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Research Article

Renewable Energy Options Households Among Rural

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ABSTRACT

Developing nations are plagued by energy issues that are not only ubiquitous but also extremely serious. According to estimates, about ninety percent of the population in many developing nations is affected by the lack of access to adequate and sustainable energy supplies. In order to survive, people are required to live without a consistent and high-quality supply of power. In order to prepare their daily meals, the rural populace continues to rely on fuels such as animal dung, agricultural wastes, fuel wood, and charcoal. People's efforts to engage in productive activities and improve their quality of life are hindered when they do not have access to energy that is both efficient and clean (Barnes and Floor, 1996). According to the Census results from 2011, India has approximately 68.84% of its entire population living in rural areas, making it the country with the highest rural population in the world. It is essential for rural households to have access to contemporary energy sources and fuels that are friendly to the environment in order to make a contribution to India's overall growth. Through the expansion of energy systems, there is a need to bridge the access gap in order to meet the energy requirements of the rapidly growing population and to reduce the risk of climate change.

In order to address the issues of energy poverty, the transition toward environmentally friendly energy technology is the most effective solution that can be found. The current situation has resulted in unmanageable increases in the consumption of non-renewable energy sources including fossil fuels, oil, and natural gas, which has caused fluctuations in both the demand and supply of these resources. As a result of this negative energy balance that has persisted for decades, India has been compelled to purchase energy from other countries in order to satisfy the requirements of the entire nation. For this reason, having access to electricity is not only an essential component of sustainable human growth but also an essential component of effective poverty alleviation. Providing rural populations, which are frequently deprived of clean and uninterrupted energy supply for their day-to-day energy requirements, with sustainable energy solutions has been the primary focus of a number of development programs that have been established by the Government of India. The State of Haryana and the State of Himachal Pradesh were the locations where the research project titled "Renewable Energy Options among Rural Households" was carried out. The findings of the study offer a road map that may be used to facilitate the implementation of future programs that encourage the utilization of energy technology that are energy-efficient, environmentally friendly, and cutting-edge. The findings would be of further benefit to the primary and secondary key stakeholders who are involved in research and development, the formulation of policies and regulations, the promotion of sale and purchase, and the provision of financial assistance to future energy programs that are intended to popularize the use of renewable energy technologies.

Keywords: Renewable energy, Rural households, Energy access, Energy poverty, Solar energy**.**

INTRODUCTION

In every region of the world, the existence of life is dependent on the availability of energy. The widespread nature of activities related to energy has a significant impact on the quality of the environment all over the world. With the current pattern of energy production, distribution, and consumption, the resources will be depleted considerably more quickly, which will both hasten the destruction of the environment and significantly slow down the development that is being made. Because of the enormous investments that are

necessary to satisfy the ever-increasing demand for energy, the energy industry is required to play a crucial role, particularly in emerging countries for this reason.
Non-renewable and renewable energy resources are the two categories that have been used to classify the energy resources currently being utilized in this research. When we talk about non-renewable energy resources, we are referring to those sources of energy that are drawn from a limited and unchanging supply of energy. They cannot be created, grown, developed, or used on a scale that is capable of maintaining the rate at which they are consumed. Some examples of non-renewable sources of energy are fossil fuels including coal, petroleum, natural gas, and nuclear power. Other examples include nuclear power. In the context of energy, the term "renewable energy resources" refers to those resources that are readily available, have an indefinite supply, and are environmentally beneficial. Solar energy, wind energy, biomass energy, wave energy, and tidal energy are all examples of these resources (Varun and Chauhan, 2014).

Energy Access to Rural House holds in India

Ensuring that people in rural parts of India have access to electricity is not only an essential component of reducing poverty but also an essential component of bringing about a change in the quality of life of rural residents. The number of individuals who do not have access to electricity services continues to be relatively unchanged due to the fact that the population is growing, notwithstanding the progress that has been made in the electrification of rural areas. The lack of energy services puts a great number of mothers and children at risk of suffering from incapacitating illnesses or passing away prematurely. The reason for this is that fundamental social services, such as healthcare, are extremely expensive, which makes it more difficult to sustain economic growth. When the necessary infrastructure for the supply of energy, particularly electricity, is lacking, a situation known as energy poverty presents itself.
Within a decade, India has moved up from being the seventh greatest energy consumer in the world in the year 2000 to the fourth largest energy consumer in the world. Additionally, India is the fifth largest power generator in the world. According to Pawar and Kaur (2014), India's energy basket is comprised of a variety of every resource that is currently available, including renewable energy resources. When compared to the numerous industries that make use of energy, the household sector is the energy consumer that consumes the most. Traditional biomass resources, such as fuel wood, crop residue, and dung cakes, are frequently utilized by rural households (HHs) in developing nations for a variety of purposes, including but not limited to cooking, domestic lighting, water heating, preparation of calf feed, and heating of indoor spaces. In addition to providing a minimal energy service that is necessary for life, it also carries a high financial cost, has a severe impact on human health, and places a tremendous amount of stress on environmental resources.

Changesin Quality of Life through Renewable Energy Technologies(RETs)

It has been demonstrated in a number of studies that the availability of energy has an effect on the quality of life of individuals who live in rural areas. According to Rehling (2004), energy, and more specifically electricity, is necessary in order to fulfill fundamental requirements, which include the provision of services related to health, education, agriculture, communication, information, and other infrastructure-related services. In addition, he said that there is a connection between the context of human development and the human development per capita income. According to Chaurey et al. (2004), the United Nations Commission on Sustainable Development (CSD-9) highlighted renewable and rural energy as two of the most important issues for sustainable development.
Traditional approaches frequently have a very low level of efficiency, and a significant portion of the energy output is lost as a result of the utilization of antiquated technologies that are inefficient. It is for this reason that sustainable energy services are regarded as an absolute requirement for enhancing the quality of life, easing the process of development, and lessening the impact on the environment. The utilization of decentralized and small-scale technologies that make use of new, locally available, renewable resources such as the sun, biomass, wind, water, and other similar resources appears to be the most effective option. According to Mahapatra and Dasappa (2012), renewable energy technologies have the potential to deliver universal contemporary energy services that can propel development and enhance living conditions, particularly in rural populations.
It has been said by Kumar et al. (2010) that in order for India to fulfill the energy requirements of such a rapidly expanding economy, the country will require a guaranteed supply of three to four times the amount of energy that is currently being utilized collectively. In order to assure a future that is sustainable, renewable energy sources (RETs) are gradually becoming more popular as an alternative to traditional energy supplies. In India, there has been a strong emphasis placed on activities that are associated with the manufacture, application, research and development, demonstration, and awareness of a wide range of renewable energy technologies (RETs) that are intended to be utilized in various industries. Access to clean energy resources has a multitude of advantages for rural areas, including the reduction of deforestation and carbon emissions, the enhancement of healthcare services as a result of the decreased consumption of raw water and smoke from open fire cooking, the generation of clean energy from renewable resources, the reduction of reliance on kerosene, wood, and coal, the enhancement of agricultural production, and the provision of access to potable and clean water. There is a momentum that is created by renewable energy sources, which increases the amount of time that is available for productive, income-generating work and the accumulation of wealth over

time. This has the potential to contribute to the alleviation of poverty in rural communities (Chaurey et al, 2004).

METHODOLOGY

The research was carried out in hamlets and villages located in four districts of two different states. These districts are as follows: Faridabad and Panchkula districts in the state of Haryana, and Hamirpur and Bilaspur districts in the state of Himachal Pradesh. One of the criteria that was used to identify villages and hamlets for the purpose of research was the existence of residents who were utilizing RETs, which means that they either own RETs or benefited from them (for a period of two years or longer). The villages and hamlets of Haryana and HP were chosen as the location for the study because there were households that were using RETs that were comparable to those used in both states. Additionally, there was a solar grid available in Haryana for the electrification of households, which gave the researcher the opportunity to understand the impact that electricity has on the quality of life of households. Haryana's solar electrification scheme was also beneficial to a few hamlets that were located in close proximity to the state's border with Himachal Pradesh. It was possible to make a comparison between the ownership and utilization of RETs in both states as a result of this.

As part of the ex-post facto research design, qualitative analysis and interviews were conducted with several stakeholders, including RET users, village representatives, and RET program implementation personnel from AkshayUrja (AU) stores. In order to choose the most important stakeholders for the study, the Purposive Sampling Technique was utilized. These stakeholders included officials responsible for the implementation of the RETs program, RET users, and village representatives.Resource maps were prepared with the participation of village representatives, residents, and program implementation officials (field staff from AU shops and local repair technicians) in order to gain an understanding of the locations of houses that make use of RETs, community service and facilities, sources of biomass collection, and other related topics.

