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ENERGY SELF SUFFICIENT TALUKAS - A SOLUTION TO NATIONAL ENERGY CRISIS

(A short history of research in taluka energy at NARI is here)

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ABSTRACT

It has been shown that biomass at taluka level has the potential for providing food, fuel, fodder and fertilizer to its inhabitants. It can also provide employment in the process. The study has been done for a Taluka (an administrative block of 90-100 contiguous villages) in western Maharashtra where it has been shown that all its energy needs in 2000 AD can be met by proper use of agricultural residues and energy plantations via agro-energy systems. The supply options include : a) ethanol production from sweet sorghum and molasses produced by existing sugar factories; b) pyrolysis oil production from agricultural residues; c) electricity production from energy plantations and agricultural residues. These energies can replace petrol, LPG, diesel, kerosene and electricity. Economic analysis for supply options shows that they can become economically viable only if electricity pricing for rural areas is done properly. It is also shown that biomass energy-based supply options have the capacity of providing employment to about 30,000 people in the Taluka. Thus energy self-sufficient talukas may provide an alternative development model to megacity-based centralized energy one.

INTRODUCTION

Last year India spent about Rs. 21,000 crores in importing petroleum products. Though the foreign exchange reserves of the country are good, still this resulted in substantial outflow of precious foreign exchange. Besides there is also a tremendous shortfall in electricity generation. For the eighth 5-year plan, about 30,000 MW additional electricity generation is to be added. This will require about Rs. 120,000 crores, which the government does not possess. This has resulted in opening up of power sector to foreign investment and there are estimates by the Ministry of Energy that about Rs. 75,000 crores will be invested by foreign investors in coming years. However most of these power plants will run on imported fuels like natural gas and coal etc. If the international situation becomes unstable, then these power plants may shut down thereby throwing the whole economy into chaos. Thus not only the energy situation in the country is bleak but there can be serious questions about its national security being compromised.

India, a developing country, has very low per capita energy consumption (e.g. by 2000 AD India will consume about 6400 kWh/year per capita as compared to 1,02,600 kWh/year of that you USA [1]). Besides, there is also a high levels of unemployment in rural areas and the energy demands of rural population is met by very inefficient conversion of biomass energy sources.

In this paper it is proposed that the best way to meet the country's energy needs and reduce our dependence on imported fuel is to develop energy self sufficient Talukas. Such talukas can provide food, fuel, fodder and fertilizer to its population and can also provide employment in the process. At the same time if it is possible for residents of a taluka to produce all the energy that they require then it will be a major step towards creation of a truly sustainable society.

WHY TALUKA-BASED SYSTEMS ?

The quality and quantity of energy dictates how the societies will evolve [1]. Thus they are like "dissipative" structures [2]. For a self-organizing structure, a critical mass is required before it can sustain and grow. Small villages appear to be energy and economic sinks. A heuristics approach shows that a taluka level system does possess the necessary infrastructure and has the potential to provide the critical mass for energy self-sufficiency. A taluka or tehsil is an administrative block comprising of 90-100 contiguous villages and has a small town as the headquarters. The geographical boundaries of a taluka can provide the necessary biomass and rain basins for producing food, fuel, fodder and fertilizer for sustainable development.

With the present energy scenarios in the developing countries, it is obvious that they do not have the requisite centralized energy sources to fuel the "historical" evolution. However in the absence of any other relevant model, D.C.'s are following the megacity-based, developed-nation model. Also with increased global communication, the populations of these countries aspire to a higher quality of life and in the absence of energy to sustain it, political, economic and social strife results. Thus there is a need to have an alternative decentralized energy model for sustainable development. An attempt is made in this paper to show that a taluka-directed, biomass-based energy production system does seem to have the ability to produce the above model. The model is developed for Phaltan Taluka in western Maharashtra.

