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Non-Conventional Energy Management With Special Reference To Solar Energy

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Abstract
The study intends to analyse the non-conventional resources of energy with explicitly focusing on the Indian scenario. Moreover, to determine the measures of implementing fast and sustainable growth of non-renewable resources exclusively emphasising solar power in India. The study also tries to identify the consumer perspective related to solar energy consumption.
As per the statistics of GOI, in the year 2018 Indian government set a target to produce 50% of the total electricity consumption from non-fossil fuel resources till the year 2030. Moreover, India set a target to generate 175 GW of renewable energy resources by the end of 2022 and extended this program to 500 GW by the end of the year 2030. Till the end of 2019, India developed 85.90 GW of non-conventional resources capability, which holds around 23% of the overall installed capacity. The paper selected an empirical analysis method to evaluate the objective and hypothesis. The sample data size is 400 participants who took part in the questionnaire-based study to determine their perception and the challenges facing them after installing solar energy-related technology. The results articulated that the enormous features of solar energy like zero-emission, little noise, and other associated aspects make it better, intrinsic, and trustworthy to satisfy the necessity for power and fuel for a massive mass. Moreover, the study determines specific consumers' challenges while preferring solar energy as an alternative resource are categorised into technical and financial obstacles: initial costs are very high, service support systems are inferior, inadequate availability of personnel to attend breakdowns, storage of power on rainy days among others.

Keywords- Non-conventional energy, Renewable resources, Solar energy, impediments for faster and sustainable growth of solar energy, preference function of consumers towards solar power, challenges facing the consumers while effectively utilising solar energy.

1. Introduction
The need for energy consumption all over the world is intensifying rapidly because of modernization and population growth. As the population has increased by 2 billion just in one generation specifically, this growth was contributed by the developing country. To protect the world from the energy crisis is one of the most challenging determinants lying in front of the world [1]. Henceforth to meet the energy needs, countries favour their immense potential to meet the requirement of the growing population by formulating concrete policies and control measures to develop and effectively implement their planning and strategies [2]. In the road map to meet the energy demand, countries also talk about alternative methods to eliminate carbon emission, ecologically viable, economically feasible and protect the world from global warming challenges by encouraging renewable energy resources [3].

Renewable resources of energy

Fossil fuels are non-renewable resources that extract Earth resources from beneath the Earth because of exhaustible use; these resources are on their depletion stage, and because of their expensive nature and over-exploitation, they instigate them to release enormous carbon emissions that devastatingly damage the nature and environment [2]. Conventional resources generate environmental problems and eventually adversely affect the ecological cycle through variant means. Thus, the concern started for decades to reduce or substitute the use or consumption of fossil fuels with non-conventional resources [4].

Through harnessing advanced technology, the research is still determining how to enhance the use of solar, wind, and hydrogen and convert it into a valuable source of energy to fulfil the human need and demand for business. Renewable energy is also known as non-conventional energy that replenishes itself, and one of the most prominent features is that it is environmentally friendly [1]. Several types of renewable resources come under direct or indirect correlation with the Sun. Solar energy can be directly used for heating or lightning as it generates electricity that can be utilised in a variety of commercial, domestic, and industrial use [2,3].

Non-conventional resources are not depleted and distributed over a broad geographical area; these resources are quickly renewed through the natural procedure. It has the potential to replenish itself and act environmentally friendly, and not harm or pollute the ecosystem and nature [5]. Through the effective utilisation of the technology, this energy can be extracted from Sun, wind, tidal, hydrogen, biomass, among others, for a long term in a cost-effective manner.

Non-conventional resources play a significant role because of their beneficial characteristics [6]:-

- *Environmental protection*

Non-conventional energy generating technologies are clean resources to generate power that have a low or light impact on the environment compared to conventional energy resources that enormously emit carbon responsible for global warming.

- *Sustainable form of energy*

Because of its replenishment and no depletion, these resources can be effectively utilised by generation over generation, compared to conventional energy, which is finite and limited in nature, having depletion characteristics.

- Opportunity for employment and new business

For renewable energy, the required material and the workforce to build them and adequate maintenance facilities are provided by the organisations or entrepreneurs that create a pathway to boost their economy in the global market. Also, generate a large number of employment opportunities. The business related to renewable energy resources has a bright future as it plays a significant role in the domestic market economy and trade overseas.

- *Energy security*

The main challenge is to maintain the energy available to meet the needs and requirements of the domestic and commercial sectors by the countries. Almost every country is dependent on import resources to meet their energy requirement either by importing oil, coal, or other resources. By

enhancing the use of alternative energy sources, countries adequately meet their condition. Their dependency on import energy reduces to maintain energy security and save an abundance of import currency.

