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FACTORS AFFECTING THE DEMAND OF SOLAR PANELS IN DEHRADUN

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1. Introduction

1.1 Current Scenario of Solar Panel Usage in Dehradun

Extensive research is currently underway to uncover methods for harnessing clean and renewable energy sources. This is now required to overcome the difficulties brought on by the quick depletion of fossil resources and the rising need for energy sources. Presently, the rapid exploitation of conventional fossil fuel, global warming due to the thermal power plant, and high-energy demand substantiate the adoption of green and renewable sources of energy. People living in Dehradun are becoming more aware of their surroundings and how their daily actions might affect them. Solutions such as solar energy help minimize adverse effects on the environment[i]. The rising trend of sustainable living is expected to play a major role in the increased adoption of solar technology in the future. Government policies and regulations are the most prominent factors influencing the demand for solar energy. The Indian government has initiated several programs focused on renewable energy usage in general, and solar energy in particular.

1.2 Rationale

Solar energy is one of these promising alternative energy sources since it is abundant, safe, clean, and renewable. Solar photovoltaic (SPV) installations are growing rapidly in India, due to their demand for economic, technical, and environmental benefits[ii]. The most promising source of sustainable power generation to meet the energy demand today is photovoltaics (PVs), which can be put in solar trees. These measures minimize the upfront costs for the consumer and make access to solar technology easier.

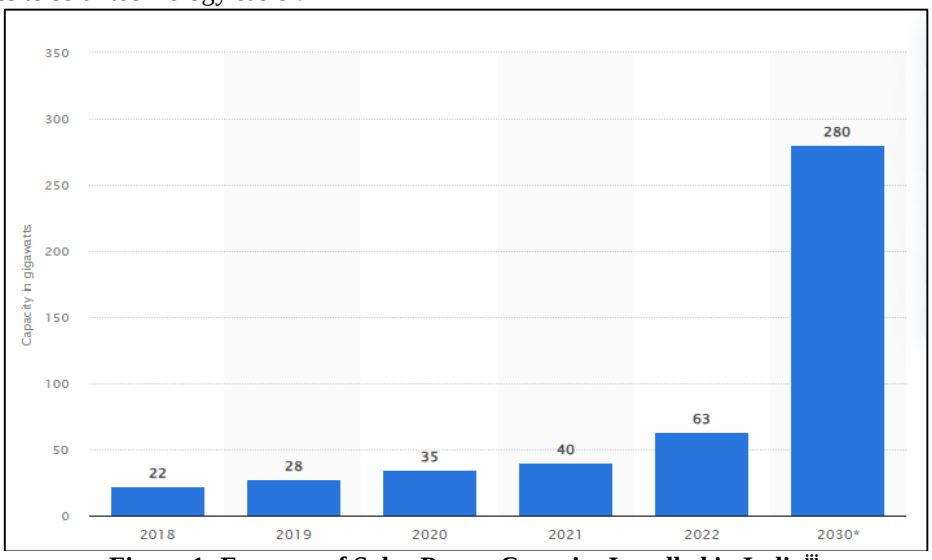

Figure 1: Forecast of Solar Power Capacity Installed in India[iii]

It can be seen from the above graphical representation that the solar power capacity installed in India has almost doubled from the year 2018 to 2021. The solar capacity installation has reached 63 gigawatts in the year 2022. It is

assumed that it will reach up to 280 gigawatts by 2030. The rationale of this thesis is to identify and analyse the key factors influencing the adoption and demand for solar panels in Dehradun, considering environmental, economic and social drivers. It aims to promote insights for promoting sustainable energy solutions in the region.

1.3 Economic Relevance

The government's drive towards renewable energy promotes an enabling environment for the proliferation of solar energy, mainly in Dehradun, due to increasing urbanization. Financial incentives play a big role in the decision of consumers to adopt solar panels. Subsidies both by the central and state governments form a vital aspect of making solar installations in Dehradun more economical for both households and businesses. Banks and financial institutions are also providing loans with excellent terms, particularly for the installation of solar panels. The availability of finance thereby eliminates one of the principal barriers facing many potential users. This financial support encourages the growth of the number of solar installations in the region[iv]. The demand for solar panels in Dehradun depends on a host of interacting factors.

2. Methodology

The chronological steps to the process undertaken for the research are revered as the methodology which serves to create a map for the overall research process. There are four types of research philosophies available usually- positivism, realism, pragmatism and interpretivism. However, in this research on solar panel usage in Dehradun, the positivism philosophy has been applied for a better understanding of data. The positivist philosophy lets the researcher stay within the boundaries of observation and make a conclusive argument. On the other hand, the research approach helps to understand the concrete ways of structuring the data collection methods. Two types of research approaches are generally applicable- inductive and deductive. Deductive reasoning helps to understand the similarities between the variables in research. Hereby, there are plausible applicability of the research variables throughout the research to understand the similarities and implications of the variables. Furthermore, the use of a descriptive research strategy has helped to develop the research with proper integrity as there have been qualitative and quantitative variables for this research. Thus, the descriptive research strategy has been most applicable to this research study.

