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RESEARCH ARTICLE

An Economic Analysis of Energy

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Abstract

Energy is required to fulfill the basic needs of a human being like food, shelter, clothing, health, sanitation, education, etc. world economy – agriculture, industry, transport, commercial, and domestic – need inputs of energy. This growing consumption of energy has also resulted in the country becoming increasingly dependent on fossil fuels such as coal, oil and gas. Rising prices of oil, gas and coal and potential shortages in future lead to concerns about the security of energy supply needed to sustain our economic growth. Increased uses of fossil fuels have also caused environmental problems both locally and globally. Against this background, the country urgently needs to develop a sustainable path of energy development. Therefore, this study concentrates on solar power as a renewable source of energy. It has many benefits compared to fossil fuels. It is clean and green, non-polluting and everlasting energy. For this reason it has attracted more attention than other alternative sources of energy in recent years. Hence primary data has been collected through interview and questionnaire methods. The result of the study shows benefits accrued from the 200 LPD solar water heaters definitely yields not only profit to the individual who owns the module but also to the society by way of pollution free environment.

Keywords: *Energy demand, Solar energy, Solar devices*

Introduction

Energy is a basic ingredient of all modern societies and a country's per capita consumption of energy is a measure of its advancement. Energy is required to fulfill the basic needs of a human being like food, shelter, clothing, health, sanitation, education, etc. However, the production and use of non-renewable energy sources cause environmental degradation. Moreover non-renewable energy sources of the world like coal and petroleum are dwindling fast. People have to realize that the world's pantry of non-renewable natural resources does indeed have a bottom shelf. The reserves of natural gas, petroleum and coal will be exhausted one day. Also, energy crises have made us aware that our total dependence on only one form of energy is not a wise step. We have to tap additional sources of energy to sustain a satisfactory growth rate for our country. World economy – agriculture, industry, transport, commercial, and domestic – need inputs of energy. The economic development plans implemented since independence and necessarily required increasing amounts of energy. As a result, consumption of energy in all forms has been steadily rising all over the country.

This growing consumption of energy has also resulted in the country becoming increasingly dependent on fossil fuels such as coal, oil and gas. Rising prices of oil, gas and coal and potential shortages in future lead to concerns about the security of energy supply needed to sustain our economic growth. Increased uses of fossil fuels have also caused environmental problems both locally and globally. Against this background, the country urgently needs to develop a sustainable path of energy development.

The ultimate solution for the secure supply of energy will be the discovery of methods of harnessing non-conventional energy sources. The extraction and utilization of non-conventional energy will not only help in meeting energy demands but also help in their development. Since non-conventional energy sources provide environment-friendly, non-polluting energy, they help keep the atmosphere and environment clean and safe. Moreover, such energy sources are available locally; therefore they will reduce the losses due to transmission. Their development and utilization will help people develop a positive change in their life style [1].

Many countries, therefore, now recognize the need for alternative fuel sources economically convertible to electrical and thermal energy. The practical use of solar energy is one of the frontiers now open to mankind. Moreover, solar energy can be used by ordinary people almost everywhere in the world. Through simple apparatuses, built cheaply from locally available resources, electricity can be produced easily besides a host of other jobs. Solar energy is a clean and non-polluting form of energy. For this reason it has attracted more attention than other alternative sources of energy in the recent years.

Economic theories related with the study

The study is based on innovation theory and sustainable theory. According to Schumpeter, it is the introduction of a new product and the continual improvements in the existing ones that lead to development [2].The basic problem today is to continue improvements in human welfare in the light of limited natural resources. Solution is sought through sustainable development, the term made popular by Brundtland Commission's Report which defines sustainability as "meeting the needs of the present without compromising the ability of future generations to meet their own needs". This essentially emphasizes the intra-generational equity as well as inter-generational equity [3].