Solar energy

With the motive to attend to a sustainable future and address the challenge associated with climate change, global warming developing countries are frequently seeking contemporary energy resources toward renewable energy resources. Solar energy is ample, conveniently available and accessible, and non-polluting in nature [2,3]. Henceforth, it is considered one of the most competitive choices compared to all the renewable energy resources [7]. The solar energy market has swiftly progressed and thrived by 50% in the last few decades all over the world. As proclaimed by the international energy agency (IEA), photovoltaic energy generating capacity will reach up to 16% by 2050 of the global electricity generation [8]. The potential of solar energy to generate electricity depends on several factors. One of the most prominent factors was land cover, which is the selection of suitable areas for PV generation installation and the use of appropriate technology that indicates the efficiency of solar power transmission. This initiative was taken by the government authorities to formulate concrete policy and also performs an indispensable role in generating and awareness of the mass to switch toward renewable resources [9].

Solar energy is usually dragged from the enriched solar surroundings where solar radiation or solar waves are available in ample amounts. From an international outlook, solar radiation is admirably and vigorously unrestricted throughout the span in the subtropical and tropical belt of the Earth [10]. Other recognized characteristics that indicate solar energy and its prospect to develop electricity rely on altitude, topography, diurnal divergence, surroundings weather conditions, and distance from the sea [2, 11]. The umbrella for efficiently appropriating solar power to forge power is the solar cell photovoltaic and the solar thermal collector harnessing technology [3, 12]. Photovoltaic technology alters sunlight into electrical energy while the solar thermal receiver heats the solution conveying the sunlight heat to develop thermal energy. The photovoltaic technology would be executed with different silicon corporealities set up to the other rendition designated in diverse conditions [11,12].

Solar power is a progressive renewable energy resource that makes it attractive and attentive from energy generating capacity [13]. It articulated zero-emission, little noise, and other associated aspects make it better, intrinsic, and trustworthy to satisfy the necessity for power and fuel for a massive mass. The energy sector is one of the renowned essential sectors contributing indispensable to extending the country's financial condition as it saves currency which is used for importing the fuel [14].

Overview of energy sector in India

India holds the second largest population in the world. Thus, the energy requirement of India is increasing several-fold in the last few years and has continuously grown in future. It has become the most crucial part of the growth and modernization of the country [17]. India is currently enormously dependent on the conventional and fossil fuel-based energy consumption mechanism

to meet their energy demands which are the significant cause for carbon. Being a member of the Paris agreement and the International Solar Alliance (ISA) is mandatory to reduce the dependency on conventional resources and pave immense measures to switch to alternative energy resources. Henceforth India committed to subdue its carbon emission by 35% to its current position by formulating robust policies and effectively implementing in the ground level that emphasises promoting renewable resources of energy, specifically solar power because it is ample, available and easily accessible throughout the country because of its geographical topography favourable conditions [18]. Presently India holds the 4th most attractive non-conventional energy market all over the world as India occupies 4th rank in wind energy, 5th in solar energy and forth in all overpower installation capacity based on the non-conventional source of power in 2020.

The government's ambition is to complete 227 GW from the non-conventional source of energy capability comprising 114 GW from solar energy and 67 GW from wind energy, till the year 2022. This accomplishment was far ahead of the target set by the Paris treaty signed in the year 2015. The illusion was extended after including the 73 GW resource from hydro based energy generating capacity, and the plan was to accomplish 523 GW energy generation by the end of the year 2030. In this planning, the significant role played by solar specific energy as it holds about 60% of the renewable energy capacity generation ambition. Till the end of 2019, India developed 85.90 GW of non-conventional resources capability, which holds around 23% of the overall installed capacity. To fulfil the target of 450 GW total installed non-conventional energy capability till the year 2030 [20].

1.1 Objective

The study intends to analyse the non-conventional resources of energy with explicitly focusing on the Indian scenario. Moreover, to determine the measures of implementing fast and sustainable growth of non-renewable resources exclusively emphasising solar power in India. The study also tries to identify the consumer perspective related to solar energy consumption.

1.2 Significance of Study

The study is comprehensively put a light through a prominent understanding of the facts and figures related with renewable solar energy having twin benefits as it provides an explicit description regarding Government initiative, where India stands in solar power generating capacity and, most significant the consumers perception, the burden on their budget after utilising the renewable resource and related challenges associated with it. Moreover, the paper also keenly analyzes the sustainability and effectiveness embraced inside solar energy and its ample use through harnessing the technology.

1.3 Research Gap

The significant gap of the research was restricted sampling as a shred of survey evidence for the fast and sustainable growth of solar energy in India is limited in amount. Moreover, the study covered a time frame of 10 years comprising 2010 to 2019 for exploring the existing secondary resources. This makes limited literature resources for analysis and enhancing the knowledge regarding the research.

1.4 Hypothesis of the Study

- The growth of non-renewable energy resources in India is insignificant.
- The correlation among the stakeholder and their response regarding the fast and sustainable growth of solar energy is presumed to be statistically independent.
- The correlation of the consumer's income related to solar energy and the challenges associated with solar energy utilisation is presumed to be statistical independence.

1.5 Research Questions

- What is the current scenario of the Indian energy sector relying on conventional and non-conventional resources?
- What are the impediments for faster and sustainable growth of solar energy in India?
- What is the preference function of consumers towards solar power?
- What are the challenges facing the consumers while effectively utilising solar energy?

