in order to build rapport and inform them of the study's objectives.

With the study objectives in mind, the data was both statistically and qualitatively analyzed. For the answers received for each question, a coding pattern was created. The coded data was entered into coding sheets created in Statistical Package for the Social Sciences (SPSS) Statistics 20, and the frequencies were calculated. As a result, the coded data was transferred to master sheets, tallied, and quantitatively examined. Further, frequency distributions and cross-tabulations were produced. Statistical measures such as the mean and standard deviation (SD) were computed. One-way analysis of variance (ANOVA) and post-hoc Tukey's honest significant difference (HSD) tests were used where necessary.

# 3. Results

## 3.1 *Framework of government initiatives*

The MNRE of the Government of India is involved in R&D, formulating policies, and bolstering the institutional framework for renewable energy in the nation. Every state and UT in India has nodal agencies that are responsible for meeting the renewable energy needs of that region and carrying out the MNRE's policy there. To further boost the renewable energy sector, certain state and UT administrations have developed their own policies and plans in addition to those of MNRE.

Capital subsidy, accelerated depreciation benefit, soft loan, and interest subsidy were the four main incentives provided by MNRE. Capital subsidies were typically computed at 30% of the system's benchmark cost (excluding special category states). The first year after installation, an accelerated depreciation benefit at a rate of 80% was offered, resulting in tax savings for the building owners. Soft loans were offered by commercial banks and non-banking financial organizations like Indian Renewable Energy Development Agency (IREDA). Another incentive provided by MNRE was an interest subsidy, in which commercial banks provided loans for the installation of off-grid solar systems at a much cheaper interest rate. A few states and UTs also provided additional state and UT incentives for off-grid solar installations, over and above the central government, such as additional capital subsidies (earlier given by Haryana) and value-added tax (VAT) exemptions (given by Punjab and Delhi) on the SPV/SWH systems.

## 3.2 *Types of commercial establishments selected for the study and government initiatives availed by them for SPV/SWH installations*

As discussed in the methodology, the study has focused on commercial buildings, both government and private. Out of a total of 24 commercial establishments chosen for the study, nine were offices, seven were educational institutions, six were hotels, and two were hostels, which were distributed between government and private buildings. As can be seen from Table 2, government buildings included more offices and educational institutions (11 out of 12), whereas private buildings had hotels (six out of 12). Further, looking at the distribution of SPV and SWH systems among the various types of buildings, it was observed that SPV systems were more common in office buildings and educational institutions, which had more electricity demand. On the other hand, SWH systems were more common in hotels and hostels, owing to their high demands for hot water. As requested by the respondents, the names of the selected buildings have been kept confidential.

In most of the cases, the building owners and managers had applied for the three most commonly used incentives, namely capital subsidies, accelerated depreciation benefits, and soft loans from MNRE. The interest subsidy was not availed of by any of the selected stakeholders. As per MNRE guidelines, commercial establishments could either avail of a capital subsidy or an interest subsidy. All the stakeholders selected for the study had applied for capital subsidies. State and UT governments had not been giving many additional incentives other than the MNRE, with the exception of Haryana, which was earlier giving additional capital subsidies. Some states and UTs were giving VAT exemptions on off-grid SPV/SWH systems.

It was observed that the number of additional incentives offered by the state and UT governments did not depend on the performance of the state and UT in terms of the solar installation base. For instance, Gujarat and Rajasthan (the two high-performing states selected for the study) were not providing any additional incentives for off-grid SPV and SWH systems other than MNRE. On the other hand, Punjab (a medium-performing state) was giving VAT exemption, and Haryana (a medium-performing state) was earlier giving additional capital subsidies. Thus, the performance of the states and UTs in terms of the solar installation base would have been high in Gujarat and Rajasthan because of better governance and better implementation of MNRE initiatives, as compared to other states and UTs.