There are generally two types of research data collection techniques available- secondary and primary. Primary data is collected from live human participants, in the form of a survey or interview. On the contrary, secondary data is collected through published books, journals, and electronic websites. However, this research has integrated the use of a ***Mixed Method*** that consists of both ***Secondary Qualitative*** and ***Primary Quantitative Data***. Primary data collection through a survey, using close-ended questions helps to understand the participants' views of the research topic. Thus, the survey method has been employed to deliver the integrity of this research. On the other hand, using Google Scholar, information from peer-reviewed articles has been generated to understand the available studies on the research topic. Furthermore, the primary quantitative data collection has been conducted through the help of a Google Form. The Google form has helped to conduct a graphical analysis using pie charts to demonstrate the views of the survey participants. On the other hand, thematic analysis has been conducted to analyse the secondary data from peer-reviewed and electronic sources. Therefore, the integration of both primary quantitative and qualitative data has enriched this research with accurate research findings.

A sample size of 51 participants including people using solar panels, people looking to use solar panels and individuals aware of solar panels have been taken for this research. Potential users such as individuals, households considering installing solar panels shortly, households and businesses that already use solar panels and individuals who are aware of solar panels but have not considered their use are included within the sample size of this research. As this research has used primary and secondary data collection methods, the granting of consent has been necessary. All the questions in the survey have been conducted based on the confidentiality of the participants. The participant's data was stored in a secure device with an encrypted feature to ensure confidentiality. Participants in the survey were fully notified about the survey process before the data collection. Furthermore, the questions in the survey do not harm an individual's right to consent or religious and personal beliefs.

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3. Results

3.1 Primary Analysis Results

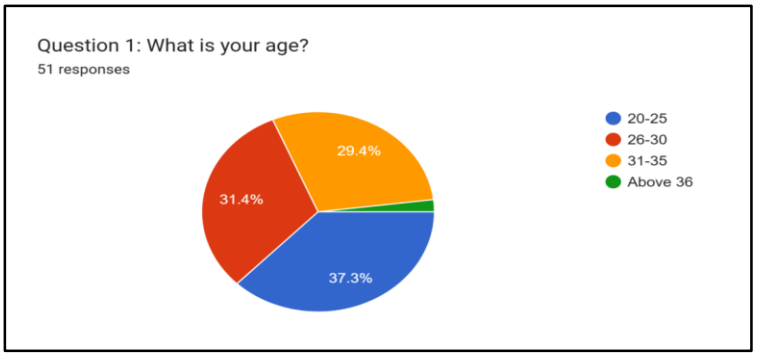

Figure 2: Age of the Participants
(Source: Google Form)

The above graph shows that the majority of the survey respondents belong to the age group of 20-25 years old. Aside from this age group, 31.4% of the participants also belong to the age group of 26-30 years old. A slight minority of the participants are aged above 36.

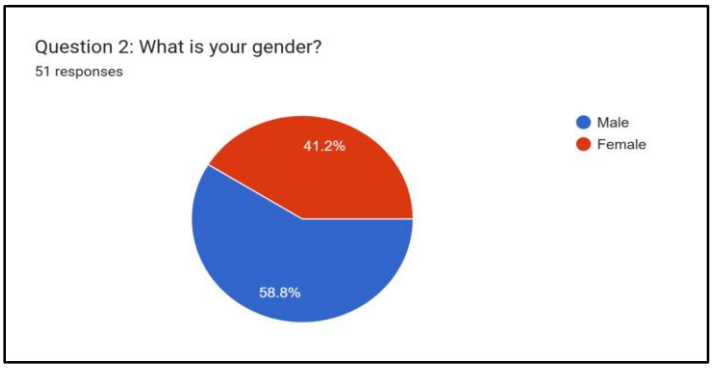

Figure 3: Gender of the Participants
(Source: Google Form)

The majority of the survey participants are male in terms of their gender. However, a solid 41.2% of the respondents are female. This shows that the survey has been conducted through only male and female participants.

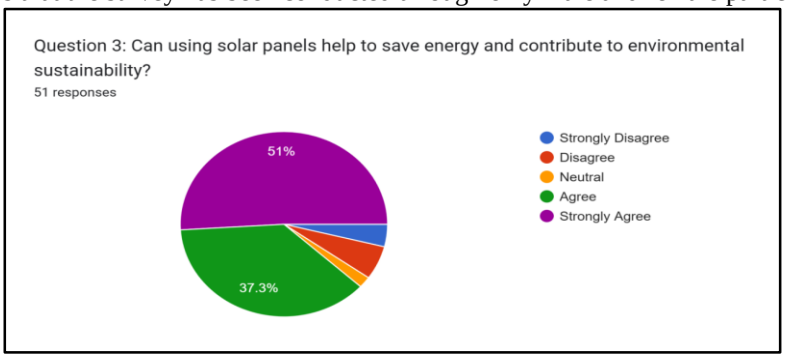

Figure 4: Solar Panels in Enhancing Environmental Sustainability
(Source: Google Form)

As can be seen in the above pie chart, 51% of respondents strongly agree can using solar panels can contribute to environmental sustainability. Moreover, 37.3% of the people agree with the fact as well.