2. Literature Review

Energy utilisation is rapidly increasing because of the increasing population and harnessing advanced technology. Henceforth the world is looking for a more reliable, economically feasible and environmentally friendly approach to meet the need for energy which can be accomplished by utilising renewable resources that have all the discussed properties to fulfil the condition of the rising population sustainably [2]. Solar energy is most promising compared to other non-conventional resources mainly because of its availability for long term fulfilment of energy crisis challenges [3]. The market of the business of solar power has immense potential with an abundance of opportunities as it not only meets the energy demand but also provides a global call to sell technology, create employment, economic feasibility, and easy accessibility in comparison to all the other resources [13].

Solar energy technology is an umbrella approach that has the immense capability to act as a single solution to multi challenges [14]. Solar energy is equipped with various characteristics. It also raises several challenges, specifically technical issues like low solar cell efficiency, standard performing systems, and financial obstacles like initially buying solar technology-related equipment are costly [25]. Moreover, other challenges are associated with solar power generation related to infrastructure and unskilled human capital. The paper [9] keenly observes and discusses all the challenges and benefits of the technology. The Paper also explores all the technical challenges associated with renewable energy resources and government policies focusing on the future aspect of generating solar energy. Another paper [18] tries to determine the economic feasibility of solar power generation capability in India through a keenly reviewing approach. For analysis, the paper goes through several market modelling strategies and frameworks that perform a critical role in India. Paper also goes through governmental policies to encourage photovoltaic installation as well as challenges comprising technology infrastructure and economic issues and recommend some measures to overcome them effectively [19].

India is currently enormously dependent on the conventional and fossil fuel-based energy consumption mechanism to meet its energy demands which are the significant cause of carbon

[11]. Being a member of the Paris agreement and the International Solar Alliance is mandatory to reduce the dependency on conventional resources and pave immense measures to switch to alternative energy resources. Henceforth India committed to subdue its carbon emission by 35% to its current position by formulating robust policies and effectively implementing in the ground level that emphasises promoting renewable energy resources. The paper [17] focuses explicitly on solar power because it is ample, available and easily accessible throughout the country because of its geographical topography favourable conditions. Paper also appropriately put a ray forward on economic and other characteristics of solar energy-related policies and structural framework manifested by the government and how India is improving itself in global ranking in terms of solar energy installation capability [22].

3. Research Methodology

3.1 Research design

The paper uses the qualitative approach to execute the evaluation and accomplish the research, which relies on a primary and secondary methodology that exclusively explores through both the sample survey approach and the existing studies.
Under the ***dependent variable*** factors related to solar energy and its growth development of non-conventional energy resources and the consumers' challenges associated with solar energy.
Under the ***independent variables***, time, income of the consumers, and the stakeholders.

3.2 Research Approach

The ***Primary data*** is usually collected from real-time sources such as surveys, questionnaires, experiments, and interviews. These are not concentrating on exploring the existing articles that mean it is singular and peculiar. In this research, the researcher implements primary data to obtain accurate results. First, it is not time-consuming and very reliable considering objectives. Through research, investigators examine in-depth the contribution made by solar energy in subduing the carbon footprint.
The study sample addresses 400 participants who took part in the questionnaire-based empirical study to determine their perception and the challenges facing them after installing solar energy-related technology.

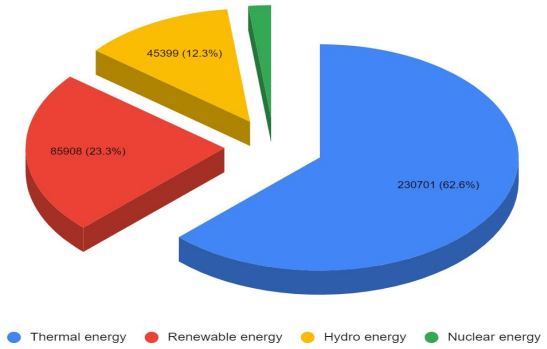
The ***Secondary approach*** is based on existing resources to comprehensively explore the research topic to enhance the knowledge and try to illustrate all the key and prominent points effectively. For secondary data, collection studies obtain information from governmental resources (MNRE), already existing journal literature, books, newspaper articles, websites, among others. The secondary approach plays a significant role in interpreting the research question and the hypothesis effectively and adequately formulating the smooth outcome. The secondary methodology is exclusively applied to observe solar energy as a future energy and related concept. For collecting data from existing resources, the keywords and titles used for searching include the related terms encompassed non-conventional energy resource solar energy, solar energy in India, policies and challenges related to solar energy, among others.

4. Analysis & Findings

4.1 What is the current scenario of the Indian energy sector relying on conventional and nonconventional resources?

The current scenario of the Indian energy sector is classified into conventional and non-conventional resources. The below description provides a brief review of total installed energy capacity in GW and related percentage as India is enormously dependent on non-renewable and fossil fuel to meet the demand of energy of the giant population as it holds 63% of total installed capacity. Moreover, the non-conventional resources steadily pace themselves in the growth pathway and have 23% of the installed capacity.

