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A study on the Economic impact of rooftop solar energy practice among households in Thiruvarur District

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Abstract

The objectives of this study are to investigate the factors that influence household adoption of solar energy in the Thiruvarur region, as well as the subsequent effects on patterns of energy consumption and quality of life. The population of households that use solar energy products is the focus of the study. Convenience sampling was used to select the study's sample, and a structured questionnaire was given to 160 households in the Thiruvarur region who are using solar energy products to collect primary data. The study found that Households/ users' perception of the Solar Energy Adoption factors is above the average level which indicates the appreciable adoption level on solar energy products in the study area. The growing demand for clean, affordable, and sustainable energy has accelerated the adoption of renewable energy technologies across the world. Among these, solar energy has emerged as one of the most viable alternatives to conventional fossil fuel-based electricity due to its environmental, economic, and social benefits. In India, government initiatives, technological advancements, and financial incentives have encouraged households to adopt solar energy systems, particularly rooftop solar installations. However, the extent of adoption and the factors influencing household decisions vary across regions, necessitating empirical investigation at the local level. The present study aims to examine the factors influencing household adoption of solar energy in the Thiruvarur region of Tamil Nadu and to assess its subsequent impact on household energy consumption patterns and quality of life. Specifically, the study investigates the socio-economic, economic, technological, environmental,

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and policy-related determinants that motivate households to adopt solar energy systems. In addition, the study evaluates how solar energy adoption contributes to reducing electricity expenditure, improving energy security, enhancing environmental awareness, and increasing the overall well-being of households.

Key words : Environmental policy, Electricity expenditure, Household adoption. Renewable energy, Solar Energy, technological advancements.

The energy plays an important role for the economic, social, professional, agricultural and business growth of a nation. In 21st century, the challenge before the countries is to achieve sustainable economic growth along with strengthening of social sector and comfortable existence of people on this earth. Electric power is a major contributor to the overall development of every nation, making it necessary for both social and economic development to occur simultaneously. Power is one of the fundamental requirements for the growth and development of human beings on this earth. In order to meet the energy needs of every nation on the planet, it is necessary to have power that is of a high quality at a price that is affordable. The carbon footprint is increasing on earth because of burning of fossil fuels for generating electricity, running trains, cars and other vehicles throughout the world. It has reached a point where, if it is not managed effectively, it will turn into a black hole and eat away at human life in the next 50 years. Therefore, the whole world is looking for renewable sources, preferably solar energy to generate power, which is clean with no fuel cost and available in abundance in most of the countries across the globe including India. Now a days there is a large imbalance between energy resource availability in India and consumption. As a result, we must develop emerging technologies to demonstrate their readiness for use. The rising demand for electricity cannot be met solely through the use of fossil fuels. Thus, there is a dire need to move towards some everlasting solution that is feasible on the basis of economic as well as environmental cost. Solar energy development in India can also be an important tool for spurring regional economic development, particularly for many under developed states, which have the extreme potential for developing solar power systems which is unlimited and clean source of energy. It can provide secure electricity supply to faster domestic industrial growth.

Energy is the amount of strength or power when applied the energy, this will help to move one object from one position to another. Energy exists in everybody whether they are human beings or animals or non-living things such as Jet, Light and Machines. Energy can be determined in different forms. It can be used as chemical energy, electrical energy, thermal energy (heat), radiant energy (light), mechanical energy and nuclear energy. Energy is commonly classified into two major groups: Renewable Energy is produced from natural sources i.e. sun, wind, rain, tides. It can be made again and again depending on what is needed. They are available in adequately and by far most of the cleanest sources of energy existing on this planet for *e.g*. Energy that we

receive from the sun can be used to generate electricity. Similarly, energy from wind, geothermal, biomass from plants, can be used this form of energy to another form. Non-Renewable energy is employed from the sources that are available on the earth in limited quantity and will vanish fifty-sixty years from now. Non-renewable sources are not environmentally friendly and it will affect our health. They are called non-renewable because they cannot be re-generated within a short span of time. It is an important source of rene-wable energy and its technologies are broadly categorized as either passive solar or active solar depending on how they capture and distribute solar energy or convert it into solar power. Active solar techniques contain the use of photovoltaic systems, concentrated solar power and solar water heating to harness the energy. Passive solar techniques include orienting a building to the Sun, selecting materials with favourable thermal mass or light-dispersing properties, and designing spaces that naturally circulate air.