This study concentrates on solar power as a renewable source of energy. It has many benefits compared to fossil fuels. It is clean and green, non-polluting and everlasting energy. For this reason it has attracted more attention than other alternative sources of energy in recent years. Many energy economists say that solar energy is going to play an increasingly important role in all our lives. To highlight the importance of such a source of energy becomes not only important but also inevitable.

Review of Literature

Bhatta Charaya et al. have developed a simplified design approach and economic appraisal of a Solar PV system. In this model, the PV array and battery bank sizes for a standalone PV system were estimated. Also a cost comparison of the standalone PV system with a PV diesel hybrid system was presented. The results indicate that the hybrid systems were more cost effective than a standalone system for a given location [4].

Agarwal (2002) has observed that solar energy with its endless origin is free from pollution and safety hazards and it may trigger a new horizon in transportation, aviation and communication [5].

Mohanlal Kolhe et al. have analyzed the economic viability of a standalone solar photovoltaic system with the most likely conventional alternative system i.e. a diesel powered system for energy demand through sensitivity analysis of life cycle cost computation. The analysis was carried out taking into consideration energy demand for different key parameters, such as discount rate, diesel fuel cost, diesel system life time, fuel escalation rate, solar isolation, PV array cost and reliability. The result showed that the PV powered systems could be a cost effective option at a daily energy demand up to 15 kWh even under unfavorable economic conditions [6].

Methodology

The researcher tries to probe into sustainable energy features by touching upon the global picture, trickling down to India's position and further narrowing down to Tamil Nadu ending with the micro study of Chennai and Thiruvallur districts. Therefore, this study attempts to find out whether solar energy devices are economically viable to the users. It tries to throw light on the cost of solar energy devices like solar water heaters and solar photovoltaic street light etc. and their benefits to households and corporate. Hence primary data has been collected through interview and questionnaire methods.

Objectives of the Study

To analyze the distribution pattern of electricity and its shortages in India and Global level.

Hypotheses of the Study

There is no significant difference in benefits accrued by using two types and 200 LPD sizes of solar water heaters.

Sample Selection

The total sample size is 592, of which 296 consists of users of solar energy devices and 296 samples consists of non-users of solar energy devices. For selection of samples, the purposive sampling technique has been adopted. Purposive sampling has been deliberately used in the place of popular methods such as multi-stage stratified random sampling technique.

Statistical Tools

Social Cost Benefit Analysis

COST: cost depends upon the capacity of the module, brand and the type of solar device.

Fixed cost (FC) + Recurring Cost (RC)
FC = (cost of the module + installation cost)
RC = (maintenance cost)
BENEFITS: benefits are measured in terms of units of electricity saved on using solar devices whe compared to other electrical appliances.

The discount factor is $D = \frac{1}{(1+i)^t}$

Where i = social discount rate.
t = time period

To check the feasibility of the modules the following techniques were adopted in the present study.

i Payback Period

Payback period = Initial investment/ Annual cash in flow

ii Benefit Cost Ratio
Benefit cost ratio = Benefits / Cost

iii Net Present value
Net present value=Discounted benefit –Discounted cost

iv Internal Rate of Return
Internal rate of return = (Net Annual Benefits/Capital investment) x 100

Result and Discussion

Energy is a key infrastructure, which is the backbone and prime mover of the economic development of any country because it is required for all the sectors of economy which include agriculture, industries, service, information and technology, transport and others. Economic growth too is driven by energy in the form of finite resources such as coal, oil and gas or in renewable forms such as solar, hydro, wind and biomass, or its converted form, electricity.

Modern economists believe that an index of energy could be used as an index of capital because in "economic parlance, energy caters both to the direct consumption and the production of goods: as consumer goods, their consumption tends to vary with changes in income and consumer preferences; as an input in production, their availability and increasing quantities are a sine qua non of rising national income" [7].

