

Titel der Abschlussarbeit

Untertitel

vorgelegt von

am Fachbereich

im Studiengang

der Hochschule für Wirtschaft und Recht Berlin

zur Erlangung des akademischen Grades

genehmigte Fassung zur Publikation

ErstgutachterIn

ZweitgutachterIn

Datum der bestandenen Abschlussprüfung

Erscheinungsort und Jahr der Publikation

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Chapter 1

INTRODUCTION

1.1 Overview

Energy is one of the vital requirements of mankind in the twenty-first century (Adeniyi and Ighalo, 2019). It drives all global economies and contributes significantly to the improvement of standard of living of humans (Wang and Guo, 2021b). The rate of industrialization of a nation is directly related to the present availability, consumption and capability for future storage of energy sources in that nation.

Coal plays a crucial part in the production of power globally. Currently, 37% of global electricity is generated by power plants using coal, and IEA projections indicate that coal will continue to produce 22% of the world's electricity in 2040, maintaining coal's position as the leading source of electricity globally. According to Environmental and Energy Study Institute (EESI), Over the last 150 years, fossil fuels like oil, natural gas and coal have remind as the key sources of energy for the world's economy, supplying around 80 percent of the energy needs of the world (EESI, 2022). When these fossil fuels that are derived from crude oil, natural gas, and coal are burned, they emit hazardous gases known as greenhouse gases into the atmosphere (Adeniyi and Ighalo, 2020). These gases can have extremely detrimental impacts on the ecosystem including slow, observable rise in global temperature leading to global warming (Liu, 2019; Mensah et al., 2021).

Other environmental issues induced by the burning of fossil fuels are air pollution, acid rain, depletion of ozone layer, water, deforestation, and emission of radioactive chemicals (Dincer, 2000; pollution (Nandan et al., 2021; Adelodun et al., 2021). In addition to these negative repercussions of conventional energy sources on the environment, it has been observed that these sources are approaching exhaustion. Thus, the rate of consumption of conventional energy sources is considerably higher than their rate of production (Kehinde et al., 2018). All these disadvantages linked to the usage

of fossil fuels have spawned the demand for superior alternatives that has a negligible impact on environment and are easily replenishable. This energy is known as renewable energy because it is continually renewed by nature - the wind, running water, sun, heat of the soil, plants, and animals (Karasmanaki and Tsantopoulos, 2019).

Today, clean and environmentally friendly energy harvesting is of utmost importance since it is one of the primary facilitators for meeting the Sustainable Development Goals (SDGs) and because it promotes social progress and improves the standard of living (Elavarasan et al 2020).

1.2 About India - Energy Scenario

India, the world's second-most highly populated country with an estimated population of 1.35 billion, ranks among the world's largest users of fossil fuels, which is one of the main contributor toward global warming. Population explosion is anticipated to continue until 2050, and as a result, the energy demand in the future decades will be accompanied by significant industrial expansion.

India as a developing nation is dedicated to meet its commitment stated in the Paris Agreement in 2015. As India's Prime Minister Shri. Narendra Modi has proclaimed that "the level of global effort necessary to prevent climate change is still insufficient. To address climate change, a comprehensive strategy is needed that incorporates values, lifestyles, and development goals" (Anjali & Sameer, 2019). India has come up with a clear cut vision and pathway to execute the ambitious action plan across all states in India. India's commitment to combating climate change predates the establishment of the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement. The ancient traditions and practises of this country have instilled in its citizens the desire to develop and flourish alongside nature and to respect and value all that it provides. Therefore, India, although having no legally obligatory mitigation commitments under the Convention, has stated a voluntary target of decreasing the emission intensity of its Gross domestic product (GDP) by 20 to 25 percent above 2005 levels by 2020 (Dhar et al.,

2017). Between 2005 and 2010, the government was able to lower the emission intensity of its gross domestic product by 12% through different administrative, regulatory, and policy initiatives (Lakshmanan and Seetharaman, 2017). In light of this, the United Nations Environment Programme (UNEP) has recognized India for its 2014 Emission Gap Report as one of the nations making excellent progress toward meeting its voluntary targets to combat climate change (Lakshmanan and Seetharaman, 2017).

As per the statistics of Central Electricity Authority (CEA, 2022), the total installed power generation capacity of India is 4,03,760 MW. Out of this only 39.7% (1,59,949 MW) is generated by renewable energy sources (RES). Wind and Solar contributes 10.1% (40,788 MW) and 14.3 % (57,706 MW) respectively.

**Table 1.1: Installed generation capacity in India as on
30.06.2022(CEA, 2022)**

Category	Installed Generation Capacity (MW)	% of share in Total
Fossil Fuel	2,36,065	58.50%
Renewable Energy Sources (Including Hydroelectric Energy)	1,59,949	39.70%
Nuclear	6,780	1.70%
Total Non-Fossil Fuel	1,67,694	41.50%
Total Installed Capacity (Fossil Fuel & Non-Fossil Fuel)	4,03,760	100%

With the backing of the National Institution for Transforming India (NITI) Aayog, the Ministry of New and Renewable Energy (MNRE) is striving to achieve the Indian government's goal of 175 GW of renewable energy resources by 2030. In an effort to satisfy future energy demand, a number of Indian states are expanding their renewable energy capacity at now (Elavarasan et al 2020).

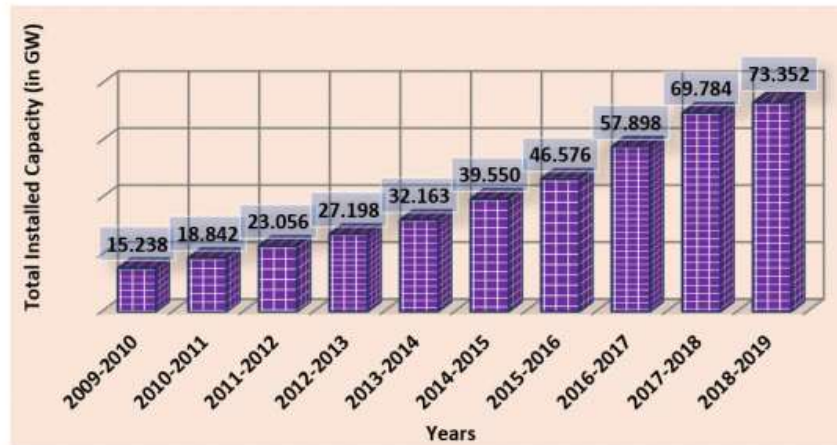


Figure 1.1: Growth of renewable energy over the past decade in India (Elavarasan et al 2020).

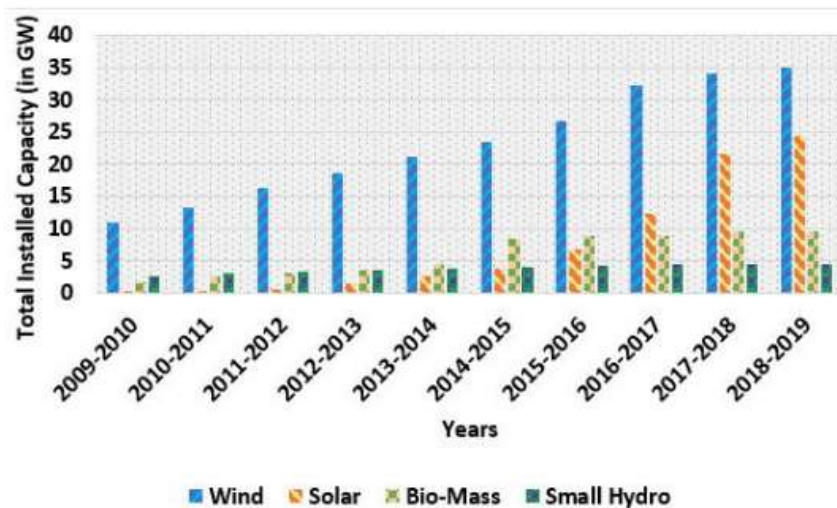


Figure 1.2: Renewable Energy installed capacity of various sources in recent years (Elavarasan et al 2020).

The State-wise installed capacity of Renewable Power (including Off-grid) as on 31.07.2022 is shown in Appendix -1. The table shows that the top states in renewable power generation are Rajasthan (19140.65 MW), Gujarat (17514.97 MW), Tamil Nadu (16725.61 MW), Karnataka (16085.39 MW), and Maharashtra (10799.36 MW). This clearly demonstrates that the past Governments of Tamilnadu have taken the right steps in their journey to transform the state into a 100% renewable energy producing state by 2060.

1.3 About the State of Tamilnadu State, India

Tamilnadu is one of the largest southern states in India, covers 130,058 square kilometres (50,216 square miles), and coastline of about 910 kilometres (600 miles). This state is having population of about 7.67 crores as per March 2022. Tamilnadu accounts for nearly 6% of India's population (census 2022).

It is located in the Indian peninsula between the Bay of Bengal, bordering with States like Kerala, Andra Pradesh and Karnataka. Tamilnadu has 38 districts and 310 taluks and 87 revenue divisions as an Administrative structure. Below figure-1.3 show the glimpse of Tamilnadu (TN, 2022). Tamilnadu is having highest renewable energy sources of Wind and Solar and possibly to generate clean electricity and reducing the carbon emissions in the state and India. Currently Tamilnadu has one third of the installed capacity of renewable energy sources in India. Tamil Nadu is committed to mitigate the climate change effects by bringing out policies to promote renewable energy generation in the State (TEDA, 2014). The Tamilnadu Government committed to make renewable energy a people's movement similar to implementation of rain water harvesting in every home and building.

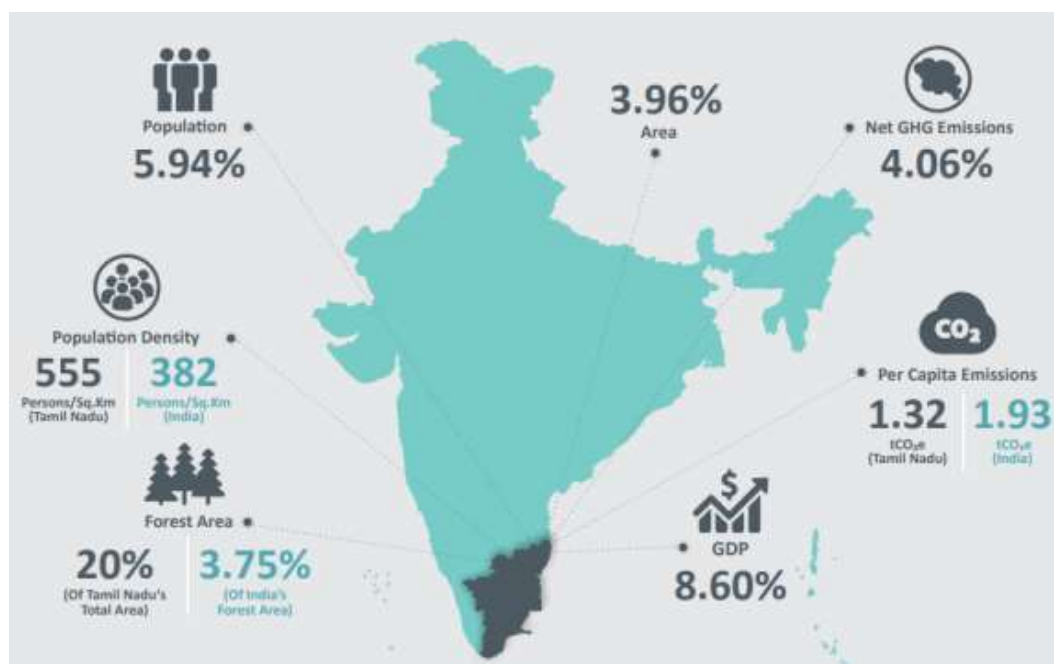


Figure 1.3: Tamilnadu State, India (GHG, 2019)

1.4 Current Status of Tamil Nadu in Renewable Energy

The Indian state of Tamil Nadu has been in the vanguard of India's aggressive decarbonization effort, which aims to cut emissions while simultaneously meeting the demand for electricity and promoting economic development. India is on track to reach its carbon reduction objectives that were agreed upon as part of the Paris deal in 2015, thanks to the fast deployment of renewable energy sources across the country. The state now has growth objectives that may potentially boost the supply of clean energy by a factor of three by the year 2030. The state has already established over 15 GW of capacity for renewable energy sources, which accounts for 16% of India's total. In the same way as the rest of the country, the state of Tamil Nadu is at a pivotal juncture with regard to the design of the electricity market and the structure of the power sector (Udetanshu et al., 20220).

According to data published by the Ministry of New and Renewable Energy (MNRE), Tamil Nadu's total installed renewable capacity was 15,914 MW (15.914 GW) as of January 31, 2022 (Balachandar, 2022). Tamil Nadu was an early proponent of renewable energy and is at the forefront of India's shift to clean energy. As a result of the State government's efforts to become energy independent, there are vast opportunities for solar energy generation across all market segments, including rooftop, large-scale solar parks, and wind-solar hybrid projects including ground-mounted, rooftop, and off-grid capacity. Tamil Nadu's total solar capacity climbed to 4,894 MW as of January 31, 2022, up from 2,575 MW as of March 31, 2019, while wind capacity increased to 9,857 MW from 8,949 MW over the same time period (Balachandar, 2022).

The installed capacity of Renewable Power (including Off-grid) as on 31.07.2022 for the state of Tamil Nadu is shown in Figure 1.4. It is seen that the installed renewable energy capacity of Tamil Nadu has increased from 15,914 MW (January 31, 2022) to 16,725.61 MW (August 31 2022).