ENERGY CONSUMPTION DATA FOR PHALTAN TALUKA

Table 1 shows the basic data for Phaltan Taluka. The Taluka produces ~ 2,10,000 Tons/year of agricultural residues mainly from crops such as Sugarcane, Wheat, Sunflower, Jowar (Sorghum), Bajra (Pearl Millet), Safflower etc. [3]. Except for residues from Jowar all others are presently burnt in the fields. At present the farmers do not have the technology of either incorporating it in the soil or baling or compacting it for transportation and use as fuel elsewhere. Also shown in the table is the fodder requirement of cattle (bullocks, cows etc.). The fodder requirements of sheep and goats are met by open field grazing. Grasses, Leucaena leaves and Acacia leaves and pods also provide the basic food for sheep and goats.

Table 2 shows the energy consumption pattern for Phaltan Taluka for 1984 and 1991. As this table gives the data only for the energy purchased by the residents of Phaltan Taluka, the use of biomass internally is not taken into account. Except for wood and biogas, all other fuel is imported into the Taluka. About 8.4×10^8 MJ of energy is imported every year into Phaltan Taluka. This is about 80% of the total purchased energy in 1994 price terms it amounts to about Rs. 6.2 crores/year* . This number would be much higher if proper electricity prices are charged for agriculture sector. There are however indications that in near future it will be so. At present the cost of electricity for agricultural purposes is about Rs. 0.14/kWhr. The table also shows that the two most convenient energy sources – electricity and LPG have the highest rate of growth (~ 16.2 and 16.7% p.a. respectively).

TABLE 1. Phaltan Taluka Data (1991-1992)[a]

1. Taluka area	~ 1.17 lakh ha
2. Cultivable area	~ 88,371 ha
3. Irrigated area	~ 48,000 ha
4. Canal flow rate	~ 840 million m^3 /yr
5. Area under forest	~ 9,000 ha (No such forest exists)
6. Annual rainfall	~ 500 mm (Average of last 11 years)
7. Total Taluka population [4]	~ 2,75,931 (increase over 1981 by 1% p.a.)
8. Agricultural residue production	~ 2,10,000 tons/yr
9. Total fodder requirement	~ 95,000 tons/yr (for cattle only)
10. Total cattle	~ 49,355 [4]
11. Sheep and goats	~ 1,50,000 [4]
12. Two sugar factories with crushing capacity of	~ 3,700 tons of cane/day
13. Synthetic Fertilizer use in Phaltan Taluka (N, P_2O_5, K_2O)	~ 8,400 tons/yr (~ Rs. 3 crores)[1 *]
14. Pesticide use (Systemic or contact insecticides, fungicides, weedicides etc.)	~ Rs. 1.3 crores/yr [1 *]

a. All the data in this table is from Ref. [3] unless otherwise noted. 1 crore = 10^7 ; 1 lakh = 10^5 . * Please see notes at the end of the paper for explanation.

TABLE 2 : Energy consumption (yearly) data for Phaltan Taluka (1991). Data for 1984 are in parentheses.

Sr. No.	Fuel	Quantity	Units	Fuel calorific value	Total Energy (x 10^7 MJ)	Growth rate % p.a.	% of total	Uses / Remarks
1.	Electricity[2*] Urban Rural	 19.5 x 10^6 76.25 x 10^6	 kWh	 3.6 MJ/kWh	 34.47 (12.05)	 16.2	 33.0	 Residential : 18.7%; Industrial 17.5%; Agricultural 56%; Rest 7.2%
2.	Petrol[3]	14.57 x 10^5	Litres (l)	32 MJ/l	4.66 (2.43)	9.7	4.5	For cars & two wheelers.
3.	Diesel[4] General State Transport Buses	5.627 x 10^6 1.851 x 10^6	l	35.6 MJ/l -do-	20.03 (10.96) 6.59 (4.53)	9.0 5.5	19.36 6.3	Mostly for tractors, jeeps & some for pumpsets. Only for S.T. buses.
4.	Kerosine[5]	4.285 x 10^6	l	34 MJ/l	14.57 (10.45)	5.0	14.0	Mostly for cookings, lighting & two wheelers.
5.	LPG cylinders[6]	56400. Each has 14.2 kg gas	Nos	44.2 MJ/kg	3.54 (1.2)	16.7	3.4	Mostly for cooking.
6.	Biogas[7]	2926. Each is 6 m^3/ day capacity	Nos	20 MJ/m^3	12.81 (-)	-	12.4	For cooking.
7.	Wood[8]	4015	Tons	14.8 MJ/kg	5.9 (4.14)	5.2	5.7	For cooking, bakeries, and brick kilns.
8.	Coal, coke etc. charcoal[9]	306.6	Tons	28 MJ/kg	0.85 (0.83)	~ 0	0.8	For cooking, bakeries etc.
				Total	**103.4 (46.6) x 10^7 MJ**			