Therefore, the availability of quality power in the required quantity is one of the most important determinants in the success of the country's development [8]. In addition providing adequate and affordable electric power is essential for economic development, human welfare and higher standard of living. India being a developing country with increasing population makes power the critical infrastructure. Hence, the study needs to know the real picture of power sector performance and its challenges therefore; power scenario of India and Global level have been examined. The following sections describe the energy demand, supply and its trend from the global, national and state point of view.

The Global Scenario

The consumption and uses of energy in the world is highly concentrated in the industrialized or developed regions: Europe, North America, Japan and Australia. Most of the tropical world uses less energy in the form of fossil fuel and electricity. The per capita annual consumption of energy in the form of fossil fuel ranges from very small in some countries to very large, more than thousand times greater, in others.

Besides fuelling 'development' activities energy consumption and its quantitative trends characterize the life- styles of a country. More than 80 percent of total world consumption of energy is by developed world which accounts for only 30 percent of the population. On the other hand, 20 percent of the energy is consumed by 70 percent of the world population in developing countries[9]. There is a direct correlation between the degree of economic growth, the size of percapita income and per capita consumption of energy.

Table 1: Per capita income and per capita consumption of energy for selected countries

Country	Per capita income*	Per capita consumption of energy **
India	3,120	455
Indonesia	3,480	753
Egypt	4,200	675
U.K.	31,430	3,893
Japan	29,810	4,053
U.S.A.	39,820	7,843

Source: World Development Report'2005 and World Development Indicators'2006
*in U.S. dollars '2004 (ppp), ** kgs.of oil equivalent'2003

In the Table 1, the column two (per capita income) compiled for the various countries, from the world development report (2005) and world development indicators (2006). The table shows that the first three countries namely India, Indonesia and Egypt are developing countries with low per capita incomes, while the next three U.K, Japan and U.S.A. are developed countries with high per capita incomes. The per capita consumption of energy in India was 455 kg of oil equivalent (Kgoe) as compared to 753 in Indonesia and 675 in Egypt. On the other hand, per capita consumption of energy was as much as 3,893 in U.K., 4,053 in Japan and 7,843 in U.S.A.

Although per capita commercial energy consumption in India has been steadily going up

during the last two decades, it is still one of the lowest in the world, compared to developed countries who consume approximately 10 times the energy than India. Hence it is very significant to study about the Indian scenario of energy pattern, its demand and the availability. The next section deals with Indian scenario of energy.

Indian Scenario

India is both a major energy producer and a consumer. India currently ranks as the world's seventh largest energy producer, accounting for about 2.49 percent of the world's total annual energy production. It is also the world's fifth largest energy consumer, accounting for about 3.45 percent of the world's total annual energy consumption in 2004. Since independence, the country has seen significant expansion in the total energy use with a shift from non-commercial to commercial sources. The share of commercial energy in total primary energy consumption rose from 59.7 percent in 1980-81 to 72.6 percent in 2006-07. It must be noted, however, that India's per capita energy consumption is one of the lowest in the world. India consumed 455 kgoe per person of primary energy in 2003, which is around 26 percent of world average of 1750 Kgoe in that year. As compared to this, per capita energy consumption in China and Brazil was 1147 Kgoe and 1232 Kgoe, respectively [10]. Table: 2 show the trend of primary energy demand and supply between 1960-61 and 2006-07 and requirement for 2011-12. While total primary energy demand registered 117.20 million tonne of oil equivalent (Mtoe) in 1960-61, it increased to 538.49 Mtoe during 2006-07. It has been increased to 715 Mtoe in 2011-12. From the table it is observed that the net imports is on the rise; it can be inferred that India is not self sufficient in meeting our country's total energy demands. The demand for energy, particularly for commercial energy, has been growing rapidly with the growth of the economy, changes in the demographic structure, rising urbanization, socio-economic development, and the desire for attaining and sustaining self-reliance in some sectors of the