Energy Resources	Capacity (MW)	Percentage
Thermal energy	230701	62.6%
Renewable energy	85908	23.3%
Hydro energy	45399	12.3%
Nuclear energy	6780	1.8%



Fossil Fuel Installed capacity	Conventional resource energy	Capacity (GW)
	Coal	205.1
	Gas	25.0
	Diesel	0.5
	Total	230.6

Non-fossil fuel installed capacity	**Non- conventional resource of energy**	**Capacity (GW)**
	Hydro	143.7
	Solar	39.3
	Wind	62
	Biomass	16.4
	Waste to power	0.4
	Total	261.8

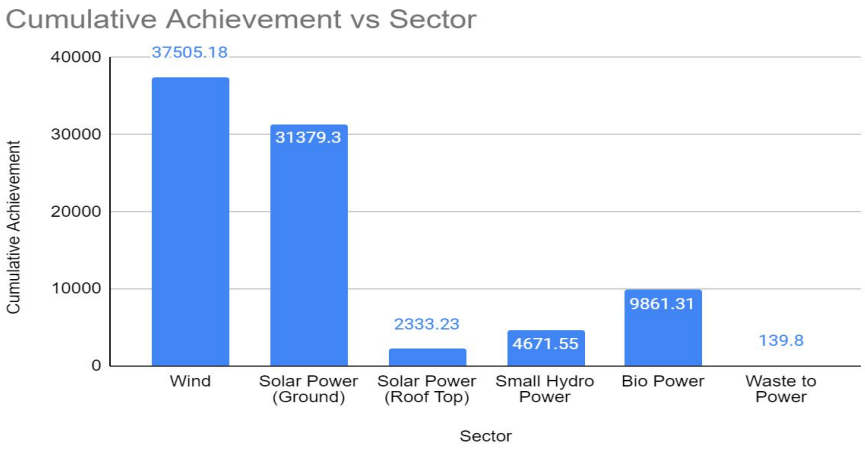
Table 1: Total installed energy capacity of India.

The table clearly showed that the largest share of energy-generating resources was coal, accounting for 56% of the total energy installed capacity. Coal is also responsible for carbon emission as it is a fossil fuel that plays a significant role in global warming. Followed by the gas and the diesel comes under conventional resources of energy.

India holds the third-largest electricity-consuming country in the world as well as the third-largest producer of non-conventional resources with 23% of the total installed energy capability. In the year 2018 Indian government set a target to produce 50% of the total electricity consumption from non-fossil fuel resources till the year 2030. Moreover, India set a target to generate 175 GW of renewable energy resources by the end of 2022 and extended this program to 500 GW by the end of the year 2030. After being a part of the international solar alliance, India was a leading country to set up a ministry of non-conventional energy resources.

The sector wise utilisation of non-conventional energy consumption by the country can be exhibited through the table given below-

Sector	Achievement (2019)	Cumulative Achievement
Wind	1879.21	37505.18
Solar Power (Ground)	5013.00	31379.30
Solar Power (Roof Top)	536.88	2333.23
Small Hydro Power	78.40	4671.55
Bio Power	83.00	9861.31
Waste to Power	1.50	139.80



India stands forth and sixth position in terms of cumulative installed capability in the renewable source of energy like wind and solar energy. Because of cumulative installed capability, India holds fifth rank in world level in the year 2018.

4.2 What are the impediments for faster and sustainable growth of solar energy in India?
In this question paper is going to show the factors responsible for the reason of impediment from faster and sustainable growth of solar energy perspective specifically focusing on the Indian grounds.

Factor	**Strongly Agreed & Agreed**	**Strongly Disagreed & Disagreed**	**Moderately Agreed**
Transmission losses due to long distance between production and consumption	270 (67.5%)	70 (17.5%)	60 (15%)
High initial investment requirements	269 (67.2%)	72 (18%)	59 (14%)
Non availability of skilled labor	257 (64.3%)	84 (21.0%)	59 (14.8%)
Exorbitant cost	249 (62.2%)	83 (20.8%)	68 (17%)
Inconsistent availability	159 (39.8%)	76 (19%)	165 (41.2%)
Non availability of huge tracts of land	147 (36.8%)	72 (18%)	181 (45.2%)

Soaring maintenance costs	250 (62.5%)	90 (22.4%)	60 (15%)
Low productivity	260 (65.0%)	105 (26.3%)	35 (8.8%)
Production is possible only when the sun shines	290 (72.4%)	70 (17.6%)	40 (10%)
Inadequate access to institutional finance	165 (41.2%)	85 (21.2%)	150 (37.5%)
Underdeveloped physical infrastructure and logistics	265 (66.3%)	75 (18.8%)	60 (15%)
Inadequate government policy support	235 (58.8%)	90 (22.5%)	75 (18.8%)
Fragmented photovoltaic power eco system	250 (62.5%)	100 (15.0%)	50 (12.5%)
Pricing policy is the most complicated issue	265 (41.3%)	70 (17.6%)	165 (41.2%)
PPAs are frequently violated	115 (28.7%)	200 (50%)	85 (21.2%)

The impediments for the faster and sustainable growth of solar energy in India are identified and arranged in the appropriate manner in the tabular form, which comprises prominent components that demonstrate that production is possible only when the sun shines, High initial investment requirements, Non-availability of skilled labour, Soaring maintenance costs, Inadequate government policy support, Low productivity, Transmission losses due to vast distance between production and consumption, Fragmented photovoltaic power ecosystem, the Pricing policy is the most complicated issue, Underdeveloped physical infrastructure, and logistics, Inadequate access to institutional finance, Non-availability of skilled labour, Non-availability of huge tracts of land, Inconsistent availability, PPAs are frequently violated and Exorbitant cost.

