Energy Utilisation in Karnataka: Part-I An Overview

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INTRODUCTION

Energy has become an important need in our life. Our primary needs for energy - for heat and light to sustain life on earth are obtained from the sun. Here we concern ourselves about the acquired needs of man for energy. The day, he "invented" fire he "invented" an acquired form of energy with its uses. He started multiplying the uses - drying clothes, cooking food, making implements, transportation etc. Initially his energy requirements were met mostly from human and animal forms and to some extent from wood. As the environment was having abundant quantities of wood, this fuel was considered a free commodity (in economists' terminology) like air and water.

But a minor leap in energy use started after the first wave - agriculture and a major leap after the second wave - industrial revolution. Once the wants of man increased, there were secondary requirements of energy - for industrial production. Industrial development mainly concentrated on the objective of improvement of "quality of life" - by inventing machines to do activities done by man and animals and to do newer activities. This effected a shift in energy from animal to fuel. Some examples are textiles, transportation (steam engines) etc. As technology proceeded at a faster pace to conquer various problems of mechanisation, energy consumption rates started to gallop. One of the major objectives of "quality of life" is convenience - convenient and easy way of doing things. Market economics was totally based on value addition and it treated many energy resources as free resources assuming infinite availability of such resources like fire-wood, coal etc. These strong concepts aided in generation of more energy intensive technologies. Increased rate of growth in population and increased use of energy cumulatively led to crisis situations in resources.

Energy is a complex, process because it is possible to convert it into different forms, transport it, store it in some form and use it in various end use modes in innumerable number of places. An energy system consists of three components;

I) Generation system - energy resources are converted into a transportable form like electrical energy in centralized systems and gas and steam in decentralized systems;

II) Transport/transmission system - energy forms transported from place of availability/generation to places of use;

III) Distribution system - distribution and uses in end use activities.

In the case of a decentralized system, all these three activities may not be present. Energy resource is transported directly to place of use and used in a suitable end use device. Before the advent of large scale technologies, decentralized systems were the only mode of energy use. Some of the examples of decentralized systems are;

i) use of firewood for domestic needs (of cooking, water heating etc.), for small industries like brick kilns, hotels, tobacco curing, sericulture, small foundries etc;

ii) use of steam in textile, chemical and other industries;

iii) use of diesel/petrol in vehicles for transportation;

Because of convenience, ease of maintenance, diversity of usage and reduced cost of operation, energy production became centralized. Electrical energy is one form easy to transmit and is produced in distant hilly areas with good hydro potential which is used in urban areas. This further spurred centralization. In developed countries, most energy forms are in the centralized form except transportation.

Let us now look at another picture of energy - mainly from the angle of resources and consumption patterns.

Energy Resource

Energy resources can be broadly categorised as renewable and depletable. Renewable resources are available every year whereas depletable resources are stored ones whose availability keeps on decreasing depending on use. Examples of renewable resources are hydro energy, solar energy, wind, biomass, energy from wastes (biogas, agro-wastes, industrial wastes etc.). Examples of non-renewable sources are petroleum products, coal, uranium, etc. Fire-wood is in a peculiar position - if our consumption per year equals our annual 'Production', it is a renewable resource; if the consumption exceeds annual growth, then it gets depleted. There are also other categorizations like commercial and non-commercial; conventional and non-conventional. Non-conventional forms are the recent developments in energy conversion and generation, examples being biogas, direct solar utilization devices like cooker and water heater, wind generators, etc.

Energy resources are also classified as primary or secondary ones - coal, firewood etc. being primary ones and electricity a secondary one. When energy is converted many times, an inherent problem is the loss incurred. Each convertion converts only a part of energy input as a usable output, the remaining part being lost to atmosphere. Estimates of the ratio of actual energy used in output to the total amount of energy spent gives values of about 0.05 - 0.1. This means that about 5% or 10% of total energy input is used, the remainder not used. Centralised systems normally invoke many conversions compared to decentralised systems.

Because of the complex nature of interlinkages of energy in various forms to many societal aspects, we will restrict our attention to mainly those aspects of the energy scene in Karnataka which directly effect its environment. In this sense, the main focus is directed towards the most important and oldest fuel-firewood. It is used in large quantities in almost every part of the State the technology needed being very simple - three stones. It is very closely linked to our ecology - the disappearance of our "forests" and areas of tree cover.

Hence we are emphasizing the use of firewood in Karnataka and the steps being taken to reduce firewood consumption by;

i) employing alternate sources like solar devices, biogas etc. and

ii) improving efficiency of end use devices.

Part I of this article will appear unbalanced - in concentrating its attention on the common man's fuel. Similarly emphasis has been placed on domestic use of energy rather than industrial uses. It is intended to focus our attention on industrial consumption in the successive articles (part II and III).

This article covers broadly the following aspects;

i) A general picture of consumption of energy in Karnataka;

ii) Potential of renewable energy sources in Karnataka;

iii) Developments in the use of renewable energy in Karnataka;

iv) Firewood consumption;

v) Affirmative policy measures to improve environment;

vi) Energy conservation strategies.

Even though these aspects do not cover the entire spectrum of energy usage - an important aspect like transport is missing - they present a picture of activities pertaining to environment related energy problems.

Any discussion on energy should lead to the solution of the question "what should be the State's energy policy?" This is after an assumption on our part that a "policy" must exist. A policy blending the need for development and the need for maintaining the fragile balance of our already marginally stable ecosystem must be evolved. Fortunately, many alternatives exist to solve the energy problems of a State, many of them having a benevolent impact on our environment. Hence a good energy policy, instead of being a dog in manger policy with adverse impacts on environment and satisfying the cry for a skewed form of development raised by individuals, should be an affirmative one leading to development of devices, technologies, incentives, diffusion mechanisms and organisations, support systems for maintenance and operation, with the objective of meeting energy requirements of every sector in a balanced manner and at the same time maintaining a very stable ecosystem. It is our hope that based on these reports, environmentally sound, renewable energy technologies for energy conversion and energy efficient devices should be encouraged and promoted not on a small scale but with a conscious effort.

Another important factor that needs a careful look in our energy planning exercise is the relationship between costs and energy projects. Presently energy projects do not consider costs due to ecological degradations - even visible costs like loss of timber in a submerged forest area for a hydroelectric project are included at a nominal value only, not at a realistic level. Secondly, because of a popular belief that energy should be given at a subsidised cost to consumers, project planners adopt strategies to cut costs without considerations to ecology. Given the fact that energy users are prepared to accept higher costs for energy - for example, industries spend about Rs. 3/- per unit of electricity obtained from diesel generation; rural households spend about Rs. 8

to 10 per month on kerosene for a "poor" lighting - we should include in our policy a new look at criteria for project clearance by the Planning Commission. Energy solutions should be looked at in totality and all possible and feasible alternatives for each project should be analysed. It is not enough to seek new generation strategies alone, but it is essential to analyse energy conservation methods based on long range benefits and not on minimising capital costs, since these large projects are irreversible for short time spans (of even tens of years).

Energy Consumption Patterns :

Consumption

Normally various organisations are preoccupied with predicting energy demands. In order to understand future growth patterns, it is desirable to see the distribution of energy amongst various sectors and amongst various sources. Such a macro-level study will reveal the critical areas which need strengthening. **Table 1** gives the sourcewise energy consumption in Karnataka for the year 1979-80 and partially for the year 1982-83 in terms of million tons of coal replacement (a unit identified by the Fuel Policy Committee, Government of India, 1974). Some interesting aspects that can be seen from this table are;

i) the top position is occupied by fire wood;

ii) oil is the next important resource, accounting for 26.7% of energy in 79-80 (55.07% of commercial energy).

Table 2 illustrates sectoral distribution of energy for the year 1979-80. It also compares energy/unit output for Karnataka and India. From this, we can see that;

i) Industry and transport are major consumers, followed by domestic users;

ii) Industries are energy intensive as can be seen from the fact of 1.96 tons of coal replacement is needed for Rs. 1000/- of output in Karnataka, where as the figure is 1.63 for India;

iii) Agriculture uses much less energy; Karnataka uses only 1/3rd energy as against the Indian average for the same output.

