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Integrated energy planning for sustainable development in rural areas: A case study from Eastern Uttar Pradesh

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Abstract
Energy is required for every aspect of our daily life. At present, commercial energy consumption makes up about 65% of the total energy consumed in India. This includes coal with the largest share of 55%, followed by oil at 31%, natural gas at 11% and hydro energy at 3%. Non-commercial energy sources consisting of firewood, cow dung and agriculture wastes account for over 30% of the total energy consumption. The critical feature of India's energy sector and linkages to economy is the import dependence on crude and petroleum products. Import bill is likely to grow to more than 100% in the near future because of population explosion and improved living standard in the country. Being a tropical country India has unlimited potential for producing renewable energy sources. These sources of energy can play an important role in the sustainable development by providing basic energy needs of rural and remote areas.
A survey of energy consumption pattern has been carried out in different sector domestic, agricultural, transport, rural industries and miscellaneous uses in a cluster of 3 villages, district Ballia, Uttar Pradesh India during 2008. The questionnaires have been filled by gram pradhan, respective old persons and head of the family of the surveyed households.
This paper discusses the current energy status, choice of energy options and potential of renewable energy systems for creating sustainable livelihoods in rural areas.
The outline plan at decentralized level was prepared with the objective of providing energy security in villages by meeting total energy needs for cooking, lighting and motive power through various forms of available renewable energy sources.

Keywords: Rural areas, Integrated rural energy planning, Renewable energy systems.

1. Introduction
Energy is an integral part of a society and plays a pivotal role in its socio-economic development by raising the standard of living and the quality of life. The state of economic development of any region can be accessed from the pattern and consumption quality of its energy. Energy demand increases as the economy grows bringing along a change in the consumption pattern, which in turn varies with the source and availability of its energy, conversion loss and end -use efficiency.
The fuel crisis in early seventies and consequent oil price hike necessitated exploring for ecologically sound, economically viable and technically feasible energy alternatives. Around 30% of the total population has access to electricity. The vast majority of the rural population that comprises 76% of the

total population is deprived of easy availability to commercial energy resources. In rural India, people used dung cakes, agriculture wastes and fuel wood for their energy needs. With better economic conditions, more and more people are using cleaner and more conventional form of energy such as electricity and LPG for home usage. The availability of both these forms of energy is limited, the shortage results in frequent power break-downs and disrupts daily life, man-power losses in offices, agriculture activities and adversely affect the industrial production and thereby the economy.

Increased energy supplies and greater efficiency of energy use are thus of paramount importance to meet the basic needs of a growing population. It is therefore considered necessary to exploit all sources of renewable energy and to use these in an efficient form for the benefit of the people.

The micro-level planning can meet the energy need of the rural area by the locally available renewable energy sources. The government has been supporting various renewable energy programmes for the promotion of biogas plants, solar thermal systems, photovoltaic devices, biomass gasifiers, as well as the integrated rural energy programs, for several years. A few new programmes such as the remote village electrification, biomass gasification programme, biogas power generation and village energy security programmes were introduced during the tenth five-year plan. Most programmes have undergone modifications in keeping with the feedback received apart from development in various technologies and operation conditions that have taken place over the years. During the 11th Five-Year Plan (2007 – 2012), a comprehensive rural energy programme has been started which include two sub-programmes, namely Remote Village Renewable Energy Programme (RVREP) and Grid–Interactive Village Renewable Energy Programme (GVREP). While running these programmes, the committed liabilities of Integrated Rural Energy Programme (IREP) have been taken into account. Though the share of modern renewable is small, there has been a steady growth in the installation of different renewable. A total grid-connected renewable power generation capacity of 14,485 MW has so far been achieved, which is about 9% of the total installed power generating capacity in the country Figure 1 shows the growth in electricity generation capacity from renewable during 2002-2009 [1].

