Integrated Renewable Energy System - Perspectives and Issues.

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ABSTRACT :

Today's crisis in the field of energy supplies, environmental control, population increase, poverty and shortage of food and materials are closely interrelated. It is gradually realised that they demand a holistic, systematic and integrated approach to deal with. Now we see that a 5 % yearly increase in the use of energy not only points to fuel depletion, but is also a main cause for increase in pollution level and related disasters. Too many ambitious single-purpose plans are made with little or no regard to the interdependent short and long-term social-economic and environmental effects, which has caused concern over the arising global environmental issues.

Population increase, pollution, hunger and shortage have clearly demonstrated the limits to growth. Resource limitation today demands their judicial use, which otherwise threatens to its end. The visual effect of the shortage we have already started picturing in terms of limited reserves of coal, oil, and gas which may last only for 197, 40, and 56 years respectively.

Integrated Renewable energy system discussed in this paper aim at mix of possible renewable energy sources taking in to consideration sector-wise energy demand along with socio-economic and environmental aspects of energy use. Use of energy, whether renewable or non-renewable and its effect leads to different kinds of arguments in terms of its effect on environment, social cost and economic viability. Solar energy when considered on human scale is renewable and is environmentally acceptable, but its use is still in primitive stage in many parts of the country mainly because of economic barriers. Likewise, biomass energy is being used in many forms all over the world, but the most needed eco-friendly forms are still in premature stage in most of the world.

Can we become self-sufficient in energy, fully protect our environment, help feed the world, and assist in economic development, all at the same time, and yet slow our growth and retreat to a smaller and fairer share of the world's raw material? These are the questions to be answered if we need to achieve sustainable development in real term. And the solution to these questions lies in integrated approach to our planning in all the spheres.

The present paper highlights the perspectives and some issues related to integrated renewable energy system. Though the global issues related to renewable energy are discussed here, the paper concentrates on the issues, which are more directly related to developing country like India. Extensive survey has been carried out in Kolar (a dry district in Karnataka State) so as to cover domestic, agricultural and industrial sector to know their energy related details. The study shows that bioenergy caters about 84% of the domestic energy needs. This study shows that the present use patterns is non-sustainable and planning of regional energy lacks integrated approach. Thus, even though the bioenergy is a renewable resource, because of vast gap between rate of consumption and rate of regeneration has led to unsustainability. The factors, which directly and indirectly affect the use and promotion of energy sources in the area, are discussed in detail.

INTRODUCTION :

Ever since 1973 oil crises, many countries have justifiably maintained an abiding interest in renewable energy sources and as a result many renewable energy programs were developed. Since then, research and development in the field were more promising and reliable. Main advantage of renewable energy is that its main ingredient is renewable and it plays crucial role in meeting environmental standards by combating global warming and other threats. Above all, it is the only sustainable option to satisfy growing energy needs of the growing population. At the current rate of energy consumption, the limited reserves of coal, oil, and gas may last only for 197, 40, and 56 years respectively [1]. Our forests on the other hand are declining due to many reasons and recent studies show that firewood demand is not the only reason for forest degradation, though it contributes significantly. Environmental health of our planet is degrading and it is loosing its ecological balance. Climate change, ozone depletion, acid rain, global warming, loss of biodiversity are some of the threats to be tackled if planet earth has to survive for long time. Energy issues are the focus of all these threats and therefore it needs special attention. Renewable energy sources promise to meet all the challenges, so as to attain the sustainable development.

Ever since man learnt to make use of fire and other energy resources there is a gradual transition and growth in energy use. From biomass to nuclear, wind and solar, the journey was too long. Many factors influenced and affected energy use. As a hunter-gatherer, needs were limited to biological energy in the form of food. With the development of agriculture practices and related transportation, energy need changed to animate energy. But industrial development and the development of fossil fuels brought about the major transformation in energy use. In fact discovery of fossil fuel made 'industrial revolution' possible and is considered as the most convenient fuel. On the other hand, burgeoning population is adding pressure on the existing resources (Table-1). This has necessitated for alternative energy sources.

