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Study of product adoption practices of solar water heater

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Abstract
With the fast diminishing conventional energy sources such as fossil fuel, coal natural gas and the world's demand for energy is increasing at a brisk pace. One can imagine the hardship of life without energy. The research paper is focusing on consumer's attitude towards Green Energy product i.e. Solar water Heater. The study has been conducted to explore the adoption practices for such non-conventional products. It dwells deeper through analyzing present policies and world as well as Indian solar market. The study is limited to Bhopal city and samples have been drawn exclusively from user category. The distributors of various manufacturing companies have been interviewed to get 360 degree insight into non-conventional energy market.

Keywords: fossil fuel, coal natural gas, solar water heater

1. Introduction

With the immense environmental benefits and clear visible energy savings Solar Water Heater is a boon for India and any research to make this devise a household name is the need of the hour.

Solar Water Heater has emerged as the most popular Green Solar Energy options adopted worldwide. Researches show that more than 80% of the Solar Water Heaters are being adopted by the domestic customers and the market is increasing at a healthy pace [5].

This study explores many geo-demographic factors as well as attitudinal and behavioural aspects behind adoption of Solar Water Heater, though limited to Bhopal region only but can be a significant indicator to delve down in to further explorations in different geographical and demographical setups.

This study will also help to align policy makers efforts towards creating a conducive environment for adoption of Solar Water Heater at the same time give vital indicators to manufacturer and marketing firms to understand consumer needs and develop product and marketing mix accordingly.

The technical overall potential assuming that 75% of concrete based houses of the country occupied by the owners will have solar water heaters could be taken as 140 million sq. m. of collector area. The achievable/economic potential based on purchasing power of people/ requirement of hot water in a year/ availability of space for installation of system/ availability of solar radiation etc. may, however, be taken as 35-40 million sq. m. of collector area [7].

The Economy calculations

If we don't calculate advantages of such technology over conventional one the entire purpose of the study gets defeated, we have considered 2 major criteria to judge the saving potential of Green technology.

1.1.1 Savings on Electricity/Diesel

- A 100 litres per day (LPD) system (2 sq.m of collector area) installed in a home can save 4-6 units of electricity/day depending on the place of installation & hot water use. On an average it could be taken as 5 units/day. Maximum average saving with 300 clear days, therefore, could be taken as 1500 units/year [6].
- Assuming 300 days of solar hot water use in cities like Bangalore and 150 days in Delhi, the savings could be 1500 & 750 units per year respectively i.e. replacement of a 2 KW electric geyser working for 2 ½ hours in a day. Considering all parts of the country and maximum installations in areas where hot water requirement is more during the year, average saving could be taken as 1200 units/year/100 lpd system.
- 1 million such systems installed will be able to save 1200 million units of electricity/year.
- A 100 LPD system (2 sq.m of collector area) installed in an industry can save around 140 litres of diesel in a year.
- 1 system of 100 LPD can replace an electric geyser of 2 KW capacity in a home.
- 1 million such systems will replace 1 million geysers of 2 KW capacity each in homes. Assuming that at least 50% of geysers are switched on at a time, this will have a peak load saving of 1000 MW [10].

1.1.2 The Environmental savings - CO_2 Reduction

A 100 LPD system on an average saves up to 1500 units of electricity/yr. To generate that much of electricity from a coal based power plant, 1.5 tone of CO_2 /year is released in atmosphere. One million solar water heating systems installed in homes will, therefore, also result in reduction of 1.5 million tone of CO_2 emission in atmosphere [11].

With having such sustainable benefits, Solar Water Heater is still struggling to be adopted as a common consumer durable. Very less amount of research work have been undertaken to diffuse this green energy entity. A very little published information exists on the Solar Water Heater markets. In recent years, two research studies have presented methodologies for the assessment of Solar Water Heater potential. There are very few studies which talk about consumer behaviour towards Solar Water Heater adoption not only in India but in the world as well.