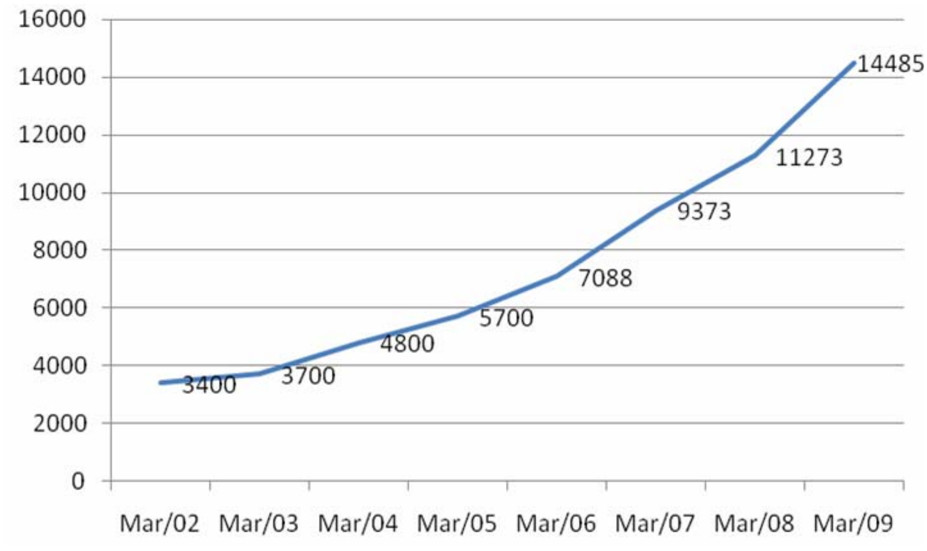

Figure 1. Growth in the electricity generation (MW) capacity from renewable during 2002-2009

Panchayats are the such institutions of India which act as medium for Indian Government to meet local people and local needs of them. At present Panchayats do not have the strong work plan to meet rural energy needs. The objective of the study to make an attempt to know the available energy sources, their utilization and to find out the role of renewable energy devices to meet the energy demand of villages.

2. Economic, social, geographical, demographic scenario of the selected rural areas

The rural area selected for survey is the cluster of 3 villages in district Ballia, Uttar Pradesh, India. The 3 villages in the selected cluster of villages Mudera, Beswan, Baijalpur. These villages comprise of 17 hamlets. Mudera consists of 11 hamlets: Dharmaja (household No.80), Akatahi (household No.70), Saihar (household No.30), Gavadevat (household No.20), Partipar (household No.20), Sagarpar (household No.10), Hurarahi (household No.40), Lohtolia (household No.50), Bharpurva (household

No.80), Dubaulli (household No.40) and Mudera (household No.123). Beswan consists of 3 hamlets: Beswan (household No.118), Kotwa (household No.17) and Terahipur (household No.147). Baijalpur consists of 3 hamlets: Baijalpur (household No.310), Purukhupur (household No.48) and Pipari (household No.23). The villages are located about 1.5 km from the main road and the distance from block headquarter Rasra is roughly 7 km, from bus station roughly 7.5 and from railway station (Rasra) 7 km. Geographically Ballia falls under eastern plains of Uttar Pradesh. The soil characteristics of the area is silti domat, matiyar domat, bhaat domat and balui domat .These are the different types of alluvial soil which formed by the sediment brought down by rivers. District has the temperature range 05- 45^{0}C with average rainfall 1015mm and is located between 25°51′N, 83°51′E and 25.85°N, 83.85°E. It has an average elevation of 55 metres (180 feet). The climate of the area can be broadly described as the tropical monsoon type with five seasonal variations winter, spring, hot summer and pre-winter transition. A scotching westerly wind called loo contains high temperature and low relative humidity, blows in summer causing dust and storms. The resource mapping and household survey study of cluster of 3 villages during 2008 helped to understand village level situation where traditions, modern ties and continuity have formed a complex system of development. Primary data were collected through door to door survey of 100% households and secondary data were collected from concerned departments such as Revenue and Statistical Office, Ballia, Office of SDM, Rasra Tehsil, Director of Census Operations, Uttar Pradesh, NREDA HQs, Lucknow and Project Officer, Ballia and additional information was sought from market surveys. These data includes energy consumption pattern, energy supply and demand on the basis of their existing facilities, such as availability of various energy sources, education facilities, social hierarchy, etc. The demographic details of the cluster are given in Table 1.

Table 1. Demographic details of the cluster

Village	Total Hamlets	Total Households	Population				
			SC/ST Male	SC/ST Female	Total Male	Total Female	Total
Mudera	11	563	254	233	1982	1922	3904
Beswan	3	282	336	349	986	1029	2015
Baijalpur	3	381	130	122	1397	1438	2835

SC/ST: Schedule Caste and Tribes

The cluster has heterogeneous population belonging to many income and social groups. The male female ratio is almost equal. Majority of the households are in the farming category including agriculture laborers. The income of 78% population of the cluster is directly or indirectly based on agriculture and the 22% population come under different occupational groups such as trade, shop, furniture industry, brick making, handloom, carpentering, blacksmithing, shoemaking and poultry. The villages have marginal farmers having agricultural land holding of less than one hectare ranging from 18-70%, small farmers having holding of 1-2 hectare ranging from 3- 22%, large farmers having holding of more than 2 hectare ranging from 0-11% and other ranging from 2-70%. Livestock population consists of bullocks, cow, buffaloes, pigs, goats, bull and others. In addition, there are 4 horses, 30 sheep and about 1700 hens in the poultry industry. Livestock population details are given in the Table 2.