This demonstrates that the challenges facing solar energy in India concentrate on the prominent factors like high cost of the technology, unavailability of labour or skill man force, cost of maintenance, low productivity, unavailability of land to install photovoltaic solar power plants, inadequate infrastructure, among others. These challenges create barriers to the rapid and sustainable growth of solar energy from the Indian perspective. As mainly solar technology relies on imported products that make the technology expensive and because it is capable of using it at night also despite the availability of Sun energy during daytime it makes it capable of using all over the day. Moreover, the maintenance charges of the PV cell also involve costly measures.

Additionally, to the cost, PV cells require an appropriate amount of space to fit the number of solar panels to produce adequate energy.

The data related to the demographic variables cover the factors like age, salary, gender, education, among others. The factor age and the participant's salary demonstrate that 76% of the stakeholder belong from the age group of 26 to 55 years. Around 64% of the stakeholders belong from the category of consultant and senior manager. About 81 % of the participants are having experience between 4 to 12 years. Moreover, 52% of the stakeholders belong to the technical education field. Around 56.2% of the participants belong to the annual income groups from 11 to 20 lakh.

4.3 What is the preference function of consumers towards solar power?

The characteristics of solar energy make it promising and attractive and make it preferable for consumers to switch toward solar energy as an alternative resource of energy to meet their energy demand. Solar power is a progressive renewable energy resource that makes it attractive and attentive from energy generating capacity. It articulated zero-emission, little noise, and other associated aspects make it better, intrinsic, and trustworthy to satisfy the necessity for power and fuel for a massive mass. The energy sector is one of the renowned essential sectors contributing indispensable to extending the country's financial condition as it saves currency which is used for importing the fuel. Solar energy is ample, conveniently available and accessible, and non-polluting in nature. Henceforth, it is considered one of the most competitive choices compared to all the renewable energy resources because-

- Environment- friendly approach
- Clean energy
- Sufficient energy
- Infinite energy
- Employment opportunity
- Little scope for power crisis
- Ensure energy security
- Sustainability energy measure
- Cost efficiency

Non-conventional renewable energy sources built from solar, wind, hydro and biomass systems face ever-increasing importance for solving global energy problems and environment issues. The supply of renewable energy exceeds fossil fuel resources while offering environmental sustainability through its green nature. Society needs to adopt these resources to minimize global warming together with decreasing reliance on resources that quickly disappear from the environment. According to the International Energy Agency (IEA) renewable energy sources generated approximately 30% of global electricity while solar power supplied about 6% of this total in 2023 during a period of quick expansion.