It has been found that in India, the growth has reached up to 20% and there is around 10 million square kilometer of

installed capacity of Solar Water Heater till August 2015, these are available at an average cost at around Rs 18,000.

2 The Energy Scenario

It is impossible to succeed in today's economy without access to energy. Our current energy system, largely based on fossil fuels which is quite limited and briskly getting exhausted. A prime culprit of global warming and actively harmful to not only human health but health of our planet as well.

The answer to all the worries is "Green Energy", one among the five megatrends which will decide the future of this world for years to come. The fact that these resources are considered to be infinite and are strong backbone of such belief.

Green energy is the answer to the world search of constant and sustainable energy source, does not harm the environment and having sustainability for years to come.

The World population is growing at a brisk pace, economies are investing heavily on developmental projects, every step towards development and improvisation of standard of life requires one common source known as "Energy". The conventional sources like coal, petroleum, wood and many such resources are reaching towards the state of extinction.

India being one of the fastest growing economies of the world is also facing similar challenges. If we look at the present energy scenario of India, during the fiscal year 2013-14, the electricity generated in utility sector is 1,030.785 billion KWh with a short fall of requirement by 38.138 billion KWh (-3.6%) against the 5.1% deficit anticipated. The peak load met was 141,180 MW with a short fall of requirement by 7,006 MW (-4.7%). Southern and North Eastern regions are anticipated to face energy shortage up to 11.3% [11]. The disparity of states demand and supply situation, peak season deficit and transmission losses makes conventional power even more expensive and These sources are not only consumes scares resources like coal and gas but also very expensive to generate and to maintain.

The current research paper presents an approach to understanding the consumer adoption behaviour towards usage of a sustainable energy resources i.e. Solar Water heater. The research delves deeper into consumer behaviour and their decision making aspects, it helps to understand the major factors responsible for adoption and ones act as barriers. What are their post purchase views and how these views help in making others adopt this technology.

In order to understand the adoption behaviour; let us go stepwise and understand each aspect one by one. To start with let us understand "Green Energy" first.

2.1 The Green Energy Scenario

Renewable energy popularly known as Green energy has been in lime light for quite few years across the world. Wikipedia defines Renewable energy as energy that is collected from resources which are naturally replenished on a human timescale, such as sunlight, wind, rain, tides, waves, and geothermal heat. Renewable energy often provides energy in four important areas: electricity generation, air and water heating/cooling, transportation, and rural (off-grid) energy services [14].

It is broadly classified into

1. **Conventional energy:** is in practice for long duration of time and well established technology is available to tap and use them. E.g. Coal, oil, natural gas, hydro power, nuclear power etc.
2. **Non-conventional energy:** source can be used with advantage for power generation as well as other applications in a large number of locations and Situations. These energy sources cannot be easily stored and used conveniently. E.g. Solar, wind, tidal and geothermal etc.

Based upon nature, energy sources are classified as:

1. **Renewable energy** sources are inexhaustible and are renewed by nature itself. Solar, wind, tidal, hydro and biomass are few examples.
2. **Non-renewable energy** sources are exhaustible within a definite period of time depending upon its usage. Fossil fuels (coal, oil, gas) and nuclear fuels are few examples.

2.2 Need of Solar Energy for India

With this scenario one of the most popular and economical ways of generating green energy is through Solar Energy. India to grow at a steady pace of 7-8% desperately need this alternate sources of energy.

Solar power is one of the boons. In just one year the Earth's surface receives as much solar energy as two times the total reserves of the Earth's non-renewable resources of coal, oil, natural gas, and mined uranium combined.

Due to technical potential of 5,000 trillion kWh per year and minimum operating cost, Solar Power is considered as the best suited energy source for India. Today the Solar power, has an installed capacity of 9.84 MW which is about less than 0.1 per cent of the total installed renewable energy of India [14].