Table 2. Livestock population

Village	Bullocks	Cows	Buffaloes	Goats	Pig	Donkey
Mudera	30	252	350	300	10	05
Beswan	50	198	285	400	20	10
Baijalpur	10	150	195	70	10	02
Total	90	500	830	770	40	17

Tones river flows near the cluster of villages (Table 3). The water is available all over the year, however, in summer session water availability is low. For the drinking water facility, there are no pipe water supplies or drinking water tanks. The villages have open wells and hand pumps which are the sources of drinking water.

Table 3. Salient features of the cluster, district Ballia, Uttar Pradesh state obtained from survey

Particulars	Data and comments
Total number of houses	The house in the cluster are of a mixture of pacca and kaccha houses. There are 5824 pacca 2915 kaccha houses in the cluster.
Total human population and occupation	8754**,** The income of 78% population of the cluster is directly or indirectly based on agriculture.
Education- Literacy rate	67.74% , female literates: 23.65%, matriculation:31.5%, graduates:30%, post- graduates:6.24%.
Total land area	887.24 hectare**.**
Net crop sown area	623.57 hectare.
Net irrigational area	333.38 hectare.
Cropping intensity	151.20%.
Major crop types	Wheat, paddy, sugarcane, mustard, maize, barley, lentil, arhar, gram, etc.
Animal population	Total bovine population:1420,others: 2561 including hens.
Energy resources	Agriculture waste, firewood, bovine excreta, electricity, coal, LPG, kerosene oil, animal and muscle power.
Rural industries and conventional activities	Jaggery, domestic goods such as dalia, etc. prepared by bamboos and other wild bushes, six pot-makers, seventeen blacksmiths, nine general shops, ten wood processors, three rice mills, poultry.
Natural water resources	Tones river flow near the cluster, 12 pokharas (get dried during April to mid June).
Drinking water resources	100% ground water: hand pumps -250, which includes private and government installed hand pumps under different rural development scheme, open water well – 30.

3. Estimation of renewable energy supply

Assessment of available local energy sources is helpful in revealing its status and helps in taking conservation measures and ensures a sustained supply to meet the energy demand. Assessment of renewable energy potential can be theoretical, technical or economic. Of all the three potential estimates, the economic potential is subjected to high variability, as economic conditions fluctuate drastically over space and time.

Studies were made for the total energy available which can play important role in meeting the household energy need such as cooking, lighting, to run small industries, health clinics and agriculture equipment. The most important available locally energy resources of the cluster are solar energy, animal excreta, and biomass energy resources basically include agriculture wastes, firewood and animal excreta, etc. These are important fuel sources in the cluster especially for the domestic purposes. Wind energy potential in the cluster is negligible because it is available in the dilute form.

3.1 Solar energy

A detailed assessment of available energy resources in the villages has been carried out. For the assessment of solar energy in the cluster, an assessment of available solar energy in 10m^2 in each household of the cluster has been made which is roughly 19700 kWh annually [2]. There are 1226 households in the cluster. The potential of solar energy is 24.15x10^6 kWh annually.

3.2 Biomass energy

Biomass can be categorized broadly as woody, non-woody and animal wastes, energy plantation.

3.2.1 Woody biomass

Comprises of forests, woody biomass is generally a high valued commodity and has diverse uses such as timber, raw material for pulp and paper, pencil and matchstick industries and cooking fuel. There is only a forest cover of 0.24 ha in Mudera village. Forest residues parameter has not been considered because of strict laws relating to exploitation of forest residues.

3.2.2 Non-woody biomass

Comprises of crop residues like straw, leaves and plant stems (agro wastes), processing residues like saw dust, bagasse, nutshells and husks and non agricultural waste like tree and wild bushes found on agriculture and non agriculture land. Crops are harvested at the village level and are essentially used either as fodder or cooking fuel. Majority of the land under cultivation of food crops. Agriculture waste is considered as one of the important sources of biomass for energy production such waste consists of stalks, leaves, straws, husk etc. The consumption of agriculture waste is basically for fodder and fuel purposes. To calculate the agriculture waste, the crop production is multiplied by the crop residue ratio and the figure for the cluster for the agriculture waste in Kharif and Rabi seasons amounts to 1705.238 ton/year for the cluster.