Table 1: Consumption of Energy - sourcewise: Karnataka: 1979-80 and 1982-83

Sl.No.	Item	Consumption for 1979-80 in MTCR	%	Consumption for 1982-83 (partial) in MTCR	% increase
	Commercial Energy				
1	Coal	0.952	3.51		
2	Oil	5.518	20.33	7.37	33.36
3	Kerosene	1.739	6.41	2.31	33.00
4	LPG	0.110	0.41	-	-
5	Electricity	4.858	17.90	6.41	32.00
	Total of commercial energy	13.177	48.54		
	Non-commercial Energy				
6	Firewood	11.208	41.29	15.50	38.30
7	Cow dung cake	0.224	0.83	-	-
8	Agro-wastes	2.536	9.34	-	-
	Total of non-commercial energy	13.968	51.46		
	Total	27.145	100.00		

Table 2: Consumption Pattern of Commercial Energy, userwise for Karnataka

Sl.No.	Category	Energy Consumption		Energy in tcr per Rs.1000 of output	
		(1979-80) MTCR	%	Karnataka	India
7	Household	2.391	18.1	-	-
2	Agriculture	0.735	5.6	0.05	0.15
3	Industry	5.798	44.0	1.96	1.63
4	Transport	3.215	24.4	3.35	4.79
5	Others	1.038	7.9	-	-
	Total	13.177	100.0	0.54	0.64

Electricity Consumption :

Electricity use in Karnataka dates back to 1900 when the first hydroelectric project in the State was built in Shivasamudram. Some of the major projects are Sharavathi Valley Project, Kalinadi Project, MGHE, etc. Currently power generation is from hydroelectric plants only. The first thermal plant is under construction at Raichur. Tables 3 and 4 give details regarding electricity generation and consumption. Important aspects are;

i) More than 70% of energy goes to industrial sector; next to the industrial users come All Electrical Homes (average energy consumption per house of AEH users is 2234 units per year - 186 units per month);

ii) Connected load to installed capacity ratio is 2.19;

iii) Number of units generated/kw of power is 4118 and load factor is 0.47;

iv) Whereas industries lead in energy consumption, pumpsets for irrigation have a connected load of 1193 MW (29%); consumption/installation is 1310 units/year - indicating an average use of about 300-400 hours/year of each pumpset - i.e. one hour/day;

v) Similarly AEH also has a large connected load.

Another interesting aspect is the difference between projected values for 1982-83 and actual values as shown in **Table 3.** This shows that energy shortage is increasing year by year and it is essential to solve this problem in an innovative manner. So far we have seen the consumption pattern of recorded forms of energy at macro level. Let us look at rural and urban domestic energy consumption as revealed by two case studies. **Table 4** gives Electrical energy consumption (categorywise) 1982 - 83

Table 3: Electricity Generation in Karnataka

	1982-83	1983-84
Installed capacity (MW)	1874.8	1874.8
Energy generated (million units)	7720	7822.8
Energy consumed (million units)	6413	
Energy availability (as estimated in 1978)	10090	
Energy requirement (as estimated in 1978)	11554	

Table 4: Electrical Energy Consumption (categorywise) 1982-83

Category	Connected load (MW)	No.of installations (1000's)	Consumption (million units)
Domestic	463.0	1741	328
All Electric	720.0	269	601
Commercial	94.0	263	161
LT industries	664.0	114	545
HT industries	871.6	1.43	4021
Public lighting	26.7	373	83
Irrigation	1193.0	358	469
Water works	71.9	3.144	-
Licensees			25
Goa			180
Total	4103.6	3122.574	6413

Energy Consumption in Rural Areas :

Very little is known about energy used in rural areas. Impressions exist that rural energy needs lead to deforestation. As a first step to understand rural energy problems, ASTRA of IISc conducted a detailed survey in six villages in Kunigal Taluk (Tumkur District) in Karnataka - based on observations, discussions, measurements and checks. Some of the findings are listed below;

i) Firewood is a dominant energy source (81.6%). This is used mainly for household activities. The surprising finding was that 71% of the households depend on gathering firewood, and 48% of firewood used is gathered from the neighbourhood consisting of twigs and small branches only. About 19% of firewood came from one's own land leaving about 33% to be purchased. Hence gathered firewood does not tribute to deforestation. Supporting evidence to this comes from the fact that gathering is done mostly by children and women;

ii) Cooking activity is a major one consuming human and fire wood energy. Efficiencies of choolas are in the range of 5.08%. Hence it is desirable to study improvements in the design of choolas;

iii) Human energy (especially women and children) was inefficiently used in firewood gathering (2.6 hrs/day/hh), cooking (3.68 hrs/day/hh), carrying food to farms (1.82 hrs/day/hh), fetching water (1.53 hrs/day/hh), taking cattle for grazing (5.54 hrs/day/hh) etc. The share of domestic burden between men, women and children is 24%: 56%: 20%;

iv) Kerosene consumption for lighting is about 4.3 litres/un-electrified house, 78% of the houses being un-electrified;

v) Industrial consumption is very small.

The sourcewise and sectorwise energy consumptions are given in **Table 5.**

Table 5: Pattern of Village Energy
(sourcewise and sectorwise)

A) Sourcewise	Percentage Energy
Human	7.7 + 0.5
Animal	2.7 + 0.5
Firewood	81.6 + 2.6
Kerosene	2.1 + 0.2
Electricity	0.6 + 0.5
Others	5.3 + 2.9

B) Sectorwise Consumption	
Enduse	Percentage
Agriculture	4.3 + 1.0
Domestic	88.3 + 4.1
Lighting	2.2 + 0.2
Transport	0.5 + 0.1
Industry	4.7 + 4

Table 5:A)

	Agriculture	Domestic	Lighting	Transport	Industry
Human hours	721,181	2,979,065	-	-	167,634
Bullock hours	117,537	-	-	13,372	1,520
Firewood	-	2,141,320	-	-	112,610
Husk	-	1,185	-	-	325
Veg. Wastes	-	198,537	-	-	5,352
Coal	-	-	-	-	5,731
Kerosene	-	712	23,165	-	1,157
Electricity	42,108	-	24,371	-	6,428
Diesel	148	-	-	-	-

Table 5: B)
Energy Matrix (Normalised - 10 million K cals)

	Agriculture	Domestic	Lighting	Transport	Industry	Total
Human hours	165.30	584.02	-	-	39.52	789.02
Bullock hours	270.04	-	-	30.70	3.50	304.60
Firewood	-	8140.00	-	-	426.00	8566.00
Husk	-	3.50	-	-	0.97	3.47
Veg. Wastes	-	397.00	-	-	10.70	407.70
Coal	-	-	-	-	25.80	25.80
Kerosene	-	6.40	208.00	-	10.40	224.80
Electricity	36.10	-	20.60	-	5.53	62.23
Diesel	1.33	-	-	-	-	1.33
Total	473.13	9131.10	228.60	30.70	522.42	10385.95

Domestic Energy in Karnataka :

Another excellent study of domestic energy consumption in Karnataka has been done by the Perspective Planning Division, Planning Department of Government of Karnataka. This was based on NSS 32nd round (1977-78) and gives the variations in rural and urban areas in different districts (**Table 6** and **Table 7**). This reveals that per capita firewood consumption varies from

13.69 kgs (D. K. Dist.) to 73.35 kgs (U. K. Dist.); 0.33 to 0.73 litres for Kerosene (Kodagu, Hassan Districts). Per capita expenditure is minimum in Tumkur (Rs. 43.33) and maximum in Chikmagalur (Rs. 74.91). An interesting observation is that energy expenditure is a major expenditure - a person may starve not because of non-availability of food but because of non-availability of fuel.

Comparing urban and rural energy consumptions, we find that;

i) Bangalore City and rural show a contrast in use - electricity 6.28 and 1.09 units; kerosene 1.83 and 0.71 litres; LPG 0.27 and 0 kgs; firewood 14.12 and 23.5 kgs; Dung 0.41 and 0.33 kgs; expenditure Rs. 99.36 and Rs. 55.98;

ii) Chitradurga also shows a large variation - expenditure Rs. 78.3 for urban and Rs. 48.31 for rural;

iii) Dakshina Kannada, Dharwar etc. show increased expenditures;

iv) Rural and urban consumption of firewood show a difference of about 25%; electricity consumed in urban areas is about six times that for rural areas; for kerosene the ratio is nearl 2;1.

Table 6: Monthly per capita consumption of energy of the Rural Households
Sourcewise and Districtwise: 1977-78

Sl.No	District	Expenditure (Rs.)	Coal (Kg)	Kerosene (Lt)	Electricity (KWH)	Firewood (Kg)	Dung (Kg)
1	Bangalore	55.98	0	0.71	1.09	23.50	0.33
2	Belgaum	59.23	neg.	0.61	0.27	22.81	1.82
3	Bellary	63.35	0	0.51	0.28	28.06	0.34
4	Bidar	48.36	0	0.37	0.03	25.35	3.06
5	Bijapur	56.76	0	0.37	0.22	13.98	1.81
6	Chikmagalur	74.91	0	0.58	0.63	68.69	10.93
7	Chitradurga	48.31	0	0.53	0.53	17.23	2.89
8	Dakshina Kannada	61.21	0	0.55	0.96	13.69	0.00
9	Dharwar	62.93	0.02	0.62	0.51	20.90	0.84
10	Gulbarga	56.61	0	0.53	0.01	21.64	4.67
11	Hassan	64.23	0	0.73	0.53	55.97	6.84
12	Kodagu	81.83	0	0.33	0.00	29.51	0.00
13	Kolar	67.16	0	0.55	1.69	27.54	0.02
14	Mandya	63.08	0	0.52	0.74	38.08	0.12
15	Mysore	49.82	0	0.49	0.22	20.62	0.00
16	Raichur	58.31	0.03	0.51	0.50	30.58	1.75
17	Shimoga	61.28	0	0.46	0.55	43.64	0.04
18	Tumkur	43.33	0.01	0.47	0.66	22.86	0.00
19	Uttara Kannada	66.19	0	0.49	0.40	73.35	0.00
	Karnataka	58.69	neg.	0.54	0.54	20.38	1.69