Two sets of interview schedules were distributed, one of which was directed toward the officials in charge of implementing the RET program. These officials provided information on a variety of topics, including the function of AU shops, the operation of RETs, and their maintenance. Subsequently, an interview schedule was delivered to the rural inhabitants who were RET users. The purpose of this schedule was to collect information regarding the rural residents' socio-economic profile as well as their energy-use behaviors in relation to the NRETs and RETs that they utilized. A number of people and a representative from the village participated in informal conversations, which were used to enrich the interview schedules with additional information. Interviews with the relevant stakeholders were conducted informally, and narratives were recorded during those conversations (with prior consent). In order to acquire knowledge on procedures pertaining to RETs and NRETs, the observation schedule was highly beneficial. Two distinct rating measures were utilized in order to investigate the perceptions of RET users regarding the efficacy of RETs, as well as the subsequent changes in quality of life that occurred as a consequence of RET utilization. The effectiveness of RETs encompassed a variety of characteristics, including the ease of operation, the capacity to repair and maintain the product, the affordability of the product, the design of the product, the reliability of the product, and the start and maintenance of RETs. These five dimensions were included in the rating scale for Change in Quality of Life of Residents with Respect to RET Usage. These five dimensions were education of children, healthcare, convenience and social life, safety and security, and income-generation and financial security. The rating scale was consistent with the other framework of Quality of Life index that had already been developed. A SWOC analysis was carried out in order to gain an understanding of the people who use NRETs and RETs and their perspectives on the advantages, disadvantages, opportunities, and difficulties associated with their utilization.

Significance of the Study

The only way for rural communities to be able to achieve their goals on an individual, community, and global scale is if they have access to electricity that is both affordable and reliable. Through this, jobs would be strengthened, security would be enhanced, clean food would be provided, money would be increased, and improvements in health and education would be made. According to the Census Report on India from 2011, around 68.84% of the country's population lives in rural areas. Rural India is a powerhouse of natural energy resources and offers a significant opportunity for the generation of renewable energy. This energy can be exploited for the benefit of rural households, the community as a whole, and the improvement of their built environment, which includes schools and health centers. A number of studies have been conducted on renewable energy technologies (RETs) and quality of life (QoL), with the primary focus being on the viability of renewable energy for rural residents, the policies and regulations of the government, the achievement of targets (capacity of RETs installed and coverage of rural areas), the evaluation of the effectiveness of RET implementation, and the obstacles that researchers face when attempting to implement RETs. However, there is a lack of research studies that are meant to take a holistic perspective of users, aiming to comprehend their knowledge about RETs, their perceptions regarding the usefulness of RETs, and the changes in quality of life that occur as a result of their utilization.

It is therefore vital to acquire information directly from rural residents about their requirements and expectations from rural development programs in order to construct an effective and efficient renewable energy program for rural regions. This is a fundamental assumption that the study is based on. An in-depth understanding of the characteristics that influence the effectiveness of RETs in rural regions and changes in the dimensions of quality of life that the inhabitants (RET users) intended to be enhanced with the utilization of RETs in order to bring about an overall improvement in their quality of life was the purpose of this study.

Objectives of the Study

1. To study the socio-economic profile and energy use practices in selected villages/hamlets.
2. To explore the types of renewable energy resources and the gap in technology transfer in selected villages/hamlets.
3. To investigate the effectiveness and adoption of renewable energy as an alternative resource.
4. To determine the change in the quality of life of the residents in selected villages/hamlets, with the use of renewable energy technology.

RESULTSANDDISCUSSION

IProfileof*Akshay Urja(AU)*Shops

- The SNAs had initially erected the AU shops in the villages that were chosen, specifically HAREDA in the state of Haryana and HIMURJA in the state of Haryana. One AU shop was located in the Panchkula district (HR), one was located in Faridabad district (HR), and one was located in Mandi district (HP). All three of these businesses were located in or near the designated villages and hamlets.
- The business offered a maintenance and servicing facility for RETs that were installed or purchased from either their own shops or from any other supplier as well. There was an insufficient display of pertinent information that was available regarding renewable energy technologies (RETs) programs and policies, energy saving techniques, benefits of RET usage, pricing and subsidies, and other related topics. It was necessary to enhance the layout of AU shops as well as the system that was used to provide services.
- The AU stores had the appropriate schedules, and there was always some staff available during the hours that they were open. From Monday through Friday, the stores were open from nine in the morning until five in the afternoon. A Project Officer, an Assistant Project Officer, a Technical Assistant, and a Clerk were among the staff members that were present in each shop, which had between three and four members. The officers at each and every business, in addition to the people who used the RET, stated that there was a shortage of workers. There was a feeling of being overburdened with work for the policemen who were stationed at these shops.
- The MNRE has given its stamp of approval to the products that are sold in the AU shops. It was necessary for RETs to comply with the minimum technical specifications that were established by MNRE. presentation boards, proper signs that provided information about RETs, and a nice presentation of products were all present in the shops that were controlled and administered by the government authorities. These shops were also well maintained and tidy. The businesses that were run by local business owners were not well maintained; the objects that were brought in for repair were stacked vertically, and there was no room to sit or move around in the stores.
- A form that was unique to the product was made available to the buyers. An inspection of the location was carried out by either the technical staff or the project officer in the event that there were specific space needs for the installation of renewable energy technologies (RETs) such as solar power plants, solar water heaters, and so on.
- The staff informed the staff that in the event that the goods was damaged or counterfeit, the channel partner (firm or corporation) was responsible for repairing or replacing the product at no cost, provided that it was still within the warranty term. AU shops offered support for repairs even after the warranty term had expired, and they charged a minimum amount in order to minimize any additional burdens that the consumer might be experiencing.
- The establishment of stalls in a variety of camps (ormelas) that were established locally in a number of districts was the method that was utilized to generate awareness. Additionally, advertising were published in newspapers and broadcast on radio in conjunction with this. Additionally, the Block District Officer (BDO) had meetings with the village sarpanch every 15 to 20 days. During these sessions, the BDO shared information with the village sarpanch regarding new schemes and programs that were intended to be distributed to the members of the rural population.
- The trainees were supplied with the essential knowledge and skills through the training programs, with a particular emphasis on those who were unemployed and women living in rural regions. Additionally, follow-up and refresher courses were offered on a periodic basis. The most well-known of these are the Surya Mitra Skill Development Programs, which are run by the National Institute of Solar Energy (NISE). These programs provide participants, including young people and women, with the knowledge and abilities required to install and maintain renewable energy technologies (RETs). As a result of the fact that

RET users from other blocks had to travel up to 16 to 25 kilometres in order to take advantage of their services for the purchase, repair, or replacement of RETs, there was a requirement for additional AU stores in each block.

ProfileofStakeholders

(a)ProfileofRETUsers

- There were 66% male respondents in the study sample, whereas there were 34% female respondents. In the state of Haryana, 75% of the respondents were male, while 25% were female. Male respondents made up 56% of HP, while female respondents made up 44%.
- The bulk of the people who used RET were members of the general caste population (90 percent), followed by members of other backward castes (7 percent) and schedule castes (3 percent).
- In the state of Haryana, the majority of respondents (46%) belonged to the age category of 35 to 64 years, but in the state of Himachal Pradesh, the majority of respondents (42%) were over the age of 65, which is considered to be elderly. The selected respondents in Haryana had a mean age of 48 years, while those in HP had a mean age of 54 years. Comparatively, the percentage of young adults in Haryana was 31%, while the percentage in HP was 27%.
- Pucca made up the majority of homes in both states, accounting for 56% of the total, followed by semi-pucca (33%), and then kuccha (11%).
- HHs were chosen from a variety of topographies, including plains, low hills, and high hills, for the purpose of the study. 52% of the HHs were located in low hills, followed by 48% of the HHs that were located in high hills, and 29% of the HHs that were located in plains.
- Four to five rooms were the most common number of rooms in the HHs (46%) followed by one to three rooms (37%) and six or more rooms (17%).
- Forty-two percent of the households in rural areas consisted of four to six persons (nuclear families with one dependent member), whereas thirty percent of the households were joint families consisting of seven or more members. The number of nuclear families, which consisted of one to three members, was relatively low (28%) to begin with. When compared to the percentage of nuclear families in Haryana, which was 35%, the percentage of joint families in Haryana was 35%.
- The majority of the respondents had completed their secondary education, with 44% of them hailing from Haryana and 39% coming from the state of Haryana. Twenty-five percent of the graduates in HP were higher than the twenty-one percent in Haryana. Twenty-two percent of the professionals were from the state of Haryana, while the remaining twenty-two percent were from the state of HP. In Haryana, only 15% of respondents had completed primary school, while in HP, only 13% of respondents had done so.
- Farmers made up forty percent of the population in the rural areas that were chosen, while thirty percent of the respondents were in the service category. Homemakers made up twenty-two percent of the population, and business persons made up eight percent. The percentage of citizens working in service-related jobs in Haryana was 27%, whereas the percentage in HP was 35%.
- A family's income could range anywhere from 5,000 rupees or less to 25,000 rupees or more. Among the households that were chosen, the majority of them (48%) had a monthly income that was between Rs.15,000 and Rs.25,000. This was followed by households with a monthly income of Rs.5,000 to Rs.15,000 (29%), households with a monthly income of less than or equal to Rs.5,000 (12%), and households with a monthly income of more than Rs.25,000 (11%). When compared to Haryana, where the average monthly income was Rs.24,750, the mean income in HP was Rs.25,352 per month.
- Fourty-four percent of the families held less than one hectare of land, followed by those with one to two hectares of land (28 percent), those with more than two hectares of land (14 percent), and those with no landholding at all (14 percent).
- Forty percent of households in the state of Haryana and twenty-two percent of households in the state of HP did not own any animals. Compared to the people of HP, the people of Haryana owned a greater number of animals.

(b)ProfileofVillageRepresentatives

Atotalofsixteenvillagerepresentativeswereselectedfor interactionwhichincludedvillagerepresentativesandenergy committee members(responsibletooperate and maintainthe solargrids).