Trees like semal, peepal, imly, sahjan, bargadh, etc. and wild bushes are found in agricultural and non-agricultural land. Various tree species found in the village land are neem, shisham, babul, ber, eucalyptus and various types of wild bushes such as jungle jalebi, sarkandi, kaurada, madar, dhatura, etc. The average biomass yield from non-agricultural land can be taken as 4 ton/hectare firewood and timber for Ballia district this includes areas under forest, canal strips, village wood lots, community spaces etc. The cluster does not have pastures. Only the barren land and other land come under non-agriculture land so it can be taken into account for biomass yield.

3.3 Energy plantation

It is recommended that the energy plantation should cover 6% of the total land area according to the report of the advisory Board of energy, Government of India [3]. Taking total area of the cluster into account, 84.77 ha can be for energy plantation. The average biomass availability from energy plantation can be taken as 6 ton/ha/year and so the biomass availability in the cluster will be 508.6 ton/year which can be realized in a period 6-7 years.

3.4 Animal wastes

Constitute the wastes from the animal husbandry. Livestock population is important parameter which is 6792 includes buffaloes, cows and bullock. Sheep, goat, poultry, etc. have not been included in the bovine population. Taking an average collection of around 75% of animal excreta and an average excreta yield of the cattle of 11 kg/day, 12.30 ton of wet dung is available per day or 2.46 ton of dry dung per day (assuming 80% liquid) [4]. This has a potential of 1867.8 cum/day of generation of biogas.

4. Present energy consumption pattern

Data on energy inputs and outputs were collected and analyzed for the cooking devices, lighting, cooking fuels and their consumption, energy consumption in other household devices such as electric fan, coal, electric iron, TV, etc. from 100% household survey.

Commercial fuel includes petrol, diesel, kerosene and electricity. Kerosene for which the supply is 3 lit/card holder per month is amounting to 57.6 kl/year through the public distribution system. Diesel, petrol and LPG are scarcely available in the cluster. Two hamlets of Beswan village and two hamlets of Baijalpur are un-electrified. There is very irregular supply of electricity, average 4 hours/ day. Poles which supply electricity are damaged during stormy and strong windy days therefore the villages come under dark for many days and sometimes for many months. Studies were made for the total energy from all the available energy resources by using the conversion factors from Table 4 [6].

Main energy consuming sectors in the village are domestic and agricultural. Energy consumption in these sectors is described below:

4.1 Domestic sector

The energy in the domestic sector is obtained from non-commercial as well as commercial sources like cow dung, firewood, coal, biogas, kerosene, LPG and electricity and for different domestic uses, they contribute differently.

As per survey, it has been found that the most popular appliance used for cooking is still the traditional Chulhas, though it has an efficiency 5 to 10% (Figure 2 and Figure 3). It is also very hazardous to health as it emits much smoke because of its low thermal efficiency [5]. As per present study, all the households have this device.

Kerosene is a minor fuel used for cooking activities. About 0.8% of the households use kerosene stoves, share of this source is only 0.049 % of the total energy consumption in cooking energy. 106 households have been found in the cluster that use LPG stoves. None of the households use biogas stoves. The share of LPG is 5.21% of the total energy in cooking.

As per survey, the entire households use firewood and its share in energy terms is 48.28% in cooking.

A major quantity of agricultural waste generalized is consumed for fodder/ feeding and other purposes in cluster, 86% of households use agricultural waste as a fuel source. It share in energy terms is 15.2% in cooking.

As per survey, 100% of the households use dung cake for cooking activities. Most of the dung available is used for making dung cakes in the cluster. Share of the dung cake in energy terms in cooking is 31.26%.

Although there are 4 family size biogas plants installed in cluster, but all the plants are non-functional and so biogas is not used for cooking purposes in the households.

The main energy source for domestic lighting in the cluster of villages is kerosene followed by electricity. All households use kerosene in domestic lighting. Majority of households are not having proper electricity connections while none of the households use biogas. The energy consumption in other domestic activities like running electrical appliances i.e. fan, coal and electric irons, TV, etc. has also been surveyed. There are few battery powered TV sets, which have not been taken into account in the analysis.