Table 7: Per capita monthly consumption of Energy: Urban

Sl.No	District	Expenditure (Rs.)	Coal (Kg)	Kerosene (Lt)	Electricity (KWH)	LPG (Kg)	Firewood (Kg)	Cowdung (Kg)
1	Bangalore	99.36	0.07	1.83	6.28	0.27	14.12	0.41
2	Belgaum	57.85	0.15	0.54	1.18	0.00	22.66	0.07
3	Bellary	74.73	0.01	0.52	2.43	0.19	20.48	0.37
4	Bidar	47.75	0.00	0.46	0.33	0.00	28.09	2.44
5	Bijapur	59.47	0.02	0.48	0.60	0.04	17.58	1.23
6	Chikmagalur	78.67	0.00	0.45	2.71	0.00	50.00	6.48
7	Chitradurga	78.30	0.20	0.74	4.48	0.00	26.32	0.00
8	Dakshina Kannada	99.71	0.00	0.60	3.30	0.12	16.56	0.00
9	Dharwar	86.13	0.40	0.90	2.21	0.08	17.03	0.25
10	Gulbarga	71.27	0.73	0.69	0.93	0.00	18.32	1.76
11	Hassan	56.63	0.00	0.73	1.43	0.00	48.96	4.38
12	Kodagu	(Not available)						
13	Kolar	85.62	0.13	1.05	2.07	0.08	20.68	0.00
14	Mandya	74.27	0.00	0.59	1.62	0.00	32.12	0.00
15	Mysore	60.11	0.47	0.82	1.52	0.02	19.31	0.00
16	Raichur	64.14	0.11	0.51	1.42	0.00	25.42	1.05
17	Shimoga	82.96	0.07	0.63	3.70	0.13	37.11	0.02
18	Tumkur	65.09	0.00	0.84	3.28	0.00	21.09	
19	Uttara Kannada	74.78	0.29	0.45	1.07	0.05	66.39	0.12
	Karnataka	80.04	0.16	0.98	3.12	0.11	21.56	0.59

Firewood Consumption

As already explained, firewood is a dominant energy source and is closely related to deforestation in our State. Accurate figures on firewood consumption are not available and only estimates are obtained. Consumption can be categorised into two parts - rural domestic needs

and urban domestic and traditional industrial needs.

Based on many rural surveys, estimates for firewood vary from 15-20 million tons/year for Karnataka - very much lower than the recorded values available with Forest Departments. Fortunately, observations show that rural people mostly gather their firewood - twigs and small branches from the neighbourhood. Hence this does not lead to deforestation. But urban domestic requirements and needs of industries like brick and tile, tobacco, sericulture, hotels etc, consume logs obtained from forests mainly supplied by private contractors. It is this usage which causes concern specially from the point of view of deforestation. It is desirable to consider these uses.

Table 8 illustrates estimates to firewood required by some industries in Karnataka (about 4.27 million tons). Recorded values for forest output is less than 1 million tons (see **Table 9**). Some of the industries not included in **Table 8** are brick industries (about 1 million tons), sericulture, small scale industries, hotels, canteens etc. These needs do not include demands for wood as a raw material in industries, house construction, construction of sheds and small "bridges' seen in Uttara Kannada, fences, small dams, agricultural implements, bullock carts, wooden boards etc.

The problem of maintaining a desirable tree cover and at the same time meeting these requirements needs to be overcome by various strategies like;

i) Afforestation programmes leading to planting of trees in large tracts of unused land, compounds of buildings, roadsides, bunds of tanks, grazing lands, betta lands, community lands etc.;

ii) Energy conservation strategies and

iii) Use of other alternate sources like biogas for cooking, solar energy for water heating etc.

These three aspects will be discussed later.

We will now look at firewood consumption in urban areas based on studies conducted for Bangalore, Tumkur, Mandya and Hassan.

Table 8: Estimated annual requirements of firewood by some industries in Karnataka

Sl.No.	Industry	Estimate (tons/year)
1	Tobacco curing	124000
2	Tile manufacture	100000
3	M/s Sandur Manganese and iron ore	20000
4	Tea curing	9000
5	Harihar Polyfibres	66000
6	Sandal oil factory	5000
7	Talaulicar Carbons (Londa)	25000
8	Rubber	1000
9	West Coast Paper Mills	39000
10	Mysore Paper Mills	30000
11	Cremation	500000
12	Urban domestic needs	3352160

Table 9: Forest Produce

Sl.No.	Produce	Removed in 80-81 (lakh tons)
1	Timber	6.2
2	Bamboos	2.5
3	Eucalyptus	1
4	Firewood for industries	2.5
5	Firewood for domestic use	7.0*

* Estimate of consumption for domestic use varies upto a maximum 37 million tons

Firewood Consumption in Urban Areas

Since the availability of LPG is limited and electricity is yet to catch up on popularity, a large number of urban activities - households, hostels, canteens, crematoria, industries, bakeries, road building etc. - consume firewood in large quantities and it is felt that this firewood comes mostly from forests leading to deforestation. A study on firewood use in Bangalore was sponsored by KSCST to get data for the 1980-81 period and analyse it. Some of the findings of this study are;

i) Average quantity of firewood in Bangalore City is 0.44 million tons/year; about 35% of this quantity comes from a distance of 30-40 kms; 50% from forests at distances of 120-150 kms; two small percentages of 6-7% at a distance of 300-400 kms and 8-9% from a distance of 650-900 kms. This means about 10 hectares of forest is cleared everyday;

ii) Transportation of firewood involves energy expenditure - about 114 trucks and 10 railway wagons transport firewood to Bangalore City everyday. This leads to 2.2 million litres/year of diesel consumption;

iii) Most of the supplies (95%) come from private contractors; distribution also is in the hands of commission agents (10%) and retail depots (85%). This aspect should be considered for the success of any control strategies imposed. It may be useful to make concerted efforts towards minimising consumption;

iv) Sectorwise consumption figures are; 78% for households (54% for cooking and water heating; and 24% for water heating only); 5% for dyeing; 4.4% for factories; 3.8% each for hotels and industries; 1.9% for choultries and hostels. Another important aspect is that 82% of domestic consumption goes to persons with income less than Rs. 200/- per month. Coupled with the fact that their budgets are crippled by energy expenditure, it is desirable to go on in for popularising improved efficiency choolas;

v) Interestingly, 53% of firewood goes for water-heating and 42% for cooking. Hence inexpensive, pillow type solar water heaters can become very popular for households and reliable, trouble free, good solar water heater systems for hostels, hotels, canteens, etc.

Similar studies have also been conducted for Tumkur, Hassan, and Mandya towns by the Engineering colleges under KSCST's programmes. Their studies substantiate the above conclusions (**Table 10**).

Charcoal, a derivative of firewood, is also used as an energy source. The estimate of charcoal used per day in Bangalore is 142 tons, coming from places at distances of 70,180,220 and 250 kms from Bangalore; 19 trucks transport it to Bangalore everyday. Households, hotels and industries use 70.4%, 13.1% and 6.7% of total charcoal used. 58% of charcoal is used for cooking and 32% for water heating. Hence solutions like improved choolas, inexpensive solar water heaters, energy forests around Bangalore City, proposed for the firewood problem, apply equally well for the charcoal problem.

Table 10

A) Quantities of Firewood Supplied

	Hassan t/m	%	Tumkur t/m	%	Mandya t/m	Bangalore
Forest Department	65	3	-	-	-	5%
Private contractors	2066.2	97	2070	100	3660	95%

B) Enduse Analysis

	Hassan	Tumkur	Mandya	Bangalore
Cooking	75.4%	64.9%	87.7%*	54%*
Water Heating	23.6%	15.9%	9.4%	24%
Industries	1%	19.2%	2.9%	22%

(* includes water heating also)

Renewable Energy Sources

Energy sources that are generated every year - like solar energy, hydro, wind etc. - are called renewable energy sources. Since this energy is available every year except for marginal changes, any good energy policy should be designed so as to meet all energy requirements by means of renewable sources and use non renewable sources like oil, coal etc., only when it is not possible to meet requirements by renewable sources and energy conservation methods.

Potential :

Normally energy falling on earth from sun is quite large so that theoretically it is possible to meet our needs from the annual energy derived from solar insolation. The potential of energy available in the State of Karnataka has been estimated by many persons.

Agrowastes provide an important energy source to rural poor in addition to other uses like fodder, manure etc. **Table 11** gives a list of various agricultural crop residues in Karnataka as estimated for the year 1979-80. From this, we can see that about 54 billion thermal units of energy can be generated (which is more than twice our annual energy consumption); but only 20 billion units will be available for energy use - the remaining having other competing uses.