(c)ProfileofRETProgrammeImplementationOfficers:

Staff members that were responsible for the implementation of the RET included a project officer, an assistant project officer, field staff, and local technicians. It was decided to conduct interviews with three project officers, three field staff members, and four local technicians who had received training. Not only did the personnel provide repair and maintenance services for the goods that were sold at the shop, but they also provided these services for other RETs that were installed or purchased from other shops or suppliers. In addition to selling RETs and offering maintenance and servicing services, the personnel were also responsible

for distributing information about RETs and making it easier for individuals and institutions to make use of RET in their operations.

I. Energy Use Pattern in Rural Households from Haryana and Himachal Pradesh

To meet their day-to-day energy requirements, rural households in Haryana and HP utilized both non-renewable energy sources (NRETs) like biomass, fossil fuels, and electricity (from conventional electric grid) as well as renewable energy sources (RETs) like solar photovoltaic (SPV) technologies, solar thermal systems, solar grid, and biogas plants.

NRETsUsed

Biomass-based Energy Resources: Fuelwood, crop debris, and dung cakes were the components that made up these. There was a widespread practice of bartering, in which residents who did not own land were granted permission to use biomass (fuel wood and agricultural residue) and, in exchange, were required to provide the owners with services. These services included the production of dung cakes for the owners, the maintenance of their agricultural fields, assistance with household chores, assistance during events such as weddings and functions, and so on.

The compact and long-lasting nature of fuelwood, along with its familiarity, powerful but consistent heat generation, and accessibility, contributed to its considerable popularity. Kikar, aak, mango, jamun, eucalyptus, babul, and amrood were the tree species that were utilized the most frequently by people living in rural sections of the country. A monthly average of sixty to one hundred and twenty kilograms of fuel wood was purchased, with the price ranging from one hundred eighty to three hundred and sixty rupees (about three rupees per kilogram).

HHs in rural areas who were engaged in agricultural activities were the primary users of crop residue. It was made up of residue from agricultural and processing processes. The primary use of this substance was to serve as a fuel for starting fires, which made the burning of fuelwood easier. Additionally, it was utilized as a source of food for animals.

Women living in rural areas made an average of fifteen excursions each month in order to collect fuelwood. The majority of the settlements had a distance of less than one kilometer to walk in order to acquire wood. It took around 1.4 kilometers on average for women to collect the fuelwood, with the majority of them being accompanied by a girl kid. To obtain fuel, a single individual traveled approximately 21 kilometers per month, spending 1.7 hours per day, for a total of 42.4 hours per month.

Rural households were primarily responsible for the utilization of dung cakes, either for the purpose of composting farmyard manure or for the purpose of directly preparing dung cakes for use as a cooking fuel. Following the deduction of these consumptions, the surplus manure in question was utilized by user HHs for the purpose of producing biogas. Based on the findings, it was discovered that the dung cakes were utilized by HHs whose primary occupations consisted of cattle raising and agricultural production. Residents of HP indicated that many families had stopped using dung cakes because there were not enough individuals available who were skilled in the preparation of dung cakes and who could protect them from going bad (as a result of drying).

Fossil Fuel-based Resources: Liquefied petroleum gas (LPG), kerosene, coal, and candles were the three components that made up these.

LPG was offered in cylinders weighing 14,2 kilograms and 5 kilograms. A total of twelve subsidized cylinders were made available to each HH on an annual basis. Depending on the usage pattern and the size of the family, the average monthly consumption of LPG was approximately 9 kilograms, which means that one cylinder of LPG, which weighs 14.2 kilograms, was used for at least one and a half months. The most common applications for kerosene were in the kitchen and for illumination. The majority of the time, residents purchased kerosene through the Public Distribution System (PDS), which was made available at the kerosene depots. The families that did not have ration cards were able to purchase kerosene from the open market marketplace. The monthly allotment for each family was twenty liters per month for homes that did not have any LPG cylinders, three liters per month for families that had a single LPG cylinder, and nothing for families that had two or more LPG cylinders. In the state of Haryana, the price of a liter of kerosene is currently Rs.14.8, whereas in the state of HP, it is Rs.14.5. Due to the restricted availability of fuelwood during the winter months, the demand was often lower during the summer months, medium during the rainy season, and generally higher during the winter months. It was reported by users that they consumed approximately six to seven liters of kerosene every month. A household household (HH) spent between Rs. 85 and Rs. 100 per month on kerosene, which is equivalent to around Rs. 14.2 per litre. Due to the fact that there was not a significant initial expenditure, the usage of kerosene lamps, which are also referred to as dibri or mittiketelkediyeas, was widespread in rural households of Haryana and in certain regions of HP.

Coal was utilized by rural households in both states for the purpose of heating water and space, and it was also used for cooking on occasion. Various pieces of equipment, such as sigri and hamam, utilized coal for the purpose of heating the room and the water, respectively. At a price of thirty rupees a kilogram, it was readily available in the neighborhood market. The cost of coal on a monthly basis ranged from Rs. 180 to Rs. 210 per household (for 6 to 7 kilograms of coal).

Residents of rural areas in both states relied on candles as their primary source of illumination for their homes. The inconsistency of the energy supply and the prolonged power outages that were relatively prevalent in the villages of Haryana were the primary factors that determined the frequency with which candles were used. 20 to 25 rupees was the price range for a pack of ten candles in rural areas.

Electricity (from conventional power grid): Rural households made use of electricity for a variety of purposes, including lighting their homes, heating, cooling, and ventilating their spaces, cooking, heating their water, and powering their appliances and equipment. Compared to the rate of electricity in HP, the rate in Haryana was significantly higher.

It is estimated that lighting accounts for 33–44.43 KWh of energy per month in rural households, which accounts for 6-49% of the overall energy cost in rural households. This is a significant amount of the power budget. Inefficient GLS usage was popular in kuchahouses, and as a result, their energy share of lighting was fairly high (33 KWh). The findings of the research showed that puccahouses employed efficient lighting devices such as CFLs and LEDs, but while their operational hours were longer than those of other HH categories, the operational hours of these devices were longer than those of other HH categories.Different kinds of lights, such as GLS (Incandescent Bulbs), CFL (Compact Fluorescent Lamps), fluorescent lights, and LEDs (Light Emitting Diodes), were utilized for the purpose of artificial illumination, both inside and outside the building. The use of lighting systems that are both efficient and well-designed could result in energy savings for HH. The GLS that was utilized by HHs (two to three in number per HH) had a power range of forty to sixty watts and was present for one to four hours each day. CFLs with wattages ranging from 9 to 20 were utilized for a duration of two to four hours every day, and one to four systems were utilized for each heath. In the majority of the rural HHs (ranging from one to four in number), 40W FLTs were discovered. These HHs were active for two to four hours each day. Some puccahouses (two per HH) made use of LEDs with power outputs ranging from 3W to 7W for a period of two to three hours every day. Heating the water was yet another task that consumed a significant portion of the available electricity. People used hot water for a variety of functions, including bathing, washing clothes, cleaning utensils, mopping the floor, and growing cattle, among other things. Hot water was essential for household hygiene purposes. In both states, the most prevalent water heating devices utilized by households were immersion rods (1.5 KW) and a geyser with a capacity of 100 liters, which had a power output of 2 KW. According to the findings, water geysers were utilized by 37% of households in the state of Haryana and 36% of households in the state of HP. Both Haryana (20%) and Maharashtra (64%) had a significant presence of immersion rods. As a result of the fact that the purchasing power of inhabitants of Kuccha HHs was relatively low in comparison to that of residents of other HH categories, they were primarily reliant on traditional energy resources (fuelwood and biomass) for the purpose of heating water. These resources were readily available and had a low cost involved. Immersion rods were utilized for the purpose of water heating in semi-pucca homes where they were employed for up to one hour per day and consumed approximately 45 KWh of energy per month. In pucca HHs, water geysers with a capacity of one hundred liters were often utilized for one to two hours per day, resulting in a monthly energy consumption of forty-five to two hundred and forty kilowatt hours, depending on the usage pattern.

It was primarily via the utilization of ceiling fans, table fans, and coolers (for the purpose of cooling the indoor space), room heaters (for the purpose of heating the indoor space), and exhaust fans (for the purpose of ventilation) that the requirements for heating, ventilation, and cooling the interior space were satisfied. Within rural households, the amount of power that was consumed by HVC systems ranged from 25.2 to 240.6 KWh per month, which contributed an energy contribution of 32% to 37%. Residents, the majority of whom were older, took use of the shade provided by trees located close to their homes or in agricultural fields during the summer months in order to spend some time resting with their families or friends, eat, and other activities. The people found that sitting in the sun throughout the winter months provided them with a sense of comfort from the cold weather.

The act of cooking was the major activity in every single rural HH. A wide variety of conventional cooking appliances, including as pressure cookers, mixer/grinders, microwaves, and various cooking stoves, were utilized in rural households. These stoves included the traditional kucchachullha, the upgraded chullha (with or without chimney), the LPG stove, the kerosene stove, and the biogas stove. In terms of the electrical cooking appliances, 28% of households in Haryana and 18% of households in HP owned mixers and grinders with a power output of 50W. On the other hand, only 11% of households in Haryana and 10% of households in HP owned microwave ovens with a power output of 50W.

HHs were equipped with a variety of HH equipment, including a television (70W) and a radio (11W), a dish antenna (3W), a cable box (2W), a refrigerator (250W), a washing machine (150W), a computer (120W), an iron (1100W), a water pump (1.34 horse power), and a provision for mobile charging (3W). It was observed that pucca households owned a washing machine, an iron, and a domestic water pump, all of which utilized a significant amount of energy (67.5 KWh per month) despite the fact that their usage was only for one hour.