Table 4. Energy conversion factors

Particulars	Units	Equivalent (energy in MJ)	Remarks
1. Human labour			
(a) Adult men	Man-hour	1.96	
(b) Women	Woman–hour	1.57	1 Adult woman= 0.8 adult man
(c) Children	Child–hour	0.98	1 child = 0.5 adult man
2. Animals			
(a) Bullocks	Pair–hour	10.10	Body weight 352–450 kg
(b) Medium Pair–hour			
3. Diesel	1L	56.31	
4. Petrol	1L	48.23	
5. Electricity	1kWh	11.93	

Figure 2. Images show three major cooking fuels : Firewood, agriculture waste, dung cakes which are available in the cluster of villages, Ballia, Eastern Uttar Pradesh

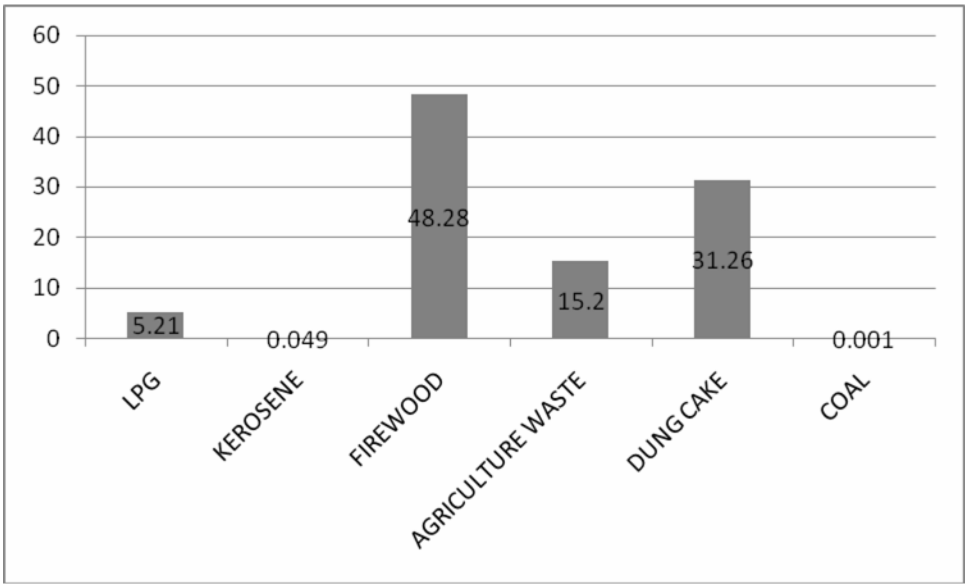

Figure 3. Energy consumption pattern in cooking from different energy sources on % basis

4.2 Agriculture sector

This sector includes the total energy used in various practices for different activities like soil preparation(tiling), seeding, transplantation, irrigation, inter-culturing, weeding, harvesting, thrashing and transportation. The energy consumption shares (in percentage) for different energy sources in different agricultural activities are different. Through the study it is found that irrigation and tiling activities consume maximum energy as reported in Table 5 and it is about 40% for irrigation and 37.1% for tiling. Tractor, diesel powered electric engines, electric powered tube wells and muscle power provide major energy shares for agriculture. Other agricultural activities like seeding, transplanting, inter-culturing, weeding, harvesting, threshing and transportation consume comparatively less energy than in irrigation and tiling as shown in Table 5.

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Table 5. Energy consumption pattern in various agricultural activities from different energy sources on percent basis

End use	Energy consumption (on % basis)				
	Human power	Animal power	Tractor	Motor/engine	Total
Tiling	4.8	3.2	29.1	0	37.1
Seeding	3.0	0	.2	0	3.2
Irrigation	10.2	0	5.0	25.0	40.0
Weeding	0.5	0	0	0	0.5
Harvesting	3.5	0.3	2.5	0	6.3
Threshing	1.5	0.5	4.1	0.8	6.9
Transportation	1.2	0.6	4.2	0	6.0
Total	24.5	4.6	45.1	25.8	100

Table 6 presents the total energy consumption in all the three villages in the cluster. The maximum energy share 78.71% is for non commercial fuels (dung cake, fuel wood and agriculture waste) in the villages.