Currently total installed renewable energy stands at 47,346 MW as per MNRE. India's power sector has a total installed capacity of approximately 1,46,753 Megawatt (MW) of which 54% is coal-based, 25% hydro, 8% is renewable's and the balance is the gas and nuclear-based. Power shortages are estimated at about 11% of total energy and 15% of peak capacity requirements which is likely to increase in the coming years**[11]**. Much of the country does not have an electrical grid, so solar power will indeed be a boon through various solar energy technology such as solar thermal technologies, which utilize sun's energy and solar photovoltaic technology, which convert solar energy directly into electricity.

According to the 11th five year plan, the government of India projects a massive expansion in installed solar capacity, and aims to reduce the price of electricity generated from solar energy, to match that from fossil fuels like coal and diesel by 2030. The Integrated Energy Policy of India envisages electricity generation installed capacity of 80,0 000 MW by 2030 and a substantial contribution would be from renewable energy. India has been ranked 7th worldwide for solar photovoltaic (PV) cell production and 9th rank in solar thermal power generation [10]. This capacity is growing rapidly due to the entry of various private players in manufacturing of solar energy equipment.

Some of the important applications of solar energy are in Space cooling and heating through solar architecture, Potable water via distillation and disinfection, Solar cooking, Solar water heater, Day lighting, High temperature process heat for industrial purposes, Solar air-conditioning, Solar desalination, Solar electricity – photovoltaic, Solar electricity – thermal, Solar vehicles, Solar chimney etc.

3 The Solar Water Heater

Out of these, Solar Water Heater has been one of the most popular solar installations across the country. Solar water heater is considered as the widely accepted and proven green energy devises widely used by households and industrial setups.

We are blessed with Solar Energy in abundance at no cost. The solar radiation incident on the surface of the earth can be conveniently utilized for the benefit of human society. One of the popular devices that harness the solar energy is solar hot water system (SHWS).

A solar water heater consists of a collector to collect solar energy and an insulated storage tank to store hot water. The solar energy incident on the absorber panel coated with selected coating transfers the hat to the riser pipes underneath the absorber panel.

The water passing through the risers get heated up and are delivered the storage tank. The re-circulation of the same water through absorber panel in the collector raises the temperature to 80 C (Maximum) in a good sunny day. The total system with solar collector, storage tank and pipelines is called solar hot water system.

Broadly, the solar water heating systems are of two categories. They are: closed loop system and open loop system. In the first one, heat exchangers are installed to protect the system from hard water obtained from bore wells or from freezing temperatures in the cold regions. In the other type, either thermo syphon or forced circulation system, the water in the system is open to the atmosphere at one point or other. The thermo syphon systems are simple and relatively inexpensive. They are suitable for domestic and small institutional systems, provided the water is treated and potable in quality. The forced circulation systems employ electrical pumps to circulate the water through collectors and storage tanks.

The choice of system depends on heat requirement, weather conditions, heat transfer fluid quality, space availability, annual solar radiation, etc. The SHW systems are economical, pollution free and easy for operation in warm countries like ours.

3.1 Solar Water Heating System - Salient features

- Solar Hot Water System turns cold water into hot water with the help of sun's rays.
- Around 60 deg. – 80 deg. C temperature can be attained depending on solar radiation, weather conditions and solar collector system efficiency.
- Hot water for homes, hostels, hotels, hospitals, restaurants, dairies, industries etc.
- Can be installed on roof-tops, building terrace and open ground where there is no shading, south orientation of collectors and over-head tank above SWH system.
- SWH system generates hot water on clear sunny days (maximum), partially clouded (moderate) but not in rainy or heavy overcast day.
- Only soft and potable water can be used.
- Stainless Steel is used for small tanks whereas Mild Steel tanks with anticorrosion coating inside are used for large tanks.
- Solar water heaters (SWHs) of 100-300 litres capacity are suited for domestic application.
- Larger systems can be used in restaurants, guest houses, hotels, hospitals, industries etc.