Table 2: Demands and supply of primary energy in India

	1960-61	1970-71	1980-81	1990-91	2000-01	2006-07	201112*
Domestic production of Commercial Energy	36.78	47.67	75.19	150.01	207.08	259.56	435
Demand of Commercial Energy	42.82	60.33	99.82	181.08	296.11	390.93	546
Non-Commercial Energy	74.38	86.72	108.48	122.07	136.64	147.56	169
Total Primary Energy Demand	117.20	147.05	208.30	303.15	432.75	538.49	715
Net Imports	**6.04**	**12.66**	**24.63**	**31.07**	**89.03**	**131.37**	**111**

Source: Planning commission Government of India'2008
Note: # Mtoe = million tonne of oil equivalen

Domestic production of commercial energy includes coal, lignite, oil, natural gas, hydro power, nuclear power and wind power. (ii) Net imports include coal, oil and LNG imports economy. The demand for commercial energy has increased to 390.93 mtoe during the period 1960-61 to 2006-07, it is further increased to 54.6 mtoe in 2011 12. Non-commercial energy resources include the traditional fuels such as wood; cow dung, crop residue, and biogas constitute a significant quantity of total primary energy demand. A large share of this fuel is used by the households, particularly in rural areas, for meeting their cooking and heating needs. The consumption of 147.56 Mtoe of non-commercial energy in 2006-07 includes consumption of fuel wood, dung, and agricultural waste. It is increased to be at 169 Mtoe in 2011-12. From the table it is observed that there is a constant increase in demand for primary energy.

Table: 3 Energy requirements and availability in 2011-12

Primary energy	Unit	Quantity of requirement	Domestic production	Quantity of imports
Coal	Mt	731	680	51
Lignite	Mt	55.59	55.59	-
Oil	Mt	145	40	105
Natural Gas	Bcm	106	47	23.75

Source: Planning commission Government of India'2008

Table 3 shows projected commercial energy requirement of all the available resources in the terminal year of the Eleventh Plan period in physical units. Coal demand of 731million tonnes (mt) covers 51 mt of imports, because of the consumption by the power sector including captive plants (private power producers). Out of the oil demand of 145 mt, domestic production will be around 40 mt and the balance would be imported.Domestic availability of natural gas in the terminal year of the Eleventh Plan shows about 47 billion cubic metre (bcm). An import of 23.75 mt of LNG (Liquefied Natural Gas) would augment the supplies to meet the demand shortfall. There will be a gap of around 35.25 bcm (106 - (47+23.75) = 35.25) between availability and demand if no addition by the private sector is achieved. The shortfall in availability will adversely affect the sector which consumes natural gas as their main usage. The fundamental economic reality of fossil fuels is that such fuels are found only in a relatively small number of locations across the globe, yet are consumed everywhere.

Cost benefit analysis for flat plate collector

Table 4: Flat plate collector of 200 LPD

No. of years	Total cost	Discounted factor	Discounted cost	Total benefit	Discounted benefit	B - C
(a)	(b)	(c)	(d) (b x c)	(e)	(f) (e x c)	(g) (f-d)
1	35,000	0.9099	31846.5	9,000	8189.1	-23657.4
2	4500	0.826	3717	9,000	7434	3717
3	500	0.751	375.5	9,000	6759	6383.5
4	500	0.683	341.5	9,000	6147	5805.5
5	500	0.621	310.5	9,000	5589	5278.5
6	500	0.564	282	9,000	5076	4794
7	500	0.513	256.5	9,000	4617	4360.5
8	500	0.467	233.5	9,000	4203	3969.5
9	500	0.424	212	9,000	3816	3604
10	500	0.386	193	9,000	3474	3281
11	500	0.35	175	9,000	3150	2975
12	500	0.319	159.5	9,000	2871	2711.5
13	500	0.29	145	9,000	2610	2465
14	500	0.263	131.5	9,000	2367	2235.5
15	500	0.239	119.5	10,500	2509.5	2390
	Total		**38498.5**		**68811.6**	**30313.1**