**Table 2.** Types of the commercial buildings selected for the study

| Types of commercial buildings selected for the study | Categories of selected states and UTs | | | | | | Total (N = 24) |
|---|---|---|---|---|---|---|---|
| | High (Gujarat, Rajasthan) (N = 8) | | Medium (Punjab, Haryana) (N = 8) | | Low (Delhi, Chandigarh) (N = 8) | | |
| | Government | Private | Government | Private | Government | Private | |
| | N (4) | N (4) | N (4) | N (4) | N (4) | N (4) | N |
| Offices | 2 | 1 | 2 | 1 | 2 | 1 | 9 |
| Educational institutions | 2 | 0 | 2 | 1 | 1 | 1 | 7 |
| Hotels | 0 | 2 | 0 | 2 | 0 | 2 | 6 |
| Hostels | 0 | 1 | 0 | 0 | 1 | 0 | 2 |
| Total | 4 | 4 | 4 | 4 | 4 | 4 | 24 |

| Types of commercial buildings selected for the study | Categories of selected states and UTs | | | | | | Total (N = 24) |
|---|---|---|---|---|---|---|---|
| | High (Gujarat, Rajasthan) (N = 8) | | Medium (Punjab, Haryana) (N = 8) | | Low (Delhi, Chandigarh) (N = 8) | | |
| | SPV | SWH | SPV | SWH | SPV | SWH | |
| | N (4) | N (4) | N (4) | N (4) | N (4) | N (4) | N |
| Offices | 2 | 1 | 2 | 1 | 2 | 1 | 9 |
| Hotels | 0 | 2 | 0 | 2 | 1 | 1 | 6 |
| Educational institutions | 2 | 0 | 2 | 1 | 1 | 1 | 7 |
| Hostels | 0 | 1 | 0 | 0 | 0 | 1 | 2 |
| Total | 4 | 4 | 4 | 4 | 4 | 4 | 24 |

## 3.3 *Designation and experience of the officials from the selected buildings*

The study highlighted that more than 45% of the officials from the selected buildings who were interviewed were designated as assistant managers or managers (Table 3). Further, 25% were facilities managers, more than 19% were supervisors, and only about 10% were owners or directors. The study has, thus, looked into the perspective of various managerial positions, starting from owners or directors to the level of supervisors in the selected buildings, ensuring a wide range of opinions.

**Table 3.** Designation of the officials from the selected buildings

| Designation of the officials from the selected buildings | Categories of selected states and UTs | | | | | | Total (N = 72) | |
|---|---|---|---|---|---|---|---|---|
| | High (Gujarat, Rajasthan) (N = 24) | | Medium (Punjab, Haryana) (N = 24) | | Low (Delhi, Chandigarh) (N = 24) | | | |
| | SPV | SWH | SPV | SWH | SPV | SWH | | |
| | N (12) | N (12) | N (12) | N (12) | N (12) | N (12) | N | Percentage (%) |
| Assistant manager or manager | 5 | 9 | 7 | 4 | 5 | 3 | 33 | 45.83 |
| Facilities manager | 3 | 2 | 3 | 6 | 2 | 2 | 18 | 25.00 |
| Supervisor | 2 | 0 | 0 | 0 | 5 | 7 | 14 | 19.44 |
| Owner or director | 2 | 1 | 2 | 2 | 0 | 0 | 7 | 9.72 |
| Total | 12 | 12 | 12 | 12 | 12 | 12 | 72 | 100.00 |

It was observed that approximately 68% of the selected building owners and managers had about six to 15 years of

experience in their organizations (Table 4). Further, about 14% had less than six years of experience, and about 18% had more than 15 years of experience. The mean number of years spent by the respondents in their respective organizations was 11.31 years, with an SD of 4.71. On the other hand, the mean age of the SPV/SWH system was found to be 2.75 years, with an SD of 1.24. Thus, most of the building managers selected for the study would have been part of the installation process of the SPV/SWH systems in their buildings, and thus, they could report the barriers faced at the various stages of the installation of SPV/SWH systems and avail themselves of government incentives for the same.