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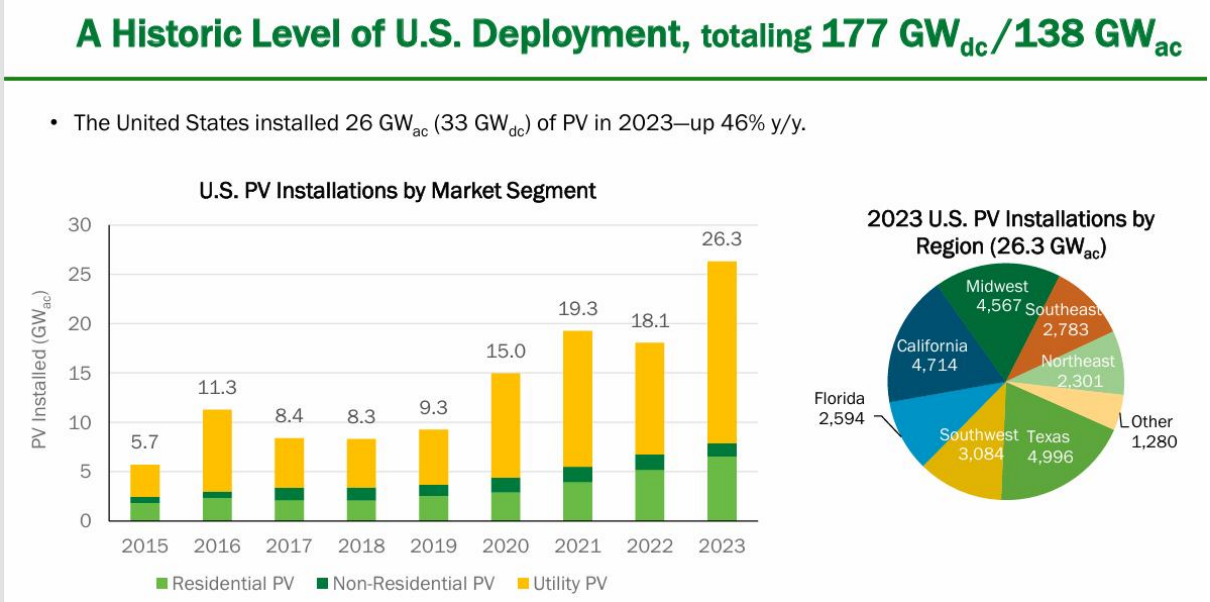
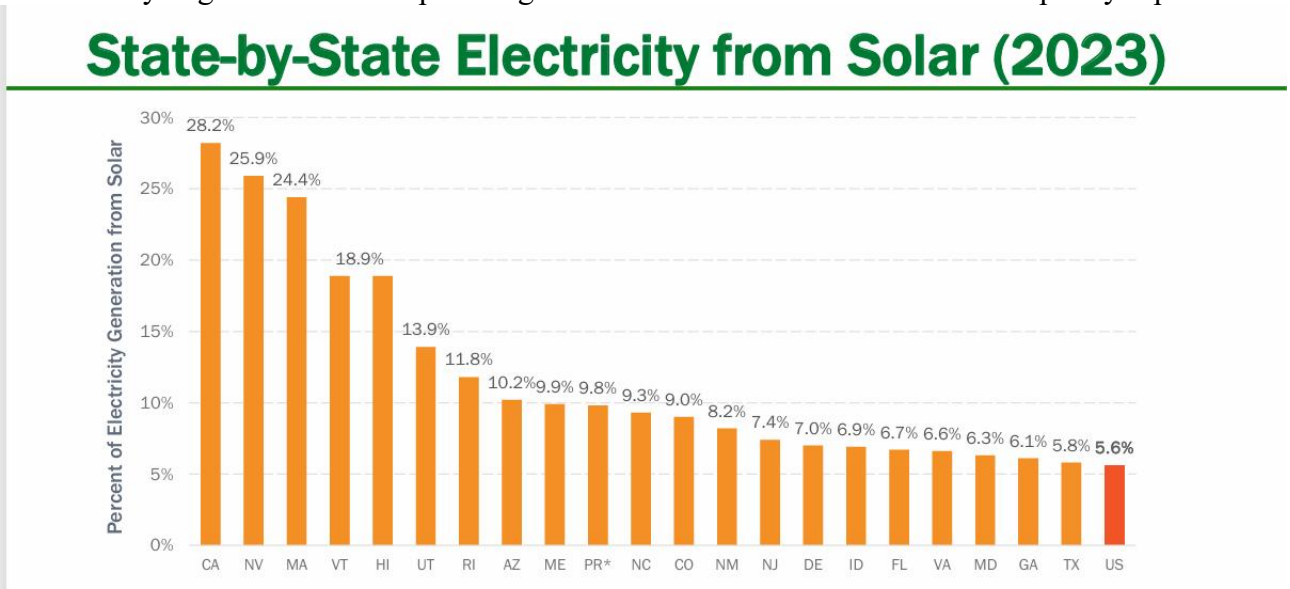


Rising energy crisis emerges because of increasing geopolitical tensions, increasing demand along with decreasing fossil fuel reserves. The necessity for transitioning to sustainable energy solutions has become more critical because of the situation in the energy sector. Countries now focus on decarbonization strategies because energy combustion generated 36.8 billion tonnes of CO_2 emissions throughout 2022. This transition serves both environmental requirements and establishes a structure for permanent energy stability and economic resistance. Solar energy, in particular, plays a crucial role in this shift. The solution has expanded in size and declined in cost while offering benefits for reducing greenhouse gas emissions. The focus of this research examines how solar power supports decarbonization efforts and energy security development beside analyzing its economic aspects together with environmental elements and policy aspects.



The worldwide solar photovoltaic (PV) industry has shown extraordinary progress because of its critical importance to power system evolution. In 2023 the world surpassed 1.6 TWdc of solar photovoltaic capacity installations worldwide which represented a substantial achievement regarding renewable energy deployment. The solar deployment speed continues to surge worldwide because new installations expanded by 89% year-over-year. The deployment of solar PV technology has reached its absolute peak in China. The country increased its solar capacity to 250 GWdc during 2023 which exceeded the combined totals of most worldwide continents. Solar power growth accelerates because of powerful policy support together with established production facilities and intensified efforts towards energy independence as well as carbon emission reduction targets. China leads global solar capacity because it has built more than 40% of the installed solar systems worldwide thus establishing itself as the key market player in international solar energy. Various energy analysts have generated contrasting forecasts which reflect positive expectations for the solar market during the period of 2024–2027. The International Energy Agency predicts that solar PV will grow to 2.4 TWdc by 2025 yet BloombergNEF predicts between 2.4 TWdc to 3 TWdc will be reached by 2027 depending on policy support and changes in technology costs and supply chain conditions. Several ongoing difficulties exist despite the positive direction that solar energy is taking.