* Please see notes at the end of the paper for explanation.

ENERGY SUPPLY OPTIONS FOR PHALTAN TALUKA

The strategy for taking care of energy requirements of Phaltan Taluka is based on biomass resources. Thus the cultivable land area of Phaltan Taluka has to provide for food, fuel, fodder and fertilizer for its inhabitants. If all of these can be provided then the Taluka can become energy self-sufficient. Besides it can also show the limits to growth. As a future possibility, if some mechanism is found by which residents of the Taluka only consume the energy they produce their area, then it can point towards a truly sustainable society.

From Table 2 it is also evident that energy in the form of electricity, liquid and gaseous fuels accounts for 93% of the total energy purchased in Phaltan Taluka. Hence renewable energy supply options should replace this energy first. Besides, the supply options may become operational earliest by 2000 AD. Hence it is instructive to develop the strategy to supply the energy demands for 2000 AD. Table 3 shows the possible energy consumption for Phaltan Taluka in 2000 AD. The data are generated by taking into account the historical growth rates (from Table 2).

TABLE 3 : Estimate of Commercial Energy use in Phaltan Taluka in 2000 AD.

Sr. No.	Fuel	1991 consumption	Growth rate % p.a. (Table 2)	2000 AD consumption	Energy (x 10^8 MJ)	% of Total
1.	Electricity	9.575×10^7 kWh	16.2	3.7×10^8 kWh	13.32	55.9
2.	Diesel	7.478×10^6 l	9.0	1.62×10^7 l	5.76	24.2
3.	Petrol	14.57×10^5 l	9.7	3.35×10^6 l	1.07	4.5
4.	Kerosene	4.285×10^6 l	5.0	6.65×10^6 l	2.26	9.5
5.	LPG, cylinders	56400 numbers	16.7	226420 numbers	1.42	5.9
				Total	23.83	100.0

It is proposed that the energy supply options will have the following components :

- Liquid fuel production via :

  i) Ethanol production from sweet sorghum
  ii) Ethanol production via molasses from sugar factories
  iii) Pyrolysis oil production from biomass residues

- Electricity production via 30-40 MW biomass-based power station and cogeneration from sugar factories.

A (i) **Ethanol Production from Sweet Sorghum :**

Area under Jowar (Sorghum) in Phaltan Taluka is 48,500 ha [3]. Most of this area is grown under rainfed conditions and can easily be put under sweet sorghum (SS) crop. This can be done since there is very little difference between the agronomy of grain sorghum and sweet sorghum crops. Under rainfed condition SS varieties developed at NARI can produce about 7 tons of fresh stalks/ha and 0.25 tons of grain/ha [5]. Thus Phaltan Taluka has the potential of producing ~ 3,40,000 tons of sweet sorghum stalks and ~ 12,000 tons of grain. Sweet sorghum stalks are an excellent source of fodder for cattle and hence after taking care of all fodder requirements of the Taluka about 2,40,000 tons of sweet stalks remain. Data [6] have also shown that 1 ton of SS stalks can produce 40 l of 95% (v/v) ethanol. This yields a production capability of 9.6 million litres of ethanol per year in Phaltan Taluka. This alcohol can be produced from a 32,000 lpd distillery, which is a medium-sized unit.