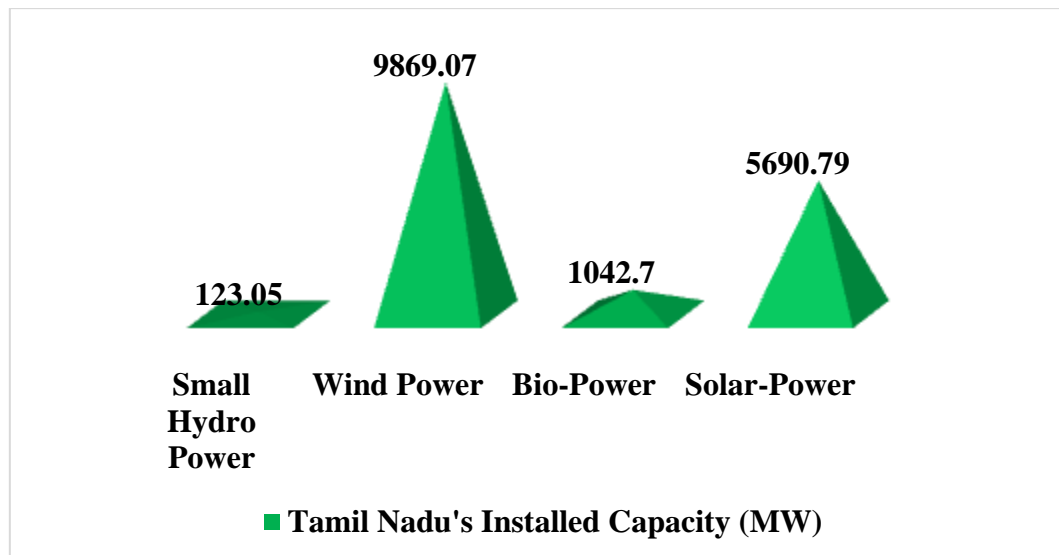


Figure 1.4: Current Status of Tamil Nadu in Renewable Energy

1.5 Problem Statement

The state of Tamilnadu faces acute power shortage leading to factory and industries shutdown during the business hours. The state is already running with the shortfall of 2,500 MW per day against the requirement of 16,000 MW per day (CEA, 2022). This is due to shortage of the coal reserves. This leads to power shutdown of 3-4 hours daily for Manufacturing Industries, Agriculture sector, other commercial sectors which has negative impact on the state economic growth.

The emissions from electricity generation are from using coal, lignite, naphtha and gas-based power plants (GHG, 2019). The state of Tamilnadu energy sector reported 87% of the emissions in total in 2013. Fuel combustion sector contributes 99% emissions and 1% from Fugitive. Energy sector emissions grew from 90.1 MtCo2e to 114.7 MtCo2e between from 2005 to 2013.



Figure 1.5: GHG Emission from Energy Sector in Tamil Nadu

(Source: GHG Platform India <http://www.ghgplatform-india.org/>)

50% of emissions from electricity generation are the high contribution than other sector emissions. Most of the GHG emissions is from coal consuming thermal power plants 52%, and 40% emissions from lignite and 5% emissions from Natural Gas as given in the below figure 1.6. Tamilnadu estimates (MtCO₂e) per capita is 1.27 in 2015.

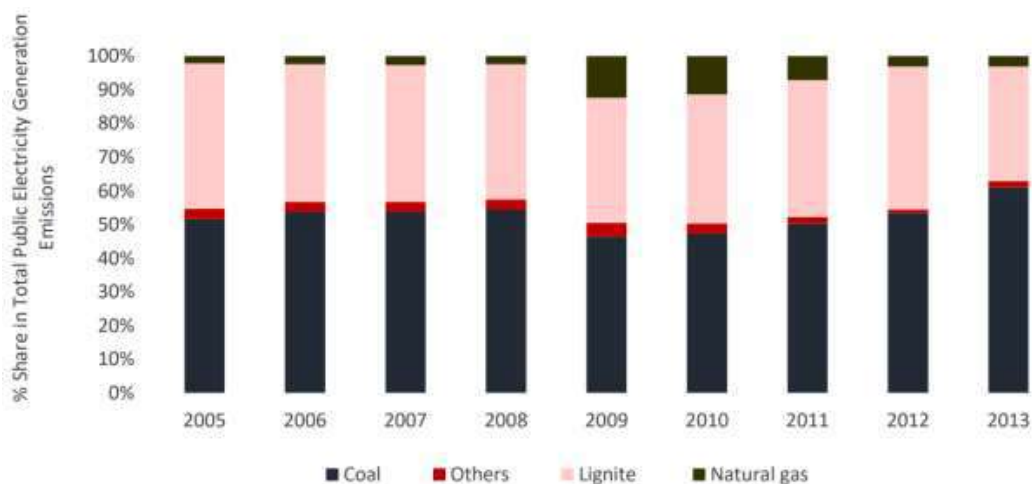


Figure 1.6: GHG Emissions share - Public Electricity Generation

(Source: GHG Platform India <http://www.ghgplatform-india.org/>)

India's commitment to limit global warming 1.50° C indicates reaching Net Zero globally by 2050. In nutshell, clean energy is triggering factor which stimulates the state's social economic development and change undoubtedly. The impacts of energy generation from fossil fuels and depletion of non-renewable energy sources requires immediate actions though demand keep growing. Continuous production and distribution of clean energy security is prime aspect of the sustainable development. It is internationally evident that

clean electricity generating from renewable sources is the solution for containing pollution and greenhouse gas emissions globally. In this work, the pathway in clean energy transition of the state of Tamilnadu, India is explored.

1.6 Research Question

- Can the state of Tamilnadu, India transform to clean renewable electricity 100% Zero emissions by 2060?

1.7 Research Objectives

- To study the current state of growth in renewable energy in India and the state of Tamilnadu.
- To assess the consumers awareness towards transition to renewable energy in the state of Tamilnadu.
- To examine consumers perception toward different influential factors in the adoption of clean energy.
- To examine the challenges perceived by expert/professionals in the clean energy transition.

1.8 Organization of Chapters

The present study is organized into five chapters as described below:

Chapter 1 – Introduction

The first chapter discuss about the energy scenario in India. A brief overview of the current status of renewable energy resources in the state of Tamilnadu is also provided in this chapter. The statement of the problem, justification of the research, research questions, limitations of the study are provided in this chapter.

Chapter 2 – Literature Review

Chapter two is divided into two sections. The first section focuses on a review of the studies on clean energy transition in India. The second section focuses on consumer perception toward renewable energy transition. The concluding

part discusses the key conclusion gained from the literature review and highlights the gap in the literature that drives the present investigation.

Chapter 3 – Research Methodology

The third chapter outlines the research methodology utilized in the study. The chapter describes the study design, sample, and context, as well as the data collecting techniques, their validity and reliability, and the data processing procedure.

Chapter 4 – Data Analysis and Discussion

The fourth chapter presents an in-depth analysis of the data obtained from the participants of the study. The results are given in tabular and graphical formats.

Chapter 5 – Summary and Conclusions

The final chapter provides a summary of the findings and a discussion of the results, as well as ideas and recommendations, key implications, study limitations, future research opportunities, conclusions and suggestions and recommendations.

Chapter 2

REVIEW OF LITERATURE

2.1 Introduction

India has an ambitious goal to increase the use of clean energy, yet until 2021, coal accounts for 71 percent of its electrical mix. Policymakers will benefit from an analysis of the clean energy potential and the capabilities of various states to implement energy transition in the next years.

2.2 REVIEW OF STUDIES ON CLEAN ENERGY TRANSITION IN INDIA

2.2.1 Potential for Clean Renewable Transition

Jha and Singh (2019) have undertaken a study that presents a comprehensive and trustworthy rating of the Indian states in the field of

renewable energy generation. The study adopted a modified Data Envelopment Analysis (DEA) technique to produce a comprehensive and reasonably reliable ranking of states in the production of renewable energy. The result showed that Tamil Nadu was the top state followed by Haryana and Uttar Pradesh (Figure 2.1). The lagging states were Madhya Pradesh, Rajasthan, and Andhra Pradesh. The findings of the study and the rankings obtained will be beneficial for policymakers in identifying the leaders and laggards in the renewable energy industry and, consequently, for fine-tuning policies to promote greater deployment of renewable energy. The rankings will also be beneficial to investors in the industry by providing them with a straightforward method for identifying attractive investment opportunities.

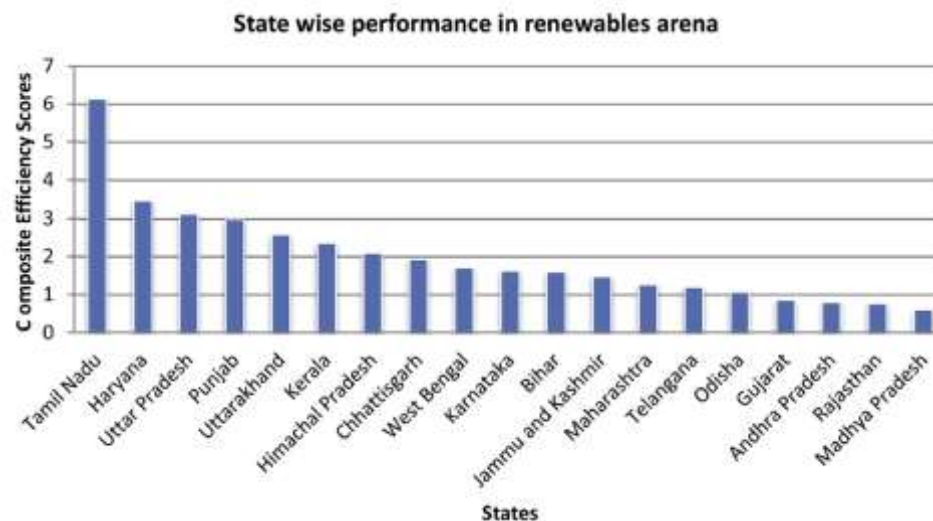


Figure 2.1: State wise performance in Renewable Arena (Jha and Singh (2019))

India's renewable energy capacity is the fourth biggest in the world and is expanding at the quickest rate of all major nations. As of March 31, 2022, India's renewable energy capacity, including big hydro-electric power stations stand at 156.6 gigawatts contributing to 39.2% of its total capacity.

Table 2.1: Total Installed Generation Capacity (Source: Ministry of Power, India)

Source	Installed Capacity (MW)	Share
Coal & Lignite	2,10,700	52.74%
Large Hydro	46,722	11.70%
Other Renewable	1,09,885	27.50%
Gas	24,900	6.23%
Diesel	510	0.13%
Nuclear	6,780	1.70%
TOTAL	3,99,497	100.00%

In the Union government budget 2021 - 2022, Solar Energy Corporation of India has been awarded a whopping capital pool of Rs. 1,000 crore and the Indian Renewable Energy Development Agency has been allocated Rs.1,500 crore. Similarly, the Union budget for 2022-23 has allocated an additional Rs 19,500 crores under the government's PLI (Production Linked Incentive) plan to encourage local manufacture of high-efficiency modules, with a preference for manufacturing units that are completely involved in fabricating integrated solar photovoltaic (PV) modules. In 2020-21, India successfully obtained USD 797.21 million in FDI for the renewable energy sector projects.

As per the data 31st March 2022 (Ministry of Power, Govt of India), the total installed renewable energy capacity in India excluding the existing large hydro-electric power projects in India has revealed that a large chunk of renewable energy is produced by Solar Energy (53,997 MW) which accounts for 49% of the total installed capacity. This is followed by Wind Energy with installed capacity of 40,357 MW accounting for 37% of the total installed capacity. Thus, the data clearly showed that future projects should focus on solar and wind energy as a viable source of renewable energy in future clean energy transition projects.

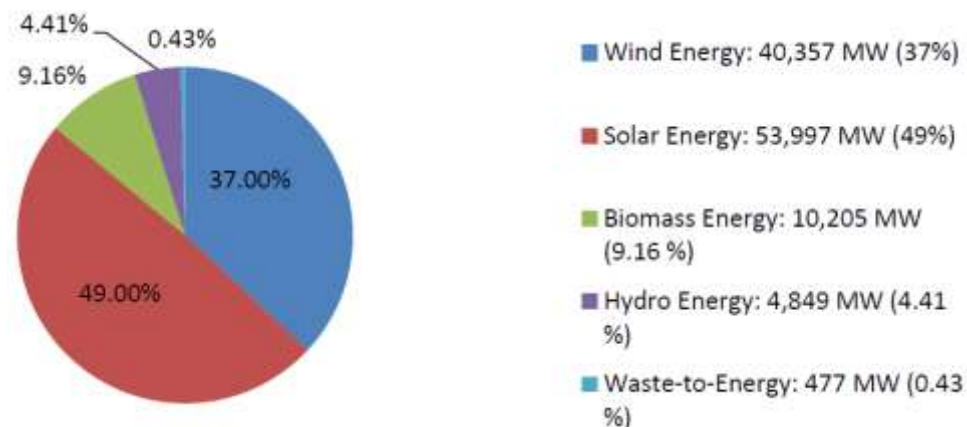


Figure 2.2: Installed Renewable Energy capacity in India
 (Ministry of Power, Govt of India)

2.2.2 Consumer Perception toward Clean Renewable Energy Transition

Painuly (2001) developed a framework to identify the impediments to the penetration of renewable energy and also proposed solutions for overcoming

them. The author stated that though the technology for renewable energy is cost-competitive when compared with traditional energy sources in several applications, their full potential has not yet been fully realised. Even if renewable energy is only able to capture a small portion of the energy market's in developing nations, it might give a vast opportunity for its development. The study found positive efforts to increase the proportion of renewable energy in industrialised nations due to environmental and sustainability issues in energy consumption. However, a number of obstacles are emerging in different quantum from one country to another country, which restricts the penetration of renewable energy production and consumption. An extensive review of literature was carried out to identify the potential barriers for renewable energy. A framework was developed based on the outcome of the literature review, site inspections, and engagement with key stakeholders. The stakeholders consisted of manufacturers of plant, equipment, and appliances, plant owners, consumers, NGOs, experts, policymakers (government), and professional associations. According to the study, some of the major obstacles in the adoption of renewable energy included market barriers, economic and financial barriers, institutional barriers, and technological barriers.