RETsUsed

RETs that were utilized for the purpose of meeting the daily energy and electricity requirements in rural areas comprised both stand-alone and grid-integrated technologies. These technologies included solar power grids,

solar photovoltaic (SPV), solar thermal, and biomass-based technologies. Each of these technological advancements has been described in the following manner:

Solar Grids: Because it was not economically feasible to electrify these villages using the conventional grid, the Ministry of National Resources and Environment (MNRE) implemented the Remote Village Electrification (RVE) program in 2006. This program electrified these villages using decentralized systems, solar grids with a capacity of 5 KW, and hybrid solar-wind power plants with a capacity of 10 KW in order to make it easier for these households to gain access to energy. In accordance with this program, the Central Government supplied 90 percent of the financial assistance, while the remaining cost was borne by the respective SNAs (HAREDA in Haryana and HIMURJA in HP) and the village panchayat(s). The support that was made available through this program was available to hamlets and villages that had not been connected to the conventional grid until the year 2012.

Solar Photovoltaic Technologies: The various SPV technologies used by rural residents in both the states had been explained in detail as follows-

SolarTorch: The Solar Lighting Program began with the installation of solar torches that were powered by compact fluorescent light bulbs in rural areas. It was now possible to purchase even the portable illumination gadget that was based on LEDs. According to the findings of the study, 45% of households in Haryana and 32% of households in HP used solar torches that were powered by CFLs. LED-based torches were owned by a smaller percentage of households, specifically 6% of households in Haryana and HP (each). The fact that they were portable and could be carried when traveling in the dark, particularly in hilly terrain, was something that the locals found to be quite beneficial.

Solar Lantern: It became apparent that there was a requirement for the creation of a solar illumination device that was comparable to a kerosene oil lamp. People living in rural areas of Haryana and HP made use of a portable device known as the solar lantern. It was made up of a photovoltaic module, a battery, a lamp, and electronics that were all contained within a housing that was either made of metal, plastic, or fiber glass. Both a solar lantern that was powered by a compact fluorescent light bulb (CFL) and a solar lantern that was powered by an LED were utilized by rural households. In places that were not connected to the electrical grid, solar lanterns were used as room lighting, as emergency lighting in areas that were connected to the grid, as a table lamp for reading, as a means of generating cash, as a means of educating children at home and at tuition centers, and as a means of patrolling farms and cow sheds. 53% of inhabitants in Haryana and 50% of residents in HP used lanterns that were powered by CFLs, whereas just 11% of residents in Haryana and 8% of residents in HP used lanterns that were powered by LEDs.

Solar Home Lighting System (SHS): In particular, SHS were among the most well-liked RETs, particularly in the un-electrified hamlets of Haryana, where locals had experienced light for the very first time in their lives during the course of the previous few years. SHS, in contrast to solar lanterns, offered a greater number of capabilities for lighting, including both interior cooling and entertainment, as well as charging for mobile devices. It was an independent unit that consisted of one or more solar modules, a battery charge controller, and a few loads, which were typically in the form of lights, a television, or a fan. In contrast to a portable solar light, the system was permanently installed. People living in rural areas of both states were more likely to use systems that were based on CFL technologies. There were 73% of households in Haryana that used CFL-based SHS, which is higher than the 62% of households in HP. On the other hand, just 6% of households in HP and 5% of households in Haryana used LED-based systems.

Solar Street Light: The villages and hamlets of Haryana and HP were equipped with solar street lights thanks to the installation of standalone systems. The system consisted of an external lighting unit that was utilized to illuminate the traffic lanes and by-lanes, as well as agricultural fields and open areas. Solar street lights were among the most widely used renewable energy technologies (RETs), and they were an integral component of virtually all rural electrification programs. This was due to the fact that they made life easier and more comfortable for the rural population. Despite the fact that it was a community RET, solar street lights had been acquired by household households in HP in order to ensure that the verandhas and agricultural farms were adequately illuminated. In addition to LED-based variants, there were also CFL-based solar street lights available.

The most common problems that occurred with solar photovoltaic (PV) technologies were the following: the CFLs became black, the battery became non-functional, there was a problem with the charge controller, the battery did not charge or was undercharged, the solar panel was not positioned correctly under the sun, and the system was left in the "switch on-mode" while it was charging. AU shop officers relayed that the systems functioned effectively provided that the users maintained them in the appropriate manner. The performance of the systems was negatively impacted by the users' lack of knowledge and ignorance, which operated as the primary limitation. As a result, there was a requirement for increased knowledge throughout both states about the operation and maintenance of operations.

Solar Thermal Technologies: In addition to the solar photovoltaic modules, inhabitants of Haryana and HP also made use of solar thermal technologies. Utilizing the sun's energy, these devices were able to raise the temperature of water and prepare food. On behalf of the Indian Solar Thermal Energy Programme, the Ministry had been promoting the utilization of a wide range of solar thermal devices for a considerable amount of time. These solar water heaters and solar cookers were utilized by the households living in rural areas.

Solar Water Heaters (SWH): One of the most common applications of solar thermal technology in rural regions was for the purpose of heating water for residential use. In the villages and hamlets, there were two types of solar water heaters that were utilized. The first type was the Flat Plate Collector (FPC), which was the most frequently used water heater in rural areas. The second type was the Evacuated Tube Collector (ETC), which was distinguished by its low heat loss, high efficiency, and reduced panel area to collect heat. Additionally, it was suitable for colder regions. Because of the high initial cost of the SWH, the number of people using it in rural regions was significantly lower than the number of people using SPV technologies. When compared to Haryana, the outcomes of the study indicated that the utilization of both FPC and ETC systems was higher in the state of Haryana. In the state of Haryana, only 6% of households had FPC and 4% had ETC, however in the state of HP, 19% of households had FPC; 13% had ETC. Complaints from users included water that was not heated appropriately, sluggish system performance, water that was not hot enough, or a volume of hot water that was not available in sufficient quantities.

Solar Cooker: The government had been promoting solar cooking technologies as a straightforward, risk-free, and uncomplicated approach to the process of preparing food. The box-type cooker and the curved concentrated cooker, also known as the parabolic cooker (SK-14), were the two types of cookers that were most typically seen in rural areas. The parabolic cooker was able to cook food at higher temperatures more quickly than the box-type cooker, which cooked food at a moderate temperature. According to the employees of the AU shop, solar cookers are often maintenance-free equipment that only need to be cleaned on a regular basis to ensure consistent operation. If it was properly maintained, the system had a life expectancy of approximately ten to twelve years on average. The verandas or roof tops of the HHs were found to be the locations where the parabolic cookers were established, as was seen. Despite the fact that people were aware of solar cooking, the use of solar cookers was limited to a small number of households in both states. For example, only 12.5% of households possessed a sun box cooker, and only 5% of households were using a solar parabolic cooker. This was owing to the fact that solar cookers have a limited usage, involve a delayed cooking procedure, and are not widely known.

BiogasPlant: As a means of generating biogas for use in cooking in rural households, biomass energy was utilized. The family-sized biogas plants were discovered in a small number of rural households, specifically eight percent in the state of Haryana and three percent in the state of Haryana. The low income level of the population, the lack of information, and the absence of a well-established sustainable biomass supply were identified as the causes for such a low degree of acceptability.

One of the primary substrates that were utilized in the digestion process that took place in a biogas plant was both liquid and solid manure from cattle. HHs also made use of organic waste, which included trash from fruits and vegetables that were collected separately, eggshells, and plant waste that was comprised of things that were left over from the fields. In the area under investigation, the KVIC model, which is of the fixed-dome type, was discovered with capacities ranging from one to two cubic meters.

IV. COMBINATIONOFENERGYRESOURCES USED FOR HOUSEHOLD ACTIVITIES

For the purpose of satisfying their daily energy requirements for various household activities, such as cooking, domestic lighting, water heating, and indoor space heating, cooling, and ventilation, rural communities in both states were in the process of utilizing a variety of energy resources.

(a) Energy Resources Used for House hold Cooking

It was a combination of LPG and firewood or biomass that was the most commonly used energy resource for cooking at HHs. For the purpose of cooking, the majority of households in Haryana (52%) utilized a mix of fuelwood or biomass as the primary resource and LPG as the secondary energy resource at their disposal. Among those who participated in the survey, the majority of respondents (57%) indicated that they would like to use a combination of fuelwood and LPG as their primary cooking resource.

In comparison, none of the people who used biomass wanted to use RETs, while only 6% of respondents from Haryana and 2% from HP indicated that they used RETs as a secondary energy resource in addition to utilizing LPG. According to the respondents, the primary reasons for selecting fuelwood or biomass were the low cost (96 percent from HP and 62.50 percent from Haryana), familiarity with the use of biomass (80 percent from HP and 78 percent from Haryana), and ease of availability (67 percent from HP and 33.3% from Haryana). Additionally, the respondents mentioned that it was easy to use (30 percent from HP and 12.5% from Haryana).

In contrast, the majority of respondents (86 percent from Haryana and 81 percent from HP) chose LPG because it was easier to use than fuelwood. However, fuelwood was not easy to utilize. Almost 66.5% of respondents from Haryana and 52% of respondents from HP cited the ease of availability as another major factor in their decision to select LPG for cooking purposes rather than use alternative resources. In view of the ease and comfort it provided in the form of reduced drudgery for women and reduction in associated health concerns, there were respondents who deemed LPG to be affordable. 40% of respondents in Haryana and 33% of respondents in HP were of this opinion.