3.2 Fuel Savings

A 100 litres capacity SWH can replace an electric geyser for residential use and saves 1500 units of electricity annually.

The use of 1000 SWHs of 100 litres capacity each can contribute to a peak load saving of 1 MW.

3.3 Environmental benefits

A SWH of 100 liters capacity can prevent emission of 1.5 tons of carbon dioxide per year. With having average life span of 15-20 years, the Approximate cost of a 100 liters SWH is around Rs.15000- 20,000 for a 100 liters capacity system and while Rs.110-150 per installed liter for higher capacity systems

3.4 The Payback period

The payback period can be calculated based on conventional energy sources

- 3-4 years when electricity is replaced
- 4-5 years when furnace oil is replaced
- 5-6 years when coal is replaced

Though the initial investment for a solar water heater is higher compared to available conventional alternatives, the return on investment has become increasingly attractive as the prices of conventional energy is increasing day by day. The payback period depends on the site of installation, utilization pattern and fuel replaced

4 Research Methodology

The current study has been undertaken to explore the consumer behaviour of domestic solar water heater users in Bhopal city. Being a fast growing city, the lifestyle of residents is also heading towards adoption of various consumer durables, Green energy devices such as solar water heater is among one of the most popular ones. The study has been undertaken keeping the following objectives in mind.

4.1 Research Objectives

Solar Water Heater being a new emerging entity requires lots of consumer behavioral explorations in order to understand their adoption psyche properly. Being a product which involves more non conventionality than any other available products; every insight opens many thought and action provoking actions [1].

To achieve the Core objective of understanding Solar Water Heater Adoption practices adopted by the consumers of Bhopal region following objectives have been established in order to accomplish the very purpose of this research study, these are listed as below:

- To understand the demographic profile of Solar Water Heater adopters in a particular region.
- To explore the dependency and trust on Solar Water Heater as a standalone equipment for hot water requirements
- To Gain an understanding of consumer awareness towards solar water heating systems.
- To understand the role of various stakeholders in creating conducive environment for Solar Water Heater adoption
- To identify the key drivers responsible for Solar Water Heater adoption
- To know their view on decision of Solar Water Heater adoption and thereby resultant satisfaction/ dissatisfaction through its usage
- To identify Key barriers in Solar Water Heater adoption.

- To know what the majority of consumer thinks on various behavioural aspects responsible for Solar Water Heater adoption.
- To determine the indicative future of Solar Water Heater as a consumer durable.
- To determine the user's adoption indicators through various parameters such as investment, usage duration, LPD etc.
- To analyse various policies and initiatives undertaken by the government in their role in adoption Solar Water Heater
- To explore consumer's view on improvising the Solar Water Heater adoption scenario.

In order to answer above mentioned objectives focused towards understanding consumer buying behaviour with special emphasis on adoption behaviour, the research methodology has been designed as qualitative research.

Since the current research incorporate understanding of behavioral aspects of Solar Water Heater in Bhopal city. It describes behavioral approach towards Solar Water Heater of a set of respondents drawn from a population in a particular region.

4.2 Population size

Since the research is aimed at understanding the Adoption Practices of Solar Water Heater in Bhopal The population for this study was chosen by applying single important criteria i.e. The customers who have already using / adopted Solar Water Heater in their Home. The Population size is based on the indicative inputs obtained from the Dealers, Distributors and from the government websites such as MNRE and other research websites which are working in the similar fields. The total population size in Bhopal is estimated at approximately 22000 active domestic users.

4.3 Calculation of sample size

With an approximate population of approximately 22,000 active users in Bhopal the sample size has been calculated with 95% confidence error with response distribution of 50%, the total calculated sample size N comes out to be 377 respondents. To collect the appropriate numbers of responses, 450 respondents have been approached, out of which the received responses complete in all respect came to be 367 in numbers.