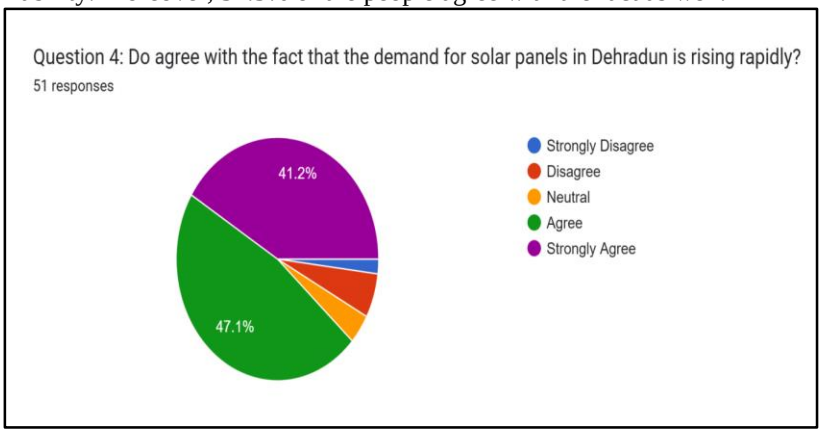

Figure 5: Increasing Demand of Solar Panels
(Source: Google Form)

The above graph shows that 47.1% of the majority agree with the fact that demand for solar panels is rising in Dehradun at present.

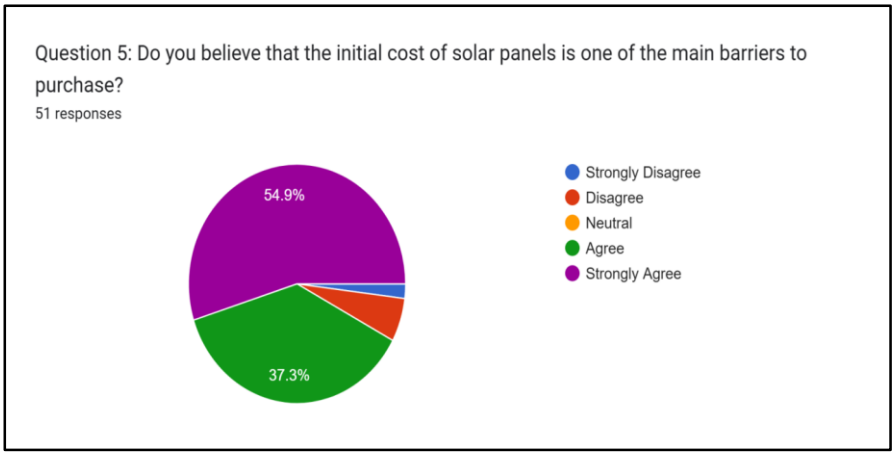

Figure 6: Implementation Cost as a Main Barrier
(Source: Google Form)

Among the main barriers to using solar panels, the initial cost has been determined to be the reason for people's hesitancy in adopting solar panels. As good as 54.9% of participants strongly believe that initial cost stands as the main barrier to purchase.

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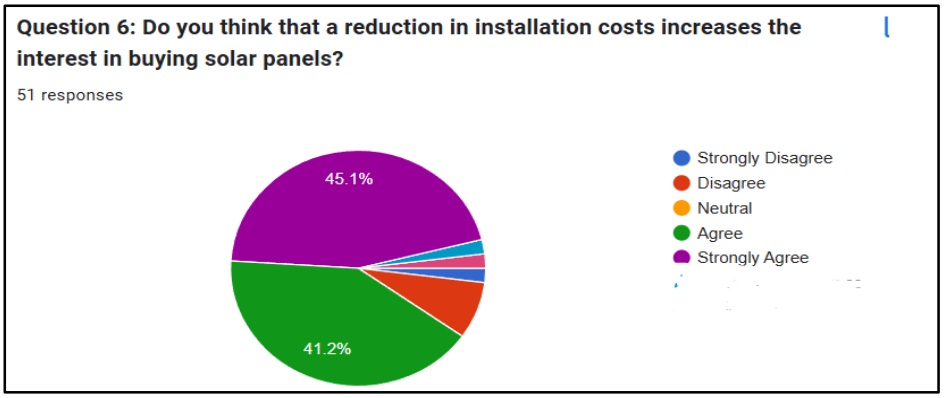

Figure 7: Less Implementation Cost Increases Buying Interest
(Source: Derived from Google Form)

Reducing installation costs can increase people's purchasing of solar panels in the future. 41.2%- 45.1% of respondents tend to believe this.