The chi-square test revealed that there was a statistically significant connection between the features of the sample and the energy resources that were utilized for food preparation in the home. The level of education

was found to have a strong association with non-renewable energy sources (NRETs) such biomass, electricity, LPG, and RETs. The use of biomass, LPG, kerosene, electricity, and renewable energy technologies were found to have a strong relationship with income. It was found that there was a substantial correlation between density and biomass. The findings, therefore, centered on the fact that the following variables had an impact on the choice of fuel for cooking:

- The respondents who had completed primary and secondary education selected biomass as their preferred fuel because there was no barrier to technology and these fuels were already familiar to them.
- As a result of the preference of educated respondents for cleaner fuels, the majority of graduates and professionals utilized LPG, electricity, and RETs for cooking the food they prepared.
- The majority of respondents who belonged to high income groups (with an income of Rs. 25,000 or more) were the ones who utilized LPG because the cost of each cylinder was relatively expensive and these households were able to pay it.
- .Households with low incomes, defined as those earning up to Rs. 5,000 per month, were the most likely to use biomass because it was readily available in nature at no cost, allowing them to avoid the expense of purchasing fuel.
- Due to the fact that electricity was a costly fuel and also a clean fuel associated with higher social standing, the amount of electricity that was used for cooking grew as household income climbed.
- On account of their high cost and the fact that they required an investment, RETs were utilized for cooking by households with a monthly income of Rs. 250,000 or more. This was due to the fact that only families with a high income could afford to purchase them.
- The respondents who lived on high hills favoured biomass since it was readily available in large quantities and was not difficult to obtain.

(b) Energy Resources Used for Household Lighting: People who participated in the survey mentioned that in addition to making the most of the sunlight, they utilized a variety of different sources of energy. The majority of the respondents (74% from Haryana and all of the inhabitants from HP) used electricity (from conventional grid) as their primary energy resource for home lighting. This was followed by renewable energy sources (RETs), which emerged as preferred lighting resources for 64% of homes in Haryana and 60% of homes in HP. The use of candles was practiced by 34% of households in Haryana and 35% of households in HP, respectively. Kerosene was utilized by 48% of households in Haryana and 25% of households in HP. Kerosene (28 percent from Haryana and 25 percent from HP) and candles (25 percent from Haryana and 21 percent from HP) were the next most popular combinations of lighting energy resources. The most popular combination of lighting energy resources was electricity (from conventional grid) as a primary energy resource, with renewable energy sources (RETs) as secondary (47% from Haryana and 54 percent from Haryana). Electrical power and renewable energy sources were favored due to their user-friendliness and accessibility.

According to the results of the chi-square test, there is a correlation between the features of the sample and the energy resources that are utilized for HH illumination. Education was just an important factor when it came to RETs; money was important when it came to kerosene use; age was important when it came to RETs and kerosene; and geography was extremely important when it came to RETs and candles. Specifically, the findings highlighted the fact that the following variables had an effect on the fuels that were chosen for lighting:

- The usage of contemporary and environmentally friendly fuels was linked to higher levels of knowledge.
- Because kerosene was a costly fuel, there was a correlation between higher income and the usage of kerosene for household lighting. The elderly and young individuals favored the use of electricity and renewable energy sources (RETs) for illumination because these fuels were safer.
- As a result of the lack of availability of conventional grids, the majority of respondents who lived in steep terrains resorted to using RETs for illumination.

(c) EnergyResourcesUsedforWaterHeating

Different combinations of energy sources, such as biomass, LPG, coal, electricity, and renewable energy technologies (RETs), were utilized by rural households. The most often used energy sources for heating water were fuelwood and biomass, which accounted for 62% of the total; Haryana accounted for 59%; and electricity, which accounted for 55% of the total; Haryana accounted for 41%. The majority of respondents who used fuelwood as their primary resource for water heating selected electricity as their secondary energy resource in addition to it. From Haryana, 54% of respondents chose electricity, and from HP, 29% chose electricity. In addition, the findings of the study indicated that RETs were popular in conjunction with fuelwood (37%), followed by LPG (35%). On the other hand, in HP, LPG was a popular alternative resource that was used in conjunction with fuelwood (31%), followed by candle users (12%). Nearly 29 percent of people who used biomass for water heating in Haryana and only seven percent of people in the state of Haryana did not use any other fuel.

On the other hand, every single one of the respondents who relied on electricity as their primary resource also made use of other resources in order to meet their daily water heating needs. Among the respondents from Haryana, the combination of electricity and LPG was the most popular choice, with 43% of them preferring it. Fuelwood users came in second, with 38%, and RETs were used by 19%. 66% of respondents in HP indicated that they would prefer a combination of fuelwood (25%), LPG (53%), and electricity with renewable energy sources (RETs). In neither of the states did any of the respondents claim that they did not use electricity for the purpose of heating water.

The results of the chi-square test revealed that there was a statistically significant connection between the features of the sample and the energy resources that rural households used to heat their water. Education was found to have a substantial association with the utilization of renewable energy sources, electricity, LPG, and biomass. Biomass, electricity, LPG, and renewable energy technologies were proven to have a considerable impact on income. The relationship between biomass and topography was shown to be significantly important. As a result, the data brought to light the various considerations when choosing fuels for water heating. These were as described below:

- The majority of respondents who had completed primary and secondary education expressed a preference for biomass.
- Among those who had completed their education and were working professionals, the use of electricity was particularly prevalent.
- Those respondents who had completed secondary education, were professionals, and had graduated from college utilized LPG.
- The percentage of people who used electricity was higher among professionals and graduates. One hundred and fifty percent of households with monthly incomes ranging from five thousand to fifteen thousand rupees favored using biomass as a source of water heating.
- An increase in revenue was shown to be connected with the utilization of LPG for the purpose of water heating.
- Homeowners who maintained a monthly income of more than Rs. 15000 were the most likely to make use of electricity and RETs.
- The majority of people who used biomass were those who lived on high hills,
- while the majority of people who used LPG were those who lived in families that were located on low hills and plains.

(d) Energy Resources used for Indoor Space Heating, Ventilation and Cooling

Electricity (from the conventional grid) was the primary means by which rural households met their requirements for heating, ventilating, and cooling the interior of their homes. The combination of electricity (from the conventional grid) and fuelwood/biomass (36 percent from Haryana and 19 percent from HP) was the most chosen combination and was used as the principal energy resource. Coal (10 percent from HP and 8 percent from Haryana) was the next most preferred combination. A small number of rural households made use of coal in a traditional device known as sigri for the purpose of space heating, mostly in steep terrains. In the chi-square analysis, it was found that there was a significant correlation between the features of the sample and the energy resources that were utilized for heating, cooling, and ventilation of the interior area. A low level of education was shown to be strongly associated with the utilization of biomass, which suggests that a prolonged reliance on conventional fuels was the result of this low level of education. Because of the high cost of coal in comparison to other technologies that use biomass, households with high incomes were the ones who used coal for heating their indoor spaces. This was a strong correlation between income and the use of coal.

EFFECTIVENESSOFRETs

The reliability of RETs was seen as the most effective dimension, with a mean score of 72.21, according to the total mean scores concerning the efficacy of RETs. On the other hand, the parameters of program commencement and sustenance, repair and maintenance, and product design were rated as being of poor quality. Both the ease of operation and the affordability were generally regarded as being below average. On the other hand, the scores on all of the factors that were chosen did not differ by a significant amount (the range of scores was from 59.11 to 72.21). Between 37 to 50 was the range of the modal scores. The parameter program initiation and maintenance received the lowest modal score, while the parameter repair and maintenance and product design received the highest modal score compared to the other parameters.

The vast majority of users, 55% from Haryana and 46% from HP, rated the effectiveness of RETs as above average, while 41% and 44% of users from Haryana and HP, respectively, assessed the effectiveness of RETs as below average. When it came to the effectiveness of RETs, only 4% of users from Haryana and 2% of users from HP thought them to be good, while only 7% of consumers from HP viewed them to be poor. On the other hand, none of the users from Haryana state deemed RETs to be poor according to their effectiveness. It was determined that the effectiveness of the RETs parameters, specifically "reliability,""affordability," and "ease of operation," were rated above average. On the other hand, the effectiveness of "program initiation and sustenance,""repair and maintenance," and "product design" was rated below average. This revealed that

users of RET experienced a struggle when it came to criteria that received ratings that were below average. When the six efficacy of RETs parameters were ranked according to state, it was discovered that the mean scores for the state of Haryana were significantly higher than those for the state of HP. With the exception of "repair and maintenance," which received a mean score of 57.50, all of the parameters, including "reliability,""affordability," and "ease of operation," as well as "program initiation and sustenance" and "product design," had scores that were greater than sixty. In the state of HP, the categories of "reliability,""ease of operation," and "repair and maintenance" were regarded as being superior to "program initiation and sustenance,""affordability," and "product design," which received mean scores of 59.03, 54.17, and 58.18, respectively.