Reddy and Painuly (2004) have conducted a study with households, respondents of industrial and commercial establishments, and policy specialists in order to obtain their perspectives on the hurdles to the proliferation of renewable energy technology. The study was conducted in the state of Maharashtra, India. This study has presented a systematic classification and ranking of barriers to the adoption of renewable energy technologies (economic, technological, market, and institutional) based on the perspectives of various stakeholders. The results demonstrate how consumers acquire renewable energy technology information and use their limited analytical ability to make judgments. By providing concepts based on behavioural theory, the analysis is utilised to increase understanding. These notions not only aid in comprehending the consumer's perspective, but also in the development of governmental responses. The objective is to characterise

each barrier and describe its manner of effect in order to design policy measures for each barrier's elimination.

While aggressive targets are being fixed to enhance the proportion of renewable energy technologies implemented in the various European Union member states, it is becoming apparently evident that societal acceptance could be a major limiting factor that impacts the faster adoption, implementation and utilization of renewable energy technologies. Moula et al (2013) have carried out a study that explored the social acceptance of renewable energy technology implementations in Finland. They developed a questionnaire to measure the awareness of renewable energy technologies and readiness to invest in renewable energy projects. The empirical results showed that 33% of the fifty interviewees indicated that the long-term economic viability of deploying renewable energy technologies in residential settings was not evident. 62% of respondents were willing to pay additional costs to acquire green energy. More over half of those surveyed (52,4%) have believed that the government should take the initial move toward renewable energy generation. Similarly, according to the respondents, the public sector should take the lead in implementing renewable energy technologies by offering economic models and incentives to encourage individuals to put renewable energy technologies in their homes.

Ribeiro et al (2014) have conducted a study in Portugal with public on opinion toward renewable energy technology using a survey research method. The assessment examined four energy sources viz. hydro, wind, biomass, and solar. The study found that hydropower was the most well-known technology, whereas biomass was the least well-known. The study recorded a significant favourable attitude toward new renewable energy projects, which was most obvious for solar power, whereas new hydro power plants had the least but still substantial support. The study also found that in communities with biomass, NIMBYism (not in my back yard) was more evident, yet it was not felt by the great majority of the people. The study concluded that Portuguese public has optimistic view toward solar power plants as the most desired technology from an economic and environmental standpoint. In addition,

hydropower was perceived as the most beneficial to the welfare of local populations. Similarly, people who perceived that renewables would increase power costs also exhibited a strong willingness to pay. On other hand, few respondents have feared that renewable energy consumption would increase the electricity bill. The study has demonstrated that Portuguese people with the possible exception of biomass were usually in favour of the development of additional renewable energy projects in the country.

The catastrophe at Fukushima has affected public perceptions of energy sources and technology, including nuclear energy and other energy sources. Before and after the catastrophe, it would be worthwhile to investigate how the event affected public attitudes of renewable energy and its technology. Park and Ohm (2014) have investigated the consequences of the Fukushima tragedy on public opinions of renewable energy technology in South Korea, the country that is geographically closest to Japan. The study found that before and after the earthquake, there were significant variations in public views, including attitudes, perceived advantages, trust, intention to use, knowledge, and hazards in energy production. In addition, the perceived cost of renewable energy technologies was the key antecedent of the desire to employ the technologies before the accident, whereas public sentiments regarding the technologies were the primary antecedents after the event. Using a multi-dimensional matrix, the authors studied the underlying factors in the public adoption of renewable energy technology by public in South Korea. Based on empirical analysis, it was found that the perceived trust, benefits and risks play key roles in the adoption of renewable energy technologies.

Wojuola and Alant (2017) have pioneered a study on Nigerian public's understanding (comprising knowledge, beliefs, perceptions, and attitude) renewable energy technology. The work utilised a mixed-method approach and was grounded in the theory of reasoned action (TRA) and the technological acceptance paradigm (TAM). The empirical results have revealed that there are substantial positive relationships between perceived utility, perceived ease of use, and intention to use renewable energy technology. Poor impressions of the National Electric Power Authority

(NEPA), a lack of knowledge about how renewable energy technologies are operated, high costs, and corruption have found to be significantly contributed to the public's negative perceptions of the implementation of renewable energy.

Makki and Mosly (2020) have investigated the influence of different factors on the public adoption of renewable energy technology in the western area of Saudi Arabia. Initially, a comprehensive literature analysis was accomplished, which resulted in the identification of 19 factors that influence the public's propensity to accept renewable energy technology. Using an online questionnaire, cross-sectional data were obtained from randomly selected 416 participants. Using exploratory factor analysis and principal component analysis as the data reduction technique, nineteen factors were extracted. These factors were clustered into five major components namely, "cost and government rules and policies", "public awareness and local market", "environment and public infrastructure", "residential construction", and "renewable energy technology systems". The results of the study aid in leading governments, regulatory and policy makers, marketing agencies, and investors to a better understanding of the public's concerns and drivers for adopting renewable energy technology.

Wall et al. (2021) have examined the factors influencing the adoption of renewable energy (RE) by Thai consumers. The research employed a quantitative technique to obtain primary data from a survey of customers in five major Thai cities. Structured equation modelling was used to examine the data (SEM). The results of the empirical analyses have shown that perceptions of self-efficacy, environmental concern, awareness toward renewable energy, and perceptions on the advantages of renewable energy have a substantial and favourable influence on consumers' desire to adopt renewable energy. It was discovered that the cost of renewable energy had a negative but insignificant effect on consumers' adoption of renewable energy, whereas risk/trust perception had a positive but insignificant effect.

Indrajayanthan and Mohanty (2022) have undertaken a study to evaluate the possibilities for a transition to clean energy by analysing the top seven power-producing states in India like Maharashtra, Gujarat, Tamil Nadu, Uttar Pradesh, Karnataka, Madhya Pradesh, and Andhra Pradesh. Using multicriteria decision analysis approaches namely Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) and Multi-Objective Optimization Technique by Ratio Analysis (MOORA), the clean energy transition potential was evaluated. The study was grounded on four primary factors that included reliance on high carbon energy resources, reliance on low carbon energy resources, clean energy potential, and policy support. In addition to these four criteria at the primary level, the study focused on another fourteen criteria at the secondary level. Using the Fuzzy Analytic Hierarchy Process (AHP), the relative importance of each parameter and criteria to the features of the potential for the transition to clean energy was analysed. The results revealed that the state of Gujarat has the greatest potential for transitioning to renewable energy based on both multi-criteria decision analysis approaches. In contrast, Uttar Pradesh performed the worst, and a comprehensive energy shift to renewable resources could be less possible in this state. The remaining states were ranked intermediately, and a comparison of the two methodologies was also conducted. This study recommends that India should prioritise a clean energy strategy with a strong emphasis on high-performing states, which will expedite the decarbonization of the power industry.

2.3 Literature Review Summary and Framing of Hypothesis

In this work we hypothesize that the socio-psychological factors might play an important role in the transition toward renewable energy sources in the state of Tamilnadu. Thus, the review focussed on the awareness, attitude and acceptance toward the adoption of renewable energy sources instead of conventional fossil fuel-based energy sources.

However the review has clearly demonstrated that there is a dearth of studies focussing on India on the level of awareness, attitude, perception toward renewable energy technology implementation and transition to renewable

energy. Particularly, studies pertaining to the state of Tamil Nadu which is the front runner in terms of the implementation of renewable energy projects is hard to find. Thus, the present study has been designed to fill the gap in research literature on what would be the perception of Tamil Nadu public in its journey in the adoption of clean energy based on renewable energy technologies. The proposed study addresses the research question that Can the State of Tamil Nadu transform to clean renewable energy 100% Zero Emissions by 2060?.

2.4 Operationalization of Variables

Based on the review and analysis of factors in clean energy transition, this study has identified six potential factors in the clean energy transition process. The factors considered for measurement was based on the variables like awareness, belief, perception, concern, cost and intention to use. The factors used in the study were,

- Consumer awareness toward clean energy,
- Consumer belief about clean energy,
- Self-Effectiveness perception,
- Environmental concern,
- Perception toward cost of generation of clean energy and
- Intention to adopt renewable energy.

Consumer Awareness

Consumer awareness is one of the main factors that influence the adoption of renewable energy technology (Wall et al. 2021). It measures consumers' perception and knowledge toward the advantages, drawbacks, cost associated with the use of renewable energy technologies (Irfan et al. 2021). Often consumers with heightened awareness toward the application of renewable energy technologies for sustainable environment tend to develop positive attitude toward its adoption (Cruz et al. 2020).

Consumer belief

Perceived belief of consumers toward a particular products/technology has significant impact on the purchase intention that particular products/technology (Wall et al. 2021). Thus, if the consumers strongly believe that the proposed renewable energy adoption would enhance their socio-economic aspects positively, they would develop the intention to use the clean energy products (Ntanos et al. 2018).

Self-Effectiveness Perception

Self-effectiveness focus on the belief of individuals on their efficacy in the adoption of new technologies like renewable energy and abilities to perform (Zainudin et al. 2022). More than individual skills, Self-Effectiveness focus on the perspectives of the use of new technology in achieving the desired results (Makki and Mosly 2020).

Environmental Concern

Concern for the environment refers to an individual's understanding and knowledge and position on environmental problems including pollution and climate change. Consumers are increasingly becoming more conscious and dedicated to tackling these problems as a result of greater worldwide knowledge toward developing environmental challenges (Jabeen et al. 2019).

Perception toward cost of Renewable Energy

Cost of transition toward renewable energy is one of the determining factors in the adoption of renewable energy (Wall et al. 2021). It is an undeniable fact that the installation of renewable energy technologies requires higher capital and involves high risks in the construction of renewable energy projects. Several studies have pointed that the high cost related with renewable energy projects could negatively impact consumers toward the adoption of renewable energy technologies (Kiprop et al. 2019; Majid 2020).

Intention to Adopt Renewable Energy

According to Theory of Planned Behaviour (TPB) (Fishbein and Ajzen 1977), behaviour of an individual is influenced by his/her behavioural intention. This

implies that people contemplate the repercussions of their actions before engaging in behaviour and often prefer to engage in behaviours that may lead to intended results. TPB has been popularly used in studies related with reasoning the performance of behaviour and intention (Liu et al. 2013). In this work TPB has been adopted for measuring the attitude toward transition to renewable energy. However, instead of measuring actual behaviour or prediction of behaviour, this study measured the intention to involve in the behaviour (Adoption of Renewable Energy).

2.5 Framing of Hypothesis

As an outcome of the review in literature and factors identified, Six hypotheses were developed to examine the significance of the difference in the mean rating on different factors in Clean Energy Transition based on the gender, marital status, age, qualification, experience, and income of the participants. The hypotheses are stated below:

- H1: No significant difference is observed in the mean rating given by participants toward different factors in Clean Energy Transition based on the Gender
- H2: No significant difference is observed in the mean rating given by participants toward different factors in Clean Energy Transition based on Marital Status.
- H3: No significant difference is observed in the mean rating given by participants toward different factors in Clean Energy Transition based on the Age.
- H4: No significant difference is observed in the mean rating given by participants toward different factors in Clean Energy Transition based on the Qualification.
- H5: No significant difference is observed in the mean rating given by participants toward different factors in Clean Energy Transition based on the Experience Level.

- H6: No significant difference is observed in the mean rating given by participants toward different factors in Clean Energy Transition based on the Income Level.
- H7: The different perceptual factors in clean energy transition have significant impact on the Intention to Adopt Renewable Energy.

Chapter 3

Research Methodology

3.1 Introduction

Research methodology is the mechanism through which researchers undertake their investigations. It illustrates how a research scholar constructs the research problem and objectives and presents his/her conclusions based on the data collected throughout the period of study. This chapter also describes how the final research outcome will be attained in accordance with the study's objective. This chapter presents methodology adopted in the research process. The chapter describes the research design, sampling design, and context, as well as the data collecting techniques, their validity and reliability, and the data processing procedure.

3.2 Research Design

The main purpose of the research design is to provide an appropriate framework for the study. Research design serves as a guide for data collection and analysis. It is the plan that must be adhered to when conducting a study (Churchill, 1996). The research design aids a researcher in ensuring that the study is acceptable and relevant to the context of the research and that all essential procedures are followed properly and effectively (Naoum, 2012).

This work employed descriptive research design to assess the perception of consumers toward different factors in clean energy transition. The reason for using descriptive research design was that it can accurately depict people,

events, or circumstances. This methodology offers researchers with a profile of the phenomena of interest from an individual, organisational, and business perspective (Miller 1991; Saunders et al. 2009).

3.3 Population and Sample

The population consisted of consumers of electricity in the Chennai Region, Tamilnadu. The inclusion criteria in the selection of participants were based on average consumption per household exceeding 600 units in a month. The entire Chennai Region was divided into five zones and 40 participants were selected randomly from each zone for the study. Thus, the overall sample size was 200. In addition, 25 expert/professionals from electricity companies were also included in the study for gaining deeper insights in identifying the hurdles in 100% transition toward clean energy by 2060. In total, data were collected from 200 respondents. However, some responses from consumers were received with missing details and wrongly filled information. Hence, only 175 responses were identified as suitable for final data analysis. The effective response rate was 87.5%. Convenient sampling procedure was used to select the expert/professionals from electricity companies for the study.

3.4 Sources of Data

The study used both primary data and secondary data. The primary data were collected from the participants of the study (consumers, professionals/experts). On the other hand, the secondary data were collected from different sources. The main sources of secondary data included research reports, technical reports, whitepapers, periodicals, journal articles, newspapers, websites, magazines and other sources.