Table-1: World population and energy demand
(Source: World renewable energy congress, Feb, 1999)

YEAR	POPULATION (Millions)	ENERGY DEMAND (Million Barrels /Day)
1940	2,400	70
1960	3,000	90
1970	3,600	100
1985	4,800	200
1995	5,300	300
2000	6,100	350

Last sixty years has seen two and half time growth in population, while increase in energy demand for the corresponding period was about five times. This was mainly because increased standard of living in developed countries. Roughly 80% of the

resources are consumed by developed countries, which constitute only 20% of the worlds' population. Such a wide disparity in resource use is a matter of concern for sustainable development. This paper looks in to issues related to the energy consumption across various regions. Integrated energy plan proposed has been discussed for Kolar district taking in to consideration energy demand, energy sources available, consumption of non local energy sources and prospects of harnessing renewable sources of energy.

GLOBAL ENERGY ISSUES

There are two possible paths to provide energy services to the people:

1) The hard/unsustainable path continues with heavy reliance on unsustainable resources- fossil fuels and nuclear power. This leads to serious pollution problems and disposal problems of radioactive wastes.

2) The soft/sustainable path relies on energy efficiency and renewable resources to meet the regions energy requirement. This is a radical departure from what most energy planners in the region are considering. Local area planning with an emphasis on renewable sources of energy and improvement in end use efficiency ensures sustainable development.

The centralised planning approach is adopted currently for resource management and energy policy decisions. There is a need to move towards the softer path, to ensure sustainable development for the present and for the future.

Renewable energy ensures supply security and diversity, and unlike fossil fuels or nuclear power avoids exhausting the planet's resources and causing other negative environmental impacts and represent the sustainable way of producing and using energy. Renewable such as wind, geothermal, solar and farm grown energy crops contribute today less than 2% of global energy supplies. The World Energy Council (WEC) projects a total contribution from all the renewable energy sources in the range of 20 - 50 % of the world primary energy supply by the middle of the next century. Renewable energy (mainly bioenergy) currently provide nearly 14% of the total global energy needs, but use of bioenergy is not very satisfactory all over.

In the developing world wind, water, sun, waste and crops have begun to make significant contribution to meet heat and power needs. The renewables are likely to play an increasing role in coming years, largely because of their ability to help combat global warming and other environmental problem causing concern to the international community. A recent UN study concluded that, in certain circumstances, renewables could account for as much as 60% of the world's market by the mid- 21st century. This potential however depends on a number of factors such as stimulating a market, addressing the barriers to renewables' deployment and raising awareness of the benefits and opportunities these clean energy sources offer.

The principle types of renewable energies available today are:

- Biomass Energy
- Hydro power
- Wind power
- Solar Energy
- Municipal waste
- Industrial waste
- Wave energy
- Tidal power
- Geothermal heat

All the above renewables could make a major contribution to meet the present energy needs.

In response to the progress in renewable energy technologies all over the world, Government of India created the Department of Non-Conventional Energy Sources (DNES) in 1982, which later has been converted into full fledged Ministry of Non-Conventional Energy Sources (MNES). Taking in to account the limitations of the conventional banking approach and to accelerate the momentum of development and large scale utilisation of renewable energy sources and primarily for promoting, developing and financing NRSE technologies, Indian Renewable Development Agency Limited (IREDA) was developed in March 1987. In its first decade of operation, IREDA committed financial assistance to the tune of US $ 397million for renewable energy projects.

Table 2: Renewable energy potential in India.

Energy source	Estimated Potential
1. Solar Energy	20 MW/sq. km
2. Wind Energy	20,000 MW
3. Small Hydro	10,000 MW
4. Ocean thermal power	50,000 MW
5. Sea wave power	20,000 MW
6. Tidal power	10,000 MW
7. Bio energy	17,000 MW
8. Draught Animal power	30,000 MW
9. Municipal waste	1,000 MW
10. Biogas plants	12 Million plants
11. Improved wood burning stoves	120 Million stoves

Much of the estimated potential is yet to be tapped. Development of renewable energy needs proper planning strategies. Supply and service network is the backbone of success to any technology, which should taken into consideration while formulating policies for energy issues. Integrated approach in energy planning is the key for sustainable development. Many factors affect technology progress and use. The major being Government intervention in

promotion and development.

Physical Progress of Renewable Energy Technologies in India(Cumulative Achievement up to September 1995).