Wind energy potential has been estimated by Prof. R. Narasimha as about 40 billion units assuming an efficiency of 10% and available land area for installation of wind mills to be 0.4% of the unforested area. Similarly estimates of biogas energy have been computed to be 12.290 billion units. In addition to major hydroelectric projects, estimates of energy potential in canals for micro and mini plants has been estimated by K.P.C. A maximum power estimate is around

840 MW giving an equivalent energy of about 3.2 billion units. Microhydel potential on streams has not been surveyed so far. The Centre for Ecological Sciences is conducting a survey on this. Details on some of the identified streams as well as canals are given in **Table 12.** Similarly major hydroelectric potentials are identified in **Table 13.**

Solar energy can also be directly used by installation of solar water heaters (for heating bath water and for pre-heating water for boilers), solar cookers, solar driers, solar kilns and solar furnaces at end use points and by conversion of solar energy into electrical energy either by direct photovoltaic conversion process or by solar thermal route.

Table 14 summarises estimates of the potentials of various renewable energy sources in our State. From the table , we can see that it is possible to switch to renewable energy sources for various applications thereby reducing our dependence on oil and coal.

Table 11: Agricultural Residues in Karnataka (1979-80)

Sl. No.	Crop	Waste in lakh tons				Energy in m. units that can be produced		Other uses
		Husk	Stalk	Other uses	Energy usage	Used for burning	Other uses	
1	Paddy	10.00	33.40	33.40	10.00	3,489	11,653	Fodder
2	Jowar	-	20.00	20.00	-	-	8,141	-do-
3	Bajra	-	2.50	-	2.50	-	1,018	-do-
4	Maize	4.50	9.00	9.00	4.50	1,832	3,663	-do-
5	Ragi	-	28.00	28.00	-	-	9,769	-do-
6	Wheat	-	1.25	1.25	-	-	509	-do-
7	Minor millets	-	1.00	-	1.00	349	-	-do-
8	Bengal gram	-	0.45	-	0.45	52	-	-do-
9	Tur	-	5.00	-	5.00	1,745	-	-
10	Horse gram	0.90	-	0.90	-	-	105	Fodder
11	Black gram	0.07	-	0.07	-	-	8	-do-
12	Green gram	0.13	-	0.13	-	-	15	-do-
13	Avare	-	0.06	0.06	-	-	7	-do-
14	Other pulses	-	0.06	0.06	-	-	21	-do-
15	Sugarcane	-	2.95	-	2.95	1,201	-	
16	Ground nut	2.20	-	-	2.20	896	-	-
17	Sesamum	-	1.10	-	1.10	384	-	-
18	Sunflower	-	0.46	-	0.46	160	-	-
19	Castor	-	0.30	-	0.30	105	-	-
20	Cotton	-	25.00	-	25.00	8,723	-	-
	Total	16.99	131.18	92.87	55.90	20,071	33,892	

(Total energy available = 54 billion units (thermal)

Table 12: Micro Hydroelectric Plants

Some identified sites

Sl.No.	Source	Flow (cusecs)	Head	Power
1	Malebennur branch canal of Bhadra Reservoir Right Bank canal (27-27.5 miles)	Max. 100 Min. 52	9.85'	80kw 40kw
2	-do- (27.5 - 28 miles)	Max. 68 Min. 10	17.10'	92.5 kw 13.7 kw
3	-do- (28 - 29.5 miles)	Max. 45 Min. 10	26.9'	21.6 kw
4	Tungabhadra left Avg bank canal	350	12.50'	350.0 kw
5	Streams Bhairumbe, UK District		10.00'	
6	Kalave 1		7.00'	
7	Kalave 2		7.00'	
8	Kalave 3		15.00'	
9	Kalave 4		10.00'	
10	Kappremane		6.00'	
11	Vanalli		10.00'	
12	Vanalli (4 numbers)		30.00'	
13	Vanalli		15.00'	
14	Vanalli		120.00'	
15	Vanalli (2 numbers)		150.00'	
16	Vanalli (2 numbers)		200.00'	

Table 13: Hydroelectric Power Potential

Sl.No.		Capacity (MW)	Energy (mkwh)
1	Upper Krishna Project	870	2975
2	i) K.R.Sagar Dam	40	
	ii) Kabini	32	82
	iii) Shivasamudram - Hoganekal (Cauvery Valley)	890	3500
3	Tungabhadra left bank canal		
	- Sivapur	32	
	- Mallapur	10	
4	Ghataprabha Dam	32	130
5	Netravathi river	228	955
6	Varahi	239	1100
7	Chakra		500
8	Bedthi	240	1040
9	Kalinadi II Stage	110	578
10	Sharavati Tail Race	240	895
11	Bedthi - Sonda II Stage	210	1100
12	Mahadayi	140	685
13	Barapole	180	823

Table 14: Potential of Renewable Energy Resources in Karnata

Sl.No.	Source	Potential/year (million kwhrs)
1	Biogas (animals)	11790
2	Biogas (sewage)	500
3	Agricultural Residues	20071
4	Wind (covering only .4% of unforested area)	40000
5	Microhydel on canals	800-3200
6	Microhydel on streams	1500-2500
7	Major Hydro Projects approx	14500
8	Firewood (renewable)	5000
9	Solar	

Present energy consumption(approx.) 35000

Technologies :

One of the main impediments in large scale use of renewable energy sources is the non availability of inexpensive, reliable, simple, locally maintainable and efficient technologies for energy conversion. Many activities are in progress for developing acceptable technologies in the State. Some of them are listed below.

Biogas Plants:

Cowdung based gobar gas plants were introduced in 50's and their growth rate is very slow. Biogas plants have many advantages the Nitrogen content in the slurry of a biogas plant/kg of dung put in is three times the Nitrogen got per kg. of dung by normal composting practices; the 60-70% methane gas is a useful by product which can be used to meet the rural energy requirements for cooking, lighting, water lifting, transportation etc; because of a closed system, hygiene in the surrounding areas improves considerably - there will be lesser number of flies in the neighbourhood; the waste water is a good source to produce algae like azoles or BGA a good nutrient for paddy; installation of a decentralised source of Energy, might create infrastructure for local industrial development.

Because of these multiple advantages affecting directly the quality of rural life, popularisation of biogas plants has been identified as an important item in the development plans of Government. The reasons for slow growth rate of biogas plants in India as compared to that of China are many - costlier construction costs (capital costs); uneven distribution of cattle; total absence of institutional structures to build biogas plants and more important to maintain them (one of the important links in fast diffusion of cycles transistors technology is availability of repair shops in villages or neighbouring small towns; this is totally absent in the case of biogas plants); social reasons like unwillingness to accept gas from cowdung; poor designs and operating systems leading to poor or no gas yields and problems of restarting; minimal training/extention facilities, etc. In order to increase growth rate, action on many fronts - technology, training, financial and institutional assistance - are being taken up and coordinated by a biogas directorate in the State Government.

Karnataka is quite fortunate in many infrastructural aspects like;

i) Biogas plants have been accepted by people and plants, both household ones and bigger ones, have been in operation for a number of years;

ii) KVIB has employed technicians in each taluk to handle biogas projects;

iii) A number of new designs have been developed in Karnataka - like ASTRA optimised design, University of Agricultural Sciences Bhagyalaxmi design, private farmer's design Amar and Raithabandu plants;

iv) Many organisations have taken up propagation on a turnkey basis despite many odds.

The State Government's enthusiasm can be seen from the fact that whereas until 1980 the number of biogas plants was about 8024, it decided to build 10,000 plants in one year 1982-83. Out of this target, nearly 7413 plants have been built through proper coordination and use of multiple approaches. The District Rural Development Societies and the Agriculture Department of the State Government are playing an important role in the diffusion process.

Regarding the Research and Development work on plant designs, the following important activities are taking place;

i) Normally, the plant design used has been the conventional KVIC (Khadi and Village Industries Commission) design. This uses a steel movable gas holder; due to corrosion this may need replacement/repairs. The University of Agricultural Sciences, Bangalore has designed a fixed drive model masonry/ concrete construction. This is considered to cost less than a KVIC model of corresponding capacity. The UAS through its extension services did a commendable job of installing a large number of plants in many places. The feed back information obtained was used in removing bugs in the design. Currently, the UAS is actively involved in training and installing biogas plants in the State. This plant still has some bugs especially in the Malnad region. To overcome these problems, two new designs have been evolved by two private farmers in Sirsi and Sagar taluks. Details of these plants are given later.

ii) ASTRA, IISc realised early that biogas is a potential and important decentralised and environmentally sound energy source in rural areas. With this aspect, it started many research programmes. The first programme was to build an instrumented biogas plant of about 6.7 cum/day capacity (gas). A side pit was dug to facilitate instrumentation. Samples taken at different heights showed that the minimum height of digester needed for anaerobicity and optimal gas production is around 5'. Secondly temperature probes were also used to measure temperature at various points. The plant went into operation in 1979 and continues to be operative. Yield analysis, mass flow analysis, input/output/gas analysis were conducted to study ingradients and other aspects.