3.5 Design of Survey Instrument

Based on the insights and ideas generated from the review of literature, the questionnaire for the study was designed. In addition, several past works have been referred to develop the items for measuring the factors. The factors like Awareness toward Clean Energy and Intention to Adopt Renewable Energy were developed based on the work of Alam (et al. 2014). Liu et al.

(2013) was used for developing the constructs for measuring Self-Effectiveness Perception and Belief about Clean Energy. Jabeen et al. (2019) was used for developing the items for measuring Environmental Concern and Makki and Mosly (2020) was used to develop the items in Perception toward Cost of Generation of Clean Energy.

The variable (factors) identified for measurement were Awareness toward Clean Energy (measured using 5 items), Belief about Clean Energy (5 items), Self-Effectiveness Perception (5 items), Environmental Concern (5 items), Perception toward Cost of Generation of Clean Energy (4 items) and Intention to Adopt Renewable Energy (4 items). Out of these six factors, first five were input factors (predictor) and the factor “Intention to Adopt Renewable Energy” acted as outcome (dependent) variables.

The first section of the survey instrument measures the demographic and professional characteristics of the study participants like Gender, Age, Marital Status, Occupation, Education, and Income. The study also measured participants perception on the importance of Transition to Renewable Energy for the state of Tamilnadu. The second section measures the perception toward different factors influencing the renewable energy adoption. 28 items were used to measure the factors in Clean Energy Transition. The questionnaire was designed based on five-point Likert scale with rating ranges between 1 to 5 where 1: Strongly Disagree (SD), 2 : Disagree (D), 3 : Neutral (N), 4 : Agree (A) and 5 : Strongly Agree (SA). The conceptual model of the study is presented in Figure 3.1.

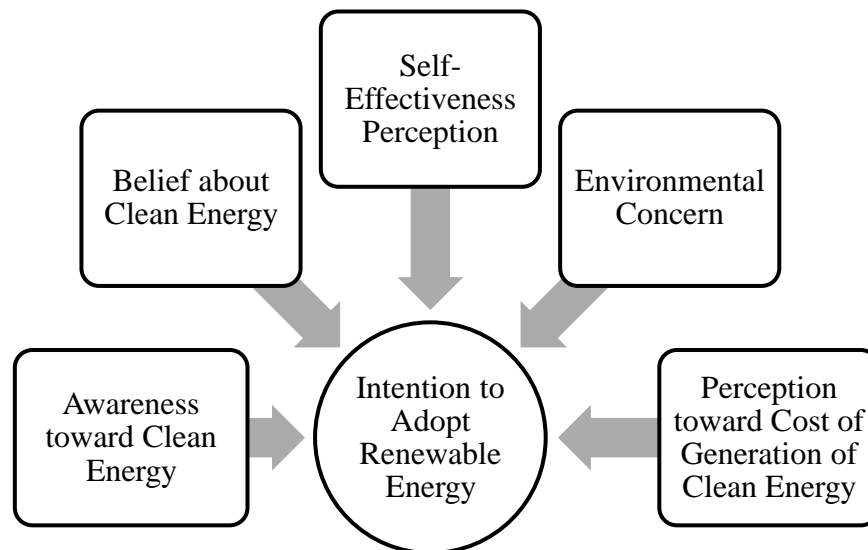


Figure 3.1: Conceptual Framework

3.6 Validity Measurement

The validity of the instrument was tested using face validity method. Face validity refers to the subjective evaluations of the presentation and applicability of a questionnaire by researchers in terms of whether its items look meaningful, logical, clear, and obvious (Babbie 2020).

A team of experts was employed to evaluate the face validity of the survey instrument. The panel of experts comprised of two faculty members and two experts from renewable energy technologies firm. The questionnaire was scrutinised in every respect. Few alterations were made to the final version of the instrument as a result of the feedback from the expert team. The panel also contributed to the improvement of the instrument's aesthetics by providing acceptable language and usage of appropriate word for the instrument's statements to increase lucidity and conciseness.

3.7 Reliability Measurement

In quantitative research, reliability is associated with trustworthiness, stability, and repeatability in time of the survey instruments (Cohen et al. 2007). In this study, internal consistency method (Cronbach's alpha) was used to measure the consistency of the instrument. The value of Cronbach's alpha coefficient ranges between zero and one. As a rule of thumb, Cronbach's alpha

coefficient value of greater than 0.7 indicates that the instrument is reliable (Hair et al., 1998).

For measuring the reliability, a pilot test with a representative sample of 30 respondents was conducted. The results indicated that all the six factors have recorded Cronbach alpha coefficient value above 0.7. This confirmed the reliability of the instrument and it was decided to pursue the main study.

3.8 Statistical Analysis Procedure

The data collected from the study participants was subjected to statistical analyses using SPSS software package (Version 21.0). The data analysis procedures performed in the study included frequency and percentage analysis, mean, standard deviation, skewness, kurtosis analysis, reliability statistics, mean comparisons using Independent Sample t-test and One way Analysis of Variance (ANOVA) and finally, linear regression analysis.

3.9 Summary

This chapter has provided an overview of the overall methodology adopted in the study. Using the descriptive research method and mixed method of research both quantitative and qualitative data were collected from the respondents of the study. This chapter provided a detailed description of the population and sampling procedure, details of the instrument, validity and reliability using pilot study, and plan of statistical analysis procedure. The subsequent chapters discuss on the analysis of results and discussions on findings.

Chapter 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter summarizes the findings of the data analysis based on the information gathered from energy users in the Chennai Region, Tamil Nadu. For data analysis, Statistical Package for the Social Sciences (SPSS) Version 21.0 was utilized. The chapter was divided into two sections, the first of which discussed the descriptive statistical analysis, in which statistical techniques such as frequency, percentage, mean, and standard deviation were used to analyse the responses to the questionnaires employed in the study's data collection. The next part focuses on inferential statistics, which include testing hypotheses with different statistical analysis procedures and methods

4.2 Demographical Profile of the Participants

4.2.1 Gender

The gender details of the study participants are shown in Table 4.1. It is evident that majority of the study participants are male 67.4% (N=118). 32.6% (N = 57) of the study participants were female.

Table 4.1: Gender Profile

Gender	Frequency	Percent
Male	118	67.4
Female	57	32.6
Total	175	100.0

4.2.2 Marital Status

The marital status of the participants of the study shows that majority were Un-married 61.1% (N = 107) and only 38.9% (N = 68) of the participants were married (Table 4.2).

Table 4.2: Marital Status

Marital Status	Frequency	Percent
Un-married	107	61.1
Married	68	38.9
Total	175	100.0

4.2.3 Age

The age profile of the participants of the study is presented in Table 4.3.

Table 4.3: Age Profile

Age (Yrs)	Frequency	Percent
18 – 34	70	40.0
35 – 54	69	39.4
Above 54	36	20.6
Total	175	100.0

From the table, it is clear that majority of the participants (40.0%, N = 70) are young belonging to age group 18 - 34 years, closely followed by participants with age group of 35 – 54 (39.4%, N = 69). The sample also included participants above 54 years (20.6%, N = 36).

4.2.4 Educational Qualification

The educational qualification of the participants of the study is presented in Table 4.4.

Table 4.4: Educational Qualification

Educational Qualification	Frequency	Percent
Higher Secondary and Below	31	17.7
Under Graduate	67	38.3
Post Graduate	44	25.1
Others	33	18.9
Total	175	100.0

The majority of the participants 38.3% (N=67) have Undergraduate Qualification. Around 25.1% (N=44) of participants are having Post Graduate qualification. 18.9% (N = 33) of participants have “Others” qualification which includes certifications, doctorate, etc. Around 17.7% (N = 31) of participants have educational qualification higher secondary and below level.

4.2.5 Occupation

The details of occupation of the participants are shown in Table 4.5.

Table 4.5: Occupation

Occupation	Frequency	Percent
Self-Employed	23	13.1
Privately Company Employee	69	39.4
Government Employee	48	27.4
Other	35	20.0
Total	175	100.0

It is seen that most of the participants 39.4% (N = 69) are privately employed in organizations. 27.4% (N = 48) of participants were employed in government organizations. 20% (N=35) were consisted of homemakers, part-time participants and involved other businesses like financing, running chit-funds etc. 13.1% (N = 23) of participants were self-employed and running their own businesses.

4.2.6 Income

The details of income level of the participants of the study are presented in Table 4.6.

Table 4.6: Income

Income Per Month (Rs.)	Frequency	Percent
Below 25,000	69	39.4
25,001-50000	30	17.1
51,000-75,000	18	10.3

Income Per Month (Rs.)	Frequency	Percent
76,000 – 1,00,000	38	21.7
1,00,000 above	20	11.4
Total	175	100.0

From the above table, it is clear that majority of the participants 39.4% (N = 69) were drawing income below Rs. 25000 per month. 21.7% (N = 38) of participants were earning between Rs. 76,000 – Rs. 1,00,000 per month. 17.1% (N= 30) of participants were earning between Rs. 25,001 – Rs. 50000. The study also included participants with income above Rs. 1 lac per month 11.4% (N=20). Finally, 10.3% (N=18) of the participants have income between Rs. 51,000 – Rs. 75,000.

4.3 Importance of Transition to Renewable Energy for Tamilnadu

The study analysed the perception of participants about how important it is for the state of Tamilnadu to adopt and use renewable energy as an alternative to fossil fuel-based energy production methods.

Table 4.7: Transition to Renewable Energy

Level of Importance	Frequency	Percentage
Very Important	88	50.29
Somewhat Important	55	31.43
Not Important At All	22	12.57
No Opinion	10	5.71
Total	175	100.00

50.29% (N=88) of participants have expressed that the transition to renewable is inevitable and imminent. 31.43% (N=55) have believed that that the transition to renewable is Somewhat Important. While 12.57% (N=22) have opined that the transition to renewable is not important at all. The study observed that the participants who opposed the complete transition to renewable energy have pointed out that installing renewable energy sources like wind mills and solar energy parks require large swath of land area and

huge cost for installation and maintenance. They argue that agricultural lands are being taken away from farmers for developing energy parks.

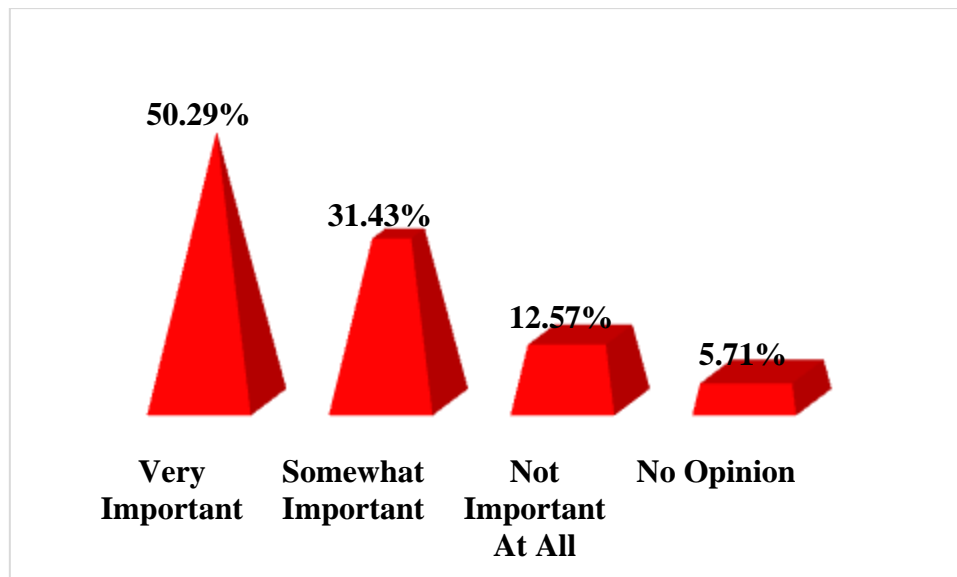


Figure 4.1: Importance of Transition to Renewable Energy for Tamilnadu

4.4 Descriptive Statistics

Table 4.8 displays the descriptive statistics for the data gathered from the research participants. Minimum Statistic, Maximum Statistic, Mean, Standard Deviation, Skewness, and Kurtosis are the descriptive statistics evaluated in the study.

Table 4.8: Descriptive Statistics (N=175)

Factors	Minimum	Maximum	Mean (M)	Standard Deviation (SD)	Skewness	Kurtosis
Awareness toward Clean Energy	3.60	5.00	4.31	0.41	0.49	-0.86
Belief about Clean Energy	3.00	5.00	3.85	0.63	0.83	-0.50
Self-Effectiveness Perception	3.00	5.00	3.80	0.62	1.23	-0.04
Environmental Concern	2.00	5.00	3.74	0.50	0.12	1.80
Perception toward Cost of Generation of Clean Energy	3.00	5.00	3.95	0.57	0.70	-0.29

Intention to Adopt Renewable Energy	2.00	5.00	3.92	0.45	0.24	1.36
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From the above Table 4.8, it is found that, the factor “Awareness toward Clean Energy” was highly rated with mean value of 4.31 and standard deviation of 0.41, followed by “Perception toward Cost of Generation of Clean Energy” (M = 3.95, SD = 0.57) and “Intention to Adopt Renewable Energy” (M = 3.92, SD = 0.45). The factor “Belief about Clean Energy” received a mean rating of 3.85 (SD = 0.63) and the factor “Self-Effectiveness Perception” received a mean rating of 3.80 (SD = 0.62). the factor “Environmental Concern” received the lowest mean rating (M = 3.74, SD = 0.50). The Skewness and Kurtosis values for all the study factors are within the specified range of (+2 to -2) suggesting that the data is normal and suitable for further statistical investigation.