**Table 4.** Number of years spent by the building owners and managers in the organization

| Number of years spent by the building owners and managers in the organization | Categories of selected states and UTs | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | High (Gujarat, Rajasthan) (N = 24) | | Medium (Punjab, Haryana) (N = 24) | | Low (Delhi, Chandigarh) (N = 24) | | Total (N = 72) | |
| | SPV | SWH | SPV | SWH | SPV | SWH | | |
| | N (12) | N (12) | N (12) | N (12) | N (12) | N (12) | N | Percentage (%) |
| < 6 years | 2 | 1 | 1 | 2 | 4 | 0 | 10 | 13.89 |
| 6 to 10 years | 4 | 3 | 4 | 4 | 6 | 3 | 24 | 33.33 |
| 11 to 15 years | 3 | 6 | 6 | 6 | 2 | 2 | 25 | 34.72 |
| 16 to 20 years | 3 | 2 | 1 | 0 | 0 | 7 | 13 | 18.06 |
| Total | 12 | 12 | 12 | 12 | 12 | 12 | 72 | 100.00 |
| Mean | 11.25 | 11.08 | 11.58 | 10.50 | 8.25 | 15.17 | 11.31 | |
| SD | 5.71 | 3.68 | 4.06 | 4.01 | 3.55 | 4.99 | 4.71 | |
| | Categories of selected states or UTs | | | | | | | |
| Year of installation of the SPV/ SWH systems | High (Gujarat, Rajasthan) (N = 24) | | Medium (Punjab, Haryana) (N = 24) | | Low (Delhi, Chandigarh) (N = 24) | | Total (N = 72) | |
| | SPV | SWH | SPV | SWH | SPV | SWH | | |
| | N (12) | N (12) | N (12) | N (12) | N (12) | N (12) | N | Percentage (%) |
| 2009 to 2010 | 6 | 3 | 0 | 3 | 3 | 0 | 15 | 20.83 |
| 2011 to 2012 | 0 | 3 | 9 | 9 | 3 | 9 | 33 | 45.83 |
| 2013 to 2014 | 6 | 6 | 3 | 0 | 6 | 3 | 24 | 33.33 |
| Total | 12 | 12 | 12 | 12 | 12 | 12 | 72 | 100.00 |
| Mean age of the SPV/SWH systems | 3.00 | 2.50 | 2.25 | 3.50 | 2.75 | 2.50 | 2.75 | |
| SD | 1.65 | 1.17 | 0.87 | 0.91 | 1.55 | 0.91 | 1.24 | |

## 3.4 *Awareness of building owners and managers regarding government incentives*

It was observed that all the building owners and managers were aware of the capital subsidy scheme of MNRE; however, out of the 12 building owners and managers from Haryana (the only state giving additional state capital subsidy), only seven were aware of the state capital subsidy scheme (Table 5). Further, about 71% of the building owners and managers were also aware of the accelerated depreciation benefit offered by MNRE. Approximately 51% of the building owners and managers reported that they knew about the soft loan scheme of MNRE. Awareness regarding interest subsidies was found to be very low, with only 14.28% reporting about the same. Out of the total sample of 12 building owners and managers from Punjab (the only state giving VAT exemption), only 50% were aware of this incentive.

The most common source of information regarding governments' initiatives for building owners and managers was web sources, which got a mean rating of 4.36 (on a scale of 1 to 5) with an SD of 0.78. Various web sources, like the

MNRE website, state nodal agencies' websites, websites of NGOs working in the area of environment and renewable energy, online articles, websites of channel partners, government reports, policy documents, blogs, and e-newspapers, were reported to be the most common sources of information for building owners and managers. The second most common source of information regarding SPV/SWH systems and the government initiatives for them were the channel partners, which got a mean rating of 3.21 with an SD of 0.44. In most of the cases, the building owners and managers reported that they were approached by the channel partners to install the SPV/SWH systems in their buildings, who were instrumental in explaining the details of the SPV/SWH systems as well as the government support available for the same. Print media, including both newspapers and magazines, received mean ratings of 3.19 and 2.44, respectively.

**Table 5.** Awareness of building owners and managers about government incentives for SPV/SWH systems for commercial establishments

| Awareness among building owners and managers about government incentives for SPV/SWH systems | Categories of selected states and UTs | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | High (Gujarat, Rajasthan) (N = 24) | | Medium (Punjab, Haryana) (N = 24) | | Low (Delhi, Chandigarh) (N = 24) | | Total (N = 72) | |
| | SPV | SWH | SPV | SWH | SPV | SWH | | |
| | N (12) | N (12) | N (12) | N (12) | N (12) | N (12) | N* | Percentage (%) |
| Capital subsidy | | | | | | | | |
| • MNRE | 12 | 12 | 12 | 12 | 12 | 12 | 72 | 100 |
| • State and UT | NA | NA | 5 | 2 | NA | NA | 7 | 58.33 |
| Accelerated depreciation benefit | 10 | 8 | 7 | 9 | 8 | 9 | 51 | 70.83 |
| Soft loans | 7 | 8 | 6 | 4 | 7 | 5 | 37 | 51.39 |
| Interest subsidy | 2 | 1 | 3 | 2 | 1 | 1 | 10 | 14.28 |
| VAT exemption | NA | NA | 0 | 6 | NA | NA | 6 | 50.00 |

Note: NA = not applicable; and * = the total sample is exceeding N because of multiple responses given by the respondents

## 3.5 *Responses of building owners and managers regarding accelerators behind the installation of SPV/SWH systems*

Table 6 reveals that the highest mean rating of 3.71 (on a scale of 1 to 5) was given to environmental concern, with an SD of 1.07. Due to the intensive promotion of SPV/SWH installations by the government and the new targets set for solar energy, commercial users have become more aware of the benefits of SPV/SWH systems for the environment. This was closely followed by savings in electricity bills, which received a mean rating of 3.42 with an SD of 1.21. For businesses and commercial entities, savings can have a tremendous impact on their bottom line. Investing in solar power led to both long-term savings and quick paybacks.