Table - 3:

SL. No.	Program	Unit	Achievement*
	Wind-Energy		
1	Windfarms	MW	556.855
2	Wind pumps	Nos.	3289
	Small-Hydro		
3	Mini-micro (up to 3 MW)	MW	122
	Bio-Energy		
4	Bio-based Cogeneration	MW	16
5	Biomass combustion-based Power	MW	10
6	Biomass gasifiers/stirling engines	MW	20
7	Family-size biogas Plants	Million Nos.	2.12
8	Community Night Soil Plants	Nos.	1,395
9	Improved cook stoves	Million Nos.	18.93
	Solar-Thermal		
10	Solar thermal systems (collector area)	Square meters Million liters/day (LPD)	3,03,487 15
11	Solar cookers	Nos.	3,72,293
	Solar-PV		
12	PV-power-units	KWh	825
13	PV community lights/TV & community facilities	Nos.	954
14	PV domestic lighting units/Lanterns	Nos.	85,000
15	PV street lights	Nos.	32,871
16	PV water pumps	Nos.	1,373
	Transportation		
17	Alcohol Operated Vehicles	Nos.	148

Study Area: Kolar District

The Kolar District is located in the southern plains region of the Karnataka State, India. It lies between 770 21' to 780 35' east longitude and 120 46' to 130 58' north latitude and extends over an area of 8,225 Sq. km. The population was 22.17 lakhs in 1991 (as per census report). For administrative purposes the District has been divided into 11 Taluks. There are 15 towns and 3,325 inhabited villages in the District. Kolar belongs to the semi arid zone of Karnataka. In the semi arid zone apart from the year to year fluctuations in the total seasonal rainfall, there are

also large variations in the time of commencement of rainfall adequate for sowing as well as in the distribution of drought periods within the crop-growing season. Kolar district depends upon the distribution of rainfall during the southwest and northeast monsoon seasons. Out of about 280 thousand hectares of land under cultivation 35% is under well and tank irrigation. There are about 951 big tanks and 2934 small tanks in the district.

The average population density of the district is 2.09 persons/hect (rural) and 2.69 persons/hect (rural+urban). The population density ranges from 1.44 (Bagepalli), 1.69 (Gudibanda), 1.70 (Srinivaspura) to the maximum of 2.55 (Kolar). While, the population density in taluks lies within this range - Bangarapet (2.52), Malur (2.38), Gauribidanur (2.36), Sidlaghatta (2.16), Chintamani (2.10), Mulbagal (2.04), Chikkaballapur (1.92).

The average livestock density of the district is 0.81. It ranges from 0.68 (Bagepalli, Malur), 0.70 (Kolar) to a maximum of 1.09 (Gauribidanur). Extent of forest cover in the district is about 6.5%. It ranges from 1.71 % (Bangarpet), 2.3% (Malur), 2.78% (Kolar) to 15% (Srinivaspura) and 20% (Chikballapur). Taluks are grouped in to three groups (<10 %, 10-20%, and >20% cover) based on percentage of forest cover . Chikballapur and Bagepalli have forest cover > 20%, Gudibanda and Srinivaspur are in the range 10 - 20% while remaining taluks have forest cover < 10%.

Renewable Sources of Energy: Prospects and Issues

Solar Energy

Solar energy is produced when sunlight is used to generate electrical energy. Photovoltaic (PV) panels use silicon cells, which transform solar radiation into direct current. The energy is used simultaneously (for example to pump water) or is stored in batteries to provide electricity. Solar energy can also be used to cook food by trapping and concentrating the sun's heat in a cooker, and to heat water or to generate steam which, in turn, can be utilised for mechanical applications. This is usually done by flat plate collectors which is expose a large thin surface, containing a liquid, to the sun. The sun's heat can be intensified with lenses and mirrors and stored in salts and stones. Solar energy is still not viable on economic front to many developing countries therefore its use is promoted by various agencies. The World Bank has a program to install home lighting system in 200,000 homes to Indonesia. Of the 200 million Indonesian, 60 million people still rely on kerosene for lighting.