Moorthy:[4] - This study conducts a cost-benefit analysis of domestic solar power as a sustainable development strategy in Coimbatore, TN, India. With rising energy demands and environmental concerns, solar energy presents a viable solution for house holds seeking to red use electricity costs and carbon footprints. The analysis evaluates both the financial implications and environmental benefits of installing solar photovoltaic systems, highlighting initial investment costs, potential savings, and available government incentives. Data collected from 183 households reveals a term return on investment, despite challenges such as high upfront costs and limited awareness among consumers. The findings under- score the importance of government policies and community engagement in promoting solar adoption. This study aims to inform residents and policymakers about the economic and environmental advantages of domestic solar power, ultimately contributing to Coimbatore's sustainable development objectives. In order to make it easier for households to switch to renewable energy sources, the research emphasizes the need for increased public awareness and regulatory structures that are supportive.

Manimegalai, & Seethalakshmi:[3] This study investigates the factors influencing house-hold solar energy adoption in Tiruchi-rappalli District, India, amidst national efforts to promote renewable energy. Employing a mixed method approach, including a survey of 50 households, the research aimed to assess adoption status and examine influencing factors. "Economic Readiness and Technical Comfort" and "Structural and Social Environment" were the two primary underlying dimensions identified by Principal Component Analysis for a specific educational subgroup. The study concluded that targeted interventions that improve financial incentives, raise public awareness of technical aspects, leverage community influence, and investigate novel models to expand access beyond traditional home- owners are necessary to accelerate household solar adoption and contribute to a more equitable and sustainable energy transition in Tiruchi-rappalli and other similar regions.

Dahiya:[1] The shift to renewable energy sources like solar energy has become crucial in light of the growing signi-ficance of environmental sustainability. However, consumer awareness and compre-hension of these products' advantages and functions have a significant impact on their widespread adoption.

This study looks at how consumer awareness of solar products is influenced by demographic factors like age, monthly family income, and educational level. The analysis, which includes Chi-square tests and descriptive statistics, reveals significant associations between consumer awareness and demographic factors. Younger consumers, those with higher income, and individuals with higher educational qualifications are more likely to be informed about solar products. The findings emphasize the need for targeted education and outreach to enhance awareness, promoting the adoption of solar energy solutions for a more sustainable future.

Swetha and Moorthi:[5] This research explores the public perception, awareness, and adoption patterns of solar energy systems in Chennai, Tamil Nadu—a region with high solar potential and growing urban energy demands. The study aims to assess the general public's knowledge of solar technologies, affordability concerns, awareness of government subsidy schemes, and willingness to adopt solar systems in residential settings. The chi-square test and Karl Pearson's correlation were utilized in the analysis to evaluate the connection between income and affordability and the relationship between awareness and adoption. Results indicate that while there is a moderate level of awareness about solar energy, knowledge of government incentives and technical feasibility remains low. The findings emphasize the importance of targeted awareness campaigns, simplified subsidy processes, improved financing options, and community-based solar initiatives. This study contributes valuable insights to policymakers, solar developers, and stakeholders aiming to accelerate the diffusion of solar energy in urban India, especially in high-potential regions like Chennai.

Devi:[2] The argument in favour of implementing sustainable energy systems in households has received a lot of support due to the rise of electricity as a necessity and the environmental issues or concerns that accompany the utilization of conventional power sources that are based on fossil fuels. Solar power is now an option with advantages for the household's finances and the environment. Household adoption decisions continue to be influenced by issues with the initial establishment cost, opportunity costs, and uncertainty regarding the financial payoff. The paper shall seek to perform a cost-benefit analysis on the application of solar energy in a household, specifically with respect to the opportunity cost of using solar energy and comparing the economic implications of using solar energy and the traditional consumption of electricity. This study followed the quantitative research design, whereby a survey of 100 house holds was carried out with secondary data collection tools such as government and policy reports. The trend in baseline consumption and expenditure was selected through descriptive statistics, and inferential analysis was selected in order to provide more information about financial results. Paired sample t-test compared the expenditure on household electricity in pre- and post-adoption of solar energy, and savings in the new phase were found to be significant. The independent variables of net financial benefits were calculated using multiple regression, where the consumer units of net financial benefits, solar-generated units, imported units, and with- and without-solar costs were important predictors. According to the opportunity cost estimation, there was a 643.22 R strong effect of the relative advantage of investing in solar energy in comparison to the constant expenditure of conventional

energy on monthly savings for the household and significant savings in the dependence on a grid-based power source. The findings show that though adoption of solar energy is costly in the short run, its economic benefit is higher in the long run, and most importantly, the consumption cost of solar energy is considerably low by its comparison to the use of fossil fuels. Results of studies declare that, in addition to the viability of the economy, the deployment of solar is also strategically feasible in localities where households have an opportunity to save cash and, in addition, ensure that the shifts to sustainability in energy are accomplished. The occupants of the houses will be influenced to decide on green energy using the findings, and also sway the debate to implement clean energy in the developing economies.