Table 6. Village-wise and sector-wise annual fuel consumption in the cluster. Energy consumption pattern in various agricultural activities from different energy sources on percent basis

Fuel	Unit	Mudera	Beswan	Baijalpur	Total	Share %
Firewood	ton	887.5	582.4	655.9	2125.8	49.9
Dung Cakes	ton	500.3	312.4	408.6	1201.3	21.2
Agriculture waste	ton	165.2	52.5	99	306.7	7.9
Kerosene	kl	40.5	32.6	35.7	108.8	6.8
Coal	ton	25.1	11.9	18.5	55.5	2.4
Electricity	000’kWh/yr	47.8	14.9	17.8	80.5	0.5
Biogas	000’cum/yr	00	00	00	00	00
LPG	ton/yr	3.5	2.4	2.0	7.9	0.7
Diesel	kl	55.3	30.2	53.4	138.9	9.1
Animal Power	000’h	38.1	33.7	31.0	102.8	1.7

5. Result and discussion

The village was self-sufficient for cereals and milk products. Energy was imported as diesel, electricity, etc. Energy demand and supply and the consumption pattern in the cluster in different sectors like domestic, agricultural, rural industries and miscellaneous was also calculated. To carry out energy security analysis for energy planning, it is important to assess the energy gap in the cluster. The overall assessment of demand and supply of energy sources in the cluster are given in Table 7.

Solar energy is totally unexploited. The solar thermal and solar photovoltaic systems can be installed to harness the available solar energy. For assessment of solar energy in the cluster an assessment of available solar energy in 10 m^2 in each household of the cluster has been made which is roughly 19700 kWh annually. There are 1226 households in the cluster. The potential of solar energy is 24.15 x 10^6 kWh annually.

In terms of wood it is basically used for domestic firewood and local timber requirement. Assuming that 20% of the wood is utilized as timber, the remaining firewood from energy plantation and from non-agricultural land will be 255.53 ton/year of firewood and 843.744 ton/year of firewood respectively against the annual consumption of 2125.8 ton of firewood. This is an alarming situation.

In terms of animal waste, the annual consumption of dung cakes is 1201.3 ton while the availability of 4090.48 ton/year of dry dung. Annual dung cake deficit in the cluster is 61.04 ton. In agriculture waste, assuming that 30% of total production of agriculture waste is being used for fodder and thatching, the total surplus of agriculture waste in the cluster is 886.97 ton/year. In terms of kerosene, the villagers in the cluster buy the kerosene amounting to 51.2 kl/year from black market to match up the consumption in the cluster.

Table7. Energy scenario of the cluster

Category	Total energy supply (available)	Total energy demand(consumption)	Gap between supply and demand
Solar Energy	$24.15X10^6$ kWh/ yr	0	$+24.15x10^6$ kWh/ yr
Energy Plantation	319.41 ton/yr	0	+319.41 ton/yr
Agricultural Waste	1705.238 ton/yr	306.7 ton/yr + 511.57 ton/yr fodder and thatching	+886.97 ton/yr
Animal Excreta	1140.26 ton/yr of dry dung is generated in the villages assuming 75% collection efficiency	1201.3 ton/ yr dry dung	-61.04 ton/ yr
Biomass from Non-agricultural Land	1054.68 ton/yr of biomass	2125.8 ton/yr	-1070.32 ton/yr
Kerosene	57.6 kl/yr	108.8 kl/yr	51.2 kl/yr

6. Integrated energy planning model

Integrated energy planning mechanism takes into account various available resources and demands and involves minimization of annual cost function in a region. The planned interventions to reduce energy scarcity take various forms, such as [7]:

(a) Energy conservation through promotion and use of energy efficient stoves for cooking and water heating, compact fluorescent bulbs, LED in place of ordinary incandescent bulbs,
(b) Supply expansions through energy plantation which includes agro forestry, farm forestry and community forestry, and,
(c) Alternatives—renewable sources of energy such as solar and biomass based systems.

The survey covered the willingness of the villages to adopt the renewable energy system instead of additional devices. The following numbers of renewable energy systems as given in Table 8 are proposed to be implemented in the period of 5 years in different villages of cluster.

Provision of SPV pump for drinking water and biomass gasifier, solar passive architectural house, solar drier and solar still, solar module for tape recorder and transistor is meant for demonstration model for the villagers.

The conversion technologies and energy devices basically form a critical link between the available primary and secondary energy resources and the perceived energy needs of the users.

The basic consideration for selecting any energy device or any energy conversion technologies are the device should be convenient to use the device should be reliable with trouble – free operations and minimum maintenance requirements, the energy delivered should be in appropriate form in order to match the user’s needs, the energy should be cheaply available, the device should have a positive social and environmental impact and the device and conversion technology should be efficient and effective in using primary energy resources.