Energy consumption pattern in Kolar

A detailed study of rural Kolar reveals that, about 84% of the energy need in the district is satisfied by bioenergy and its use is not sustainable. Bioenergy in use, mainly constitute twigs and branches of the locally available species, agriculture residue mainly from Sericulture activity and cattle dung. Domestic firewood need ranges from 1.7 to 2.5 kg per person per day, which is on higher side when compare to the state average of 1.7 kg/person/day. Higher level of consumption is mainly due to inefficient traditional cookstoves. Use of kerosene and electricity use is restricted due economic and

availability constraints and need is 0.72 litre/person/month and 1.16 kWh/person/month respectively. [2] Animate energy in the form of human energy contributes significantly in domestic sector. Domestic activities such as cooking, fuel collection and chopping, fetching water, cloth washing, utensils washing, marketing etc, consumes as much as 7.74 hrs/day/household. Women contribute about 5.6 hrs, men and child contributes 1.12 and 1.02 hrs respectively. [3]

Solar energy scenario in Kolar

Solar energy use in rural Kolar is almost negligible. But rural population is aware of solar technology and very much interested to see and know more about solar equipment. Many place people are even ready to go for solar equipment, but unfortunately they are handicapped with the knowledge of market and related issues. Urban Kolar also is as bad as rural in solar energy use as there is not much progress in spite of market opportunities. Only some commercial firms like Hotels, hostels are using solar thermal water heaters for their water heating needs. Even some households have installed solar water heaters, but their spread is negligible. A recent installation of solar lighting system at Chinmayaswamy temple, Chokkahalli, Kolar is a progressive step taken by KSCST (Karnataka State Council for Science and Technology). Kolar is hotter districts of Karnataka and has a good potential for solar energy development. Promotion of solar energy from Govt. side can bring in some major changes in energy sector.

Solar Potential in Kolar:

The empirical relationships between global radiation (GR) and climatological parameters such as sunshine mean daily temperature, relative humidity, specific humidity, minimum and maximum temperature and rainfall (based on data at Bangalore) are used to compute global radiation (GR-kWh/Sq.m.) for Kolar. Kolar has GR range of 5.2-6.77 during January-May and is in range of 4.6 - 5.1 during monsoon months, July-September.

The Dominican Republic is another example of growing rural PV market. Currently there are five NGO's providing revolving credits for the purchase of $400 to $800 solar home systems. Japan is providing generous subsidy for roof top solar power system, which has led to solar boom. About 9400 solar home systems were installed in 1997 and the number is expected to reach 70000 mark by the year 2000. Europe and US have launched ambitious solar power program. Each has announced a million roof initiatives to boost the domestic system market. Around the world there are many projects utilising PV in such diverse climates, cultures and economies as Germany, with 200 homes, the US Department of Energy sponsoring a rural electrification project in Brazil for 500,000 homes. There are 100,000 families in rural developing countries of Dominican Republic, Kenya, Sri Lanka and Zimbabwe, all using PV power for lighting, radio and television. [4]

India also is making its mark in solar energy development and use. India lies in the sunny regions of the world. Most part of the country receives 4 to 7 kWh of solar radiation per square meter per day, with 250 to 300 sunny days in a year. This make India potential area in solar

energy. As a result solar energy development is seen all over the country. Auroville(Pondiecherry) has successfully tried solar energy options. As a result there are more than 100 houses fully equipped with PV panels and 35 houses using solar power in conjunction with a Tamil Nadu Electricity Board grid connection. In July 1996, the capacity of photovoltaics in Auroville was a total of 150 kWh. Most of the PV panels are manufactured in India. These panels are used for home lighting systems, solar pumping for drinking water and agriculture, and solar hybrid power systems. In 1994-96, 185 solar pumps were installed in Auroville and different parts of India by CSR. Of these, 150 are operating in Auroville and nearby areas. Further examples of the use of solar power in Auroville are solar hot water systems, solar cookers and solar dryers for food processing. Other solar applications developed are solar curing chambers for ferrocement-prefabricated elements, solar concentrators, and solar dryers for curing wood. In a town like Auroville, where many houses are partly or fully powered by energy generated by solar photovoltaic panels, and where even a large complex like the Visitors. Centre runs entirely on solar, it is perhaps not revolutionary any more to imagine a big kitchen providing lunches and dinners for up to a thousand people using mainly solar energy. HUDCO has sanctioned Rs.1 million ($30,000) for the buildings, and the Ministry for Non-Conventional Energy Sources (MNES) granted Rs.1.5 million ($45,000) for the solar bowl and a fully automatic hybrid boiler. In addition, several of Auroville's larger commercial units and individual Aurovilians have been given the financial assistance. One hundred Micro Solar Lighting Systems, named "Solux II", were imported from Germany by Computer Aided Research and Engineering (CARE), a unit of the CSR. CARE wants to explore the market for Solux II and see if it could be manufactured in India using indigenous parts, and sold at a reasonable cost. The solar power program seeks to produce grid quality power using solar thermal and solar photovoltaic technologies. A 140 MW capacity solar thermal power project is coming up in Rajasthan as a centrally assisted project. In the solar photovoltaic power program, 11 projects with an aggregate installed capacity of 810 MW are now functioning satisfactorily. Of these five are in Tamil Nadu, two in U.P., one each in Maharashtra, Madhya Pradesh, Karnataka and West Bengal. The main problem with solar power is that it has not yet reached the stage of commercial viability. But with Govt. initiatives and subsidy it can be brought in commercial use.