Solar Energy Scenario in India :

Solar energy is the light and radiant heat from the Sun that control Earth's climate and weather and protract life. A lot of heat and electromagnetic radiation are produced by this action. The produced heat remains in the sun and is helpful in upholding the thermonuclear reaction and electromagnetic radiation together with visible, infrared and ultra-violet radiation flow out into space in all directions. Solar radiation sustains all forms of life on earth. Solar radiation is notable for its widespread distribution, inexhaustible supply, and pollution-free energy source. India receives solar energy equivalent to about 500 trillion kWh per annum, more than enough to provide for the entire country's needs. In India, the daily solar energy incidence varies from 4 – 7 kWh per m^2 and many regions in the country enjoy 250 to 300 sunny days annually. Solar power systems are broadly categorized as (1) Solar Thermal System and (2) Solar Photovoltaic system. Unlike solar PV which can be used only to generate electricity, solar thermal systems can be used for power production or for heating/ cooling applications. Key application for solar thermal include: (1) solar water heaters (2) solar dryers (3) solar air-conditioners (4) solar industrial process heating (5) concentrating solar thermal (6) concentrating solar power. Solar Photovoltaic (PV) systems generate electricity from the light of the sun's rays. Broadly, solar PV systems can be classified as thin film or crystalline solar PV systems. Owing to their modularity, solar PV systems can be implemented on small rooftops to large MW, scale ground mounted power plants.

Key application for solar PV includes: (1) Utility scale solar power plant (2) Roof top solar power plant (3) solar street light (4) solar lanterns (5) solar water pumps. The techno-commercial potential of photo-voltaic in India is enormous. The energy "gap" between supply and demand will only get wider as GDP grows by more than 8%. Solar PV is a renewable energy resource capable of bridging this 'gap'. During JNNSM's initial phase, the Ministry of Renewable Energy proposes adding 500 MW. In terms of all renewable energy, currently India is ranked fifth in the world with 15,691.4 MW grid-connected and 367.9 MW off-grid renewable energy-based power capacity. India is among top 5 destinations worldwide for solar energy development as per Ernst & Young's renewable energy attractiveness index. Solar power is attractive because it is abundant and offers a solution to fossil fuel emissions and global climate change. Earth receives solar energy at the rate of approximately 1,73,000 TW.

Solar Energy in Tamil Nadu :

Tamil Nadu has reasonably high solar insolation (5.6-6.0 kWh/sq.m) with around 300 clear sunny days in a year. Southern Tamil Nadu is one of the most suitable regions in the country for the development of solar power projects. With substantial solar insolation in these, the strong commitment of the State Government and rapidly declining Solar Power costs, there are remarkable opportunities in the solar energy domain. Renewable technologies will enhance energy security, making Tamil Nadu the global reference in the solar energy sector. The government has announced a variety of incentives and programs to promote the PV industry in terms of increased indigenous manufacturing, increased solar power generation, and increased industry participation in R&D and technology development in light of the enormous potential market for solar energy. Tamil Nadu, which has installed wind power for 40% of India's capacity, will add a maximum of 4,339 MW, while Maharashtra will add the second most wind power, 3,763 MW. Rajasthan will add 3,513 MW of solar power capacity, followed by Tamil Nadu with 3,014 MW. At present, India's estimated total renewable generation potential is 147615 MW as on 31.3.2014. It is estimated that the total installed capacity of renewable energy in Tamil Nadu will go up to 16237 MW from 8,062 MW, while Rajasthan will have the second highest capacity of 9,060 MW. By 2015, 3,000 MW of solar power must be fed into the grid, according to Tamil Nadu's solar energy policy, of which nearly one third has already been completed.