4.5 Reliability Statistics

The reliability of the questionnaire items was tested using coefficient of reliability - "Cronbach's Alpha". Cronbach's Alpha values vary from zero to one. The bigger the value of Cronbach's alpha, the more reliable the survey questionnaire will be (Nunnally 1975). In general, a Cronbach Alpha score above 0.7 indicates that the questionnaire is reliable.

Table 4.9: Reliability Analysis

Factors	No. of Items	Cronbach's Alpha
Awareness toward Clean Energy	5	0.857
Belief about Clean Energy	5	0.948
Self-Effectiveness Perception	5	0.931
Environmental Concern	5	0.882
Perception toward Cost of Generation of Clean Energy	4	0.918
Intention to Adopt Renewable Energy	4	0.754

Table 4.9 displays the Cronbach's alpha values of the study's variables. Clearly, the Cronbach's alpha values of all the items used to measure the factors are above the minimum threshold of 0.7. Therefore, it can be affirmed that the survey questionnaire employed in this study is trustworthy and may be utilized to collect data from the study's sample of participants.

4.6 Hypothesis Testing

4.6.1 Hypothesis 1

Null Hypothesis H1: No significant difference is observed in the mean rating given by participants toward different factors in Clean Energy Transition based on the Gender.

Independent sample t-test was used to test this hypothesis with gender of the participants as the independent variable and Clean Energy Transition factors like "Awareness toward Clean Energy", "Belief about Clean Energy", "Self-Effectiveness Perception", "Environmental Concern", "Perception toward Cost of Generation of Clean Energy" and "Intention to Adopt Renewable Energy" were used as the dependent variables.

Table 4.10: Independent Sample t-test between Gender of the participants and Clean Energy Transition Factors

Factors	Gender	N	Mean	Standard Deviation	t-value	p-value
Awareness toward Clean Energy	Male	118	4.27	0.42	2.19	0.03*
	Female	57	4.41	0.38		
Belief about Clean Energy	Male	118	3.80	0.63	1.60	0.11(ns)
	Female	57	3.96	0.63		
Self-Effectiveness Perception	Male	118	3.77	0.59	1.05	0.30(ns)
	Female	57	3.87	0.67		
Environmental Concern	Male	118	3.74	0.50	0.22	0.83(ns)
	Female	57	3.73	0.51		
Perception toward Cost of Generation of Clean Energy	Male	118	3.92	0.60	1.11	0.27(ns)
	Female	57	4.02	0.52		

Factors	Gender	N	Mean	Standard Deviation	t-value	p-value
Intention to Adopt Renewable Energy	Male	118	3.90	0.43	0.87	0.39(ns)
	Female	57	3.96	0.50		

*. Significant at 0.05 level (2-tailed). (ns) No-significance

From the above table 4.10, it can be seen that male and female participants of the study do not differ significantly in the mean rating for all the factors in Clean Energy Transition except “Awareness toward Clean Energy” as the p-value exceeds 0.05. However, male and female participants of the study differ significantly on “Awareness toward Clean Energy” as the p-value is less than 0.05 and t-value is 2.19.

Result; The null hypothesis that “No significant difference is observed in the mean rating given by participants toward different factors in Clean Energy Transition based on the Gender” was accepted for all the factors in Clean Energy Transition except “Awareness toward Clean Energy”.

4.6.2 Hypothesis 2

Null Hypothesis H2: No significant difference is observed in the mean rating given by participants toward different factors in Clean Energy Transition based on Marital Status.

Independent sample t-test was used to test this hypothesis with Marital Status of the participants as the independent variable and Clean Energy Transition factors like “Awareness toward Clean Energy”, “Belief about Clean Energy”, “Self-Effectiveness Perception”, “Environmental Concern”, “Perception toward Cost of Generation of Clean Energy” and “Intention to Adopt Renewable Energy” were used as the dependent variables.

Table 4.11: Independent Sample t-test between Marital Status of the participants and Factors in Clean Energy Transition

Factors	Marital Status	N	Mean	Standard Deviation	t-value	p-value
Awareness toward Clean Energy	Single	107	4.28	0.42	-1.39	0.16(ns)
	Married	68	4.37	0.40		
Belief about Clean Energy	Single	107	3.80	0.64	-1.30	0.20(ns)
	Married	68	3.93	0.62		
Self-Effectiveness Perception	Single	107	3.77	0.60	-0.70	0.48(ns)
	Married	68	3.84	0.64		
Environmental Concern	Single	107	3.70	0.52	-1.12	0.26(ns)
	Married	68	3.79	0.46		
Perception toward Cost of Generation of Clean Energy	Single	107	3.93	0.61	-0.73	0.47(ns)
	Married	68	3.99	0.51		
Intention to Adopt Renewable Energy	Single	107	3.91	0.43	-0.54	0.59(ns)
	Married	68	3.94	0.48		

(ns) No-significance

From the above table 4.11, it is evident that married and unmarried participants of the study have not differed significantly in the mean rating for all the factors in Clean Energy Transition as the p-value exceeds 0.05.

Result: The null hypothesis that “No significant difference is observed in the mean rating given by participants toward different factors in Clean Energy Transition based on Marital Status” was accepted for all the factors in Clean Energy Transition.

4.6.3 Hypothesis 3

Null Hypothesis H3: No significant difference is observed in the mean rating given by participants toward different factors in Clean Energy Transition based on the Age

One way ANOVA test was used to test this hypothesis with Age of the participants as the independent variable and Clean Energy Transition factors like “Awareness toward Clean Energy”, “Belief about Clean Energy”, “Self-

Effectiveness Perception”, “Environmental Concern”, “Perception toward Cost of Generation of Clean Energy” and “Intention to Adopt Renewable Energy” were used as the dependent variables.

Table 4.12: One Way ANOVA between Age of the participants and Factors in Clean Energy Transition - Descriptive

Factors	Age (Years)	N	Mean	Standard Deviation
Awareness toward Clean Energy	18 – 34 yrs	70	4.29	0.42
	35-54 yrs	69	4.29	0.42
	Above 54 yrs	36	4.39	0.39
	Total	175	4.31	0.41
Belief about Clean Energy	18 – 34 yrs	70	3.77	0.63
	35-54 yrs	69	3.92	0.67
	Above 54 yrs	36	3.87	0.56
	Total	175	3.85	0.63
Self-Effectiveness Perception	18 – 34 yrs	70	3.77	0.59
	35-54 yrs	69	3.86	0.67
	Above 54 yrs	36	3.74	0.55
	Total	175	3.80	0.62
Environmental Concern	18 – 34 yrs	70	3.68	0.54
	35-54 yrs	69	3.76	0.46
	Above 54 yrs	36	3.82	0.48
	Total	175	3.74	0.50
Perception toward Cost of Generation of Clean Energy	18 – 34 yrs	70	3.83	0.54
	35-54 yrs	69	4.04	0.62
	Above 54 yrs	36	4.02	0.52
	Total	175	3.95	0.57
Intention to Adopt Renewable Energy	18 – 34 yrs	70	3.88	0.46
	35-54 yrs	69	3.96	0.41
	Above 54 yrs	36	3.92	0.51
	Total	175	3.92	0.45

Table 4.13: One Way ANOVA between Age of the participants and Factors in Clean Energy Transition

Factors	Mean Comparison	Sum of Squares	df	Mean Square	F-value	p-value
Awareness toward Clean Energy	Between Groups	0.30	2.00	0.15	0.88	0.42(ns)
	Within Groups	29.42	172.00	0.17		
	Total	29.72	174.00			
Belief about Clean Energy	Between Groups	0.83	2.00	0.41	1.03	0.36(ns)
	Within Groups	68.99	172.00	0.40		
	Total	69.82	174.00			
Self-Effectiveness Perception	Between Groups	0.45	2.00	0.22	0.59	0.56(ns)
	Within Groups	65.47	172.00	0.38		
	Total	65.92	174.00			
Environmental Concern	Between Groups	0.51	2.00	0.26	1.03	0.36(ns)
	Within Groups	42.74	172.00	0.25		
	Total	43.25	174.00			
Perception toward Cost of Generation of Clean Energy	Between Groups	1.71	2.00	0.85	2.65	0.07(ns)
	Within Groups	55.46	172.00	0.32		
	Total	57.17	174.00			
Intention to Adopt Renewable Energy	Between Groups	0.23	2.00	0.12	0.57	0.56(ns)
	Within Groups	35.05	172.00	0.20		
	Total	35.29	174.00			

(ns) No-significance

From the Table 4.13, it is apparent that there was no significant difference on the mean rating between participants from different age group on all Clean Energy Transition Factors (as the p-value exceeds 0.05).

Result: The hypothesis that “No significant difference is observed in the mean rating given by participants toward different factors in Clean Energy Transition based on the Age” was accepted.

4.6.4 Hypothesis 4

Null Hypothesis H4: No significant difference is observed in the mean rating given by participants toward different factors in Clean Energy Transition based on the Qualification

One way ANOVA test was used to test this hypothesis with Qualification of the participants as the independent variable and Clean Energy Transition factors like “Awareness toward Clean Energy”, “Belief about Clean Energy”, “Self-Effectiveness Perception”, “Environmental Concern”, “Perception toward Cost of Generation of Clean Energy” and “Intention to Adopt Renewable Energy” were used as the dependent variables.

Table 4.14: One Way ANOVA test between Qualification of the participants and Factors in Clean Energy Transition – Descriptive

Factors	Qualification	N	Mean	Standard Deviation
Awareness toward Clean Energy	Higher Secondary and Below	31	4.39	0.48
	Under Graduate	67	4.29	0.42
	Post Graduate	44	4.24	0.32
	Others	33	4.39	0.43
	Total	175	4.31	0.41
Belief about Clean Energy	Higher Secondary and Below	31	3.94	0.82
	Under Graduate	67	3.79	0.56
	Post Graduate	44	3.80	0.61
	Others	33	3.96	0.62
	Total	175	3.85	0.63
Self-Effectiveness Perception	Higher Secondary and Below	31	4.02	0.75
	Under Graduate	67	3.73	0.55

Factors	Qualification	N	Mean	Standard Deviation
	Post Graduate	44	3.72	0.54
	Others	33	3.84	0.67
	Total	175	3.80	0.62
Environmental Concern	Higher Secondary and Below	31	4.03	0.51
	Under Graduate	67	3.56	0.54
	Post Graduate	44	3.83	0.33
	Others	33	3.70	0.44
	Total	175	3.74	0.50
Perception toward Cost of Generation of Clean Energy	Higher Secondary and Below	31	3.81	0.57
	Under Graduate	67	3.91	0.54
	Post Graduate	44	4.03	0.62
	Others	33	4.07	0.55
	Total	175	3.95	0.57
Intention to Adopt Renewable Energy	Higher Secondary and Below	31	3.97	0.68
	Under Graduate	67	3.86	0.42
	Post Graduate	44	3.93	0.30
	Others	33	3.98	0.41
	Total	175	3.92	0.45

Table 4.15: One Way ANOVA test between Qualification of the participants and Factors in Clean Energy Transition

Factors	Mean Comparisons	Sum of Squares	df	Mean Square	F-value	p-value
Awareness toward Clean Energy	Between Groups	0.68	3.00	0.23	1.34	0.26(ns)
	Within Groups	29.04	171.00	0.17		
	Total	29.72	174.00			
Belief about Clean Energy	Between Groups	1.00	3.00	0.33	0.83	0.48(ns)
	Within Groups	68.82	171.00	0.40		
	Total	69.82	174.00			
Self-	Between	2.12	3.00	0.71	1.89	0.13(ns)

Factors	Mean Comparisons	Sum of Squares	df	Mean Square	F-value	p-value
Effectiveness Perception	Groups					
	Within Groups	63.80	171.00	0.37		
	Total	65.92	174.00			
Environmental Concern	Between Groups	5.11	3.00	1.70	7.64	0.00**
	Within Groups	38.14	171.00	0.22		
	Total	43.25	174.00			
Perception toward Cost of Generation of Clean Energy	Between Groups	1.51	3.00	0.50	1.55	0.20(ns)
	Within Groups	55.66	171.00	0.33		
	Total	57.17	174.00			
Intention to Adopt Renewable Energy	Between Groups	0.42	3.00	0.14	0.69	0.56(ns)
	Within Groups	34.87	171.00	0.20		
	Total	35.29	174.00			

** . Significant at 0.01 level (2-tailed). (ns) No-significance

From the Table 4.15, it is apparent that there was no significant difference on the mean rating between participants from different Qualification group on all Clean Energy Transition Factors (except “Environmental Concern”) as the p-value exceeds 0.05.

Result: The hypothesis that “No significant difference is observed in the mean rating given by participants toward different factors in Clean Energy Transition based on the Qualification” was accepted for all factors except “Environmental Concern”.

4.6.5 Hypothesis 5

Null Hypothesis H5: No significant difference is observed in the mean rating given by participants toward different factors in Clean Energy Transition based on the Experience Level

One way ANOVA test was used to test this hypothesis with Work Experience of the participants as the independent variable and Clean Energy Transition factors like “Awareness toward Clean Energy”, “Belief about Clean Energy”, “Self-Effectiveness Perception”, “Environmental Concern”, “Perception toward Cost of Generation of Clean Energy” and “Intention to Adopt Renewable Energy” were used as the dependent variables.