The current solar installation trends show that most of the solar capacity exists primarily in select regions which represents a major challenge for solar development. Regions in Sub-Saharan Africa together with Southeast Asian areas have postponed their solar energy development because of minimal investment along with poor infrastructure. Furthermore, solar energy's intermittency—its dependence on sunlight—necessitates substantial investment in energy storage and grid modernization. The optimal deployment of solar energy faces constraints from inappropriate power grid transmission systems and from limited land availability in busy urban zones. The rapidly growing global solar PV sector needs complete solutions for structural and technical obstacles to establish sustainable growth equality throughout all regions.

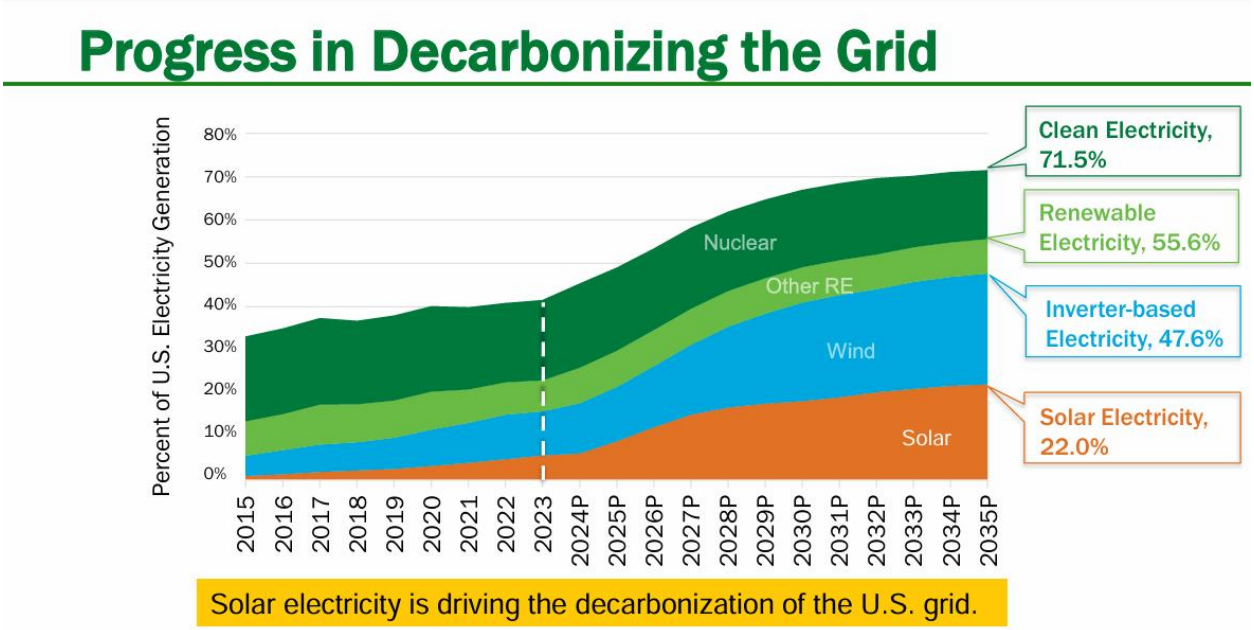
4.4 What are the challenges facing the consumers while effectively utilizing solar energy?

Because of its abundance and environmentally friendly nature, solar energy is one of the most practical energy resources. Although solar energy is a dependable energy source embraces certain challenges. The consumer's challenges while preferring solar energy as an alternative resource are categorized into various issues like technical issues, financial obstacles, and environmental issues. Under the technical challenges, safety measures improvement in technology like meeting high heat capability, material supply of appropriate and adequate manufacturing components, and efficiency in the photovoltaic cell should be handled effectively. Under the economic challenges, import technology is expensive in comparison with conventional technology, the initial installation of the energy is still expensive. Additional to the per-unit generating cost is also costly compared to the other renewable and non-renewable resources for generating electricity to meet the consumption need.

The Era of Wind, Solar, and Natural Gas

The deployment of solar energy has propelled the United States into a decisive stage of electric power transition which now leads its electricity generation mix. The United States experienced solar energy surpassing wind and natural gas installations to become the leading new electricity

capacity addition source in 2023. The U.S. Energy Information Administration (EIA) reported that solar captured 54% of all new capacity additions which established a significant milestone for the national clean energy direction. Chinese solar energy developers continue their aggressive growth strategy at the same time the country moves away from using coal plants alongside nuclear facilities and hydroelectric facilities for power generation.



The electricity generation share of coal has experienced a continuous decline from 23% in 2019 to almost 17% in 2023 because power companies have been decommissioning older facilities. Both nuclear power stations and hydroelectric facilities have suffered from reduced generation because high maintenance expenses and environmental limitations exist. Solar and wind energy systems have accelerated their market penetration at a rapid pace because costs declined and new tax incentives along with increasing climate goals took effect.

Decarbonization Challenges

The current speed of solar PV implementation does not match the requirements needed to reach U.S. 2035 decarbonization targets. A Decarb+E scenario presented in the Department of Energy's Solar Futures Study projects solar will generate about 42% of U.S. electricity by 2035. The projected growth rates of solar installations fall below projected targets unless the United States achieves two times higher installation numbers during this decade. The United States reached its first milestone of 160 GWdc solar PV capacity installation during 2023. The Decarb+E pathway will require cumulative capacity to reach 750 GWdc by 2035 in order to continue on this path. The current implementation gap demands rapid policy backing along with enhanced renewable sector workforce development and transmission infrastructure financing. National decarbonization goals demand exponential deployment speed increases instead of merely incremental growth because both deep decarbonization and affordable reliability require it.