4.4 Sample selection

The single important criterion to choose respondents was that they should be an active users of Solar Water Heater. Thus the method adopted for sampling has been Judgmental / Purposive. According to Paul Oliver purposive sampling is a form of non-probability sampling in which decisions concerning the individuals to be included in the sample are taken, based upon a variety of criteria which may include specialist knowledge of the research issue, or capacity and willingness to participate in the research.

4.5 The Research and Statistical Hypothesis

In order to develop a questionnaire which can answer the above mentioned objectives research hypothesis and derived statistical hypothesis have been developed and tested through One tailed Test of Hypothesis for a Proportion (Z - test)

The null hypothesis to be tested is H0: $\pi \leq 0.50$, and the alternative hypothesis is Ha: $\pi > 0.50$. The sample proportion is calculated using the formula $p = X/n$, where n is the sample size and X is the number of respondents possessing the characteristic under study. Finally the Z statistic is computed and compared with the critical value of Z at the desired level of significance α (generally taken as 0.05). Using the critical value approach, the *null hypothesis is rejected* if the calculated value of Z statistic is *greater than* the critical value and we conclude that the observed proportion is significantly higher than the hypothesized proportion and is not due to sampling fluctuations.

The *Z statistic is calculated with the* equation given below:

$$Z = \frac{p - \pi}{\sqrt{\frac{p(1-p)}{n}}}$$

Where π = population proportion
p = Sample proportion
n = Sample Size

4.6 The data collection

The Primary data

To know the behavioural adoption aspects of Solar Water Heater in Bhopal city following two approaches have been adopted

1. A short semi-structured interviews conducted to gain preliminary understanding on Solar Water Heater and Consumer Behaviour related matters with Academicians, Dealers, Customers etc.
2. Based on the preliminary study the survey questionnaire using structured, closed questions have been developed.

There are total 23 questions of various nature have been developed, The Questionnaire thus designed has following 3 major parts:

- **Part I Demographic and Solar Water Heater adoption facts:** The set of 15 questions were designed to gather background information about the respondents and the primary demographic facts and properties of the Solar Water Heater they own / using and about the premises where these Solar Water Heater are installed.
- **Part II Behavioral:** The set of 6 questions have been designed to examine the factors affecting the adoption of Solar Water Heater by the users. These questions were developed to analyse behavioral aspects of Solar Water Heater adoption and to analyse their post purchase behaviour.
- **Part III Post Purchase Behaviour:** The last 2 questions have been designed to know the overall opinion of Solar Water Heater users and also what they wish to recommend to policy makers and manufacturers in order to bridge the gap.

4.7 The Data Analysis tools

The data has been analysed using various EDP methods. The tools used for basic data analysis and presentation are Descriptive Statistics while Z test was used test the research hypotheses using advanced data analysis

For our research we have used descriptive analysis to examine cases of one variable at a time. There are three major characteristics of a single variable that we looked at:

- The distribution
- The central tendency

- The dispersion

These analysis tools have been widely used to get interpreted directions to define the outcomes this achieved.

4.8 The Data Presentation

The present research used following 2 data presentation tools

- **The Bar Chart:** used to represents the count of responses of one category with many data points. We found bar chart better than a summary table at making the point that a particular category is having greater value than the other.
- **The Pie Chart:** We heavily used pie chart to see each category's portion of the whole. This helped us to look into the percentage proportion taken by each variable.

5 The Findings

A structured survey questionnaire has been designed containing 23 questions on different aspects of buying behaviour to explore the adoption practices prevailing among Solar Water Heater users. Also to explore further 20 Research hypothesis have been framed and analysed through one tailed Z Test, so that the interpretations could be based on statistical tests.