With the emphasis on green technologies increasing, most of the modern distilleries can also produce biogas from their effluent. Their norms are production of 28 m^3 of biogas/m^3 of effluent produced [7]. Hence 9.6 million liters/year of ethanol distillery will produce ~ 3.8 x 10^6 m^3/yr of biogas. This can easily be used as energy for ethanol distillation and can thereby release 65,700 tons (dry)/yr of sweet sorghum bagasse. This bagasse has potential to generate ~ 8.7 MW electricity via a biomass power point.

(ii) **Ethanol production via molasses from sugar factories :**

Phaltan Taluka has two sugar factories with total crushing capacity of 3,700 tons of cane per day. They produce about 23,300 tons of molasses during their crushing season. This molasses can generate about 5.6 x 10^6 l of ethanol (95% v/v) [23]. The biogas generated via effluent treatment can be used for running the distillery. At present one distillery attached to a sugar factory uses steam from it and uses wood during off-season.

(iii) **Pyrolysis oil production from biomass residues :**

Pyrolysis oil is produced by rapid pyrolysis of biomass [8]. This oil is highly oxygenated with heating value of ~ 18 MJ/kg. It is equivalent to No 6 heating oil and has been experimentally evaluated as furnace oil substitute [8]. Recently [9] it has been used as a diesel substitute in comparison ignition (CI) engines. Thus conversion of biomass residues to pyrolysis oil is projected as the most competitive liquid fuel from biomass [9]. On an average, 1 kg (dry) of biomass produces 0.75 kg oil, 0.1 kg of char and 0.15 kg producer gas [10].

As soon from Table 1 Phaltan Taluka produces ~ 2,10,000 tons of agricultural residues. Out of this, ~ 96,000 tons of residue are from grain sorghum (Jowar). Since all the grain sorghum area will be replaced by sweet sorghum the residues production will be ~ 1,00,000 tons/year [3] (with residue collection efficiency of 88%). The land area under cultivation in the Taluka is 75% of total area, hence it is estimated that this much residue production will remain more or less constant in future.

The pyrolysis oil can replace diesel oil and kerosene and hence only that amount of agricultural residues should be used which will produce enough pyrolysis oil for above replacement. Thus the amount of residues come to 60,000 tons/year. The rest 40,000 tons can go for electricity generation.

This residue can produce 45,000 tons of oil, 6000 tons of charcoal and 9,000 tons of producer gas. The gas is used internally in the plant for oil production and hence oil and char are the only useful products for external consumption [8]. For this oil to be used as diesel substitute in CI engines, about 10% diesel will be required as a pilot injection, hence only 90% of diesel consumption will be saved [9].

B. **Electricity production from biomass :**

Phaltan Taluka will at least require 3.7×10^8 kWh of electricity by 2000 AD (Table 3). This amount of electricity can be produced as :

i) Cogeneration by existing two sugar factories in Phaltan.

ii) From a biomass-based power station using 40,000 tons of agricultural residues, and wood from energy plantations based on fast growing tree species.

In Phaltan Taluka there are two sugar factories with total crushing capacity of 3,700 tons of cane/day. They are old units with inefficient machinery. With improved high pressure steam boilers they have capability of generating 50 kWh of surplus electricity per ton of crushed cane [11]. Thus they are capable of producing ~ 3.9×10^7 kWh of surplus electricity during crushing season. This season lasts normally for 7-8 months [12].