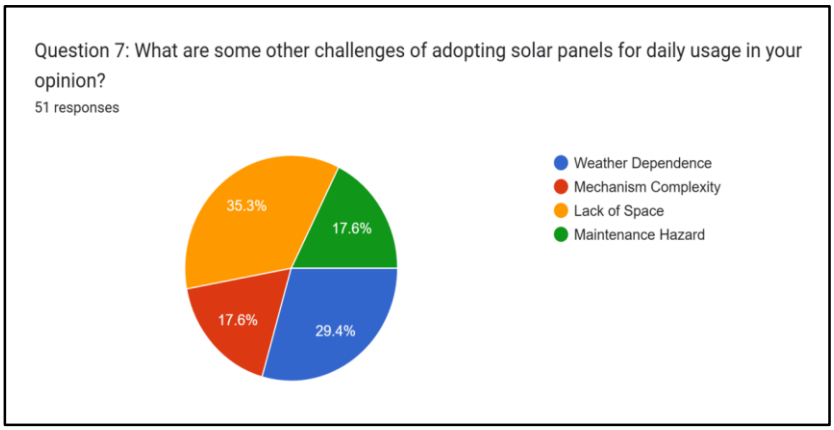

Figure 8: Challenges in Adopting Solar Panels
(Source: Google Form)

Among the four challenges of solar panel usage, lack of space has come up as the main challenge for using solar panels in the home. 29.4% of respondents also believe that the usage of solar panels depends on the weather conditions to a greater extent.

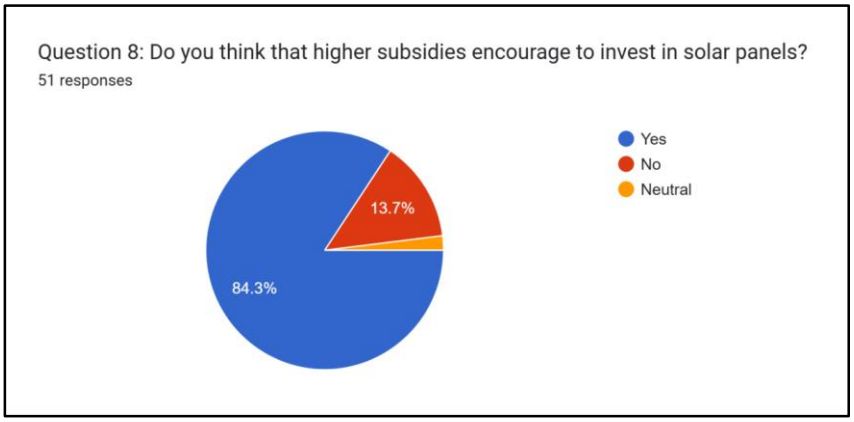

Figure 9: Higher Subsidies Encourage to Invest in Solar Panels

(Source: Google Form)

84.3% of respondents have agreed that higher subsidies can encourage people to invest more in solar panels.

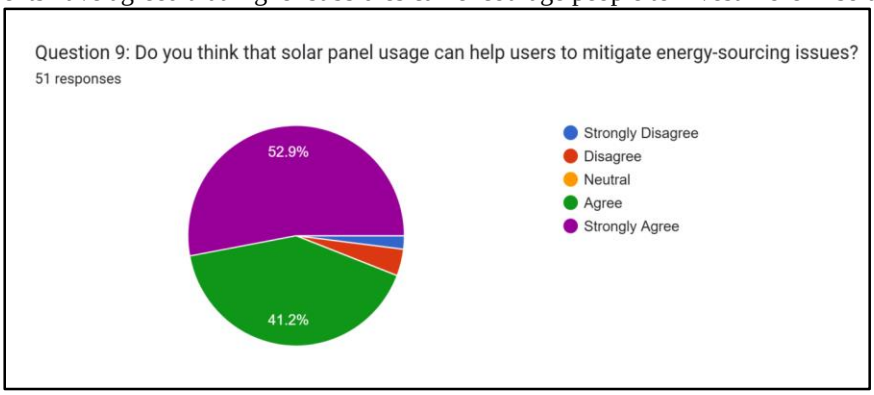

Figure 10: Solar Panel Mitigates Energy-Sourcing Issues

(Source: Google Form)

Energy-sourcing issues can be mitigated through the usage of solar panels. As shown in the image, 52.9% of respondents strongly agree with the fact that energy-resourcing issues can be mitigated by using solar panels in households. 41.2% of people also agree with this fact.