In terms of cost analysis Table 9 reflects the total cost including the Government subsidy (wherever applicable and the beneficiary) the data has been obtained from the New and Renewable Energy Development Authority, Lucknow and the market survey.

In order to assess the benefits of recommended systems, the table also provides the cost - benefit analysis in terms of energy savings in fuel utilization and also in monitory terms taking the firewood cost as Rs. 1500/ton, cost of diesel Rs. 34/lit and the cost of electricity Rs. 3.75/kWh.

Table 8. Recommended systems and devices

System/ Device	Villages Mudera	Beswan	Baijalpur	Cluster
Biogas Plant	26	17	19	61
Improved Chulha: Fixed	340	190	208	818
Improved Chulha: Portable	194	90	124	408
Solar Cooker (Plane Box Type)	60	23	28	121
Solar Cooker Dish Type	20	9	11	40
Solar Hot water system	15	6	8	29
SPV home light (Model 1)	26	18	22	66
SPV home light (Model 2)	12	8	10	30
SPV lantern	69	35	40	144
CFL 8 W	35	15	19	69
CFL 14 W	35	15	19	69
CFL 18 W	35	15	19	69
Electronic fan regulator	100	47	54	201
Solar module for tape recorder	30	13	17	61
Solar module for transistor	130	54	61	245
Foot Valve	60	34	38	132
SPV pump for drinking water				1
Street light	18	10	8	36
Solar passive architecture house				1
Biomass Gasifier				1
Leaf cup making machine				1
Solar dryer	1	1	1	3
Solar Still				1

From Table 9, it is clear that out of the investment of Rs 3.585 million excluding investment figures Rs. 1.063 million in demonstration models in the 5 years. Total energy saving in monitory terms will be 1.951million/year i.e. Rs. 9.755 million in 5 years.

7. Future energy projection on the basis of socio economic parameter

It is important to project the energy demand for the cluster in next five years, based upon potential variation growth rate in key sectors like agriculture, industry, etc., likely increase in per capita consumption level for domestic activities with improved economic status. Some basic assumptions on switching over from traditional fuels to commercial fuels and perceptible improvement in the villages have been taken to estimate the energy demand in next five years which is given in Figure 4.

7.1 Firewood

Additionally 426.24 ton/year of firewood from energy plantation and 1142.464 ton/year of firewood from non -agricultural land may be available.

On the implementation of proposed programmes for biogas plant, improved chulhas (fixed and portable), solar cooker (plane box and dish type), pressure cooker and solar water heaters, there will be a saving of 1610.04 ton/year firewood.

7.2 Dung cake

Out of 1140.26 ton/year of dry dung is generated in the villages, assuming roughly 1/3rd of the amount may be used for running of biogas plants and the remaining may be used for fuel purposes in the form of dung cakes.

7.3 Agricultural waste

The rice husk available in the cluster may be used to run the biomass gasifier and the remaining agriculture waste may be used as fuel purpose. A sufficient amount is available in the cluster. The installation of biomass gasifier and the remaining agricultural waste may be used as fuel purposes. The installation of biomass gasifier in the cluster will go a long way in improving the supply of electricity in the area.

Table 9. Cost analysis of the system proposed and the cost- benefit analysis

System/ Device	Capacity	Per Unit cost (Rs.)	Total Cost (Rs.)	Annual saving of fire wood/ electricity/ diesel	Annual saving in monetary terms (Rs.)
Biogas plant	2 cum	8000	488000	167.75 ton/yr of firewood	251625
Improved Chulha: fixed	-	100	81800	449.9ton/yr of firewood	674850
Improved Chulha: Portable	-	140	40800	224.4 ton/yr of firewood	336600
Solar Cooker (Plane Box Type)	-	1500	181500	91.16 ton/yr of firewood	136740
Solar Cooker Dish Type	-	5000	90000	23.36ton/yr of firewood	35040
Solar Hot water system	100 lit	20000	580000	7.975 ton/yr of firewood	11962.5
SPV home light (Model 1)	One 9 W CFL	6050 with 5 yr AMC	399300	4.71MWh/yr of electricity	17662.5
SPV home light (Model 2)	Two 9 W CFL	9950 with 5 yr AMC	298500	4.28 MWh/yr of electricity	16050
SPV lantern	5W CFL	3250	468000	26.215 MWh/yr of electricity	98306.25
CFL	8 W	100	6900	11.68 MWh/yr of electricity	43800
CFL	14 W	120	8280	13.147 MWh/yr of electricity	49275
CFL	18 W	140	9660	29.93	112237.5
Electronic fan regulator	-	100	20100	11.2266	42097.5
Solar module for tape recorder	9W	900	54900	-	-
Solar module for transistor	1W	200	49000	-	-
Foot Valve	-	200	19800	2.9kl/yr	98600
SPV pump for drinking water	-	467000		-	-
Street light	11-18W CFL	24800	892800	7.06	26475
Solar passive architecture house		100000	100000	-	-
Biomass Gasifier	40kW	381580	381580	0.0241	90.375
Leaf cup making machine	-	4000	4000	-	-
Solar dryer	$1.5m^2$	4000	4000		
Solar Still	$2.1m^2$	2600	2600		