Government incentives received a mean rating of 2.71, with an SD of 1.03. This accelerator was more predominant in the case of SPV systems than for SWH systems. This was because the SPV systems required more initial capital investments, and thus, incentives from the government helped reduce that cost to some extent. Further, improved prestige and image received a mean rating of 2.25 with an SD of 0.87. By using SPV/SWH systems, the commercial entity expressed its responsibility to fight against global warming. This also acted as a great marketing tool. Having an environmentally responsible and green image was good for commercial establishments, as it could generate a positive response from consumers and shareholders. Power cuts acting as an accelerator for SPV/SWH installations got a mean rating of 1.88 with an SD of 0.77. Off-grid SPV/SWH is a self-sustaining system working on solar power. Thus, even if there was some problem with the conventional supply from the grid, the building did not run out of power or hot water. The least mean rating of 1.69 was given to a better rental value of property because of the installation of SPV/SWH systems.

Table 6 also presents the classification of accelerators as major, medium, and minor. Accelerators with a mean

rating > 2.0 have been classified as minor; those with a mean rating of 2 to 3.5 are medium; and those > 3.5 have been grouped under major accelerators. The one-way ANOVA was applied, which revealed a statistically significant difference in the mean scores for four of the accelerators for SPV systems, namely savings in electricity bills, government incentives, improved prestige and image, and power cuts. The difference was also found to be significant for two of the accelerators for SWH systems, namely savings in electricity bills and power cuts.

### 3.5.1 *Differences in the mean scores for accelerators for SPV systems*

Differences in the mean scores among the three categories of states and UTs (for SPV installations) on their ratings given to savings in electricity bills as an accelerator were found to be significant with F (2, 11.55), p = 0.000 at the 0.05 level of significance. Post-hoc comparisons using Tukey's HSD test indicated that the mean score for savings in electricity bills as an accelerator was significantly different among the responses of building owners and managers from all three categories of states and UTs for the SPV category. Savings in electricity bills were rated higher as an accelerator by building owners and managers in low-performing states and UTs than those from high- and medium-performing states and UTs. According to building owners and managers in low-performing states and UTs, since government incentives in these states and UTs were very few, the major accelerator for organizations to install SPV/SWH systems was savings in electricity bills.

Similarly, for government incentives, a statistically significant difference was found in the means of responses given by the building owners and managers from the three categories of states and UTs {F (2, 3.78), p = 0.033}. The mean score for government initiatives as accelerators (SPV category) was significantly different between the medium- and low-performing states and UTs (p = 0.011), as revealed by the post-hoc Tukey's HSD test. Building owners and managers from low-performing states and UTs gave it a lower rating than those from medium-performing states and UTs. According to the former, limited incentives were offered by the governments in these states and UTs for off-grid SPV/SWH systems. For improved prestige and image, the difference in the responses given by building owners and managers from the three categories of states and UTs was significant with F (2, 4.38), p = 0.021 at the 0.05 level of significance. There was a significant difference between medium- and low-performing states and UTs (p = 0.015), as revealed by post-hoc Tukey's HSD test. Building owners and managers from the medium-performing states and UTs gave it a higher rating than the low-performing states and UTs, as they felt that the installation of SPV/SWH systems created a green image of the organization in the eyes of its stakeholders, thus acting as an accelerator.

ANOVA further revealed that the difference in the mean scores for power cuts was significant at F (2, 8.98), p = 0.001 at the 0.05 level of significance. Regarding power cuts as an accelerator, significant differences were observed among the responses of building owners and managers among all three categories of states and UTs for the SPV category, as revealed by post-hoc Tukey's HSD test. Since the high-performing states and UTs were by and large not having power shortages as compared to the other two categories of states and UTs, power cuts, as an accelerator, were given a lower rating by building owners and managers from high-performing states and UTs.