The comparison analysis between two states, which was based on mean scores, revealed that consumers believed that reliability contributed the most to the effectiveness of RETs in rural regions. The mean score for Haryana was 73.93, while the mean score for HP was 69.35. owing to the depletion of conventional energy supplies, power shortages, and the absence of an electricity grid (in hamlets of Morni block, Panchkula district), inhabitants of Haryana reported higher levels of satisfaction compared to those of HP. This is likely owing to the fact that Haryana's dependency on renewable energy sources (RETs) was greater than that of HP. The non-polluting quality of RETs was highly prized in HP, and they were used as a supplement to NRETs in order to help save money on electricity bills, reduce the amount of labor that women had to do in order to obtain fuel, and conserve natural energy supplies.

When examining the relationship between user perceptions of the effectiveness of RETs and their socio-economic characteristics, it was found that there was a significant connection at the 1% level of significance with education, occupation, and family size. They were more happy with the effectiveness of RETs because they probably had better understanding about the many components of RETs. Graduates and professionals were more likely to have this expertise. There is a high probability that the respondents with primary and secondary education were unable to identify with the RETs because they lacked understanding regarding their utilization, operation, and maintenance. Respondents who were active in service and business noted an improvement in productivity and profitability as a result of the utilization of RET. Agriculturists desired more RET alternatives that may make their work in the fields easier and increase production and profitability. Housewives were the ultimate users of the majority of the RETs, and it is likely that they had higher expectations for these novel devices, but they lacked the skills necessary to operate them. Due to the fact that nuclear families had a smaller number of individuals, their energy requirements could be satisfied with a smaller amount of energy resources. This is in contrast to joint families, which had demands for energy that were significantly higher.

CHANGE IN QUALITY OF LIFE OF RESIDENTSWITHRESPECTTORET USAGE

On the basis of the total mean scores on the change in quality of life dimensions, the 'healthcare' dimension was regarded as the best dimension, with a mean score of 66. On the other hand, the'safety and security' and 'education' dimensions were perceived as being below average. It was determined that both "comfort and convenience" and "income generation" were of low quality. The scores on all of the specified quality of life aspects, on the other hand, did not differ by a significant amount (the range of scores was from 52 to 66). Between 30 to 75 was the range of the modal scores. "Education of children" had the lowest modal score, while "healthcare" received the greatest modal score. Both of these dimensions were evaluated differently.

The majority of respondents saw a change in quality of life that was below average, with 61% coming from Haryana and 66% coming from HP. Comparatively, 36% of residents in Haryana viewed the change to be above average, whilst only 21% of users in HP found it to be above average. While almost thirteen percent of HP users regarded the modification as being unsatisfactory, none of the users from the state of Haryana thought it was problematic. Out of the respondents from Haryana, only 4% thought the change in quality of life was positive, while none of those from HP thought it was positive.

The dimension of "healthcare" received a rating that was higher than normal, however other domains, such as "safety and security,""education of children,""income-generation and financial security," and "convenience and social life," received ratings that were lower than usual.

A comparison of the five quality of life parameters across the states revealed that the state of Haryana experienced a greater degree of change than the state of HP. The dimensions of "healthcare,""education of children," and "safety and security" all received ratings that were greater than sixty, whereas the dimensions of "income generation and financial security" and "convenience and social life" had mean scores of 59.39 and 52.18, respectively. Only one area, namely "healthcare," received a score higher than sixty in the state of HP. All other dimensions, such as "education of children" (58.15), "safety and security" (55.77), "convenience and social life" (51.07), and "income generation and financial security" (47.20), received scores lower than sixty.

The comparative analysis made it abundantly evident that people of Haryana saw a more favorable change in their quality of life in comparison to those of HP. When compared to Haryana, the electrical supply in Jammu and Kashmir was superior, and the pricing were lower. In addition, renewable energy sources were mostly utilized to supplement the existing electrical supply, which was of a high quality. The adoption of renewable energy sources was accomplished as a result of energy consciousness among rural residents of HP. Further, the state of HP has a lot of natural resources, and the government had been doing everything in its power to

protect those resources. These included the implementation of initiatives such as the selling of LEDs at prices that were significantly reduced. Due to the poor power quality in rural areas and the lack of electricity in many hamlets located in distant locations (Morni block), the introduction and acceptance of renewable energy technologies (RETs) in Haryana was primarily based on whether or not they were required. Because of this, RETs were the only source of energy that these HHs could draw upon. The findings of the study indicated that inhabitants of Haryana were grateful for the efforts made by the government since RETs had provided them with a glimmer of hope. This was due to the fact that access to energy and a lack of money made it difficult for them to carry out a variety of different HH activities.

At the 1% level of significance, the link between the user's assessment of change in quality of life and their socio-economic characteristics revealed a high level of association with education (the level of significance). As a result of having improved knowledge regarding the usage, operation, and maintenance of RETs, graduates and professionals experienced improvements in their quality of life. At the 5% level of significance, there was a correlation between changes in quality of life and occupation, income, and the number of people in a family.

In light of their hectic schedules and the fact that they are responsible for meeting the requirements of their families despite having little financial resources, respondents from the service class expressed priority to RETs. Housewives were likely not particularly ambitious and had to perform mundane duties related to household chores. Individuals who were self-employed and agriculturalists who responded to the survey connected change with increasing profitability and new start-ups, which most likely did not live up to their expectations. Traditional NRETs were the only option available to low-income households since they were familiar, readily available, and had a low cost. In addition, the recipients did not fully appreciate the significance of the RETs they had received because they had obtained part of them at no cost through a variety of programs. Given that RETs were among the most expensive durables and that respondents with high incomes had high expectations regarding their performance, they anticipated that there would be more change. It was possible for RETs to meet the energy requirements of smaller families than joint families since there were fewer persons in the joint family.

REGRESSIONANALYSIS

Regression Analysis of Socio-economic Variables Influencing Effectiveness of RETs

The scores on the overall effectiveness of RETs were regressed with socio-economic characteristics such as gender, age, education, occupation, income, and topography. Additionally, the scores were regressed with knowledge regarding RETs, knowledge regarding NRETs, change in quality of life, effectiveness of NRETs, user acceptance of RETs, and ownership of RETs. The coefficient of determination (R2) calculated to be 0.677 indicated that the independent factors described above accounted for 67.7% of the variance on the dependent variable, which was the efficiency of RETs. t-values of age, education, change in quality of life, effectiveness of non-rehabilitative therapies (NRETs), acceptance of rehabilitative therapies (RETs), and ownership of RETs were significant.

Regression Analysis of Socio-economic Variables Influencing Changein Quality of Life of Resident sw.r.t RETUsage

The scores on the change of quality of life were regressed with a number of different variables, including gender, age, education, occupation, income, topography, knowledge of RETs, knowledge of NRETs, effectiveness of RETs, effectiveness of NRETs, acceptance of RETs, and ownership of RETs. The coefficient of determination (R2) was 0.558, which indicated that the independent factors listed above accounted for 55.8% of the variation in the dependent variable, which was the change in quality of life. There was a strong relationship between the t-value of the effectiveness of RETs, the effectiveness of NRETs, and ownership of RETs.

SUSTAINABLEDEVELOPMENTMODEL FOR CO-EXISTENCE OF NON-RENEWABLE ENERGYTECHNOLOGIESANDRENEWABLE ENERGYTECHNOLOGIES

The scores on the change of quality of life were regressed with a number of different variables, including gender, age, education, occupation, income, topography, knowledge of RETs, knowledge of NRETs, effectiveness of RETs, effectiveness of NRETs, acceptance of RETs, and ownership of RETs that were used. R2 (0.558) revealed that the independent factors described above accounted for 55.8% of the variation in the dependent variable, which was the improvement in quality of life. Both of these variables were taken into consideration. The t-values of the effectiveness of RETs, the effectiveness of NRETs, and the ownership of RETs were all discovered to be significant.