Based on the above experimentation, an optimal design has been proposed reducing retention time and optimising dimensions for minimising capital and running costs. This design was used in the construction of the next ASTRA plant.

Another study modelled the plant for thermal studies in order to study the temperature profile within the plant. It is known that for optimum yields of gas, the plant temperature should be around 35 C. Hence it is desirable to minimise heat losses from the plant and also try to improve the temperature inside the plant by other simpler means. A modification to the existing plant was proposed to include a solar water heating system on top of the gar holder and charge cowdung with the hot water obtained from the solar water heater. This improved the performance of the plant and yield of gas increased from 38.4 cm^3/g of fresh dung to 42.8 cm^3/g (10.9%).

In addition, the solar water heater system supplied distilled water also (1.7 litres/day). A separate collector inside was provided to collect distilled water.

Raitha Bandhu Biogas Plant

Some of the major complaints about biogas plants in Malnad areas have been;

i) the flooding of plants by the intense rains during monsoons and

ii) non availability of gas during winter months.

This biogas plant called Raitha Bandhu has been developed by a farmer in Sagar Taluk (Shimoga District) based on practical experiences and experimentations in the field. The basic features of the plant are;

i) The digester is constructed with stone slabs;

ii) The gas holder consists of a number of mudpots kept on stone rails and covered by mud and a small percent of cement;

iii) All round trench has been provided to drain rain water;

iv) The outlet is provided at a level higher than normal so as to increase pressure inside slightly;

v) The sludge mixture on the output side has lower temperature, because of lesser reactions taking place at that end; an innovative and simple feedback mechanism has been introduced to increase the temperature. A small part of fresh dung is directly loaded into this part also by means of a separate, small pipe connected to this section. The main dung comes from the inlet pipe at the other section;

vi) Normally both inlet and outlet pipes get clogged due to various reasons; in order to clean the pipes, a plastic rope has been permanently connected through in a circular fashion; by pulling the rope, particles that clog the inlet can be pushed in thereby allowing free flow of dung.

These innovative, simple and useful features have made this biogas plant an attractive model. Its other advantages are;

i) Reduced consumption of cement (a necessity due to scarcity of cement);

ii) Low cost of construction;

iii) Ease of repair by local people (steel drum gas holder in conventional KVIC design has to be transported to an urban area even for minor repairs entailing expense and inconvenience.

Since this model was not approved by Government of India, the State Department of Science and Technology agreed to support this plant after being convinced of the feasibility and technical soundness of the design. The Department approved subsidies for construction of about 50 plants. It is now more than a year since these plants have been put up. The farmers have taken to this plant enthusiastically. It is also reported that the plants are working successfully.

Amara Gobbara Anila Yantra

In order to reduce consumption of cement by using local materials and thereby reduce the cost of construction, a farmer in Sirsi taluk has designed and constructed a stone slab based biogas plant called Amara Gobbara biogas plant. The construction of the digester and dome is by stone slabs. A thick stone rail support is given at joints between slabs so as to reduce gas leakage. This plant can be constructed above ground level to avoid flooding during rains. A registered

Society was founded in Sirsi to take up popularisation of this plant. It put up a few plants in

Sirsi. Currently, the group is trying to improve the construction to avoid leakage.

Community Biogas Plants:

Since cattle distribution amongst rural population is highly uneven (80% of cattle owned by 20% of the people), biogas can reach a large number of people by means of community systems. Many experiments on community biogas plants have not succeeded because of social problems. A successful system has been put up by ASTRA at Pura village in Kunigal taluk under a project funded by KSCST.

The project has two 750 cft/day biogas plants connected by a 1500m long network of PVC pipes to specially fabricated low cost burners in all the houses. The system is in operation from June 1, 1982. Cooperation from villagers is very good.

The village is a small and homogenous one with good social stability. Hence the biogas plants were accepted easily by local people. In addition to proving the success of a community based system, the project also had a few interesting findings;

i) Average yield of cowdung/cattle/day is around 1.86 kgs and not 7.35 as assumed;

ii) Gas consumption also is higher 0.212 m^3/person/day as against 0.072 assumed;

iii) Population increased by 35% during the period of experimentation;

iv) Diluted slurry output is not accepted by local people and so it is being filtered by a sand filteration system.

Wind Mills:

Wind energy investigations are going on at Central Power Research Institute, National Aeronautical Laboratory and Indian Institute of Science; various types of wind mills like inexpensive, local materials based savonius rotor ORP - Tool etc. have been designed, fabricated and field tested by these organisations. The IISc design, a novel one, uses local materials. The water pump is designed with the help of a scooter tyre. A wind mill based on this design costs around Rs. 3000/- and has been working for more than three years in the extension centre of ASTRA at Ungra village.

The NAL - WPZ design is a horizontal axis American metal vane type wind mill with a plunger pump. It has a 4.9m rotor carrying 12 cambered steel vanes. A practical version delivered 0.61 lts of water against a total lift of 7.6m at a wind speed of 2.8 m/s. The initial cost is about Rs. 16,000/- (Rs. 850/m^2) efficiency being 18%. NAL has also developed another multipurpose wind mill for wind speeds of 3-5 m/s at a cost of around Rs. 350/m^2. Currently they are working on large power wind mills.

The IISc - ASTRA savonius wind mill is a vertical axis sail type one with the rotor supported on two frames. One of the interesting design features is the provision of a twisted wire joint which automatically allows sails to open up a higher wind velocities. The efficiency is around 11% with a discharge of 0.22 l/s for a lift of 5.4m when wind speed is 2.5 m/s. This design is optimised for cost (Rs. 375/m^2) and low wind speed operation.

Wind potential estimates are being collected by IISc, NAL and KSCST (through its wind stations in Engineering Colleges) so that reliable data on wind energy will be available for every spatial location and every day.

Solar Devices:

Solar devices like cookers, water heaters etc. have reached the stage of commercial manufacture. Many industries have taken up manufacture of solar devices for more than three years and the State and Central Governments encourage use of such devices through subsides, tax rebates and loans.

An interesting large scale experiment is the design of solar water heating system for the Government Silk Filature Factory at Kanakapura. The system with 72 solar collectors is supposed to heat about 6000 - 8000 litres of water/day. The system became operational in 1982. Because of manufacturing defects, a set of collectors started leaking. This prompted Prof. C.R. Prasad, coordinator of this project to investigate the causes for corrosion failures. He has come out with a new manufacturing method of pressing two M. S. sheets by crimping and riveting after proper treatments so that the life of a collector is longer. The manufacture of collectors based on this design is available in the market.

Affirmative Measures

In this section, we look at policy measures for afforestation, rural energy conservation, hydel and irrigation projects. Afforestation programmes are taken up by the Forest Department, private agencies, city corporations, NSS camps organised by Universities and lastly by people themselves. Even though there is talk about afforestation at a global level, micro level detailed planning is absent and hence the percolation and success rates are very poor. It is essential to develop district level / taluk level guidelines and detailed plans regarding involvement of people. One interesting example is that of subabool plantations. The efforts of the Forest Department did not meet with any success, but when Agriculture and Rural Development officials took up the matter at the grass root level it met with great success. The programme was started in Bijapur District in 1980-81 with focus on Basavan Bagewadi Taluk. Detailed plans were drawn up on seed procurement, nursery raising, mobilisation of farmers etc. Extensive extension work was done by the Agriculture Department. The progress was monitored at every stage very carefully and imaginatively by officials of the district. Hence the success rate was very good. The concept was also accepted by farmers. This programme was extended to the other districts in successive years and it has borne fruit in the drought prone districts of our State. This illustrates the need for grass root level development, an extensive extension service and proper coordination amongst various government agencies.

Afforestation Programmes :

Providing a sustained annual yield of firewood (of about 20-25 million tons) requires a large scale afforestation programme to be continued every year. The Forest Department of the State has taken up a massive afforestation programme of raising energy plantations in an area of 22,500 hectares/year. The area identified comes from degraded forests, C and D lands, community lands, foreshore areas of reservoirs and tanks, contour bunds of fields etc. In addition they are also taking up compensatory plantations to compensate for loss of forest submerged by reservoirs built for hydro projects. Another activity of the Forest Department is to raise nurseries to supply millions of seedlings to people who want to plant them in their lands.

The Agricultural Department is popularising the planting of subabool especially in Maiden districts as a multiple benefit activity - to provide fodder, fuel and revenue during drought years. It has succeeded very well in many districts on the Maiden area through its extension programme. Each year millions of seedlings are planted with a good survival rate - in contours, marginal lands, gardens, near houses, in fields etc.