Similarly surplus bagasse (65,700 tons) from sweet sorghum distillery can produce 7.6×10^7 kWh whereas 40,000 tons of agricultural residue can produce 4.6×10^7 kWh of electricity. Thus the shortfall in electricity production will be ~ 21 x 10 kWh. This can be met by running a biomass-powered plant on fast growing trees fuel [3]. All the above residue together with wood fuel from trees will be fed to two 22 MW power plants. Thus with the norm for energy plantation of 600 ha/MW (net) [3], area under tree plantation will be about 16,000 ha. Around 9,000 ha government "forest" land in Phaltan Taluka which is under non-existent forest could easily be utilized. The remaining 7,000 ha land could be a combination of wasteland and farmers' land where energy plantation will be grown as a crop for remunerative purposes [3].

Table 4 shows the energy supply options for Phaltan Taluka in 2000 AD. It is also instructive now to look at which supply option fuels can replacing the existing fuels. Table 5 shows the replacement strategy. From this table it is evident that total supply options yield more energy than is required for the Taluka in 2000 AD. This excess energy can be used by citizens of Taluka thereby increasing their net per capita consumption or it can be exported (especially alcohol). It is also evident that the supply option strategy may undergo further refinement. However, the point to emphasize is that the Taluka can generate enough biomass to take care of all its energy needs by 2000 AD.

TABLE 4 : Energy supply options for Phaltan Taluka for 2000 AD.

Sr. No.	Biomass Energy and its quantity	End product quantity	Plant capacity	Fuel calorific value	Energy produced (x 10^8 MH)
1.	Sweet sorghum; 2,40,000 tons/yr	a) 9.6×10^6 l of 95% (v/v) ethanol	32,000 liters/day distillery	20 MJ/l	1.92
		b) 65,700 tons of bagasse		16.7 MJ/kg	-
2.	Molasses from sugar factories; 23,300 tons/yr	5.6×10^6 l of 95% (v/v) ethanol	16,000 liters/day distillery	20 MJ/l	1.12
3.	Agricultural residues ~ 60,000 tons/yr	45,000 tons pyrolysis oil	200 tons/day pyrolysis plant	18 MJ/kg [10]	8.1
		6,000 tons charcoal		20 MJ/kg [10]	1.2
4.	a) Energy plantation on 16,000 ha land	2.184×10^8 kWh of electricity	Two power plants of capacity 22 MW each	3.6 MJ/kWh	12.25
	b) 65,700 tons of bagasse	0.76×10^8 kWh of electricity			
	c) 40,000 tons of residues	0.46×10^8 kWh of electricity			
5.	Cogeneration from sugar factories	0.39×10^8 kWh of electricity	Existing sugar factories with total crushing capacity of 3,700 tons/day	3.6 MJ/kWh	1.4
				Total	1.59 x 10^8 MJ

TABLE 5 : Fuel Replacement Strategy

Sr. No.	Supply options	Can replace	Technology options	Tech. status	Energy required (Table 3) (x 10^8 MJ)	Energy available (Table 4) (x 10^8 MJ)
1.	Electricity	Electricity	Biomass-based power plants	D	13.32	13.65
2.	Pyrolysis oil	Diesel Kerosene	C.I. engines Modified burners	UR UR	5.76 2.26	8.1
3.	Ethanol	Petrol LPG	Modified IC engines Alcohol stoves	D D	1.07 1.42	3.04
4.	Char	Wood, coke etc. in small industries	Charcoal gasifiers	D	1.02*	1.2
				Total	24.85	26.59

D = Developed; UR = Under research;

* This is based on 5% p.a. growth rate of wood energy consumption (Table 1) and constant rate of coke, coal etc. consumption.

TECHNOLOGICAL ISSUES

The above energy supply scenarios can only become a reality if the technology is fully developed and it can supply the energy economically with savings to citizens of Phaltan Taluka. The following technology issues will therefore have to be addressed.

1) Harvesting and baling/compaction of agricultural residues will have to be mechanised for ease of transportation and also for reduction of cost of biomass.