In terms of requirement of kerosene for lighting purposes, the proposed installation of SPV home lights, SPV lanterns, and SPV lamps will sufficiently reduce the consumption of the kerosene in the cluster for light.

The installation of SPV street lights will improve the street lighting facilities in the villages.

The proposed installation of CFLs, electronic fan regulator and electronic ballast for tube light will conserve the electricity in the cluster. Friction- less foot valves will considerably reduce the consumption of diesel in running the pump sets. Drinking water facilities in the villages may also be improved in the cluster. However in agriculture and allied activities, rural industry and transport activities, the cluster may continue to depend upon the commercial fuels like diesel, petrol and LPG. This may however be reduced by using battery operated vehicles, solar-powered rickshaws and other systems based on renewable energy systems.

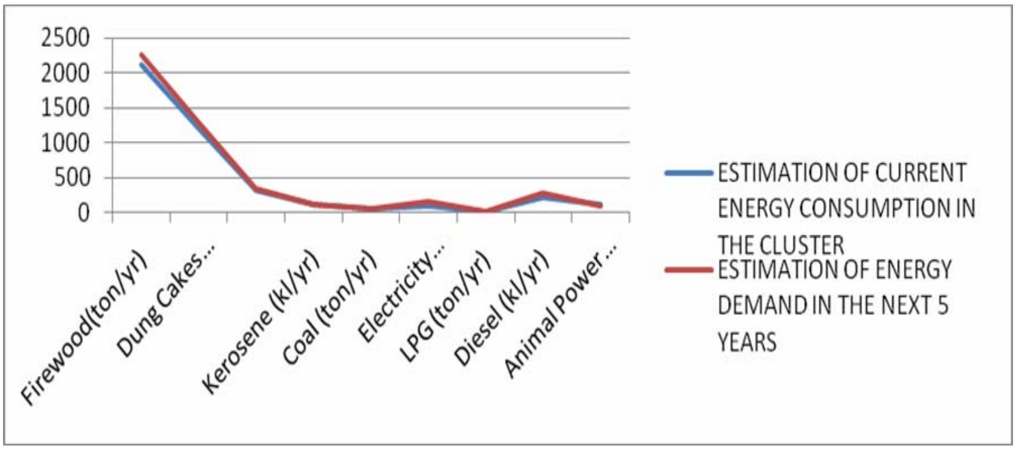

Figure 4. Projection of increasing energy demand of different fuels in the next five years (2015) in the cluster

8. Conclusion

There is more availability of non-conventional energy resources as compared to conventional energy sources. Solar energy which is the one of the major non-conventional energy resource is totally unexploited. Therefore to meet the energy demand in the sustainable way locally available renewable energy resources should be exploited.

Technical potential depends on the available technologies that can be exploited for the conversion of biomass to more flexible forms and so is subjected to change with time. Natural conditions that favour the growth of biomass determine the theoretical potential.

A major challenge will be to provide electricity to the rural poor. Electricity is needed to power small industry and enterprise, schools, home lighting, street lighting, and agriculture activities.

The proposed energy plan can be used as policy analysis tool that assess the technical, economic, environmental effects of alternative energy system and increased local employment and the creation of jobs.

To fulfill the present growing energy demand sustainable utilization of resource is necessary so that the government and institutions should try for this purpose. The study has shown that the objective of effective implementation of energy planning cannot be achieved without decentralization and community involvement.

India is fortunate that it has a wide network of local government institutions at the district and local levels. The village council is self-developed systems which have plays important role for the development of people and resource in all its covering area.

Integration is emphasized across all types of resources in the system and across all parts of the energy systems (such as sector-wise energy demand, seasonal constraints in availability and economic impacts). Thus the proposed integrated energy system is capable of meeting at least domestic need from the available local energy sources.

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