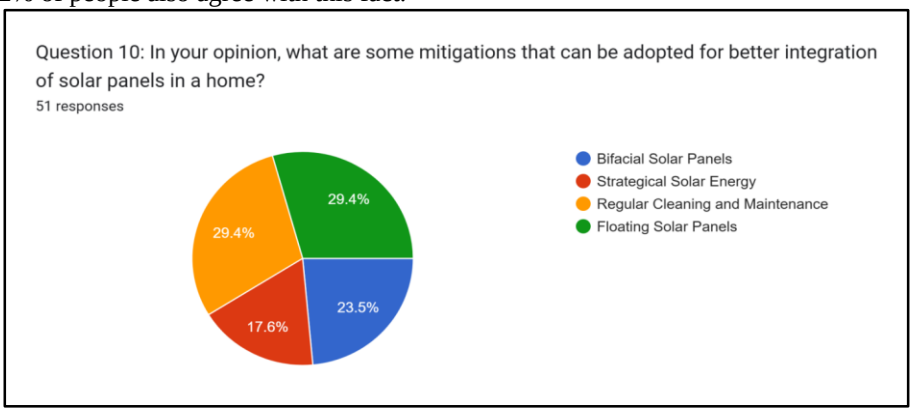

Figure 11: Mitigation for Better Integration of Solar Panels

(Source: Google Form)

Installation of floating solar panels and regular maintenance of solar panels can be a few mitigations that help in the integration of social panels. 23.5% of respondents also believe that bifacial sonal panel installation can help in the early adoption of the technology.

3.2 Secondary Analysis: Economic Framework

3.2.1 Price Elasticity of Demand for Solar Panels

The price of solar panels has played a very key role in demand. For many years now, there have been many improvements in the field of solar technology that have reduced the cost of the modules. The "International Renewable Energy Agency" has indicated that since 2010, solar PV system prices have declined by about 82%. In Dehradun, this would bring about accessibility to its residents and enterprises as well[v]. As the initial investment for solar installation decreases, more consumers will be interested in using it as a source of renewable energy, thus boosting the demand[vi]. The availability of funding options increases the demand. Many people in Dehradun might not have money to spend on solar equipment immediately. However, funding models, such as loans and leasing models, have appeared. These

alternatives enable consumers to acquire solar installations with little or no money down, rather than paying for them over time based on energy savings. Such models make solar panels accessible to a larger portion of the population.

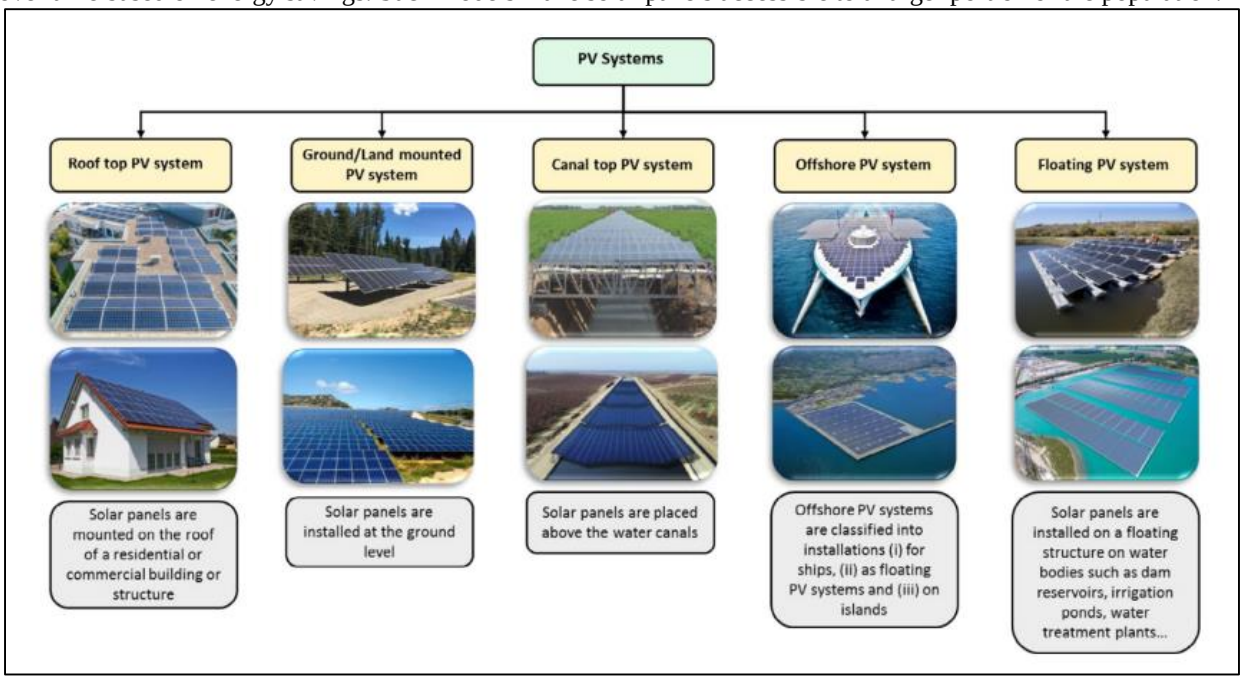

Figure 12: Different Types of Solar PV Installation[vii]

3.2.2 Solar Panels as A Merit Good

The growing concerns for clean and safe alternative sources of energy have created much awareness among people as well as business enterprises to find an alternative in terms of solar energy. For example, this will be due to diverse NGOs and awareness campaigns explaining the need to minimize the carbon footprint, thus increasing the demand for solar panels. Societal benefits of the wider application of solar energy range from energy independence to employment in installation and maintenance sectors, besides reducing pollution and health risks[viii]. Residents are forced to look for other options as the cost of traditional electricity sources rises and their bills rise as well. Solar energy is a viable option for consumers who wish to keep expenditures under control because of the savings and reduction in installation costs. Furthermore, Dehradun's solar panel requirements are influenced by several economic factors, including government subsidies, growing public awareness of the issue, technological advancements, and so on. To address these climate-related challenges in the future, significantly more attention should be paid to renewable energy sectors. The demand for solar panels in Dehradun increases with heightened environmental awareness and supportive government policies as the recognition of solar energy being a merit good increases the demand.