Following are the key findings

- The adopters belong to affluent class of the society who are educated and mostly living in independent houses, these houses are predominantly having built up area of 1500 sft and more. Most of the houses are owned by the adopters.
- The adopters have enough disposable income and having large families. They already have experienced Solar Water heater at least once before they bought it for their home.
- Among the major adoption drivers for Solar Water Heater; saving on electricity through long term usage is the major one. The Smaller Solar water Heaters such as 100 Liters per Day capacity are the most popular ones.
- Despite installation of SWH, adopters are yet not fully dependent on Solar Water Heater for their hot water needs, they still have alternate arrangements at their home in the form of conventional water heaters either run on electricity or gas.
- Adopters wish to be identified as "Environment friendly class of buyers, and believe that installation of Solar Water Heater increase aesthetics value of their house. They further believe that the adoption can be accelerated if policy initiatives such as government subsidy, tax rebates, low interest financing are provided. These adopters are well informed about the latest trends in Solar and keep themselves update on technological aspects of solar energy.
- They are of strong opinion that initial higher cost and difficulty in locating a supplier are strong barriers in adoption of Solar water heater, at the same time they also believe that promotion of such technologies needs to be more rigorous. At the same time these adopters are fully satisfied with their decisions of using SWH in their home and keep recommending it to other non -adopters.

6. The conclusion

To have Solar Water Heater adopted by the masses; both Government as well as manufacturers have to make some serious efforts. The major drivers will be easy finance, subsidies and mass communication which justifies the investment. Though it has been picked up but still there is a long way to go. With having cheap substitutes such as conventional heaters, immersion rods, wood and many such alternatives making consumer decide on Solar water Heater is really a tough task.

But if a mass adoption moment picked up this will surely be a boon for growing country like India.

The SHW have key advantage of being economical, pollution free and easy for operation in warm countries like that of India. Being a tropical country, the country has longer duration of sunshine at higher intensities and is thus endowed with vast solar energy potential. This is the driving factor for the growing potential of the solar power systems as a source of energy

We believe there is a vast potential for such technology to be adopted by the masses, thus we can draw following key conclusions.

- Solar Water Heater are among the most successful green energy technologies adopted as compared to any other a Green energy innovations and if taken seriously this will be one of the fastest adopting household entity.
- The adoption needs to be supported by policy makers and manufacturers in terms of bringing the same to the affordability limits of the common masses, at the same time needs to be supported through mass awareness campaigns. It is quite evident that the more a customer know about the technology such as Solar Water heater, the more they are likely to adopt it, so the adoption as direct relationship with level of awareness.
- Easy financing with long term pay back facilities through financial institutions such as banks, taxation policies (such as tax benefits), after sales support and reliability of the performance of SWH, combining all together can bring significant acceleration in adoption.
- The study also infers that, the solar water heaters have the capacity to save 1500 units of electric power annually, which is evaluated as the consumption of an electric geyser. The solar water heaters are environment friendly and follow the go green motive; it has the capability to prevent emission of 1.5 tonnes of carbon dioxide every year.

Moreover, the increasing prices and increasing demands of the conventional energy also tend to make the people get attracted towards SWH. Understanding the necessity for an alternate power and in order to make people afford the new technology without any hesitations, the government has also come up with strategic measures. One such significant initiative is the Jawaharlal Nehru National Solar Mission (JNNSM), contributing to the wide adoption of SWH in the country [6].

7. The Way forward

However there is plenty of room for expansion as the market penetration is still far below its potentials especially when considering the change in lifestyle, increasing constriction and the rapidly increasing price of electricity per unit. Indeed, now that the SWH industry has proven itself future looks bright with improving technologies, tax incentives and rebates, an increase in the number of qualified vendors that sell and install solar hot water heating systems.

Due to evident success and consistent performance, this Green energy technology known as solar water heaters have become integral part of the NSM (National Solar Mission). With such serious and laborious intentions, this mission is all set to achieve its ambitious targets to achieve 20 million m^2 of collector area of Solar Water Heater by the year 2022 [6].

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