Table 4.16: One Way ANOVA between Experience of the participants and Factors in Clean Energy Transition – Descriptive

Factors	Experience Level	N	Mean	Standard Deviation
Awareness toward Clean Energy	Less than 5 years	23	4.27	0.40
	5 to 10 years	69	4.27	0.42
	10 to 15 years	48	4.30	0.40
	More than 15 years	35	4.43	0.41
	Total	175	4.31	0.41
Belief about Clean Energy	Less than 5 years	23	3.74	0.63
	5 to 10 years	69	3.81	0.66
	10 to 15 years	48	3.97	0.68
	More than 15 years	35	3.83	0.50
	Total	175	3.85	0.63
Self-Effectiveness Perception	Less than 5 years	23	3.68	0.62
	5 to 10 years	69	3.81	0.61
	10 to 15 years	48	3.93	0.71
	More than 15 years	35	3.69	0.45
	Total	175	3.80	0.62
Environmental Concern	Less than 5 years	23	3.67	0.69
	5 to 10 years	69	3.69	0.47
	10 to 15 years	48	3.80	0.53
	More than 15 years	35	3.81	0.36



Factors	Experience Level	N	Mean	Standard Deviation
	Total	175	3.74	0.50
Perception toward Cost of Generation of Clean Energy	Less than 5 years	23	3.67	0.33
	5 to 10 years	69	3.91	0.65
	10 to 15 years	48	4.13	0.56
	More than 15 years	35	3.97	0.48
	Total	175	3.95	0.57
Intention to Adopt Renewable Energy	Less than 5 years	23	3.79	0.48
	5 to 10 years	69	3.91	0.46
	10 to 15 years	48	4.02	0.39
	More than 15 years	35	3.90	0.47
	Total	175	3.92	0.45

Table 4.17: One Way ANOVA between Experience of the participants and Factors in Clean Energy Transition

Factors	Mean Comparisons	Sum of Squares	df	Mean Square	F-value	p-value
Awareness toward Clean Energy	Between Groups	0.68	3.00	0.23	1.33	0.27(ns)
	Within Groups	29.04	171.00	0.17		
	Total	29.72	174.00			
Belief about Clean Energy	Between Groups	1.08	3.00	0.36	0.89	0.45(ns)
	Within Groups	68.74	171.00	0.40		
	Total	69.82	174.00			
Self-Effectiveness Perception	Between Groups	1.51	3.00	0.50	1.34	0.26(ns)
	Within Groups	64.41	171.00	0.38		
	Total	65.92	174.00			
Environmental Concern	Between Groups	0.61	3.00	0.20	0.81	0.49(ns)
	Within Groups	42.64	171.00	0.25		
	Total	43.25	174.00			

Perception toward Cost of Generation of Clean Energy	Between Groups	3.42	3.00	1.14	3.63	0.01*
	Within Groups	53.75	171.00	0.31		
	Total	57.17	174.00			
Intention to Adopt Renewable Energy	Between Groups	0.91	3.00	0.30	1.50	0.22(ns)
	Within Groups	34.38	171.00	0.20		
	Total	35.29	174.00			

*. Significant at 0.05 level (2-tailed). (ns) No-significance

From the Table 4.17, it is apparent that there was no significant difference on the mean rating between participants from different Experience group on all Clean Energy Transition Factors (except “Perception toward Cost of Generation of Clean Energy”) as the p-value exceeds 0.05.

Result: The hypothesis that “No significant difference is observed in the mean rating given by participants toward different factors in Clean Energy Transition based on the Experience Level” was accepted for all factors except “Perception toward Cost of Generation of Clean Energy”.

4.6.6 Hypothesis 6

Null Hypothesis H6: No significant difference is observed in the mean rating given by participants toward different factors in Clean Energy Transition based on the Income Level

One way ANOVA test was used to test this hypothesis with Income Level of the participants as the independent variable and Clean Energy Transition factors like “Awareness toward Clean Energy”, “Belief about Clean Energy”, “Self-Effectiveness Perception”, “Environmental Concern”, “Perception toward Cost of Generation of Clean Energy” and “Intention to Adopt Renewable Energy” were used as the dependent variables.

Table 4.18: One Way ANOVA between Income Level of the participants and Factors in Clean Energy Transition - Descriptive

Factors	Income Level (Rs.) per Month	N	Mean	Standard Deviation
Awareness toward Clean Energy	Below 25,000	69	4.34	0.45
	25,001-50000	30	4.25	0.35
	51,000-75,000	18	4.14	0.33
	76,000 – 1,00,000	38	4.31	0.41
	1,00,000 above	20	4.49	0.41
	Total	175	4.31	0.41
Belief about Clean Energy	Below 25,000	69	3.86	0.63
	25,001-50000	30	3.90	0.67
	51,000-75,000	18	3.63	0.49
	76,000 – 1,00,000	38	3.67	0.49
	1,00,000 above	20	4.31	0.75
	Total	175	3.85	0.63
Self-Effectiveness Perception	Below 25,000	69	3.79	0.59
	25,001-50000	30	3.82	0.69
	51,000-75,000	18	3.64	0.39
	76,000 – 1,00,000	38	3.64	0.47
	1,00,000 above	20	4.24	0.80
	Total	175	3.80	0.62
Environmental Concern	Below 25,000	69	3.71	0.45
	25,001-50000	30	3.80	0.56
	51,000-75,000	18	3.62	0.54
	76,000 – 1,00,000	38	3.73	0.47
	1,00,000 above	20	3.88	0.60
	Total	175	3.74	0.50
Perception toward	Below 25,000	69	3.93	0.58

Factors	Income Level (Rs.) per Month	N	Mean	Standard Deviation
Cost of Generation of Clean Energy	25,001-50000	30	4.11	0.62
	51,000-75,000	18	3.64	0.36
	76,000 – 1,00,000	38	3.84	0.49
	1,00,000 above	20	4.29	0.58
	Total	175	3.95	0.57
	Intention to Adopt Renewable Energy	Below 25,000	69	3.91
25,001-50000		30	3.99	0.42
51,000-75,000		18	3.82	0.32
76,000 – 1,00,000		38	3.78	0.46
1,00,000 above		20	4.22	0.48
Total		175	3.92	0.45

Table 4.19: One Way ANOVA between Income Level of the participants and Factors
in Clean Energy Transition

Factors	Mean Comparisons	Sum of Squares	df	Mean Square	F-value	p-value
Awareness toward Clean Energy	Between Groups	1.31	4.00	0.33	1.96	0.10(ns)
	Within Groups	28.41	170.00	0.17		
	Total	29.72	174.00			
Belief about Clean Energy	Between Groups	6.41	4.00	1.60	4.29	0.00**
	Within Groups	63.41	170.00	0.37		
	Total	69.82	174.00			
Self- Effectiveness Perception	Between Groups	5.33	4.00	1.33	3.74	0.01*
	Within Groups	60.59	170.00	0.36		
	Total	65.92	174.00			
Environmental Concern	Between Groups	0.83	4.00	0.21	0.83	0.51(ns)
	Within Groups	42.42	170.00	0.25		
	Total	43.25	174.00			

Factors	Mean Comparisons	Sum of Squares	df	Mean Square	F-value	p-value
Perception toward Cost of Generation of Clean Energy	Between Groups	5.24	4.00	1.31	4.29	0.00**
	Within Groups	51.94	170.00	0.31		
	Total	57.17	174.00			
Intention to Adopt Renewable Energy	Between Groups	2.86	4.00	0.71	3.75	0.01*
	Within Groups	32.43	170.00	0.19		
	Total	35.29	174.00			

** . Significant at 0.01 level (2-tailed). * . Significant at 0.05 level (2-tailed).

(ns) No-significance

From the Table 4.19, it is evident that there was a significant difference on the mean rating between participants from different Income Level group on majority of the Clean Energy Transition Factors like Belief about Clean Energy ($F = 4.29$, $p = 0.00$), Self-Effectiveness Perception ($F = 3.74$, $p = 0.01$), Perception toward Cost of Generation of Clean Energy ($F = 4.29$, $p = 0.00$) and Intention to Adopt Renewable Energy ($F = 3.75$, $p = 0.01$). However, there was no significant mean different among respondents on the factors Awareness toward Clean Energy and Environmental Concern as the p-value exceeds 0.05.

Result: The hypothesis that “No significant difference is observed in the mean rating given by participants toward different factors in Clean Energy Transition based on the Income Level” was accepted for the factors like “Awareness toward Clean Energy” and “Environmental Concern”. On the other hand, this hypothesis was rejected for the factors like “Belief about Clean Energy”, “Self-Effectiveness Perception”, “Perception toward Cost of Generation of Clean Energy” and “Intention to Adopt Renewable Energy”.

4.7 Multiple Regression Analysis

Hypothesis7: The different perceptual factors in clean energy transition have significant impact on the Intention to Adopt Renewable Energy.

Multiple Regression Analysis was conducted to test the above hypothesis with “Intention to Adopt Renewable Energy” as the dependent variable. The perceptual factors like “Awareness toward Clean Energy”, “Belief about Clean Energy”, “Self-Effectiveness Perception”, “Environmental Concern”, “and Perception toward Cost of Generation of Clean Energy” were used as predictor variable.

Table 4.20 shows that shows that the predictors have accounted for 84.4% of variance in the dependent variable (Intention to Adopt Renewable Energy). The change in R² was 0.844 and it was highly significant ($p < 0.000$).

Table 4.20: Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
				R Square Change	F Change	df1	df2	Sig. F Change
0.92	0.84	0.84	0.18	0.844	183.56	5	169	0.00**

Predictors: (Constant), Perception toward Cost of Generation of Clean Energy, Environmental Concern, Awareness toward Clean Energy, Self-Effectiveness Perception, Belief about Clean Energy

Table 4.21 displays the findings of One-way ANOVA test. This test evaluates the overall significance of the model. As the obtained p-value is less than 0.05, the model is valid. Consequently, it is evident that the model proposed by the study, namely Perceptual Factors in Transition to Renewable Energy has an influence on “Intention to Adopt Renewable Energy”, has been verified.

Table 4.21: ANOVA Results

	Sum of Squares	df	Mean Square	F-value	p-value
Regression	29.80	5.00	5.96	183.56	0.00**
Residual	5.49	169.00	0.03		
Total	35.29	174.00			

** . Significant at 0.01 level (2-tailed).

Predictors: (Constant), Perception toward Cost of Generation of Clean Energy, Environmental Concern, Awareness toward Clean Energy, Self-Effectiveness Perception, Belief about Clean Energy.

Dependent Variable: Intention to Adopt Renewable Energy

The Standardized Coefficient (β) is a measure of the predictor variable's contribution to the model. The "t-value" and Significance (p) values indicate the magnitude of the predictor variable's influence on the response variable. Table 4.17 demonstrates that "Belief about Clean Energy" contributes considerably to the model ($\beta = 0.47$) when compared with other factors like "Environmental Concern" ($\beta = 0.27$), "Self-Effectiveness Perception" ($\beta = 0.24$) and "Awareness toward Clean Energy" ($\beta = 0.13$). "Perception toward Cost of Generation of Clean Energy" has the least level of contribution toward "Intention to Adopt Renewable Energy" ($\beta = 0.05$).

Table 4.22: Regression Analysis – Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	t-value	p-value
	B	Std. Error	Beta		
(Constant)	0.32	0.19		1.74	0.08
Awareness toward Clean Energy	0.14	0.04	0.13	3.46	0.00**
Belief about Clean Energy	0.33	0.08	0.47	4.05	0.00**

Self-Effectiveness Perception	0.17	0.07	0.24	2.44	0.02*
Environmental Concern	0.24	0.03	0.27	8.24	0.00**
Perception toward Cost of Generation of Clean Energy	0.04	0.04	0.05	0.97	0.33(ns)

Dependent Variable: Intention to Adopt Renewable Energy

** . Significant at 0.01 level (2-tailed). * . Significant at 0.05 level (2-tailed).
(ns) No-significance

4.8 Challenges in Renewable Energy Transition

The study also collected data with experts of electricity companies on the perceived Challenges in Renewable Energy Transition.

Table 4.23 Challenges in Renewable Energy Transition

Challenges in Renewable Energy Transition	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Procurement of Resources	0	0	0	80	20
Technology factors	0	0	0	4	96
Risk factors	0	40	8	20	32
Budgeting and financing	8	16	0	48	28
Regulatory policies	0	0	52	48	0

The study found that Technology factors and Procurement of Resources for Renewable energy generation and transmission were identified as the major challenge in the transition to renewable energy. Similarly, technology related issues in the design, installation and generation of renewable energy poses serious challenge that needs to be addressed immediately.

The experts of the electricity companies have elaborated on the risks associated in the construction and operationalization of renewable energy projects. Currently the power generated from wind source is connected to 110 KV sub stations. This is getting overloaded during high peak season of the wind. This is due to less demand during high wind time, but generated capacity has to be transferred to nearby major substations (Rose et al., 2021).

Currently short-term solution of “split-bus” network infrastructure arrangements available for overload reduction. Reliable transmission lines and its network is required to integrate large scale generation of electricity from solar and wind sources.

Modernization of existing renewable energy resources requires adequate funding and resources to ensure availability vs demand instead of peak load only. Financing in solar, wind and battery storage infrastructure is expected to be competitive with thermal power generation capacity by 2060. Commercial viability of tariff levels, infrastructure investments and cost of balancing etc... are the key issues that need to be resolved. In terms of technological challenges, experts have pointed out the factors related with new storage capacity, capacity of inter-district & inter-talukas transmission, allocation of wind and solar resources for different locations, energy efficiency and electrification.

Experts have cited that acquisition of land for the construction of solar projects and wind power plants has drawn severe criticism and opposition from the land owners. Several agricultural and farming unions have opposed the construction of renewable energy projects in land under cultivation. Identifying appropriate land for these projects has remained a great hurdle in the state of Tamilnadu. Unlike few decades ago, budgeting and financing as well as regulatory policies for renewable projects has not been a great difficulty because of favourable political conditions in the state as well as in the central governments.

Majority of the experts/professional respondents have stated that more than technical, economic and political factors, the mindset of public has to be changed in order to effectuate the smooth transition to 100% clean energy in the state. They felt that consumers are ambiguous about the benefits of renewable energy as they are doubtful toward the hidden costs associated

with this newer energy systems. They strongly believe that the cost of electricity would increase because of renewable energy technologies.

The next chapter summarizes the overall findings of the data analysis along with conclusions, suggestions and recommendations.