SELF (Solar Electric Light Fund, Inc.) operates a rural solar enterprise in Karnataka, which provides solar services to rural households, and arrange financing and leasing of solar electric system.

Wind Energy

More than 2000 wind turbines are in use around the world for generating electricity, and over a million for pumping water. Although experimental wind turbines up to several megawatts in size have been built, the optimum size currently appears to be around 300-500 kilowatt. There are many areas in the world in which wind energy is plentiful. It is a pollution free means of generating electricity on a potentially significant scale that is attracting most current interest in the subject. Wind resources in the developing countries are sufficient to produce thousands of megawatts of power in Asia and Latin America. It is especially strong along coasts, Western China, parts of India, northeast

and South Brazil, the Andes and North Africa. The wind energy potential in the UK can supply all the electricity needs of all Western Europe. [4] The progress in wind power generation has earned India recognition as a "World Superpower" in the state of the world 1998 Report of the Worldwatch Institute. According to mid-80s estimates the wind power potential of India is around 20,000 MW. The installed capacity of the grid quality power generation has reached 1,300 and the ninth plan aims at the addition of 3000 MW. [5] This shows remarkable progress India made in wind power sector. From Auroville's foundation in 1968, the absence of adequate electrical connections provided the motivation to start work on pumping water with wind energy. In 1972, the Indian Aeronautical Laboratory, Bangalore, donated five discarded windmills. These were overhauled and modified so successfully that 3 are still operational. At present, there are more than 30 windmills of various designs for pumping water spread over the Auroville plateau. In 1979, the first prototype high-output windmill was designed in Auroville, which later led to new models being designed and constructed. The design of the Auroville Multiblade Windmill AV55 has evolved from practical experience gained in operating these windmills over the last two decades. Now 21 systems of AV55 wind pump model are operating successfully all over South India. A market study done for the Government of the Netherlands revealed that the AV55 wind pump is clearly the most cost-effective wind pump in India. The Ministry of Non-Conventional Energy Sources (MNES), Government of India, has included the AV55 wind pump in their subsidy program covering approx. 30% of the cost of each installation.

Wind energy status in Kolar

In spite of erratic power supply and frequent energy crisis Kolar has not taken up any potential renewable energy development activity. Wind energy is potentially feasible and economically viable when considered on long term, but unfortunately progress in wind energy sector in Kolar is negligible. Wind energy can be efficiently used for water lifting and such other purposes.

Wind potential in Kolar:

The monthly hourly average wind speed is maximum in the month of July for Bagepalli (17.9 kmph) and Chintamani (17.8 km/h). The mean annual wind speed at Bagepalli is 10.84 kmph and corresponding power density is 20 W/Sq.m.

Hydro Power

Hydropower is a well-established technology, which has been producing firm power at competitive price for about a century. It is the principal source of electric power in some 30 countries, and provides about one fifth of the world's annual electrical supply. Its power stations include some of the largest artificial structures in the world. The dams, which are constructed during the process, are considered as most vulnerable because much of the forests and fertile soil is lost under the dam spread. Therefore, recent development in hydropower concentrates on smaller projects. The classification of hydropower is: Micro (<100 kW), mini (< upto 5MW) and small hydro (about 5-30 MW).

Only 10% of the developing countries' potential have been exploited so far. [4] India has large hydroelectric resource with an estimated potential of 84,000 MW at 60% load factor. Much of this large potential is yet to be tapped. Worlds' undeveloped potential has been estimated at 1.5-2 million MW. Nearly 20,000 MW of hydropower is being added every year and most of this is taking place in Asia.