Roof top Solar System :

Since subsidies and incentives have made rooftop solar systems a viable option for both individuals and businesses, there has been an increase in interest in the state. Large-Scale Solar Farms: Tamil Nadu is home to the world's largest solar power plant. Additionally, the state intends to establish solar parks in each district. Manufacturing: Within the state, the government is encouraging investment in solar manufacturing units. Initiatives by the government include the Chief Minister's Solar Rooftop Capital Incentive Scheme, which provides subsidies for domestic solar PV systems that are connected to the grid. Obstacles: Despite adva- ncements, rooftop solar adoption has encountered obstacles such as policy complexity and bureaucratic obstacles. Future Objectives: Tamil Nadu intends to lead the way in renewable energy and significantly expand its solar capacity.

Objectives of the Study :

1. To identify and analyses the factors that influencing the adoption of Solar Energy Products in Thiruvarur.

2. To analyses the impact of adoption of Solar Energy Products on the Residential Energy Consumption in Thiruvarur.

3.To identify and assess relationship between Solar Energy Product Adoption Factors and Residential Energy Consumption in Thiruvarur.

4.To investigate the effect that households in Thiruvarur's adoption of solar energy products has had on their quality of life.

Hypothesis of the Study :

H0: There is no significant difference between the gender wise use of solar energy with respect to Perception on the adoption of Solar Energy Products.

Methodology of the Study :

The entire study is based on both primary and secondary data. A survey is used to collect primary data. This study focuses on the factors that influence the success of solar photovoltaic rooftop business in Tamil Nadu. 160 respondents were randomly selected for the study. The percentage method was used in this study. The mean and standard deviation were used to support the study's hypothesis.

Analysis & Interpretation of The Study :

Table-1: Socio-Economic & Demographic Profile

Factors		Respondents	Percentage
Gender	Male	93	58.13
	Female	67	41.87
	Total	**160**	**100**
Age	21 – 40 Years	84	52.5
	41 – 60 Years	60	37.5
	Above 60 Years	16	10
	Total	**160**	**100**
Education	School / Diploma	63	39.38
	Graduation	77	48.12
	Professional Qualification	20	12.5
	Total	**160**	**100**
Occupation	Salaried job	66	41.25
	Professional	30	18.75
	Students	18	11.25
	Home-makers/Retired	46	28.75
	Total	**160**	**100**
Income	Up-to 50,000 Rs	52	32.5
	50,001 – 10,0000 RS	76	47.5
	Above 100,000 RS	32	20
	Total	**160**	**100**
Family size	Up-to 3 Members	73	45.63
	4 – 6 Members	52	32.5
	Above 6 Members	35	21.87
	Total	**160**	**100**

Source: Computed Primary data

From the Demographic Profile of the households table-1, it is inferred that male households/users (58.13%) are more than female households/users (41.87%). 52.50% of them are between the ages of 21 and 40. Most of the households/users (48.12%) are Graduates. 41.25% of them are Salaried persons and 47.50% of the households belong to the monthly family income category of 10,001 – 20,000 RS. In terms of size of family of the households/ users, 45.63% of them have up-to 3 members in their family.

Table-2. Type of Solar Energy Product used by the respondents

Factors	Respondents	Percentage
Solar Rooftop Panels for electricity usage Solar Battery	48	30
Solar Lantern Solar Heater	22	13.75
Purifier Solar Cooker	14	8.75
Solar Air Conditioners	30	18.75
Other Solar Energy Products	46	28.75

Source: Computed Primary data

Table-3 Period of using Solar Energy Products

Factor	Respondents	Percentage
Up-to 3 Years	53	33.13
4 – 6 Years	76	47.5
More than 6 Years	31	19.37

Source: Computed Primary data

Table-4 source of awareness about solar energy products

Factor	Respondents	Percentage
Knowledge about Solar Energy Products through Media Sources	71	44.38
Knowledge about Solar Energy Products through Non - Media Sources	89	55.62

Source: Computed Primary data

The usage patterns of solar energy products in the Thiruvarur region are depicted in tables 2, 3, and 4. It is inferred from the table that 30% of the households/users are using Solar Rooftop Panels for electricity usage followed by Solar Heater (18.75%), Solar Battery/Charger (13.75%), etc. 47.50% of the households are using Solar Energy Products for 4 – 6 Years and 55.62% of the households came to know about the Solar Energy Products through Non-Media Sources (Own Knowledge, Friends/Colleagues, etc.).