Sunlight Energy received a major boost from the U.S. Inflation Reduction Act (IRA) of 2022 which established crucial changes to support solar power deployment. The Inflation Reduction Act's allocated funding of $369 billion positions as the largest climate expenditure in U.S. history. The extension of Investment Tax Credit (ITC) benefits to 30% across 2032 provides extended investor and project developer assurance. Analysts from Wood Mackenzie predict a 40% boost of solar deployment during the period from 2027 to 2027 when analysing post-IRA projections against pre-IRA estimates. This development requires strategic planning as well as streamlined domestic manufacturing support and contemporary power grid modernization. IRAs production tax credits incentivize U.S.-based creation of solar modules together with inverters as well as polysilicon wafers to decrease American dependence on foreign manufacturers in particular China which leads global solar module production with more than 80% market domination. The complete realization of solar energy depends heavily on technological improvements. The integration of advanced inverters enables control over voltage and frequency changes to support stable operation in high-renewable energy distribution networks. Battery storage capacity has grown to 16.3 GW in the U.S. during 2023 and experts expect this figure to double by 2025 according to the EIA data which improves solar power dispatchability. The expansion of community solar projects lets renters and low-income families access shared solar power capabilities in their systems. Community solar projects now exceed 5.3 GW in total capacity throughout the United States, but continued policy support predicts additional growth of equitable solar installations in 2023.

The challenges experienced by the customers while using solar energy comprising-

- Initial costs are very high
- Service support systems are very poor
- Inadequate availability of personal to attend breakdowns
- Storage of power on rainy days
- Bad weather conditions hamper the production
- On average, cost per unit remains more or less the same (Grid Parity)
- Transmission losses occur when the connectivity is extended
- Lack of regulating institutional setup

Factor	**Strongly Agreed & Agreed**	**Strongly Disagreed & Disagreed**	**Moderately Agreed**
Initial costs are very high	264 (66%)	80 (20%)	56 (14%)
Service support systems are very poor	288 (72%)	60 (15%)	52 (13%)
Inadequate availability of personal to attend	231 (57.8%)	99 (25.3%)	68 (17%)

breakdowns			
Storage of power on rainy days	218 (54.5%)	90 (22.4%)	92 (23%)
Bad weather conditions hamper the production	264 (66%)	87 (21.8%)	49 (12.2%)
On an average cost per unit remains more or less the same (Grid Parity)	227 (56.7%)	101 (25.2%)	72 (18%)
Transmission losses occur when the connectivity is extended	219 (55.5%)	107 (26.7%)	71 (17.8%)
Lack of regulating institutional setup	270 (67.5%)	77 (19.2%)	53 (13.2%)

Other findings demonstrate that the relationship between the social status of the customers of solar energy and their level of agreement about the problems encountered by them at LOS=0.05 and DF=16 is statistically independent. The relationship between the customers' income of solar energy and their level of agreement about the problems encountered by them at LOS=0.05 and DF=16 is statistically independent. At the same time, the relationship between the education of the customers of solar energy and their level of agreement about the problems encountered by them at LOS=0.05 and DF=8 is statistically independent. However, the relationship between the type of the house of the customers of solar energy and their level of agreement about the problems encountered by them at LOS=0.05 and DF=16 is statistically independent. Moreover, the relationship between the gender of the customers of solar energy and their level of agreement about the problems encountered by them at LOS=0.05 and DF=8 is statistically independent.

5. Results

Solar energy is an enormously available source of power that is freely accessible in extensive amounts nearly all the time. Currently, the fossil fuel availability situation is deteriorating at an alarming rate. There is a necessity to competently practice alternate sources, which is a more substantial energy source, where the highest solar radiation is obtainable everywhere the year. Solar energy is also a reliable source of energy and support to diminish the vulnerable impact of global warming. It is free from carbon and other destructive greenhouse gases and, through power generation, does not wreck the ecosystem. Majority of the stakeholders in the arena of solar energy are young, consultants and senior managers, experience up to 10 years, equipped with technical education, with risk taking behaviour and technology inducement level are found

to be in the range of high to very high. The socio-economic profile of the consumers of solar energy reveal that majority of the consumers are relatively young, from socially advanced castes, from the income range of 6-20 lakh rupees per annum, equipped with above undergraduate level education, staying in independent houses and majority of the respondents are male.

6. Conclusion

India holds the second largest population in the world. Thus, the energy requirement of India is increasing several-fold in the last few years and has continuously grown in future. Henceforth India committed to subdue its carbon emission by 35% to its current position by formulating robust policies and effectively implementing in the ground level that emphasises promoting renewable energy resources. The study focusing on the country's present renewable resource position and the impediments for the faster and sustainable growth of solar energy is also identified. The study also highlighted the benefits and challenges of solar energy from the consumer perspective rely on their using practices.

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