### 3.5.2 *Differences in the mean scores for accelerators for SPV systems*

Regarding the SWH category, the differences in the mean scores among the three categories of states and UTs on their ratings given to savings in electricity bills as an accelerator were found to be statistically different with F (2, 5.93), p = 0.006 at the 0.05 level of significance. Post-hoc comparisons using Tukey's HSD test indicated that the mean score for savings in electricity bills as an accelerator was significantly different between the building owners and managers from high- and medium-performing states and UTs at p = 0.008 under the SWH category. This was because, similar to SPV installations, savings in electricity bills were rated higher as an accelerator by building owners and managers from medium-performing states and UTs than those from high-performing states and UTs. According to building owners and managers from medium-performing states and UTs, since government incentives in these states and UTs were very few, the major accelerator for organizations to install SWH systems was savings in electricity bills.

ANOVA further showed that the difference in the mean scores for power cuts was significant at F (2, 3.72), p = 0.035 at the 0.05 level of significance. Between medium- and low-performing states and UTs, it was significantly different with p = 0.036 for the SWH category, as revealed by post-hoc Tukey's HSD test. This was rated higher by the building owners and managers from low-performing states and UTs than those from medium-performing states and UTs because

of the issue of power deficits in low-performing states and UTs.

### 3.6 *Responses of building owners and managers regarding barriers faced by them*

This section sheds light on the barriers faced by building owners and managers in availing of the incentives. Out of various incentives available to the commercial sector for SPV/SWH systems, three were the most common incentives for which building owners and managers had applied. VAT exemption was one incentive for which they were not required to apply, which is why it is not on the list. All of the building owners and managers reported that they had applied for MNRE capital subsidy for the installation of SPV/SWH in their buildings, while only about 10% reported to have applied for the state and UT capital subsidy, which was only available in the state of Haryana. Since the initial cost of installing SPV/SWH systems was high, companies looked forward to capital subsidies from the government, either central or state, and UT or both. All the building owners and managers also reported that they could avail of this benefit. Another common incentive applied for and availed of, as reported by about 71% of the building owners and managers, was the accelerated depreciation benefit. This was a comparatively simpler incentive to avail of, as only a copy of the invoice had to be attached to the income tax return form by the chartered accountant. 25% of the building owners and managers had also applied for soft loans to install the SPV/SWH systems in their buildings. However, none of them could avail of this incentive, the reason being that the banks refused to pass loans for SPV/SWH systems because of collateral issues.

Regarding the capital subsidy, most of the building owners and managers reported that it required a number of documents with technical details, thus acting as a barrier to availing of the incentive. Documents like the customer agreement form, undertaking, declaration, capital subsidy reimbursement form, affidavit, and photographs were required to be submitted, as discussed earlier in this chapter. Moreover, the application form required a number of technical details of the site and the SPV/SWH systems, which were difficult for the building owners and managers to provide on their own.

Further, applying for government incentives needed the help of channel partners, as building owners and managers had limited knowledge about the entire process of preparing the application. The building owners and managers reported that in the absence of channel partners, if a company decided to install SPV/SWH systems in its building, there was limited information regarding where to go, whom to approach, the cost of the SPV/SWH systems, the incentives one could avail of for the same, and the amount and source of various incentives.

Another barrier was that the process of installing the SPV/SWH systems and getting the incentives was time-consuming. The entire process, starting from acquiring information until the receipt of incentives, requires somewhere around nine to 12 months. Further, there was inconsistency in government initiatives, which often changed without any notification. Some of the building owners and managers shared the recent withdrawal of the capital subsidy scheme for SPV/SWH installations for commercial buildings. Building owners and managers felt that the government did not necessarily need to provide capital subsidies, but whatever incentives were being provided should be long-term.

When asked about soft loans, the most important barrier was reported to be the issue of collateral when getting loans. According to them, the banks did not consider the SPV/SWH systems as collateral against the loan. Banks said that the SPV/SWH systems were of no value in cases of non-payment of loans and thus could not be considered collateral. Thus, the building owners and managers felt that this incentive was practically non-functional and that it was only on paper. Further, whenever it was available or disbursed, like any other loan, it took its due course in terms of time and procedure, thus acting as a barrier. No special advantage or privilege was given to loans for SPV/SWH systems. No barriers were reported in availing accelerated depreciation benefit and VAT exemption. Further, none of the building owners and managers reported applying for an interest subsidy, and therefore, its associated barriers could not be reported.