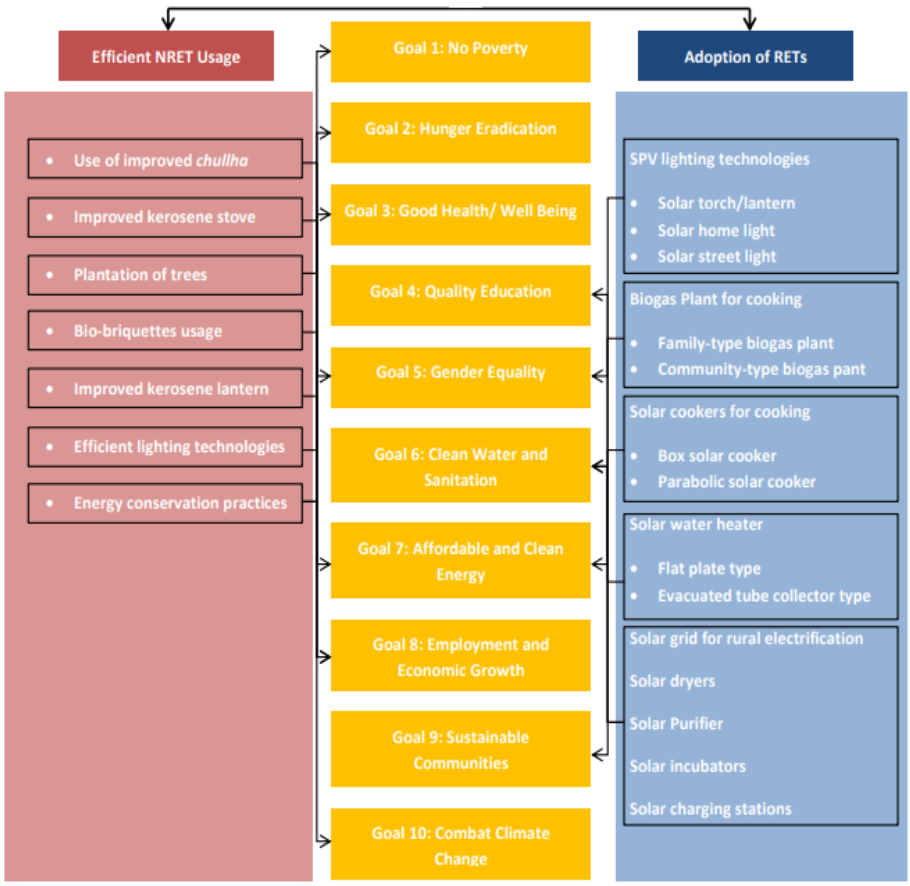

Fig.1: Sustainable Development Model

In order to achieve the three components of sustainable development—namely, economic growth, social development, and environmental safety or protecting the eco-system—the sustainable development model suggests that the utilization of renewable energy resources, in conjunction with the efficient utilization of biomass and electricity, can assist in the reduction of the environmental effects of use. Additionally, it can enable residents of rural areas to supplement and complement the conventional energy resources that are already in place. Because traditional biomass is extracted directly from the surrounding environment, it is necessary to have a responsible management of these resources in order to ensure their long-term viability. On top of that, their utilization has an impact on the environment. One example is the release of greenhouse gases (GHG) that occurs when biomass is burned in an inefficient and incomplete manner. These emissions have an effect on the environment and contribute to climate change.

Due to the fact that every energy resource has some kind of impact on the environment, making optimal use of conventional energy resources and utilizing renewable energy resources (RETs) to complement non-renewable energy resources (NRETs) might help to alleviate a significant number of concerns regarding the constraints that are placed on sustainable development. RETs have the ability to accomplish a wide variety of goals related to sustainable development. In light of these, the following has been discussed:

GOAL 1-Povertyalleviation: Residents living in rural areas were given the opportunity to generate revenue through the utilization of RETs. They made new businesses possible and boosted the profitability and productivity of work that was already being done. The establishment of a store for the repair of RETs, solar charging stations, the production of enhanced chullhas, and the opening of small businesses such as beauty parlors, boutiques, and petty shops were among the new chances for making a living that were possible in relation to RETs. Both photovoltaic (PV) solar technology and solar grids had a positive impact on the lives of those living in rural poverty. In addition, renewable energy technologies (RETs) including solar thermal technologies and biogas plants made it possible to maintain current work schedules by reducing the amount of time spent in the morning.

GOAL2-Zerohunger: The availability of clean and contemporary electricity permitted financial security, which in turn helped the family to offer meals at three different times throughout the day. Renewable energy technologies (RETs) such as solar photovoltaic (SPV) and solar grids made it possible for activities to generate cash. Additionally, solar cookers, water heaters, and biogas plants had the ability to supply consumers with clean water and food.

GOAL 3- Good health and well-being: The outcomes of the research made it abundantly clear that having access to clean and renewable sources of energy for cooking and lighting has a positive impact on the health of people living in rural areas. The users and beneficiaries indicated that they experienced a favourable change in terms of improved healthcare services, such as the availability of doctors, medicines, and midwives.

Additionally, they reported improved healthcare at home and a reduction in the amount of indoor air pollution, which led to improved health for women, children, and the elderly.

GOAL 4- Quality education: Based on the findings of the research, it was found that rural households with children attending school had access to lighting that was made possible by solar photovoltaic technologies. These technologies included solar lanterns, solar torches, and solar home lights. Residences also benefited from the installation of solar grids and street lighting, which resulted in improvements to the educational system. According to what they reported, the utilization of RETs made education possible because it allowed students to devote more time to studying, finish their homework, get ready for tests, take part in extracurricular activities, earn higher marks, and attend school more frequently.

GOAL 5- Gender equality: RETs had positive implications in terms of reducing the amount of drudgery that women had to do and saving time for more productive home-based activities. These activities included helping children with their homework and exam preparation, preparing meals for the family, increasing the amount of leisure time available, making it easier for women to carry out home-based activities, and improving the quality of family relationships. The women claimed that the installation of biogas plants and solar cookers (both box-type and parabolic-type) led to a reduction in their workload and the difficulties they faced in acquiring fuel wood, as well as an improvement in the indoor atmosphere and the health of the occupants. Additionally, the female child who typically accompanied her mother for the purpose of fuel wood collecting now had a greater chance for education, which resulted in a reduction in child dropouts at an earlier age. The findings of the research indicated that rural women should be more involved in the usage, operation, and maintenance of resources, as well as decision making and governance. It was stated by residents that the product design of RETs needed to be improved in order to make it easier for women to use them without the assistance of the male member. For instance, in rural households, the solar cooker was typically operated by the male member.

GOAL 6- Clean water and sanitation: The outcomes of the research indicated that solar thermal technologies have the potential to be utilized for the purpose of water purification. These technologies include solar cookers and water heaters. Additionally, people noted that the installation of solar street lights helped to improve hygiene in the surrounding areas, which contributed to an increased sense of security and safety among inhabitants living in rural areas. owing to the fact that residents were afraid to walk to remote locations owing to the darkness, open defecation within the vicinity of the residences was prevalent. In addition, toilets had been built in a great number of rural HHs with the assistance of the Total Sanitation Programme of the government.

GOAL 7- Affordable and clean energy: Solar thermal technologies, such as solar cookers and water heaters, were shown to be effective in the purification of water, according to the findings of the research. Residents of rural areas also said that the installation of solar street lights had improved sanitation in the surrounding areas, which contributed to an increased sense of security and safety among those living in rural areas. Because of the darkness, residents were afraid to venture to further away locations, therefore they frequently defecated in the open near their homes. Additionally, toilets have been built in a number of rural HHs with the assistance of the Total Sanitation Programme of the government.

GOAL 8- Decent work and economic growth: Residents of certain rural areas claimed that RETs had made it easier for them to maintain a regular work schedule because the availability of electricity made it possible for them to do their chores around the house. Residents who owned shops in main (local) marketplaces or those who ran petty businesses from their homes enjoyed increased productivity and profitability. This was the case for both groups. Only a few people living in rural areas decided to start new businesses, which ultimately helped them increase their household income. The elderly and women were the ones who took up the supplementary occupations, which included founding small stores and pursuing talents that could be used in the commercial sector, such as beauty parlors and tailoring, among other things. It was asked by the residents that more interventions be implemented, namely women-centric programs, in order to equip them with skills that would enable them to generate additional revenue and enhance their quality of life.

GOAL 9-Cities and communities that are sustainable: Renewable energy sources (RETs) are the best solution to ensure the sustainability of cities and communities because of their clean and inexhaustible environment. It is possible to make use of them in order to supplement and complement the NRETs, which are becoming increasingly scarce.

GOAL 10- Combat climate change: RETs have the potential to combat the negative effects on the climate that are caused by the extensive dependence on NRETs, which results in the depletion of their reserves and inefficient usage (incomplete combustion of fuels leading to indoor air pollution and health hazards to the inhabitants, particularly women and children). RETs have the potential to combat these negative effects. In addition to being environmentally friendly, the technologies of the next generation, such as fuel cells and transparent solar panels, are also examples of sustainable alternatives.

CONCLUSION

The majority of people living in rural areas of India utilize RETs as a supplement to NRETs. This has brought about a good and major improvement in the lives of the people who live in certain villages and hamlets,

particularly those that have a limited supply of traditional energy resources and a power supply of poor quality. It was evident that there was a shift toward new technology that were clean, even though it was slow. As a result of the unique nature of RETs in comparison to the traditional technologies that are well-established and well-known, the penetration of RETs is increasing, and a discernible improvement in the quality of life of RET users would follow its due course after the utilization of these technologies for a considerable amount of time. From the lives of people living in rural areas, it was not possible to extract the significance of NRETs by observation. As a result, rural energy programs ought to incorporate the enhancement of existing NRETs by educating people about the significance of energy conservation and the relevance of energy-efficient activities. The introduction of renewable energy technologies was also necessary in order to improve the quality of life of people living in rural areas. This was accomplished by combining renewable energy technologies with non-renewable energy technologies, particularly biomass technology. Some of the challenges with respect to RETs such as high cost, repair and maintenance and training of staff had been addressed with the help of various initiatives by the Government through provision of financial incentives (in the form of subsidies, provision for loans, rebate on electricity), AkshayUrjashops to enable promotion, sale, repair of RETs and Surya Mitra Program for training of local volunteers especially unemployed youth and rural women to provide repair and maintenance services for RETs.

IMPLICATIONSOFTHESTUDY

As a result of the findings of the study, a number of implications were brought to light. Increasing the deployment of renewable energy technologies (RETs) and energy efficiency programs is something that the government needs to do in order to guarantee the long-term viability of electricity supply and sustainable economic development in rural areas. In addition, the research and development centers and technological development institutions that are already in place must to be significantly strengthened in order to provide support for the transition toward increasing the utilization of RETs. For the purpose of project creation, management, monitoring, and evaluation, the development of human resources, the transfer of knowledge, and the acquisition of technical know-how should be the primary focuses. The accreditation of renewable energy technologies (RETs) should be urgently prioritized, and this could be accomplished through the establishment of standards and codes of practices, maintenance manuals for efficient usage, life cycle costing, and cost-benefit analysis tools. It is vital to ensure the long-term viability of RETs by implementing training programs and by improving infrastructure.