Chapter 5

FINDINGS, SUGGESTIONS AND CONCLUSION

5.1 Introduction

This chapter provides the overall summary of the research study along with a detailed discussion on the findings based on the data collected from 175 consumers of electricity in the Chennai Region, Tamil Nadu. The questionnaire for the study was prepared based on the insights gained from the extensive review of literature and experts opinion. The validity and reliability of the questionnaire was checked and verified before initiating the data collection process. The key findings of the data analysis are presented in the next section.

5.2 Summary of the Findings

- Majority of the study participants were male 67.4% (N = 118). 32.6% (N = 57) of the study participants were female.
- Majority were Unmarried 61.1% (N = 107) and only 38.9% (N = 68) of the participants were married
- Majority of the participants 40.0% (N = 70) were young belonging to age group 18 - 34 years, closely followed by participants with age group of 35 – 54 39.4% (N = 69). The sample also included participants above 54 years 20.6% (N = 36).
- Majority of the participants 38.3% (N=67) have Undergraduate Qualification. Around 25.1% (N=44) of participants are having Post

Graduate qualification. 18.9% (N = 33) of participants have “Others” qualification which includes certifications, doctorate, etc. Around 17.7% (N = 31) of participants have educational qualification higher secondary and below level.

- Majority of the participants 39.4% (N = 69) were privately employed in organizations. 27.4% (N = 48) of participants were employed in government organizations. 20% (N = 35) were consisted of homemakers, part-time participants and involved other businesses like financing, running chit-funds etc. 13.1% (N = 23) of participants were self-employed and running their own businesses.
- Majority of the participants 39.4% (N = 69) were drawing income below Rs. 25000 per month. 21.7% (N = 38) of participants were earning between Rs. 76,000 – Rs. 1,00,000 per month. 17.1% (N= 30) of participants were earning between Rs. 25,001 – Rs. 50000. The study also included participants with income above Rs. 1 lac per month 11.4% (N=20). Finally, 10.3% (N=18) of the participants have income between Rs. 51,000 – Rs. 75,000.
- Regarding the perception of participants with respect to the importance for the state of Tamilnadu to adopt renewable energy, the study found that 50.29% of participants have unanimously their strong intention in the transition to renewable energy. is inevitable and imminent. Interestingly, 12.57% of participants were sceptical of the proposed transition to renewable energy. Land acquisition for renewable energy projects in the past have caused several problems in the state.
- The consumers of the study displayed higher level of “Awareness toward Clean Energy” with mean value of 4.31. The “Perception toward Cost of Generation of Clean Energy” was also commendable with mean value of 3.95. The consumers have weighed “Environmental Concern” in Clean Energy Transition on a lower mean rating when compared with other factors.

- As a part of the study, seven hypotheses were framed to measure the inferential statistics. The results of the hypothesis testing are presented in Table 5.1.

Table 5.1: Summary of hypothesis

SI#	Statement	Result	Level of Significance
H1	No significant difference is observed in the mean rating given by participants toward different factors in Clean Energy Transition based on the Gender	Accepted for “Belief about Clean Energy”, “Self-Effectiveness Perception”, “Environmental Concern”, “Perception toward Cost of Generation of Clean Energy” “Intention to Adopt Renewable Energy” Rejected for “Awareness toward Clean Energy”,	- 0.05
H2	No significant difference is observed in the mean rating given by participants toward different factors in Clean Energy Transition based on Marital Status	Accepted for “Awareness toward Clean Energy”, “Belief about Clean Energy”, “Self-Effectiveness Perception”, “Environmental Concern”, “Perception toward Cost of Generation of Clean Energy”, “Intention to Adopt Renewable Energy”	-
H3	No significant difference is observed in the mean rating given by participants toward different factors in Clean Energy Transition based on the Age	Accepted for “Awareness toward Clean Energy”, “Belief about Clean Energy”, “Self-Effectiveness Perception”, “Environmental Concern”, “Perception toward Cost of Generation of Clean Energy” “Intention to Adopt Renewable Energy”	-
H4	No significant difference is observed in the mean rating given by participants toward different factors in Clean Energy Transition based on the Qualification	Accepted for “Awareness toward Clean Energy”, “Belief about Clean Energy”, “Self-Effectiveness Perception”, “Perception toward Cost of Generation of Clean Energy” “Intention to Adopt Renewable Energy” Rejected for “Environmental Concern”	- 0.01
H5	No significant difference is observed in the mean rating given by participants toward different factors in Clean Energy Transition based on	Accepted for “Awareness toward Clean Energy”, “Belief about Clean Energy”, “Self-Effectiveness Perception”, “Environmental Concern”,	-

SI#	Statement	Result	Level of Significance
	the Experience Level	“Intention to Adopt Renewable Energy” Rejected for “Perception toward Cost of Generation of Clean Energy”	0.05
H6	No significant difference is observed in the mean rating given by participants toward different factors in Clean Energy Transition based on the Income Level	Accepted for “Awareness toward Clean Energy”, “Environmental Concern”, Rejected for “Belief about Clean Energy”, “Self-Effectiveness Perception”, “Perception toward Cost of Generation of Clean Energy” “Intention to Adopt Renewable Energy”	- 0.01 0.05 0.01 0.05
H7	The different perceptual factors in clean energy transition have significant impact on the Intention to Adopt Renewable Energy	Accepted for “Perception toward Cost of Generation of Clean Energy” Rejected for “Awareness toward Clean Energy”, “Belief about Clean Energy”, “Self-Effectiveness Perception”, “Environmental Concern”, “Intention to Adopt Renewable Energy”	- 0.01 0.01 0.05 0.01

From the above table following conclusions are drawn:

- Results of Independent sample t-test between male and female participants on different Clean Energy Transition Factors shows that they do not differ significantly in the mean rating on majority of the factors in Clean Energy Transition like “Belief about Clean Energy”, “Self-Effectiveness Perception”, “Environmental Concern”, “Perception toward Cost of Generation of Clean Energy” “Intention to Adopt Renewable Energy”. On other hand, male and female participants have differed significantly on “Awareness toward Clean Energy”. This clearly shows that the perceived conceptions of male and female on different Clean Energy Transition Factors are similar.
- Results of Independent sample t-test between participants with different marital status also shows that married and unmarried participants have not differed significantly in the mean rating on all the factors in Clean Energy

Transition. This again shows that marital status has no effect on the perception of study participants on different Clean Energy Transition Factors.

- Results of One-way ANOVA test between participants from different age group on different Clean Energy Transition Factors shows that the participants have not differed significantly in the mean rating on all the factors in Clean Energy Transition. This clearly shows that irrespective of the age, the participants of the study hold similar views and belief toward different Clean Energy Transition Factors.
- Results of One-way ANOVA test between participants from different qualification on different Clean Energy Transition Factors shows that the majority of the participants have not differed significantly in the mean rating on majority of the factors in Clean Energy Transition. Participants with qualification of “Higher Secondary and Below” have given higher mean rating for “Environmental Concern” when compared with other participants.
- Results of One-way ANOVA test between participants from different experience level on different Clean Energy Transition Factors shows that the majority of the participants have not differed significantly in the mean rating on majority of the factors. Participants with experience between “10 to 15 years” have given higher mean rating for “Perception toward Cost of Generation of Clean Energy” when compared with other participants.
- Results of One-way ANOVA test between participants from different income level on different Clean Energy Transition Factors shows that the participants have differed significantly in their mean rating on different factors. Significant difference was observed on the mean rating between participants from different Income Level on the factors like Belief about Clean Energy, Self-Effectiveness Perception, Perception toward Cost of Generation of Clean Energy and Intention to Adopt Renewable Energy. However, there was no significant mean different among respondents on the factors like Awareness toward Clean Energy and Environmental Concern.

- Multiple Regression Analysis was conducted to study the impact of different perceptual factors Clean Energy Transition on the Intention to Adopt Renewable Energy. The results shows that all the factors like Awareness toward Clean Energy”, “Belief about Clean Energy”, “Self-Effectiveness Perception”, “Environmental Concern” contribute significantly toward Intention to Adopt Renewable Energy. However, “Perception toward Cost of Generation of Clean Energy” failed to contribute toward the outcome variable “Intention to Adopt Renewable Energy”.

5.3 Discussion and conclusion

For a successful transition to energy systems based on renewable energy technology, the present energy regimes in the state of Tamilnadu must undergo substantial transformations. Although the subsequent governments ruling the state are unyielding in promoting such transformation, their capacity and desire to do so depends on a variety of factors like political willingness at the national level along with the viable conditions that takes geographical and technical factors into consideration. The objective of the study was to analyze how far the resolute to transition to 100% clean energy power systems by 2060 is realistic in the state of Tamilnadu.

Unlike the case of developed nations, the environment-related societal pressures to turn toward 100% renewable energy has long been not a key driver for transition to clean energy in India in general and Tamilnadu in particular. However, an unstoppable transformational process in the energy industry, sparked by the rapid cost reductions of renewable energy technology has fueled the transition process in several states in India. Beneficial geographic conditions like higher solar radiation and wind capacity in some of the states like Gujarat, India along with a strong and stable government with good support from central government has enabled that state to take massive steps in the direction of complete transition toward clean energy. On similar

line, the subsequent governments of Tamilnadu are showing keen interest in promoting large renewable energy projects.

Today, even the most pessimistic predictions anticipate a significant global increase of renewable energy. However, there has to be a concurrent, quick phase-out of the consumption of fossil fuels in order to achieve climate and sustainable development commitments. To achieve climate and sustainable development goals, however, a quick parallel phase-out of fossil fuels is required. The rate and effectiveness of a worldwide transition to clean energy will thus continue to be determined by political decisions. Cooperation among major nations may play a crucial role in setting the pace and fostering a favourable environment in this respect. However, international energy cooperation must go beyond the pioneering ideas and strategies of these nations. The success and pace of a worldwide transition to clean energy are largely dependent on policy choices. Setting the pace and fostering a supportive environment in this respect can be made possible through cooperation among leading nations. However, international collaboration in the energy sector must go beyond the innovations being made in these nations. It will be crucial to address the specific issues that developing and growing nations face, or else there may be fresh commitments to a high-carbon economic path and unfair transitions. A collaborative initiative from all participants - policymakers, private investors, governments, and institutions - can only aid in enhancing the renewable energy friendly environment of various states of India. This will eventually assist India in reaching its ambitious goal of 175 GW of renewable power by the end of the year 2022.

5.4 Implications

The empirical analysis and findings suggest a number of crucial policy implications that might be beneficial to the Tamilnadu government. There is a popular conception that the cost of electricity would increase if the government has to provide clean energy for household purposes. Consumers anticipate that the cost toward technology in producing renewable energy

might fall on them because of the transition process. Thus, it is vital for the state government to dispel the fear that going 100% renewable would increase the cost of electricity. The government agencies need to take active steps to educate the public on the available schemes and subsidies prevalent for installing and generating solar energy for household purposes.

5.5 Suggestions and Recommendations

The resolve of the state of Tamilnadu to transition toward 100% Clean Energy is not without challenges and obstacles. As an outcome of the study and based on insights obtained from consumers and professionals in the energy industry, the following recommendations and suggestions are provided:

- It was observed that the regulatory framework and procedures for procuring, installing, and implementing renewable energy technology-based projects are different for different states across India. Every state has its own policies and procedures in procurement of components for renewable energy projects. Thus, it is suggested that a comprehensive regulatory framework should be established to facilitate state governments in purchases in the renewable sector. This will save time and cost along with increased interest from private players in investments in the renewable energy sector.
- Poor level of cooperation, coordination and lack of inter-institutional coordination between different state government agencies, institutions, and central government bodies like Ministry for New Renewable Energy (MNRE) are identified as the major hampering factors in the timely completion of renewable energy projects in the state.
- It is widely seen that there is a dearth of suitably qualified personnel, skilled and well-equipped workforce in the renewable energy domain in India. Hence, the study recommends that rigorous training have to be provided.
- Public awareness activities have to be organized in large scale on renewable energy technologies and their potential benefit to the society.

- The study recommends that government should come forward and open additional educational / research institutions that can aid in the dissemination of information on renewable technologies to the larger society.
- In addition to acute labour shortage, there is limited understanding about renewables energy in India especially in the rural areas. Employment prospects in the renewable energy sector necessitate the development of the skills and competencies of unskilled and semiskilled personnel. An increase in skilled employees might facilitate the installation of renewable energy sources promptly.
- It is undeniable fact that the cost of connecting wind and solar energy to the power grid is strongly dependent on the technical advancement, it is important to increase scientific research funding in this field and reduce the on-grid tariff. In this way, the price of renewable energy can be lowered considerably.
- The adoption of renewable energy requires a coordinated approach between facilitating institutions, implementing agencies, financial institutions, and other stakeholders.
- Technical cooperation, marketing collaboration, financial collaboration, and consultancy collaboration may all contribute to a collaborative strategy. The customer opinion toward adoption of renewable energy was shown to be favourable.

5.6 Limitations of the Study

Limitations in research refer to the boundary lines of the investigation and the options that the researcher has control over for the study. The present study's shortcomings are noted below:

- The study considered only Chennai City, Tamilnadu, India for selecting the population and sample of the study.
- The study's sample size was restricted to only 200 consumers and 25 professional/ experts in electricity board.

- Even though the investigator selected the sample with the utmost care, the study's findings may not reflect the precise results of the full population. Therefore, the outcomes of the study cannot be generalized to the entire population.
- Although every attempt was made to obtain accurate response from study participants, respondent bias was unavoidable in some cases to some questions which are of control of the investigator.