2) The pyrolysis oil technology is still in early stages of development. However enough confidence has been achieved on pilot plant basis that vendors do have plans for setting up 200-250 tons/day pyrolysis oil plants [13]. Pyrolysis oil has been successfully tested as furnace fuel oil [13] but its use in small stoves for cooking still needs to be developed. Pyrolysis oil use in a diesel engine is still in R&D stage. However, early encouraging results [9] have shown that with diesel pilot injection (10%) and additives like ethanol it should be possible to run any diesel engine with pyrolysis oil.

3) The technology for producing power (via 30-40 MW plants) from biomass is fully developed [3] as is the technology for producing alcohol from sweet sorghum [6]. Similarly ethanol based cooking stoves have been used in many parts of the world.

4) Production of combustible gases for thermal applications using charcoal gasifiers is a well developed technology. Large scale horticultural farming is coming up in Phaltan Taluka. Simultaneously, food processing units have also been set up. These units consume large quantities of heat energy (~ 80% of their total energy needs) for processing. It is envisaged that horticultural biomass residues can fuel biomass gasifiers for direct heat applications in these units.

5) Taluka geographical area also lends it to become a water basin. With average rainfall of 500 mm/year, a total of 585 million m^3 /year water falls on Phaltan Taluka area. With proper watershed development and management (e.g. building more water percolation tanks), the crop productivity of the Taluka can increase. This can further increase the availability of crop residues besides giving more remuneration to the farmers.

ECONOMIC ISSUES

Precise economic analysis of the above energy scenarios is difficult to do since it is dependent on variable like biomass cost, diesel and petrol cost and also electricity pricing policy for rural areas. All these are quite unpredictable and are dependent on government policies and international situation.

However, a simple analysis based on historical trends has been attempted. Table 6 shows the money that will be paid by Phaltan Taluka in importing energy in 2000 AD. The costing is done for 1994 prices at energy levels of 2000 AD (Table 3) and then corrected by 10% p.a. inflation rate so that cost for 2000 AD results. Historical data for changes in energy prices do show an average of 10% increase [14] and hence as a first order exercise, the inflation correction seems reasonable.

It is evident from this table that the pricing of electricity is artificial and is based on political considerations for rural areas. The data from Maharashtra State Electricity Board (MSEB) [26] shows that if MSEB sets up a thermal power plant today the electricity cost will be Rs. 2.8-3.0/kWhr. This includes line and transmission loss charges of Rs. 0.6-0.7/kWhr. Thus if proper pricing is done for rural areas (e.g. Rs. 2.80/kWhr is charged), then the energy cost for electricity increases to Rs. 183 crores and the total energy import bill for Phaltan Taluka will be Rs. ~ 227 crores !

TABLE 6 : Commercial energy cost in 2000 AD for Phaltan Taluka. The numbers in parenthesis are for Rs. 2.8/kWhr electricity unit price.

Sr. No.	Energy	Requirement in 2000 AD (From Table 3)	1994 unit price	1994 cost (Rs. crores)	Projected cost for 2000 AD (Rs. crores)	% of Total
1.	Electricity	3.7×10^8 kWh/yr	Rs. 0.6/kWhr[1] (Rs. 2.8/kWhr[2])	22.2 (103.6)	39.3 (183)	47.3 (80)
2.	Diesel	1.62×10^7 l	Rs. 8.2/l	13.28	23.53	28.3 (10.4)
3.	Petrol	3.35×10^6 l	Rs. 19.66/l	6.6	11.67	14.0 (5.1)
4.	Kerosene	6.65×10^6 l	Rs. 4 / l [3]	2.66	4.7	5.6 (2)
5.	LPG cylinders	226420 Numbers	Rs. 96 / cylinder	2.17	3.85	4.6 (~ 2)
				Total	83.05 (226.75)	99.8

1 Existing heavily subsidized price for rural areas. 2 MSEB opportunity cost.
3 This is an average price of kerosene.

Table 7 shows the economics of supply options. Detailed costing for these technologies has been done in literature cited. For 2000 AD prices, 10% inflation rate correction has been made.