3.2.3 Policy and Government Support

Under net metering, extra electricity produced is fed into the grid, and in return, they get extra credit from the distributor. Here, in the state of Uttarakhand, at Dehradun, regulations regarding net metering exist, so this energy source can be efficiently utilized; therefore, this demand also increases[ix]. It not only helps to save money in the pocket of the customers but also brings independence about energy use and ensures that it is renewable, which directly encourages homeowners in Dehradun to invest in solar energy. Seminars and workshops hosted by NGOs and the government contributed to the long-term perception of electricity conservation. This approach appeals to Dehradun's environmentally sensitive populace by demythologizing solar energy and emphasizing the significance of lowering carbon emissions. One of the most important non-monetary elements affecting demand is the simplification of the

solar panel installation process. Nonetheless, the state government has implemented simplified protocols that reduce the difficulty of the installation process. Potential clients can more easily acquire all the assistance they require by cutting down on paperwork and enhancing service delivery through dedicated helplines for solar energy.

(a) Financial Incentives

Government subsidies are very important in promoting the usage of solar energy. The Indian government launched several schemes that encourage and promote the usage of renewable energies in recent years. Such as the direct subsidy in grid-connected solar systems and MNRE under the purview of the Ministry of New and Renewable Energy. Such direct subsidies can amount to a fair percentage of installation costs[x]. It makes solar panels accessible for more residents of Dehradun[xi]. Such financial support reduces the initial investment that often acts as a barrier to embracing solar technology. The income tax benefits for installing renewable energy projects are being provided by most states in the country, and Uttarakhand is not an exception[xii]. Thus, such rebates can work out to decrease the cost of investment altogether, and thus more people consider it as an alternative option.

To be concise, the subsidy schemes with tax rebates, available financial aids, and all related advantages have greatly impacted the demand for solar panels in Dehradun[xiii]. The demand for solar panels keeps rising as a result of this grassroots level of understanding.

Nonetheless, Dehradun's climate makes solar technology even more feasible there. The performance and effectiveness of solar panels in generating a significant amount of energy over their lifetimes are favoured and supported by such advantageous placements. The pace with which the government keeps backing up renewable energy sources, giving monetary aid, and increasing consciousness from people about environmental problems may encourage growth towards solar energy utilization more quickly, helping the economy and the environment together.

(b) Non-Financial Support

Information, education, and awareness are key factors in promoting this technology. Local government actions had focused on educating citizens through direct contact on the benefits the use of solar panels poses in terms of both economic savings and environmental benefits. There were NGO and government-organized seminars or workshops that helped create a feeling of saving electricity through use over the long term[xiv]. This method not only demystifies solar energy but also brings to the fore the importance of reducing carbon footprint, thus appealing to this environmentally-conscious population of Dehradun[xv]. Simplification of the process of installing solar panels has become one of the most significant non-monetary factors that are influencing demand. However, the state government has started streamlined procedures which make the installation process less cumbersome. By reducing paperwork and improving service delivery through designated helplines for solar energy, prospective customers can get all the necessary help more easily. This regulatory support not only guarantees returns to citizens but also means that in the long term, more and more people will be committed to renewable energy sources. This would be further supported by policies that ensure the local manufacturing of solar panels, thereby ensuring that the products are affordable and reliable.

3.2.4 Social and Economic Factors

The initial cost for solar installations is considerable. However, as more households face positive income growth, more can afford to invest in solar installation. The subsidies provided by government schemes add to the affordability of these installations for middle and low-income families. In recent years, the government and different types of nongovernmental organizations have strived to give ample attention to renewable energy awareness in the town of Dehradun[xvi]. Different educational campaigns help depict the long-run benefits of using solar energy while saving the environment simultaneously. Studies reveal that communities using their social media, community workshops, and presentations, these advocates have managed to educate many residents about the pros of solar energy and encourage demand. Subsidies and incentives provided by government policies have greatly impacted the solar panel market in Dehradun. Indian governments, as well as local administrations, have implemented several policies to increase the usage of solar energy. Solar Rooftop Scheme encourages more consumers to use solar technology in residences and commerce buildings, enhancing the point of contact of consumers with the technologies[xvii].