Two interesting experiments to involve people are also going on in Karnataka with good success. One of them is the Millions of Trees Club at Tumkur encouraging Peoples' Nurseries. The other activity has been taken up by the Centre for Ecological Sciences, IISc to induce farmers to take up afforestation work in a scientific manner so as to optimise survival rate, utilisation and species diversity. About 170 farmers from five taluks of Uttara Kannada District are participating in this programme. They are planting about 25 to 37 species in the betta lands at their cost. The planting schedule, species type etc, are scientifically determined and the farmers are guided at various stages. Also liaison work with forest and other government agencies is undertaken to keep the programme going at a good pace. During the second year it was felt desirable to take up nursery development also. About six schools participated in this programme. This, in addition to ensuring supply of seedlings, also instilled in the minds of young students the knowledge of raising nurseries and an awareness for ecology. Currently the Centre has started research nurseries to develop seedlings of a number of species so that the biological/species diversity can be increased.

Integrated Rural Energy Programme :

The State Government wanted to study and analyse the problem of rural energy needs and to attempt solutions in a few villages. Normally, new developments take a long time to percolate to different rural areas; even this slow growth is diffused in many places. Hence it is difficult to study the impact of new developments, to study the societal behaviour with respect to these technologies and to hasten development of improved technologies by identifying diffusion mechanisms. In order to find solutions to these problems the integrated Rural Energy Programme was taken up in 1981. It was also felt desirable to have separate rural energy plans so as to reduce disparities in rural and urban energy uses and in use of different energy sources - both commercial and non-commercial. Activities pertaining to this programme are sequenced in **Table 15.**

Table 15: Per capita domestic energy consumption/year (1980-81)

Source of energy	Bangalore North Taluk - Byatarayana pura	Bangalore North Herohally	Dakshina Bale Kudru	Kannada Kodi
Firewood	312 (67.1)	400 (81.6)	292 (78.9)	252 (83.1)
Agro-wastes	*		14 (3.8)	14 (4.6)
Cow-dung	6 (1.3)		3 (0.8)	3 (1.0)
Biogas	2 (0.4)		6 (1.6)	2 (0.7)
Total (N.C.)	320 (68.8)	400 (81.6)	315 (85.1)	271 (89.4)
Electricity	26 (5.6)	8 (1.6)	19 (5.2)	3 (1.0)
Kerosene	119 (25.6)	82 (16.8)	36 (9.7)	29 (9.6)
Total (C)	145 (31.2)	90 (18.4)	55 (14.9)	32 (10.6)
Total	465	490	370	303

1. Case studies. A pilot survey was conducted in four villages - two from Bangalore North Taluk and two from Udupi taluk (Dakshina Kannada District). Firewood was found to be dominant source of energy - 67 to 83% of per capita consumption is firewood; per capita consumption varied from 303 kg to 490 kg. The cost/person for energy varied from Rs. 60/- to Rs.835/-. The higher cost is due to large industrial consumption. Another interesting observation was low efficiency of end use devices, thereby reducing the usable per capita consumption considerably (Table 15). Another survey was conducted in five clusters (29 villages) in July-August 1982. This survey reveals that expenditure on energy as a proportion of income varies from 7% to 22%. Total annual domestic consumptions are 4100 tons of firewood, 1.72 lakh unit of electricity and 1.3 lakh litres of kerosene.

2. Identification of villages where the programme should be initiated.

3. Survey of villages on social factors and conditions energy consumption, availability of local resources.

4. Planning of rural energy projects which employ local, renewable resources, acceptable technologies and benefit a larger percentage of population. Projects can be individual beneficiary oriented, demonstration type, community type etc.

5. Monitoring of these projects.

The physical achievements under this scheme upto 31-3-84 are;

i) Solar cookers; for demonstration 30 - distributed with subsidy 5;

ii) Solar water heaters - distributed with subsidy 10;

iii) Choolas; for demonstration 509 - distributed with subsidy 25;

iv) Improved kerosene stoves;- distributed with subsidy 1987;

v) Energy plantation; trees planted (over an area of 40 acres) - 1,93,600.

Hydroelectric and Irrigation Projects and Environment :

Long ago, when forests were considered as a source of supply of firewood and a few other produce, many giant hydroelectric projects came up supplying electrical energy to industries. Electrical energy (or commercial energy) was considered synonymous to development. The concept of ecology and the need for maintenance of forest areas were not understood. Hence power engineers designed major hydel projects with the objective of minimising capital cost and maximising the tapping of potential energy in water. That is, they wanted to tap every cc of water and every cm of head and if possible, put the whole quantity of water in one dam via tunnels etc. In their cost calculations, a nominal amount is allotted as compensation to the forests to be submerged and people to be displaced. The firewood energy that is available every year (by growth of forests/year) is not accounted for. Similarly, grass and other forest produce etc. are not costed.

With the advent of large number of hydroelectric projects and with other competitive uses for land and forest produce, the available forest is dwindling fast and it is becoming imperative to save the remaining forest areas. One of the first excercises to study in detail the effect of a project on the environment and to develop an economic model imbedding ecological costs is the study of the Bedthi Hydroelectric Project.

The project, one of the seven identified in the district of Uttara Kannada, is expected to produce 210 MW submerging 30,610 acres of land and 22 villages. The revised plans envisage a dam with FRL at 1540 ft and a submersion area of 6065 ha. The Karnataka Power Corporation has taken note of the points made at the Seminar held at Sirsi (Ed). Subsequent stages and additional project on Bedthi and Aghanashini rivers have also been identified. This project was looked at from economic, ecological and other angles by scientists from Centre for Ecological Sciences, IISc and other places like IIM (Bangalore), Madurai, Dharwar, Pondicherry, ISI (calcutta), Pune as well as by reputed ecologists and local farming and forestry experts. A seminar was held at Sirsi and 17 papers were presented in it. Some of the main points brought out are;

i) If realistic cost for forest revenue, agricultural yields, grass and firewood are included in the calculations, benefit to cost ratio comes down to 0.847 from 1.5. This means that economically the project is not a viable one and needs to be reconsidered;

ii) Based on the costs, the cost of generation of electrical energy per unit works out to 25 paise;

iii) If energy storage aspect is compared, the project will produce 1 MW for 50 hectares, whereas the forest can generate biomass with energy equivalent for 1 MW of power with 25.50 hectares. Hence this clearly illustrates that energy lost is more than the energy gained;

iv) Alternatives like micro, mini and other hydro plants had not been considered;

v) Alternative capacity and plant designs with minimal forest area submergence had not been analysed;

vi) From the ecological point of view, the area is biologically very rich; more than 89 types of birds were identified in the area to be submerged;

vii) Energy planning activities should include energy conservation measures also.

When the above factors, clearly indicating economic infeasibility of the project, were brought to the attention of the State Government, the government stayed the execution of this project and appointed an Expert Committee. The Committee is at present working on the data provided to them from various sources and is expected to submit its report shortly.

This is an interesting example where the Government is agreeable to listen to the views of the people and to take a decision after considering the pros and cons of the project. This approach of the Government is worthy of emulation for other projects also. It is to be noted that the Government agreed to take a relook after the project was cleared by the Central Government and the State Government was criticised by the Centre at a meeting of Power Ministers for not taking up this project. Considering the above facts in conjunction with the electrical energy shortage situation, the State Government's approach is commendable.

Energy Conservation Strategies

As has been emphasised again and again, only a small fraction (5-10%) of energy put in is converted into usable form. In order to be prudent with the use of environmental resources, it is essential to increase the usable output while maintaining the same quantum of input i.e. - to increase efficiencies of end use devices, to reduce losses in transport and to minimise the number of stages of energy conversion. These are known as energy conservation methods, a few of them are discussed below.

Wood Burning Stoves :

The single most important device that calls for our immediate attention is the wood burning stove-choola - used for cooking in most of our houses. Since a large amount of firewood takes the route of cooking, it is imperative to look at this device first. Efficiencies of our choolas vary from 5-15%. Any further increase will help in reducing the firewood consumption and other associated problems. Three designs have been developed claiming to have better efficiencies. Two of them - Astra ole developed at IISc and Priagni developed at CPRI - are discussed in this report.

Astra Ole:

One of the important activities taken up by the Centre for Application of Science and Technology for Rural Areas, IISc has been in the field of cooking. As stated elsewhere, ASTRA has been looking at the rural cooking problem and trying to identify solutions - to improve the efficiency of cooking stoves, to use biogas for cooking etc.

A survey and experimentation by Geller showed that the efficiency of wood stoves is in the range of 10-15%. He also identified some areas of heat losses. Prompted by the large scale consumption of firewood in cooking and its scarcity. Professor Kumar and his group started the investigations on wood stoves. They started with the following assumptions;

i) Any new design should be based on the geometry of existing choolas;

ii) The stove should be made mostly from locally available materials by local people with minimum additional skills and with minimum training;

iii) The stove should accept local fuels - twigs, bark, husk, bagasse, stems etc;

iv) It should not cost more and it should not put any constraint on existing practices.

With the above conditions, the objectives chosen are;

i) ease of cooking;

(ii) minimisation of smoke;

iii) ease of starting and stopping the fire;

iv) maximisation of efficiency.