From this Table it is clear that the major cost is in the production of electricity (64%). However it should be noted that the present electricity pricing for rural areas is heavily subsidized and it is quite likely that by 2000 AD a uniform electricity pricing policy will have similar rates as shown in Table 7 [16].

Thus it is clear from this study that renewable energy options based on biomass are very attractive as compared to fossil fuel ones, only if proper rural electricity pricing is done.

Increased energy production through agro-based systems will also increase the net income for the farmers. Thus it will be Rs. 2.4 crores from sweet sorghum stalks [6], Rs. 14 crores from energy plantation [3] and Rs. 10 crores from agricultural residues which will result in a total of Rs. 26.4 crores/year net income for Taluka farmers. Besides with the labour input norm of 2 labourers/day per hectare of irrigated farm, there is a possibility of employment of 30,000 labourers in the Taluka. The potential of other levels of labour force joining once the agro-energy system is finally set up is also great. This has been aptly shown by existing sugar factories in rural Maharashtra [20].

TABLE 7 : Cost of supply options for 2000 AD

Sr. No	Energy / Fuel	Quantity	Plant capacity	Biomass cost	1994 prices		2000 AD prices*		Total cost (Rs. crores per yr)	% of Total
					Capital cost (Rs. crores)	Unit cost (selling price)	Capital cost (Rs. crores)	Unit cost		
1.	Electricity from biomass	3.4×10^8 kWhr	2 x 22 MW	Rs. 1/kg	132.0	Rs. 2.28 per kWhr	234	Rs. 4.04 per kWhr	137	64.0
2.	Cogeneration from sugar factories	0.39×10^8 kWhr	7.7 MW	-	12.0	Rs. 0.54 per kWhr	21.2	Rs. 0.96 per kWhr	3.72	1.74
3.	Ethanol from sweet sorghum	9.6×10^6 l	32,000 lpd distillery for 95% (v/v) product	Rs. 300 / ton S.S. stalks	9.6	Rs. 14.5 per litre	17.0	Rs. 25.68 per litre	24.65	11.52
	Ethanol from molasses	5.6×10^6 l	16,000 lpd	Rs. 2000 / ton molasses	2.0	Rs. 12.5 per litre	3.5	Rs. 22.14 per litre	12.4	5.8
4.	Pyrolysis oil	45,000 tons	200 tons / day biomass through-put	Rs. 1 / kg	15.0	Rs. 4 per kg	26.5	Rs. 7.08 per kg	36.1	16.88
5.	Charcoal	6,000 tons	-do-	-	-	-do-	-	-do-		
						Total	**302.2**		**~ 213.9**	100

* All prices for 2000 AD are calculated from 1994 prices with 10% p.a. inflation rate.

FERTILIZER ISSUES

With almost all the agricultural residues taken for energy generation, the fertilizer issue can become critical. However, there exists enough potential for making fertilizer from night soil and composting of weeds and vegetable waste so that the possibility of fertilizer issue to be solved exists.

Phaltan Taluka consumes about 2870 tons (T) of synthetic Nitrogen fertilizer every year (~ 420 T of P_2O_5 and 100 T K_2O are also used) [17].

From night soil and cattle dung which does not go into biogas digester, there is a possibility of producing ~ 1200 tons/year of Nitrogen fertilizer [19]. Recently farmers in Phaltan have started to use vermiculture techniques [18] for composting vegetable waste and weeds. With more profits from cash crops like vegetables, the acreage under them is increasing. Composting of these wastes can make a very good organic fertilizer and may provide for rest of the nitrogen fertilizer needs of Taluka.

Recent data [21] have shown that ploughing back of agricultural residues in the fields helps sustainable agriculture, but it should be pointed out that farmers will try to maximize their profits from land and an income generation scheme of supply of these residues for energy purposes will perhaps appear to be more attractive to them.