Technology factors are most promising: better efficiency, lower cost, and continued innovation are all important for a technology that may otherwise be prohibitively expensive for much of the population. People are searching for sustainable alternatives as a result of growing awareness of pollution, environmental degradation, and the depletion

of non-renewable resources[xviii]. Public knowledge of solar energy has grown as a result of community-based initiatives, such as awareness campaigns. Local leaders and green activists are examples of influential people and personalities who have played a significant role in promoting and advocating for solar energy[xix]. For instance, organizations that advocate for sustainability have teamed up with educational institutions to host workshops and raise community knowledge of the advantages of solar energy. The demand for solar panels keeps rising as a result of this grassroots level of understanding. Moreover, policies for climate at both national and international levels would likely shape the market dynamics. The demand for solar panels in Dehradun is interconnected with several socio-economic determinants including income, knowledge and literacy, governmental initiatives, and cultural outlook[xx].

3.2.5 Technological Advancements and Efficiency

Scientists and entrepreneurs such as Elon Musk, Tesla CEO, have sunk fortunes into research on solar power, most especially through introducing solar roof tiles that can integrate direct collection into solar-roofed residential buildings. One of the major causes of demand in Dehradun for solar panels includes the immense technological progress taken place in the solar field over the past ten years. This development is also important in ensuring that installing such devices makes it much easier compared to solar panels with obvious aesthetic attraction. Secondly, academic institutions in India have been involved in research into the optimization of solar technology so that it can appropriately respond to the energy demands of regions like Dehradun, which has more sunshine but cannot utilize the same effectively. Subsidies and net metering policies by the Indian government are aimed at increasing the use of renewable energy.

The subsidies give consumers some form of relief financially, while the net metering policy allows users to sell their excess energy back to the grid, hence motivating more people to install solar panels by enhancing the return on investment for homeowners and businesses. Technology advancement in with conjunction, government policies, and their incentives has equally been effective in creating a demand for solar panels in Dehradun. There is a high sunny day's tally during the year here, thereby generating maximum sun power. Increasing energy charges also push homeowners to look for other alternatives that cut costs on their energy resources. The future of solar energy will be very promising with continuing technological advancements. Future improvements in energy storage solutions, smart-grid technology, and enhancing mentorship to installers will continue optimizing solar energy systems[xxi]. Advancements in solar technology, key people, and changes in the mindset of people to shift towards solar solutions have further helped to increase the adoption rate. Government policies and climate conditions in the region support demand. Despite these, prospects for solar energy in Dehradun look quite bright.

3.2.6 Sustainability and Long-Term Feasibility

The economic scenario of solar energy plays a key role in the understanding of the demand of Dehradun. The cost of setting up solar panels is quite a challenge; however, the financial gain at later stages overrules this factor. The government has brought a series of incentives that help the renewable sources in the state, significantly increasing the installations in the state of Uttarakhand. These incentives reflect the commitment of the state toward developing the infrastructure of a sustainable energy infrastructure and contribute to this growth in demand. Public awareness and acceptance of the use of the product are major determinants that can influence the demand for solar panels in Dehradun. Growing awareness of environmental degradation, pollution, and depletion of non-renewable resources has compelled people to look for sustainable substitutes. Community-based activities, including awareness programs, have increased public awareness about solar energy. Influential persons and personalities, such as green activists and local leaders, have been important in the advocacy and promotion of solar energy. For example, groups pushing for sustainability have partnered with learning institutions to hold workshops and create more awareness of the benefits of solar energy in the community[xxii]. This grassroots level of awareness creates an ever-increasing demand for the solar panels.

However, the climatic conditions of Dehradun further add to its feasibility for solar technology. Such favourable locations Favor and support the performance and efficacy of solar panels in producing a good deal of energy during their lifetimes. Global emphasis on renewable sources of energy and a resolve to minimize carbon footprint is bound to place solar energy in an increasingly positive trajectory. The renewability of solar energy, the commitment to minimizing carbon footprint around the world, and future trends look promising.

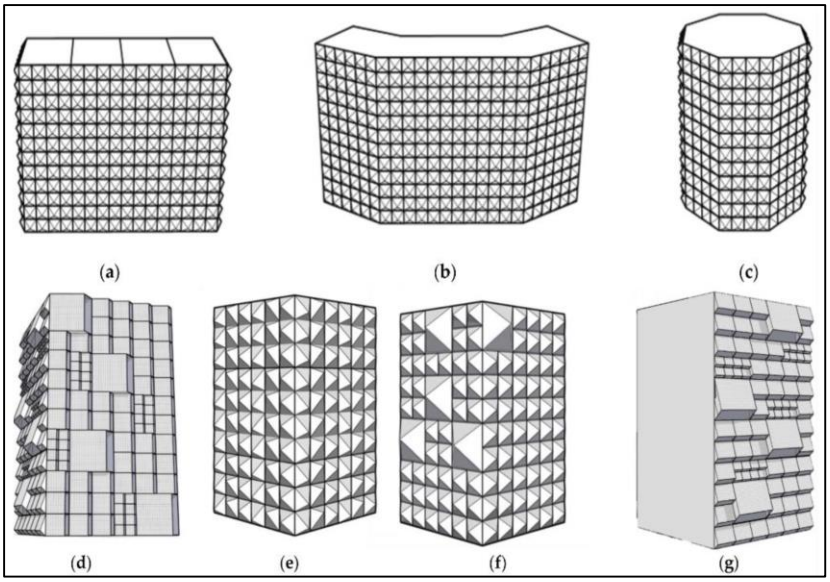

Figure 13: Increasing Solar Efficiency Through Architectural Planning: (a–c) Structural Placement, (d–g) Building Exteriors[xxiii]