REFERENCES

1. Barnes, F.D. and Floor, M.W. (1996). Rural Energy inDevelopingCountries: AChallenge forEconomic Development. Annual Review of Energy and the Environment. Power Development, Efficiency and Household Fuels Division, Industry and Energy Department, The World Bank. Vol. 21: 497-530.
2. Balachandra, P. (2011). *Energy Poverty: Global Challenges and Local Solutions*, Oxford University Press. pp 237-247.
3. Balachandra, P. (2011) 'Dynamics of Rural Energy Access in India: An Assessment'. *Energy*, 36(9).pp 5556–67.
4. Census of India (2001). Tables on houses, household amenities and assets. Retrieved from http://www.censusindia.net/2001housing/housing_tables_main.html, assessed on October 4, 2011.
5. Census of India (2011).Census of India Dashboard. Retrieved from Census of India :http://www.censusindia.gov.in/2011census/PC A/PCA_Highlights/pca_highlights_india.html accessed on August 24, 2013,
6. Census of India (2011a). Census of India Dashboard. Retrieved from Devinfolive: http://www.devinfolive.info/censusinfo dashboard/website/index.php/pages/kitchen_fueluse d/total/Households on August 27, 2013.
7. Chaurey, A, Ranganathan, M. and Mhanty, P. (2004). Electricity Access for Geographically DisadvantagedRural Communities-Technologyand Policy Insights.Energy Policy.pp 1693-1705.
8. Gupta, M (2014).'Quality of Life of Elderly in Old Age Homes and Recreation Centres'.Lady Irwin College, Delhi University, Delhi.
9. Goel, S. (2005).'Ergonomics of Lighting for Reading'. Lady Irwin College, Delhi University, Delhi.
10. InternationalEnergyAgency(IEA),2008.*World Energy Outlook*.Review of international policies for vehicle fuel efficiency, OECD/IEA, Paris. Retrieved from http://www.worldenergyoutlook. org/media/ weowebsite /2008-1994/weo2008.pdf accessed on 27 November, 2015. InternationalEnergyAgency(IEA),2009.*World EnergyOutlook*2009,OECD/IEA,Paris. Retrieved from http://www.worldenergyoutlook.org/media/weowebs ite/2009/WEO2009.pdf accessedonAugust24, 2015.
11. International Energy Agency (IEA), 2015. *World Energy Outlook*. Energy and Climate Change. Retrieved from https://www.iea.org/publications/ publication/ WEO2015SpecialReportonEnergyandCl imateChange.pdf accessed on August 22, 2015.
12. International Energy Agency (IEA), 2015. *World Energy Outlook*. 'Modern energy for all: why it

matters?'.Retrieved from www.worlenergyoutlook.orgaccessedonAugust14, 2015.
13. International Energy Agency (IEA), 2014. *World Energy Outlook 2014 Factsheet*. How will Global Energy Market Evolve to 2040? Retrieved from http://www.worldenergyoutlook.org/media/weowebsite/2014/141112_weo_factsheets.pdfaccessedon August 12, 2015.
14. India Core (2015). The Online Resource for Information on the Indian Infrastructure and Core Sectors. Retrievedfromwww.indiacore.comaccessed on November 23, 2015.
15. Kumar, A., Kumar, K., Kaushik, N., Sharma, S. and Mishra, S. (2010). Renewable energy in India: CurrentStatusandFuturePotentials.Renewableand Sustainable Energy Review, Vol 14. *Science Direct*.pp 2434-2442.
16. Kumar, A. and Kandpal, T.C. (2007). Renewable Energy Technologies for Irrigation, Water Pumping in India: A Preliminary Attempt Towards Potential Estimation. *Energy* 32(5).pp 861-870.
17. Kumar, A. and Mathur, R. (2009).Role ofRenewable Energy in India.*Yojana*.pp 28-31.
18. Kumar, U. (2012). A study of Rural Electrificationin India- Challenges and Alternatives. JJT University. *Renewable Energy Journal* ISSN 2321- 1067.pp 9-20.
19. Mahapatra, S. and Dasappa, S. (2012). Rural electrification: optimizing the choice between decentralized renewable energy sources and grid extension.EnergyforSustainableDevelopment (16).pp.146-154.
20. Martinot, E. (2005). Renewable Report GlobalStatus Report. Paris: Renewable Energy Policy Network for the 21st century. MERC (2013). Maharashtra Electricity Regulatory Commission (MERC).Retrieved from http://www.mercindia.org.in/pdf/Order%2058%2042/Order_Case%20No%2049%20of%202013-22%20July%202013.pdfaccessedonOctober4, 2014.
21. Ministry of New and Renewable Energy (MNRE), 2012. Off-grid schemes for Remote Village Electrification. Retrieved from http://mnre.gov.in/schemes/offgrid/remote-village- electrification accessed on May 4, 2012.
22. MinistryofNewandRenewableEnergy(MNRE), 2012.Solar Thermal and hotovoltaic Field Engineers Training Course, New Delhi by MNRE. Retrieved from http://mnre.gov.in/file-manager/UserFiles/Solar -thermal-and-photovoltaic- field-engineer-training-course.pdf accessed on August 8, 2014.
23. MinistryofNewandRenewableEnergy(MNRE), 2015.SolarParksandUltraMegaSolarPower Projects Scheme. Retrieved from http://mnre.gov.in/file-manager/UserFiles/Draft- Scheme-Solar-Park-and-Ultra-Mega-Solar-Power- Projects-for-comments.pdfaccessedonJanuary12, 2016.
24. MinistryofPower (MoP), 2003.DiscussionPaper on Rural Electrification Policies. Government of India, New Delhi. Retrieved from http://powermin.nic.in/Rural-Electrification accessed on August 27, 2013.
25. Ministry of Power (MoP), 2005. Rajiv Gandhi Grameen Vidhyutikaran Yojna. Government of India, New Delhi .Retrieved from http://powermin.nic.in/ initiatives accessed on August 27, 2013.
26. Huq, M.M. (2003). Building Technological Capability: Issues and Prospects, Nepal, Bangladesh and India.University Press.pp.15-80.
27. Ministry of Statistical and Programme Implementation (MoSPI), 2011.Energy Statistics 2011.Retrieved from http://mospi.nic.in/Mospi New/upload /energy _stat _2011_pdf/table_section_2_es10.pdf accessed on 12 October 2014.
28. Ministry of Power (MoP), 2012.India Electricity Scenario 2012.Retrieved from http://powermin.nic.in/upload/pdf/Annual Report 2012-13_English.pdf accessed on 12 October 2014.
29. National Sample Survey Office (NSSO), 2001.Level and Pattern of Consumer Expenditure, 1999- 2000. New Delhi: Ministry of Statistics and Programme Implementation (MoSPI), Government of India.
30. National Sample Survey Office (NSSO), 2006.Level andPattern of ConsumerExpenditure,2004- 05. New Delhi: Ministry of Statistics andProgramme Implementation (MoSPI), Government of India.
31. National Sample Survey Office (NSSO), 2011.Level andPattern of ConsumerExpenditure,2009-10. New Delhi: Ministry of Statistics andProgramme Implementation (MoSPI), Government of India.
32. National Sample Survey Office (NSSO), 2012.Energy Sources of Indian Households for Cooking and Lighting, 2010-2011.New Delhi: Ministry of Statistics and Programme Implementation (MoSPI), Government of India.
33. Painuly, J.P. (2001). Barrier to renewable energy penetration; a framework for analysis.Renewable Energy 24.pp 73-89.
34. Painuly, J.P. and Fenhann, J.V. (2002).Implementation of Renewable Energy Technologies–OpportunitiesandBarriers.Summary of Country Studies.UNEP Collaborating Centre on Energy and Environment, RISØ National Laboratory, Roskilde, Denmark.
35. Pawar, V. and Kaur, T. (2014).Overview of Renewable energy resources of India.*International Journal of Advanced Research in Electrical, ElectronicandInstrumentationEngineering*,3(2), ISSN2278-8875.pp7118-7119.
36. Planning Commission (2012).Eleventh Five Year Plan of the Government of India. In P. Commission (Ed.) New Delhi: Planning Commission. Vol. 3.pp.383-385.
37. PlanningCommission(2013).PressNoteonPoverty Estimates, 2011-12. Retrieve from Planning

Commission: http://planningcommission.nic.in/news/pre_pov2307.pdf accessed on August 24, 2013.
38. Renewable Energy Regulatory Framework (2012) . Retrieved from http://mnre.gov.in:http://mnre.gov.in/information/renewable-energy-regulatoryframeworkaccessedonOctober4,2014.
39. Renewable Energy Regulatory Framework (2013).Retrieved from http://mnre.gov.in:http://mnre.gov.in/mission-and-vision-2/achievements/ accessed on October 4, 2014.
40. Renewable Energy Regulatory Framework (2015).Retrieved from http://mnre.gov.in:http://mnre.gov.in/mission-and-vision-2/achievements/accessed on January 5, 2016.
41. Varun and Chauhan, M.K. (2014). CarbonFootprints and Energy Estimation of the Sugar Industry, An Indian Case Study. *Environmental IssuesinLogisticsandManufacturing, Assessment ofCarbon Footprintsin DifferentIndustrialSectors*. SpringerScienceandBusiness,Volume2.pp53-80.who provided expe