MANAGERIAL, POLICY AND ENVIRONMENTAL ISSUES

The following issues will have to be addressed before the above energy scenarios can become operational.

a) The agro-energy systems require interaction with a large number of farmers. Thus biomass resource mobilization is one major activity of such enterprises. The existing sugarcane cooperative do provide a charter for such agro-energy units. However, recent criticism of these factories as a base for corruption and political patronage [20] points in the direction of a joint stock company as a more favourable possible management set up.

b) For the ethanol economy to become operational, it is necessary for the Government of India to take a policy decision of allowing the use of ethanol both for IC engines and as a fuel for cooking. Appropriate measures such as use of additives will have to be taken so that it is not diverted for potable purposes.

c) The pyrolysis oil production and utilization technology is still in the nascent stage. There is however a need for setting up a pilot plant to evaluate the technology and efforts should be mounted for its use in C.I. engines. Rapid and extensive R&D is required in this area.

d) Provision of all commercial energy by biomass at taluka level has tremendous implications for the Government of India. Such model replication in other talukas can save the country foreign exchange in import of petroleum products and also reduce the burden of provision of utility infrastructure to far-flung areas of the country. Hence tax incentives should be given to parties who would like to set up such utilities in taluka areas. Similarly Government policy should be changed regarding buying of large areas of land by companies for setting up agro-energy industries.

e) Energy self-sufficient talukas have a potential to offer an alternative development model to the megacity-oriented existing model. This might lead to decentralized, rural-based high technology society, which probably will be the future of all nations. Hence it is advantageous for the developed countries to partake in this experiment. Thus the international aid agencies should help in setting up agro-energy companies in taluka areas of India.

f) Finally, the environmental considerations will overshadow all other considerations in the energy scenario. Recently it has been shown that open biomass burning is as dangerous for ozone depletion as CFCs [24]. The use of biomass residues (which are presently burned in open fire in Phaltan) for energy production offers an environmentally safe way of using them. Besides, the use of biomass for energy production will create conditions for more biomass production thereby also helping in wasteland development and consequently in environment improvement.

It should again be emphasised that though the above mentioned energy plan may undergo further refinement, the idea behind presenting it was to start a debate on the need of setting up energy self-sufficient talukas. There may however be some talukas in India where the level of agricultural residues may not be enough for the above type scenario. However, wind, solar, hydroelectric and other renewable energy systems may provide the necessary energy. Thus energy self-sufficient talukas may provide an alternative development model to megacity-based, centralized energy-driven, model of developed countries.

CONCLUSIONS

It has been shown that it is possible to meet completely the energy requirements of Phaltan Taluka for 2000 AD from agricultural residues and from biomass specifically grown for this purpose. The economics of supply options from agro-energy industries is dependent on the proper electricity pricing policy for rural areas. If the rural areas are charged the normal electricity price, then the economics of biomass energy supply options becomes very attractive.

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NOTES

1. The data on pesticides and fertilizers was obtained from shops in Phaltan selling them. Indications are that some of the material also goes outside the Taluka. Hence the numbers in Table 1 are on higher side.

2. The electricity consumption was obtained from MSEB offices both at Phaltan and Lonand towns.

3. Petrol consumption was obtained from the three petrol stations in Phaltan and one in Sakharwadi.

4. Diesel consumption was obtained from diesel stations. The State transport data was obtained from Phaltan bus depot.

5. Kerosene supply data was obtained from the supply officer Phaltan Taluka office. Anecdotal data suggests that a major part of kerosene is diverted for running the two wheelers.

6. LPG cylinders data was obtained from all the suppliers in Phaltan.

7. Biogas plants data was obtained from Panchayat Samiti office. This office gives the subsidy to the biogas plant owners for installing them.

8. 9. Data on wood, coal, charcoal, coke etc., was obtained from the wakhars (wood suppliers).

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