Hydropower in Kolar

Kolar has no power generating station and has to depend on imported grid power. Hydro potential in Kolar in minimal as there is no major river in the district. However, seasonal micro projects can be considered in small packets of the district to satisfy seasonal erratic power situation.

Biomass Energy

Biomass includes residues from forestry, purpose-grown agricultural crops, trees and plant types, organic waste, agricultural residue, agro-industrial and domestic origin waste [sewage and municipal solid waste]. On a worldwide scale Biomass contributes about 12% to today's primary energy supply, rising between 40% and 50% in most developing countries. Biomass fuel obtained from purpose-grown energy crops as well as forests and agricultural waste are being used in power plants and it is very competitive in price and quality with fossil fuels. Applying biomass technology is both an environmental and human necessity, whether on a local scale to get rid of slurries, waste and refuses, or on a global scale to reduce carbon dioxide content in the atmosphere and hence reduce global warming.

Bioamss resource	Potential annual supply in EJ
Energy crop	128
Dung	25
Forestry residue	14
Cereal residues	13
Sugar cane residues	12
Existing forest	10
Urban refuses	3
Total	205

Table: 4 - World potential for biomass energy supplies in the year 2050.

Source: Johnsson et al., 1992.

There are five routes to obtain energy from biomass

- Production of crops which yield starch, such as sorghum, sugar such as sugar cane; cellulose such as Polar, Eucalyptus trees or other wood-forming trees; and oil such as Sunflower, Euphorbia etc.
- Solid waste, which can be burnt.

- Manure which produces biogas in digesters. The two common ones are the Indian floating top and Chinese covered top.
- Landfill: This is a very ancient technique whereby all the municipal waste and refuse is accumulated in large ditches, valleys or specifically excavated holes in the land and the bacteria, decomposing waste, produces methane.

  In 1990, there were over 240 landfill gas projects in operation worldwide, 90% of them in developed countries, about one third of them in USA. The largest one is in New York and produces 150,000/day. Germany has more than 70 projects, while UK has 35 projects. The UK projects are saving more than 400,000 tones of coal per year by using landfill energy and an electrical power generation of 22MW is achieved from a few of them.

  Alcohol production: Many countries now-a-days have alcohol production plants, which utilise the alcohol directly in cars of partially mixed with petrol to upgrade the octane level, or it may be used by power station to generate electricity. Brazil is one of the leading countries in this technology where 13 x 106 tons of alcohol per year is produce which is sufficient to run 3 million cars per year.

Energy crops are being used globally. One of the most successful projects is that of Ashdown Environmental Company to grow trees which take 8 years to reach harvesting and use the solid arable coppice to generate 2.5 MW in Cornwall, UK.

The cost of electricity is about double the conventional one, but it is clean and does not contribute to the CO_2 emission.

Energy from waste in Kolar

Sericulture is a booming business all over Kolar. Mulberry (Morus alba) is the plant species which serve as food for silk warms, therefore much of the agricultural land in the area is under Mulberry plantation. During different activities of silk production different kind of waste is generated which is effectively used as a source of energy in the area. During silk rearing huge amount of waste in the form of small twig and branches is produced, which is effectively used for cooking and water heating needs in the area. Andarhalli (a village) has undergone drastic shift from firewood to agriculture waste, where wastes cater 20% of the domestic energy need. Even the waste cocoons are dumped into the biogas pit along with cattle dung. Interestingly, it is seen that the biogas production is better with waste cocoon in it.

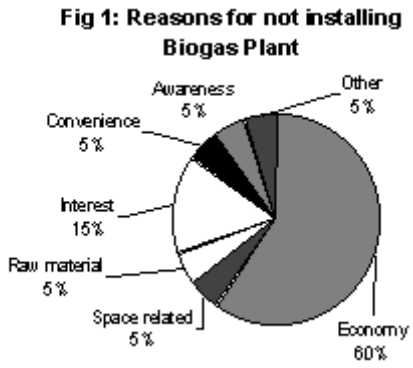
The extremely varied nature of the biofuels is a matter of controversy because of their present use and future potential. The tremendous potential of biomass has not been tapped properly, leading to their degradation which of foremost concern. Lack of adequate relevant information on different bioenergy resources in regional planning framework hamper efforts to develop alternatives to achieve multiple goals set by environmental objectives and the energy demand on the resource. Bioenergy continue to contribute significantly to the total energy consumption in most of the developing world. In domestic and rural industrial sector, they play a critical role.