5.7 Concluding Remarks

Access and availability to clean energy is often considered as an important prerequisite for ensuring better life on this planet. Clean energy technologies, processes, and related systems play a crucial role in advancement toward 100% clean energy society. Clean electricity from renewable sources is a major deciding factor in divorcing the trade and industrial development from the environmental damages. It has the potential to enhance health, means of subsistence, and quality of life. The proposed research question for the state of Tamilnadu Electricity transformation to Zero emissions electricity is highly important and need of the hour. The goal of transition to 100% renewable energy in 2060 by the state of Tamilnadu requires a coordinated approach between different actors including government agencies, facilitating institutions, implementing project teams, financial institutions, and other stakeholders. Effective technical cooperation, marketing collaboration, financial collaboration, and consultancy collaboration may all contribute to a sustainable growth strategy that revolutionize the energy sector. The customer opinion of adopting clean energy technology was shown to be favorable. The analysis of data from stakeholders has given confidence for the future steps in the path of transformation toward a cleaner environment free of fossil fuels like coal and petroleum products.

5.8 Future Directions

The study has identified that there is a limited number of studies in India in general and Tamilnadu on consumer awareness, belief, attitude, perception and behavior toward transition to clean energy. On one hand, the government of Tamilnadu, India has spearheaded the herculean task of going toward 100% renewable energy, in contrast, the quantum of empirical studies on the consumer awareness and attitude toward transition to renewable energy has been minimal to nil. Thus, the study recommends that an in-depth study involving larger population with representation from all regions like urban, semi-urban and rural areas may be conducted to gauge the awareness, attitude, belief, and intention to adopt renewable energy by consumers of different sections of the society. A separate study involving officials of power generating companies, professionals involved in renewable energy projects and personnel from government agencies could be conducted to study the prospects, feasibility, and hurdles in renewable energy transition in the state. It is strongly believed that such studies would add value to the conviction of the state in its journey toward zero carbon emission environments in the future.

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Survey Instrument

Part-A: Demographic Profile & Professional Information (Consumers)

1. Name
2. Gender: Male [] Female []
3. Age: 18–34 year [] 35–54 years [] 56 and above []
4. Marital Status: Single [] Married [] Divorced []
5. Occupation: Self-employed [] Company employee
Government officer [] technical personnel [] Other []
6. Level of Education: High school or lower [] Under Graduate []
Post Graduate [] Other []
7. Monthly Income (Rs):
Below 25,000 [] 25,001-50000 [] 51,000-75,000 []
76,000 – 1,00,000 [] 1,00,000 above []
8. How important do you think is it important for the state of Tamilnadu to adopt and use clean energy as an alternative to fossil fuel-based energy production methods?
Very Important []
Somewhat Important []
Not Important At All []
No Opinion []

9. Influential Factors in the Adoption of Clean Energy

You are requested to state your degree of agreement or disagreement on different factors and associated variables affecting the adoption of 100% clean energy in Tamilnadu. Your responses are ranked on a scale of 1 to 5, where 1 – Strongly Disagree (SD), 2 – Disagree (D), 3 – Neutral (N), 4 – Agree (A), 5 – Strongly Agree (SA).

S.No.	Statements	SD	D	N	A	SA
Awareness						
1	I have previously engaged with renewable energy resources.					

S.No.	Statements	SD	D	N	A	SA
2	I am highly aware of renewable energy consumption and requirements					
3	I am familiar with several renewable energy sources.					
4	I am aware that solutions based on renewable energy sources are available on the Indian market.					
5	I am cognizant of the advantages of harnessing renewable energy.					
Belief about Benefits of Clean Energy						
6	Renewable energy consumption minimises carbon emissions and enhances the structure of energy system.					
7	Renewable energy would provide broader environmental prospects.					
8	Utilizing clean energy sources would positively impact the environment					
9	With the implementation and adoption of clean energy, overall energy supply would be enhanced.					
10	Employment prospects will expand as a result of the implementation of new RE projects.					
Self-effectiveness Perception						
11	I have the knowledge necessary to accept renewable energy and its resources.					
12	I have complete control over the consumption of renewable energy sources					
13	I am familiar with the professionals to consult on renewable energy.					
14	I already have all the skills and capabilities to					

S.No.	Statements	SD	D	N	A	SA
	utilise renewable energy.					
15	I am aware of the source to find the necessary products and services in clean energy utilization.					
Environmental Concern						
16	I am concerned about environmental issues resulting from the non-renewable energy sources.					
17	I am aware of the climate change and its severe consequences.					
18	I am worried about environmental degradation and increased pollution levels everywhere.					
19	Environmental degradation resulting from the production energy is undesirable.					
20	I believe that adoption of renewable energy could enhance the environment.					
Perception toward Cost of Generation of Clean Energy						
21	Renewable energy production may incur significant costs.					
22	Energy production through renewable means is costly because renewable energy projects require a substantial initial financial outlay.					
23	Utilization of renewable energy requires a costly infrastructure and its deployment requires complex operations.					
24	The cost of renewable energy may be relatively significant on a continuous basis.					
Intention to Adopt Renewable Energy						

S.No.	Statements	SD	D	N	A	SA
25	I intend to adopt sustainable energy sources.					
26	The energy-efficient actions motivate me to adopt clean energy.					
27	I intend to spend more on renewable energy than on other energy sources.					
28	I highly suggest that people adopt renewable energy					

10. Challenges in Clean Energy Transition (Experts/professional)

You are requested to state your degree of agreement or disagreement on the perception toward clean energy transition projects in Tamilnadu. Your responses are ranked on a scale of 1 to 5, where 1 – Strongly Disagree (SD), 2 – Disagree (D), 3 – Neutral (N), 4 – Agree (A), 5 – Strongly Agree (SA).

S.No.	Statements	SD	D	N	A	SA
1	Obtaining necessary resources will be a major challenge in clean energy transition projects					
2	Selection and utilization of appropriate technology will pose significant challenge in clean energy transition projects					
3	Risks in the construction and operationalization hamper the idea of clean energy transition projects					
4	Budgeting and financing are a serious challenge in clean energy transition projects					
5	Regulatory policies will pose greater challenge to clean energy transition projects					

Part B (Professionals /Experts)

11. Challenges in Renewable Energy Transition

You are requested to state your degree of agreement or disagreement on the perception toward Renewable Energy transition projects in Tamilnadu. Your responses are ranked on a scale of 1 to 5, where 1 – Strongly Disagree (SD), 2 – Disagree (D), 3 – Neutral (N), 4 – Agree (A), 5 – Strongly Agree (SA).

S.No.	Statements	SD	D	N	A	SA
1	Obtaining necessary resources will be a major challenge in Renewable Energy transition projects					
2	Selection and utilization of appropriate technology will pose significant challenge in Renewable Energy transition projects					
3	Risks in the construction and operationalization hamper the idea of Renewable Energy transition projects					
4	Budgeting and financing are a serious challenge in Renewable Energy transition projects					
5	Regulatory policies will pose greater challenge to Renewable Energy transition projects					

12. Open Comments: _____

Appendix – I

Table 1: State-wise installed capacity of Renewable Power (including Off-grid) as on 31.07.2022

S. No.	STATES / Uts	Small Hydro Power	Wind Power	Bio-Power					Solar-Power					Total Capacity
				BM Power/ Bagasse Cogen.	BM Cogen. (Non-Bagasse)	Waste to Energy	Waste to Energy (Off-grid)	Bio Power Total	Ground	Rooftop	Solar in Hybrid	Off Grid	SolarPowerTotal	
		(MW)	(MW)	(MW)	(MW)	(MW)	(MW)	(MW)	(MW)	(MW)	(MW)	(MW)	(MW)	(MW)
1	Andhra Pradesh	162.11	4096.65	378.10	105.57	53.16	29.21	566.04	4240.99	152.85	0.00	88.34	4482.18	9306.98
2	Arunachal Pradesh	133.11						0.00	1.27	4.34	0.00	5.62	11.23	144.34
3	Assam	34.11			2.00			2.00	100.03	33.48	0.00	9.43	142.94	179.05
4	Bihar	70.70		112.50	12.20		1.32	126.02	138.93	30.55	0.00	21.21	190.69	387.41
5	Chhatisgarh	76.00		272.09	2.50		0.41	275.00	294.46	42.11	0.00	192.75	529.32	880.32
6	Goa	0.05				0.34		0.34	0.95	20.47	0.00	0.12	21.54	21.93
7	Gujarat	89.39	9443.02	65.30	12.00	7.50	24.46	109.26	5909.27	1923.00	0.00	41.03	7873.30	17514.97
8	Haryana	73.50		151.40	89.26	11.20	6.14	258.00	265.80	397.40	0.00	280.41	943.61	1275.11
9	Himachal Pradesh	954.11			9.20		1.00	10.20	37.10	19.31	0.00	25.75	82.16	1046.47
10	Jammu & Kashmir	144.68						0.00	2.49	22.00	0.00	23.41	47.90	192.58
11	Jharkhand	4.05			4.30			4.30	19.05	35.21	0.00	34.53	88.79	97.14
12	Karnataka	1280.73	5219.95	1867.10	20.20	1.00	13.85	1902.15	7280.26	371.99	0.00	30.31	7682.56	16085.39
13	Kerala	266.52	62.50		2.27		0.23	2.50	272.16	246.69	0.00	20.76	539.61	871.13
14	Ladakh	39.64						0.00	6.00	1.80	0.00	0.00	7.80	47.44
15	Madhya Pradesh	99.71	2519.89	92.50	14.85	15.40	8.58	131.33	2459.02	205.62	0.00	81.64	2746.28	5497.21
16	Maharashtra	381.08	5012.83	2568.00	16.40	12.59	35.16	2632.15	1739.10	980.08	0.00	54.12	2773.30	10799.36
17	Manipur	5.45						0.00	0.00	6.36	0.00	5.90	12.26	17.71
18	Meghalaya	32.53			13.80			13.80	0.00	0.21	0.00	3.94	4.15	50.48
19	Mizoram	36.47						0.00	0.10	1.55	0.00	6.35	8.00	44.47
20	Nagaland	31.67						0.00	0.00	1.00	0.00	2.04	3.04	34.71
21	Odisha	115.63		50.40	8.82			59.22	403.56	21.66	0.00	26.92	452.14	626.99
22	Punjab	176.10		299.50	173.95	10.75	7.45	491.65	828.58	222.51	0.00	66.90	1117.99	1785.74
23	Rajasthan	23.85	4537.02	119.25	2.00		3.83	125.08	11821.87	814.02	1380.40	438.41	14454.70	19140.65
24	Sikkim	55.11						0.00	0.00	2.76	0.00	1.92	4.68	59.79
25	Tamil Nadu	123.05	9869.07	969.10	43.55	6.40	23.65	1042.70	5264.95	368.50	0.00	57.34	5690.79	16725.61
26	Telangana	90.87	128.10	158.10	2.00	45.80	13.84	219.74	4360.49	255.51	0.00	8.71	4624.71	5063.42
27	Tripura	16.01						0.00	5.00	4.41	0.00	6.46	15.87	31.88
28	Uttar Pradesh	49.10		1957.50	159.76		72.73	2189.99	1851.50	258.78	0.00	134.28	2244.56	4483.65

S. No.	STATES / Uts	Small Hydro Power	Wind Power	Bio-Power					Solar-Power				Total Capacity	
				BM Power/ Bagasse Cogen.	BM Cogen. (Non-Bagasse)	Waste to Energy	Waste to Energy (Off-grid)	Bio Power Total	Ground	Rooftop	Solar in Hybrid	Off Grid		SolarPowerTotal
		(MW)	(MW)	(MW)	(MW)	(MW)	(MW)	(MW)	(MW)	(MW)	(MW)	(MW)	(MW)	(MW)
29	Uttarakhand	218.82		72.72	57.50		9.22	139.44	298.40	262.71	0.00	12.43	573.54	931.80
30	West Bengal	98.50		300.00	19.92		2.53	322.45	110.00	53.04	0.00	12.96	176.00	596.95
31	Andaman & Nicobar	5.25						0.00	25.05	4.59	0.00	0.27	29.91	35.16
32	Chandigarh							0.00	6.34	49.70	0.00	0.81	56.85	56.85
33	Dadar & Nagar Haveli							0.00	2.49	2.97	0.00	0.00	5.46	5.46
34	Daman & Diu							0.00	10.15	30.86	0.00	0.00	41.01	41.01
35	Delhi					59.00		59.00	8.96	200.70	0.00	1.46	211.12	270.12
36	Lakshwadeep							0.00	0.75	0.00	0.00	2.52	3.27	3.27
37	Pondicherry							0.00	0.80	34.55	0.00	0.18	35.53	35.53
38	Others		4.30					0.00	0.00	0.00	0.00	45.01	45.01	49.31
	Total (MW)	4887.90	40893.33	9433.56	772.05	223.14	253.61	10682.36	47765.87	7083.29	1380.40	1744.24	57973.80	114437.39

MW = Megawatt

Metadatenblatt für Veröffentlichungen auf dem OPUS- Publikationsserver der Hochschule für Wirtschaft und Recht Berlin

Name(n), Vorname(n) der Autorin(nen) und / oder Autor(en)

ORCID-Kennung (falls vorhanden)

Art der Publikation

Version

Titel der Publikation

Schlagwörter / Tags (optional, frei von Autorin(nen) und / oder Autor(en) zu vergeben)

Publikationsjahr

Originalquellenangabe (bei Zweitveröffentlichungen)

Persistenter Identifikator der Erstveröffentlichung (z. B. vom Verlag vergebene DOI)

Die vorliegende Version ist unter dem folgenden persistenten Identifikator verfügbar
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Lizenzangabe:
[Auswahl CC-Lizenz]

Muster-Zitationsempfehlung: Nachname, Name (Publikationsjahr). Titel: Untertitel.
In: Quellenangabe der Erstveröffentlichung, ISSN/ISBN, Verlag, Ort, Vol., Iss., xx-xx
[Seitenzahlen], <http://dx.doi.org/xxx> (vom Verlag vergebene DOI)

[Stand: 28.12.2021]