**Table 6.** Mean scores given by building owners and managers regarding accelerators behind the installation of SPV/SWH systems

| Ratings given by building owners and managers for accelerators behind the installation of SPV/SWH systems | Categories of selected states and UTs | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | High (Gujarat, Rajasthan) (N = 24) | | | | Medium (Punjab, Haryana) (N = 24) | | | | Low (Delhi, Chandigarh) (N = 24) | | | | Total (N = 72) | | p value for ANOVA | |
| | SPV (12) | | SWH (12) | | SPV (12) | | SWH (12) | | SPV (12) | | SWH (12) | | | | | |
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD | SPV | SWH |
| Environmental concern and CSR | 3.83 | 1.12 | 4.50 | 0.67 | 3.92 | 0.79 | 2.92 | 1.17 | 3.42 | 1.08 | 3.67 | 0.99 | 3.71 | 1.07 | 0.150 | 0.053 |
| Savings in electricity bills and the high costs of conventional power | 3.42 | 1.31 | 2.50 | 1.17 | 2.75 | 1.29 | 3.17 | 0.58 | 4.75 | 0.45 | 3.92 | 0.67 | 3.42 | 1.21 | 0.000* | 0.006* |
| Government incentives | 2.67 | 0.99 | 2.67 | 1.16 | 3.42 | 1.17 | 2.33 | 0.78 | 2.42 | 0.90 | 2.75 | 0.97 | 2.71 | 1.03 | 0.033* | 0.706 |
| Improved prestige and image | 2.33 | 0.88 | 2.17 | 0.84 | 2.83 | 1.03 | 1.75 | 0.75 | 2.08 | 0.67 | 2.33 | 0.78 | 2.25 | 0.87 | 0.021* | 0.719 |
| Power cuts | 1.83 | 0.58 | 1.33 | 0.65 | 1.92 | 0.52 | 1.50 | 0.52 | 2.58 | 0.79 | 2.08 | 0.90 | 1.88 | 0.77 | 0.001* | 0.035* |
| Better rental value | 1.50 | 0.91 | 1.33 | 0.49 | 1.83 | 0.84 | 1.67 | 0.78 | 2.17 | 0.58 | 1.67 | 0.88 | 1.69 | 0.78 | 0.100 | 0.273 |

Note: 1 = least important; 5 = very important; and * = significant at the $p < 0.05$ level

| Major accelerators | Medium accelerators | Minor accelerators |
|---|---|---|
| • Environmental concern and CSR | • Savings in electricity bills and high costs of conventional power<br>• Government incentives<br>• Improved prestige and image | • Power cuts<br>• Better rental value |

Note: CSR = corporate social responsibility; if the mean rating is < 2.0 = minor accelerators, 2 to 3.5 = medium accelerators, and > 3.5 = major accelerators

## 3.7 *Opinion of building owners and managers on the need for channel partners*

When asked whether there was a need for channel partners, all the building owners and managers responded in the affirmative. The most common reason cited was that owners and managers of commercial establishments did not have the required expertise and time to provide the technical details, do the paper work, and provide the necessary documentation for project submission to avail themselves of government incentives. This was reported by about 55% of the building owners and managers (Table 7). Further, more than 47% of the building owners and managers opined that the information regarding the government initiatives did not reach the building owners and managers without channel partners. In most cases, the building owners and managers were contacted by the channel partners themselves.

Another important reason cited by about 43% of the building owners and managers was that the channel partners made the process simpler and faster, owing to their expertise and awareness regarding technical formalities associated with the process of project submission. According to the building owners and managers, the channel partners did all the work, and without them, customers would not be able to take advantage of the government incentives. It is important to note that all the buildings selected for the study had gone through channel partners, thus indicating the need for them for the smooth functioning of the process.

**Table 7.** Reasons cited by building owners and managers for the need for channel partners

| Reasons cited by building owners and managers for the need for channel partners | SPV | SWH | Total (N = 72) | |
|---|---|---|---|---|
| | N (36) | N (36) | N* | % |
| Companies do not have expertise and technical knowledge regarding SPV/SWH systems | 24 | 15 | 39 | 54.17 |
| Without channel partners, the reach of information regarding government initiatives and SPV/SWH to commercial users is limited | 18 | 16 | 34 | 47.22 |
| Channel partners make the process of project submission to the government simpler and faster | 16 | 15 | 31 | 43.06 |

Note: * = the total sample is exceeding N because of the multiple responses given by the respondents

## 3.8 *Suggestions given by building owners and managers to overcome barriers*

It was suggested that awareness-generation campaigns by the government should be taken up on a large scale, targeting various sections of society and using the right mix of media. Building owners and managers also suggested that all the government websites should be updated at regular intervals, providing the latest information to the building owners and managers. Further, there should be a state- and UT-wise list of channel partners. It was also suggested that a fine be levied on channel partners for overshooting the deadlines. Other suggestions were easy and relaxed documentary requirements for incentives like capital subsidy and soft loans, an online mechanism for the submission of capital subsidy applications, and easy loan facilities for SPV/SWH systems. The details of the suggestions for the barriers reported by the government officials are presented in Table 8.