Table-5. Factors influencing the respondents to adopt solar energy product

S. No.	Factors	N	Mean	SD
1.	Savings in Cost of Energy	160	12.63	2.884
2.	Perceived Trust	160	11.35	3.113
3.	Perceived Value	160	13.05	2.547
4.	Environmental Concern	160	10.84	3.465

Source: Computed Primary Data

In order to identify Households/Users' perception on the factors that influencing the Adoption of Solar Energy Products, 12 Questions relating to the four factors *i.e.*, Savings in Cost of Energy, Perceived Trust, Perceived Value and Environmental Concern are inquired from the households through the structured questionnaire. From the above table 3, it is found that households/users have more perception on 'Perceived Value' (M = 13.05) factor and have lesser perception on 'Environmental Concern' factor (M = 10.84) when compared with other factors relating to the Adoption of Solar Energy Products. From the above table, it is also inferred that the households/users on the various factors that influencing the Adoption of Solar Energy Products are above the average level since all mean values of the variables are above 10 (two-third or 66.67%) out of 15. The overall perception of households and users regarding the factors that influence the adoption of solar energy products is higher than 79%, with a mean value of 47.87 (79.78%).

H0: There is no significant difference between the gender wise use of solar energy with respect to Perception on the adoption of Solar Energy Products.

Table-6. Gender wise - Perception on the use of Solar Energy Adoption Factors

Variable	Gender						T - Value	P – Value
	Male			Female				
	N	Mean	SD	N	Mean	SD		
Perception	95	48.32	5.223	65	46.33	6.314	3.154	0.027*

As the P Value (0.027) is lesser than Sig. Value at 5%, the Null Hypothesis is rejected. Based on the Mean score of Households/ Users' Perception on the Solar Energy Product Adoption Factors, it inferred that the mean score of the Male users (M = 48.32) is additional than Female Users (M = 46.33) Products. As a result, the perceptions of the factors that influence the adoption of solar energy products differ significantly between male and female users (Table-6).

Findings and Suggestions of The Study :

The study found that Households/users'

perception on the Solar Energy Adoption factors is above the average level which indicates the appreciable adoption level on solar energy products in the study area. The study also found that male households have a higher perception of the factors influencing solar energy product adoption and residential energy consumption than female households. The households that have been using solar energy products for at least six years perceive the factors that influence adoption of solar energy products more positively than other households. Despite the favorable perception, it is essential to continue educating households in the Thiruvarur region about the benefits of solar energy adoption. This can be done through community workshops, informational campaigns, and outreach programs to increase awareness among a wider audience. Recognizing that male households have shown higher perception levels, it's important to design gender-inclusive programs that target female households as well. To encourage them to adopt solar energy, specialized outreach and support initiatives can be created. Households with more than six years of experience perceive adoption factors more positively. It is recommended to consider providing support and resources to new users to help them overcome initial barriers and ensure they maximize the benefits of solar energy over time. Concentrate on ensuring the quality and dependability of solar energy products due to the significant correlation between factors influencing the adoption of solar energy products and residential energy consumption. The study suggested to encourage the use of certified products and help with maintenance and performance monitoring. Although 'Environmental Concern' was found to be a lesser predictor of quality of life, it's still an essential factor. Promoting the environmental benefits of solar energy to enhance its appeal and highlighting how individual actions contribute to environmental conservation and sustainability. The government may consider introducing or expanding incentive programs to further encourage solar energy adoption. This could include financial incentives, tax breaks, or subsidies, making the initial investment more appealing to a wider audience. Since 'Perceived Value' was a significant predictor of quality of life, focus on enhancing the perceived value of solar energy products. This can be accomplished through enhanced product features, enhanced customer service, and ensuring that customers comprehend all of the benefits.

It demonstrated the potential for reduced reliance on conventional energy sources, energy conservation, and the promotion of energy efficiency through solar energy adoption. It emphasized the potential for enhanced energy affordability, improved comfort levels, environmental responsibility, energy independence, and community engagement. Understanding residential energy consumption is essential for energy planning, efficiency programs, and policy development. The findings of this research can have significant implications for policymakers, energy planners, and households in Puducherry region. Energy planners can use the insights to design effective programs for integrating solar energy into the existing energy infrastructure. Furthermore, households can make informed decisions regarding solar energy adoption based on the identified factors,

contributing to reduced energy consumption, cost savings, and enhanced quality of life and achieving a more sustainable future.

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