Source: Calculated by the researcher from the primary data collection

Table 5: Evacuated tube collector of 200 LPD

No. of years	Total cost	Discounted factor	Discounted cost	Total benefit	Discounted benefit	B - C
(a)	(b)	(c)	(d) (b x c)	(e)	(f) (e x c)	(g) (f-d)
1	33,000	0.9099	30026.7	9,000	8189.1	-21837.6
2	4300	0.826	3551.8	9,000	7434	3882.2
3	300	0.751	225.3	9,000	6759	6533.7
4	300	0.683	204.9	9,000	6147	5942.1
5	300	0.621	186.3	9,000	5589	5402.7
6	300	0.564	169.2	9,000	5076	4906.8
7	300	0.513	153.9	9,000	4617	4463.1
8	300	0.467	140.1	9,000	4203	4062.9
9	300	0.424	127.2	9,000	3816	3688.8
10	300	0.386	115.8	9,000	3474	3358.2

11	300	0.35	105	9,000	3150	3045
12	300	0.319	95.7	9,000	2871	2775.3
13	300	0.29	87	9,000	2610	2523
14	300	0.263	78.9	9,000	2367	2288.1
15	300	0.239	71.7	9,300	2222.7	2151
	Total		**35339.5**		**68524.8**	**33185.3**

Source: Calculated by the researcher from the primary data collection

The economic reality, by contrast, is that solar resources are available, in varying degrees, all over the world. Fossil fuel and solar resource use are thus poles apart – not just because of the environmental effects, but also because of the fundamentally different economical, logical and differing political, social and cultural consequences. These differences must be acknowledged if the full spectrum of opportunity for solar resources is to be exploited [11].

Cost benefit Analysis for Evacuated Tube Collector

Therefore, this study concentrates on solar power as a renewable source of energy. It has many benefits compared to fossil fuels. It is clean and green, non-polluting and everlasting energy. For this reason it has attracted more attention than other alternative sources of energy in recent years. Many energy economists say that solar energy is going to play an increasingly important role in all our lives. To highlight the importance of such a source of energy becomes not only important but also inevitable. The above tables examine the hypothesis among the two types and 200 LPD sizes of solar devices with discounted costs and discounted benefits. From the above table 4 shows the details of 200 LPD Flat Plate Collector, it is understandable that the benefits are higher than the costs incurred for the module. The Net Present value of Rs. 30313.1 shows the economic feasibility of the module for the domestic solar water heater users. Thus it is a feasible investment to purchase this type of solar water heater.

Table 5 gives an account for a 200 LPD Evacuated tube Collector; it is vivid that the discounted benefit is higher than the discounted cost of the module. The Net Present value Rs. 33185.3 shows the economic feasibility of the module to the users.

Conclusion

It is evident from the discussions above that India and Global level are short of all energy resources and that coal will dominate India's energy basket. We need to expand our resources through research and development in the field of exploration of alternative sources of energy, energy saving techniques and usage of renewable sources of energy etc.

The environmental impact of various energy options is also a growing concern owing to widespread use of energy. It is necessary that the demand of energy in the country is met in an environment-friendly and sustainable manner. Therefore it is the need of the hour to pay much attention on renewable resources which are economical in long run and eco-friendly. Moreover, There are so many renewable to harness energy but from a longer term perspective of the growing threat of climate change and keeping in mind the need to maximally develop domestic supply options as well as the need to diversify energy sources, renewable remain important to India's especially energy sector.

Within renewable energy, solar, wind, hydro and biomass etc., energies are some of the renewable energies. While hydro energy is highly dependent on monsoon, wind energy, of late, has started getting attention and participation from both public and private sectors. Solar energy, with much of its untapped potential needs more focus, research and development since, it is obtained directly from nature, available freely and throughout the year. Hence, solar power could be important for attaining energy independence as well as green house gas-free energy system in the long run.

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