The stove designed is a three pan one, mostly made of mud - looking similar in appearance to existing stoves. There is an enclosed fuel box with a cover; the grate, and parts for primary air into the choolas; flow of fuel gas is controlled by the ducts between pans (1 and 2, 2 and 3) and chimney. The pan openings can be adjusted during construction so as to fit snugly the vessels used normally in the house.

To achieve the given objectives the following were modified or incorporated; (a) area of primary air inlet hole; (b) distances (heights) of combustion chambers; (c) flow diffuser for third pan; (d) orientation of fuel box; (e) materials used for construction and insulation of inner wall-mud and rice husk; (f) coating the grate with simple catalysts to facilitate cracking.

A number of models have been constructed and tested before arriving at an optimal model, ready for diffusion amongst villages. The production model named Astra ole was taken up for field tests - in the high rainfall Uttara Kannada district and the low rainfall Tumkur district. Results were encouraging. ASTRA put up about 100 stoves in Ungra and neighbouring villages. Field efficiencies were varied from 30% to 43% with a mean of 35.5%. This is nearly double that of a traditional stove (mean is 13.3%). Similarly, specific fuel consumption varied from 100 to 250 grams with a mean of 168 grams. The comparable figures for traditional stoves are 251 to 450 grams with a mean of 351 grams. Hence it is clearly shown that the people can save definitely half of the firewood used previously.

Similarly, Astra ole was constructed in large numbers by the Centre for Ecological Sciences, IISc., in Uttara Kannada district - both in the hilly Sirsi taluk and in the Coastal taluk of Kumta. Field studies of CES show similar results.

In addition it has also been found from field studies that the Astra ole is smokeless (so cooking is a pleasent activity for village women); it cooks faster - 40% lesser time for cooking than that of conventional ones, as flame is steady and continuous, no blowing of air is required - improves health of women doing cooking activities; various types of fuels can be used with ease.

Because of these proven advantages, the State Department of Science and Technology stepped in to take up the diffusion work. It gave primary importance to this activity and entrusted the district rural development societies the task of constructing a large number of Astra oles in all districts. As the first activity in diffusion is to generate skilled persons the Karnataka State

Council for Science and Technology (KSCST) has taken up the task of arranging training programmes. They have selected a number of persons as trainers. These were given comprehensive training. These trainers now conduct programmes in various places in all districts. Hence in a short while, it is expected to produce a large number of trained persons dispersed all over the State.

The Department of Sciences and Technology is coordinating the construction work. Targets have been set for each taluk/ district and subsidies under various programmes are also being distributed promptly to persons putting up Astra oles in their houses.

Priagni:

This is an improved wood burning stove designed by the Rural Energy Laboratory, Central Power Research Institute. It has been designed to improve efficiency, to create a steady and continuous flame for burning and to reduce smoke. It is an iron single pot stove modification of existing commercially available ones. The factors considered in design improvement are;

i) Proper height of the stove (combustion chamber) - low height means incomplete combustion and high height means more losses of atmosphere;

ii) Optimal diameter - to reduce smoke;

iii) Height of vessel mounts;

iv) Fuel feed opening - to reduce exposure of wood flames (thereby reducing radiation loss);

v) Grate design.

After optimisation of these parameters, two components have been added. The first is a set of two slotted plates - one at the top and the other at the bottom. The top plate creates turbulance, imparts velocity to the gasses and acts as a partial enclosure to combustion chamber. The bottom plate acts as an air inlet providing for symmetric air flow - helps in continuous burning of the fuel.

The second addition is a clip - on aluminium lining to the inner wall. The thin air gap between the stoves wall and the lining reduces heat flow to the walls, thereby increasing efficiency.

The stove was designed in 3-4 different sizes to cater to different family sizes. The costs vary from Rs. 35/- to Rs. 78/-. Because of its resemblance to existing stoves, it is easier to operate and so acceptability particularly amongst urban households is high. The State Department of Science and Technology took up the popularisation of this stove. It entrusted the manufacture of 750 stoves of this type to Government Workshop, Madikere. These stoves were distributed for field trials to a large number of persons. Two trials in an NSS Camp showed the advantages of this stove.

A private company has taken up the commercial manufacture of this stove; it has so far fabricated 1420 stoves and has orders for more than 15,000 stoves on hand. This stove is catering primarily to cooking needs of community kitchens, schools, hostels etc.

Building construction is an energy intensive activity. A large number of buildings are constructed with bricks. Brick is manufactured either in kilns or traditional clamps using firewood and the efficiency is very poor. A number of studies by Engineering Colleges and the National Productivity Council have been done to find out energy consumption in brick manufacture. As seen from **Table 16** the consumption varies from 167 kg to 700 kg (the kilns use coal and clamps mostly firewood). This study definitely shows that brick industry uses an estimated million tons of firewood per year. Hence it is essential to find out methods of reducing the energy used in this industry.

Table 16: Utilisation Energy in brick manufacture

Sl. No.	Name	Fuel Requirement	kg/1000 bricks
1	M/s Lingappa	Clamps	584
2	M/s Moinuddin	Clamps	700
3	M/s Yousuf Khan	Clamps	500
4	M/s Chulbule	Clamps	700
5	M/s Manik Singh	Clamps	468
6	M/s Ambika Prasad	Clamps	700
7	M/s Rajashaker	Clamps	468
8	M/s Moni Irani	Clamps	500
9	M/s Chakkiseth	Clamps	700
10	M/s Chamundeswari	Kiln	167
11	M/s Chennakeshava	Kiln	167
12	M/s Anjaneya .	Kiln	167

One solution to this problem is use of unburnt compacted dense soil blocks in place of burnt bricks. Such blocks have been tested and it has shown that their strength is equal to that of burnt blocks for right composition of clay in soil. Further improvements are possible if a small percentage (2-5%) is added to the soil. ASTRA, IISc. has used this principle and constructed a number of buildings. The compression is done in a manually operated machine. ASTRA has designed a simple inexpensive block making machine called ASTRAM. Similar machines have been developed by National Institute of Engineering, Mysore and other Engineering Colleges as part of the KSCST's programmes.

The technology has many advantages;

i) Normally a poor person, who has a mud house, would like to construct a brick house; with this machine, he can compact soil and construct a house which has a good appearance, has the same strength as a conventional brick house and is inexpensive;

ii) Energy consumption - especially firewood - is considerably reduced;

iii) Compaction of soil to make blocks means employment. This generates employment for people in rural areas. Hence this idea has become popular. Currently a large number of persons are using compressed soil blocks to construct houses, schools etc in Bangalore, Mysore and other places.

Another alternative to the problem of wall construction is being studied at S.J.C.E., Mysore - rammed wall construction. This constructs a wall in situ by ramming mud in panelled formers.

The panel can be removed later. Such a construction increases strength, reduces the number of joints, uses locally available resource, is inexpensive, uses a simple technology needing minimum skills and is one of the energy saving technologies.

Another area where there is a large scale use of energy is in roofing. Mangalore tiles used for many houses for roofs, needs an energy input of nearly 0.5 kg/tile of firewood (or about 0.33 kg/tile of coal). Some projects are under progress to devise manually operated devices for some aspects of tile making - like pug making extrusion etc. Alternate panelled roof designs - with 2' x 2' steel reinforced tile panels - are being experimented with to be an economical alternative to sloping concrete roofs. This design reduces consumption of cement, another energy intensive material. Already a few buildings - both public institutional and private houses - have adopted this design which gives an architecturally aesthetic, inexpensive and a sloping functional roof to a building. S.J.C.E., Mysore is also working on the design of similar panels for roofs.

Another way of energy conservation in brick and tile industries is to study the process of burning and find out ways of improving efficiency thereby reducing firewood consumption. The State Department of Science and Technology identified this problem and funded a project to National Productivity Council. Their findings are;

i) Use of an improved high draught kiln in brick production will result in 50% savings of fuel;

ii) If the waste heat is used to dry green ones or for preheating in another chamber, about 15-20% of fuel can be saved;

iii) Good housekeeping practices like regular measurements of temparatures, control of dampers, cleaning of ash pits etc can save upto 5% of fuel usage and

iv) Increase of fire travel distance can reduce fuel consumption.

The study has calculated thermal efficiencies for these kilns; (for intermittent kilns=13.7%; continuous kilns=34.2%) specific fuel consumption varies from 300 kg to 1000 kg per 1000 tiles. This shows that as cost of energy is about 48% of production cost and the fuel mostly fire-wood is used inefficiently, the large number of tile and brick manufactures in Karnataka (more than 140) should be educated and encouraged to adopt better practices and go in for continuous kilns.

Energy Conservation in Tobacco Curing :

Not only is tobacco in Karnataka grown in areas where once there was a good forest, but also 1.2 lakh tons of firewood are needed every year to cure tobacco leaves. This clearly shows the impact of tobacoo on forests. The State Department of Science and Technology funded a project to National Productivity Council for the study of tobacco curing. The study found that the specific fuel consumption varies from 1.63 to 4 kg of fuel/kg of cured leaf and suggested the following measures for energy conservation;

i) I.L.T.D. (of I.T.C.) uses a heating jacket costing Rs. 600/- only. Use of this reduces consumption of fuel by 10%. Even though this is popular with farmers in A.P., the farmers in

Karnataka are not using this. It is essential to popularise this jacket which is simple to fabricate, instal and use;

ii) Proper design of ventillators will reduce fuel use by 20%;

iii) Good housekeeping practices will give a savings of about 5% and

iv) Recirculation of exhaust air (closed system with a fan) will result in a further savings of 5%. Thus we can get 40% reduction (i.e. 48,000 tons of good firewood) by adoption of these simple practices in the barns.