Solar technology will only get better with time, making the efficiency of solar panels rise further shortly[xxiv]. With an upsurge in the need for solar energy, complemented by enhanced grid integration, developing energy storage solutions, and smart grid technological advancement, Dehradun can build a sustainable energy system that would be strong enough to hold.

4. Evaluation of Factors

Economic incentives account for most of the demand for solar panels. Financial mechanisms, including subsidies, tax rebates, and low-interest loans, bring down the initial costs of setting up solar panels. Solar energy becomes an investment with reduced costs for consumers because of the reduced price of solar panels, considering technological progress over the years and the increase in competition among the manufacturers that lowers the prices. The long-term savings from reductions in electricity bills and government incentives can be a significant boost for both residential and commercial users[xxv]. Therefore, there is economic attractiveness which often emerges as the main point of deliberation for would-be purchasers, thereby showcasing the interactions between economic considerations and buyer decision-making behaviour in energy markets. Such schemes like the Solar Rooftop Programme and National Solar Mission have subsidy provisions and easy approval procedures in place to encourage domestic, commercial, and industrial acceptance of solar panels[xxvi]. Similarly, the state government in Uttarakhand has also set policies that allow grid-connected solar systems, thereby increasing the local demand. The interconnection of government policy and the advancement of solar technology is very important since a benevolent regulatory framework has the outcome of reducing installation and operational costs, thereby making the solar solution more attractive to consumers in the market.

Organizations have made efforts to educate public opinion on the effects that fossil fuel usage has as well as the benefits gained from renewable energy sources. Influential groups, such as environmental campaigners and local business people committed to solar technologies, also played a significant role. The relationship between consumer environmental awareness and the adoption of solar energy shows how ecological concerns can directly affect market dynamics. Recent trends have shown that the community is increasingly taking up investments in renewable technologies, and government targets for increased production of solar energy look all the more supportive. The development in technology and regulation would most probably further support this trend. There is an ongoing effort for education and public policy to ensure this momentum leads to greater adoption of solar energy solutions for Dehradun and the rest.

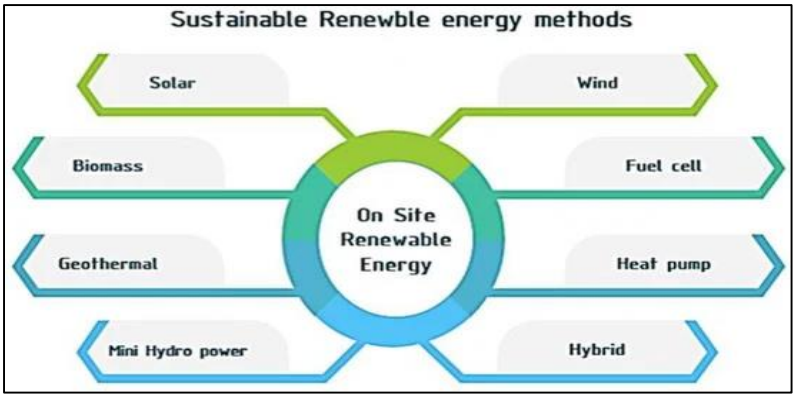

Figure 14: Numerous Options for Integrating Renewable Energy Into Structures
(Source: Reddy *et al.* 2024)

The path that has been laid forward in this region is more toward sustainability through renewable energy resources.

5. Conclusion

The cost-effectiveness and efficiency of solar panels have been enhanced with continuous innovation. Affordability of cheaper solar solutions, it becomes possible for residents and firms in Dehradun to adopt solar energy systems into their power generation portfolios. Even better technology in storing batteries enhances the management of energy, making it appealing to use solar panels. This situation of the economy of Dehradun is one of the prime concerns in this matter. Increasing cost for traditional electricity sources also increases their tariffs, hence it leaves the residents in search of some other option. The saving and decrease in installation costs makes solar energy a feasible choice for consumers wanting to control expenses. Moreover, through incentives provided by the government, increasing public awareness of this area, progressions in technology, and so forth, the solar panel needs come under many economic considerations as a conclusion in Dehradun. Times ahead for solving such climate issues, one looks to attract even greater anoint towards renewable energy areas also. Positive policies, improved public education, development of technology, and consideration of economic factors will help maximize the utilization of solar panels in Dehradun to create a bright energy future.

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