Table 8 has shed light on the suggestions given by the building owners and managers to overcome the specific barriers faced by them while installing off-grid solar systems and availing of government incentives. Table 9 presents the additional suggestions given by the building owners and managers for boosting solar installations. The building owners and managers reported that the government policies and programs for SPV and SWH systems were withdrawn without any notification. Thus, long-term policies and programs needed to be made, and if any amendments were made, they should be immediately updated on the MNRE website. They also felt that incentives like interest subsidies should be made operational and soft loans should be made easier to avail of.

Further, it was suggested that the capital subsidy scheme for commercial establishments should not be withdrawn. Moreover, higher capital subsidies should be provided to buildings with bigger SPV/SWH installations. Another suggestion given was that commercial buildings with SPV/SWH systems should get a subsidy on their electricity bills in terms of withdrawing the cross-subsidy surcharge. Building owners and managers opined that the policies should be clear in terms of the target beneficiaries and the benefits for each of them. Furthermore, because various levels of

government were frequently involved, thorough policy coordination was required, with a clear articulation of national-, state-, and UT-level policies.

**Table 8.** Suggestions to overcome barriers faced by building owners and managers

| Barriers faced | Suggestions |
|---|---|
| Unclear and technical content | • Awareness generation campaigns by the government should be taken up on a large scale, targeting various sections of society<br>• The government should effectively make use of the right mix of media. Most of the building owners and managers stressed on using social media, apart from having websites<br>• Websites like Facebook, LinkedIn, and Twitter should be used for effective dissemination of information. Facebook pages or pop-up ads on these sites provide relevant information<br>• Websites should be user-friendly<br>• Mobile-based applications should be developed for better reach of information |
| Government websites are not being updated regularly | • All the government websites (both MNRE and state nodal agencies) should be updated at regular intervals, providing the latest information to the building owners and managers |
| Limited and unreliable channel partners are available for SPV/SWH | • State- and UT-wise list of channel partners for easy availability of solar systems<br>• Incentives for start-ups in the field of SPV/SWH<br>• Channel partners to be checked by the government in terms of their timely operation |
| Requirement of intensive documentation along with technical details | • Documentary requirements for incentives like capital subsidies and soft loans should be relaxed<br>• A single window system should be there for all the incentives |
| Poor online mechanism for submission of online applications for SPV/SWH | • Online mechanism for submission of capital subsidy application should be improved<br>• Such mechanisms to be free from technical glitches<br>• Software to be regularly updated |
| Rejection of soft loans by banks | • Availability of easy loan facilities<br>• SPV/SWH to be considered under priority sector |
| Delayed verification and feedback from SNA | • SNA should be swift in processing the applications and sending them to MNRE<br>• Further, MNRE should revert to SNA within a stipulated time frame regarding the status of the applications, so that SNA could further communicate it to the building owners and managers |
| Delayed installation and commissioning by channel partners | • Stringent rules for channel partners to meet timelines<br>• Fine on channel partners overshooting deadlines |

**Table 9.** Additional suggestions given by building owners and managers to increase the solar installation base in the commercial sector

| Barriers faced | Suggestions |
|---|---|
| Inconsistent policies, programs, and incentives are withdrawn without any notification | • Long-term policies and programs should be framed for SPV and SWH<br>• If any policy or program is withdrawn, it should be updated on the website to spread the information<br>• MNRE, state, and UT government policies, programs, and incentives for SPV/SWH should aim at long-term benefits to the beneficiaries<br>• Incentives like interest subsidies should be made operational<br>• Soft loans should be made easier to avail of<br>• Capital subsidy should not be withdrawn<br>• Incentives like capital subsidy: a higher amount should be given to SPV/SWH systems with higher capacities<br>• Higher accelerated depreciation should be given to such systems<br>• Reduction in electricity bills of buildings having SPV/SWH systems<br>• Exemption from cross-subsidy surcharge for buildings having high-capacity SPV/SWH systems |
| Lack of clarity in policies and programs | • Clarity in policies has to be there in terms of target beneficiaries and focused incentives for each of them<br>• As various levels of government were frequently involved, thorough policy coordination was required, with a clear articulation of national-, state-, and UT-level policies. |