Energy Consumption in Water Lifting :

A major activity in Karnataka, is to increase irrigated area under cultivation. The farmers are encouraged to set up pump sets to lift water mostly from wells. The percentage of electrical energy consumed by I.P sets is increasing; a large number of people manufacture such sets resulting in some non-standard sets also; farmers buy normally I.P. sets with higher capacities so as to avoid burning of motors; there is no proper advice mechanism to help farmers in selection and maintenance. Hence, it is desirable to see how the energy is consumed. A number of student projects sponsored by the State Council of Science and Technology studied this problem. The efficiencies varied from 42.3% to 78.1% in one case; from 10% to 69.4% in the second case; 10.3% to 21.8% in a third case. The outputs in most of the cases studied are less than half the rated values, and in some cases, even less than one fourth rated value. These studies indicate that there is a considerable scope for improving the efficiency of such sets.

Since the Electricity Boards, normally, feel that the supply of power and energy to I.P. sets is uneconomical, it is desirable and imperative to look for;

a) Improved efficiency I.P. sets;

b) New concepts in shared I.P. sets;

c) Alternate pumps operated manually or by bullocks and

d) Pumps operated by decentralised, local energy sources like biogas.

A number of student projects in Engineering Colleges have been sponsored to design pumps operated manually or by bullocks. Pumps based on foot/pedal/wheel operations and bellows/piston/diaphragm types have been designed, and fabricated under this programme. Unfortunately, they have not been field tested so far.

A few farmers have started sharing their I.P. sets. Such a situation will improve load factor, reduce maximum load on the power system and thereby reduce cost of lines and other associated equipment, improve efficiency and result in better management and maintainence practices.

Another problem which is being seriously looked at by Electricity Boards is the lowpower factor of I.P. sets. A study by S.I.T., Tumkur, a K.S.C.S.T. sponsored project, reveals that actual power factors of most I.P. sets tested have no relation to the power factors in the name plates. Power factors were in the range of 0.5 to 0.6 whereas desirable values are in the range of 0.85 to 0.95. This increases line losses, reduces voltage levels and introduces operational problems. Hence, an appropriate policy decision on this is desirable taking into account practical constraints.

Energy in Sugar Industry :

Sugar industry is an energy producing industry. The wastes in a sugar mill can be used to produce energy. Normally bagasse is used in the boilers, molasses to produce alcohol and if a distillary is present, its effluents to produce methane gas. A demonstration project in Mysore Sugar Mills, Mandya has been taken up by H.A.L., Bangalore. This project is funded by Department of Nonconventional Sources of Energy (CASE), Department of Science and Technology (Government of Karnataka), Mysugar and HAL. The objective is to run a gas turbine (diesel/alcohol operated) producing 500 kw of electric power which can be used to supply part of electrical energy to the factory; to use waste heat from the turbine to dry bagasse from 50% moisture to 30% moisture; and to run boilers with bagasse as a fuel. The bagasse drier unit has been designed and fabricated within the country and it incorporates many innovative design concepts. The drier has been installed as well as the turbine generator set. Field trials are going on. If methane gas is produced from the distillery's spent wash and used to run the turbine, then the industry will be an energy producer instead of an energy consumer.

Energy Conservation in Jaggery Making :

People in Uttara Kannada District have been using firewood inefficiently to make jaggery. This problem was studied by a group of scientists from IISc and they designed an improved 3 pan stove with an efficiency of about 50%. This improved design was put up first in Unchagi village. It uses bagasse as fuel thereby completely eliminating the use of firewood. The plant has been working for more than three years. Since the people were accustomed to two pan stoves, modified two pan stoves have been constructed in six villages in Kumta and Honnavar taluk by Dr. M.S.Hegde. This popularisation programme was funded by the State Department of Science and Technology. An estimate of Savings in firewood consumption for jaggery making in Uttara Kannada District alone is 30,000 tons/year.

References

'A perspective on demand for energy in India upto 2004', by Advisory Board on Energy, Govt. of India, New Delhi, November 1984.

ASTRA 1982 'Rural energy consumption patterns - a field study', Biomass 2, pp 255-280, 1982.

Bowonder, B. et al, 'Energy use in eight rural communities in India', World Development, Vol. 13, No. 12, pp 1263-1286, 1985.

'Renewable energy in action', Published by Commission for Additional Sources of Energy, Government of India, New Delhi.

Report of Fuel Policy Commmittee, Government of India, New Delhi 1974.

'A review of rural cookstove effeciency and efforts to improve stove performance', in "Energy Resources; Technologies and Systems" Astra Intensive Course, held at Indian Institute of Science, Bangalore, Nov. 1979.

Report of the Energy Survey of India Committee, Government of India, New Delhi 1965.

"An analysis of 1977-79 National Sample Survey on Household Energy Consumption (32nd Round) - Karnataka", Study report, Perspective Planning Division, Planning Department, Govt. of Karnataka, Bangalore, July 1981.

Hall, D.O., Barnard, G.W. and Moss, P.A., 'Biomass for Energy in the Developing Countries', Pergamon Press, Oxford, 1981.

'Cost data for 11 kV and below for REC works during 1981-82', Rural Electricity Corporation Ltd., New Delhi, 1982.

Kalra, G.D., 'Effectiveness of incentives for energy saving devices', National Council of Applied Economic Research, New Delhi, Jan. 1989.

Annual Report 1983-84: Karnataka State Council for Science and Technology, Government of Karnataka, Bangalore, 1984.

'Gobar gas: Why and how', Khadi and Village Industries Commission, Bombay 1982.

Maheswari, R.C., Srivatsava, P.K., Bohra, C.P., 'Energy consumption and resource assessment of village Islamnagar in the district of Bhopal', Central Institute of Agricultural Engineering, Bhopal, India.

Malhotra, K.S. and Lal Chaurasia, P.B., 'A plan for energy management in 110 villages of Silora Block in Rajasthan, India', Energy, Vol. 6, No. 7, pp 591-601, 1981.

Natarajan, I., 'Domestic fuel survey with special reference to kerosene', Volume I, National Council of Applied Economic Research, New Delhi, Feb. 1985.

Natarajan, I., 'Domestic fuel survey with special reference to kerosene, Volume II, National Council of Applied Economic Research, New Delhi, Feb. 1985.

Pal, S.P., 'Contribution of irrigation to agricultural production and productivity', National Council of Applied Economic Research, New Delhi, Feb. 1985.

Ramakumar, R., 'Renewable energy sources and developing countries', Trans. IEEE on Power Apparatus and Systems', Vol. PAS 102, No. 2, pp 502-510, Feb. 1983.

Ravindranath, N.H., et al. 'An Indian village agricultural ecosystem - Case study of Ungra village Part I: Main observations', Biomass, Vol. II, Part 1, pp61-74, Sept. 1981.

Ravindranath, N.H., et al. 'Biomass productivity in monoculture energy plantations', Proc. of ASTRA Seminar, March 1985.

Ravindranath, N.H. and Chanakya, H.N., 'Biomass - based energy system for south Indian village', Biomass, Vol. 9, pp 215-233, 1986.

Reddy, A.K.N. and Krishna Prasad, K., 'Rechnological alternatives and the Indian energy crisis', Economic and Political Weekly, Vol. XII, No. 33-34, pp 1465-1502, 1977.

Reddy, A.K.N., 'An overview of energy in Society', in 'Energy Resources, Technologies and systems', ASTRA Intensive Course held at the Indian Institute of Science, Bangalore, Nov. 1979.

Reddy, A.K.N. and Subramanian, D.K., 'Design of rural energy centres', Proceedinga of the Indian Academy of Sciences, C II, Part 3, pp 395-416, 1979.

Subramanian, D.K., 'Energy consumption patterns', in 'Energy Resources, Technologies and Systems', ASTRA Intensive Course held at the Indian Institute of Science, Nov. 1979.

Subramanian, D.K. and Chetty, K.M., 'Domestic cooking and lighting energy needs of devices for rural areas: Some optimal scenarios', Proc. Seminar on 'Rural Energy Futures - Perspectives for policy Alternatives', Indian Institute of Management, Bangalore, 1983.

Reddy, A.K.N., 'Energy options for the third world' in Southern Perspectives on Rural Energy Crisis', Edited and Published by Mantilus, California, U.S.A., Auguest 1981.

'Report of Working Group on Energy Policy', Government of India, New Delhi 1979.

Renewable Energy Resources in the Developing Countries', Report World Bank, Washington, D.C., Nov. 1980.