# 4. Conclusion and recommendations

India, on its road to development, needs to significantly increase its capacity to keep up with the demands of its

quickly expanding economy. For its energy needs, it has been reliant on fossil resources, including coal, oil, and gas. There are various issues with our nation's increasing reliance on imported fuels. Due to rising demand, the world's fossil fuel supplies are under increasing pressure as they are depleting quickly. The only sustainable way to solve this issue is through the use of renewable energy. Owing to its geographical location, India has huge solar potential.

Grid-connected and off-grid solar energy usage are two viable options. The ability of an off-gird and decentralized solar system to be used in a decentralized manner is an interesting feature, in addition to its environmental credentials and inexhaustible supply. Therefore, solar thermal and SPV off-grid, and decentralized technological alternatives can efficiently be used to convert solar radiation into heat and power, giving enormous scalability for solar in India. MNRE is the nodal ministry of the Government of India at the central level for all matters relating to new and renewable energy.

The study has brought forth the awareness level, accelerators, and barriers faced by building owners and managers in the process of availing of government initiatives for SPV/SWH installations. Since the stakeholders involved in the process are currently facing a number of barriers that have been discussed earlier, the suggestions given in the study are crucial to help the government come up with better solutions to increase the installation base of off-grid SPV/SWH installations in the commercial sector.

The current study has thus identified the bottlenecks faced by building owners and managers in availing of government incentives. It is recommended that the procedure for obtaining government subsidies be clearly outlined in the policy for building owners and managers. A detailed timeline that must be followed at every stage should be included in the policy. Depending on the size of SPV/SWH systems, different government incentives should be offered, with higher incentives being offered to larger systems. Some of the suggestions given by building owners and managers included easy and relaxed documentary requirements for incentives like capital subsidies and soft loans, an online mechanism for the submission of capital subsidy applications, and easy loan facilities for SPV/SWH systems. It was further suggested that awareness-generation campaigns by the government should be taken up on a large scale, targeting various sections of society and using the right mix of media. Building owners and managers also suggested that all the government websites (both MNRE and state nodal agencies) should be updated at regular intervals, providing the latest information to the building owners and managers. Further, there should be a state- and UT-wise list of channel partners. It was also suggested that fines and penalties should be levied on channel partners for not meeting deadlines.

The findings of this study also relate to and validate earlier existing data in this area. In one such study entitled "Barriers to renewable and sustainable energy technologies adoption: Indian perspective", Luthra et al. [21] stressed the increasing energy demand and growing environmental concern in India. According to them, renewable energy technologies have faced a number of barriers that have affected their rate of adoption. They identified 28 barriers and ranked the major barriers in the Indian context through an extensive literature review. They have categorized the barriers into seven categories: economic and financial, market, awareness and information, technical, ecological and geographical, cultural and behavioral, and political and government. Another study by Painuly [22] enumerated several barriers hindering the growth of solar energy, including technical barriers, market barriers such as inconsistent pricing structures, institutional, political and regulatory barriers, and social and environmental barriers. He opined that some barriers may be specific to a technology, while others may be specific to a country or a region. Most of these barriers have also been brought forth by the current study.

The government should also facilitate demand creation through awareness-generation campaigns. Once the building owners and managers are aware of the SPV/SWH systems, their benefits, and the supporting government initiatives, they will be willing to pay the extra cost for their installation. It is critical to use the appropriate media mix. Social media should be used to its greatest potential. The awareness efforts should cover both broad topics, such as the advantages of solar energy, and particular technical information, such as off-grid SPV/SWH systems and government support for them. It is important to develop and administer training courses based on stakeholders' needs, including those of the commercial, residential, agricultural, and industrial sectors.

Solar energy is a key component of India's energy strategy, with the country setting a huge goal of deploying 280 GW of solar power by 2030. The Indian government has developed a variety of programs to increase off-grid installations in the country. This study has identified several obstacles that stakeholders face while trying to receive government incentives. To have a more conducive policy environment and an encouraging atmosphere for SPV/SWH installations to develop in India, these obstacles must be removed. The government must work on removing the obstacles by implementing the offered suggestions in order to provide building owners and managers with a supportive

policy environment that is simple to comprehend and apply.

## Conflict of interest

There is no conflict of interest in this study.

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