In this context it is necessary that the regional planning exercises formulate policies to develop sustainable bioenergy systems consistent with the objectives of ecodevelopment and environmental conservation.

Domestic activities such as cooking and water heating are the major thrust areas, where energy consumption in the form of bioresource is more in rural areas. Technological advancement, fortunately made way for cleaner energies such as biogas, electricity from biomass even in remote rural region. Of all renewable, non-conventional energy programs, biogas program in India is considered as a successful one, but only 10% of the available potential is harnessed so far.

Biogas status in Kolar

Kolar District has a biogas potential, which can satisfy as much as 30- 40 % of domestic energy need in rural areas and at least 20% energy need of the total District. But unfortunately only about 5% of the potential is been tapped so far. If the untapped potential is tapped properly then energy crisis in rural Kolar can be minimised to large extent and tree felling can be stopped to a significant extent. Various reasons for not installing biogas plants are listed in Fig.1.



First biogas in Kolar was installed in 1970, since then though there is gradual progress in its use, its promotion has many constraints. Economy is the foremost imporatant to promote energy sources, which is evident from the fig.1, where as much as 60% of the rural population could not avail biogas plant because of economic CONSTRAINTS. Other factors such as awareness, convenience, raw material, space problem, peoples' interest etc. also hampers biogas technology spread. Our study reveals the willingness of the people to install biogas plant provided Governments help them on economic front. In fact subsidy is the major boosting factor in biogas spread and success in the area. though there are many lacunae in the way subsidy is given.

Biogas Usage: Biogas can be used for many purposes, mainly for cooking and lighting in rural area. Biogas can be burned with a gas mantle or can be converted to electricity, using a dual mode engine. The per capita requirement of gas for cooking is in the range 0.34-0.43 m3/day (efficiency of a standard burner is about 60%). The gas requirement to generate one unit of electricity (kWh) is about 0.54 m3. The calorific value of m3 of gas is about 4713 kcals.

Biogas Potential in Kolar :

Taking dung yield for cattle as 3 kg/animal/day, for buffaloe 12 kg/animal/day. Per capita requirement of biogas as 0.34 m3/day. Kolar taluk data shows that in 132 villages biogas can meet energy demand of 15% of population. In 130 villages biogas potential

is sufficient to meet 15-30% of population's energy requirements. In 30 villages Biogas can meet energy demand of more than 45% of village population.

Taking dung yield for cattle as 7.5 kg/animal/day, for buffaloe 15 kg/animal/day. Per capita requirement of biogas as 0.34 m3/day. This shows that in Kolar 116 villages can meet domestic energy requirement of more than 45% of population, In 84 villages potential can meet 30 - 45% of population.

Firewood is a primary energy source and much of the world still relies on firewood for domestic and industrial energy need.

Energy Demand

Sourcewise energy demand shows that the bio resources constitute a major energy source (84% - Dimestic, household industries and small scale industries), followed by electricity (irrigation in Agriculture), Kerosene (lighting etc.)

Firewood as energy source

In Anthragange region of Kolar the per capita firewood need is as high as 2.5 kg. While, in other areas of the district the firewood consumption is about 1.7 kg. per person per day. Procurement of firewood is the issue of concern, because it directly affects green cover on the earth. Forests and the land own by farmer are the main source for firewood in Kolar. Fuelwood is mainly used for cooking and horticulture residues from the coconut trees are used for water heating purposes. Many households rely on more than one source and the belief that firewood is free resource is no more true for many in the area because about 12% of the households purchase firewood from market. Commercialisation of firewood is an indicator of difficult access in the area, though there are some social reasons for this. Firewood from own land is a step towards sustainability, but unfortunately farmers are reluctant to grow only Eucalyptus species for this purpose. The main reason for is forest departments' ignorance to monoculture in the area. If mixed plantation practice is adopted instead of monoculture, it will help maintain ecological balance to certain extent in the area. More and more available wasteland, village land can be brought under such "energy plantation" to support energy system in the district.

Sourcewise Energy Consumption, Kolar taluk Table 5 :

Energy Source	Qty/yr	Units	Qty-mkWh	% share
Fuelwood. Bio residues etc.	176277	ton	901.273	83.995
Electricity	128	mU	128.120	11.940
Kerosene	3696	kL	32.118	2.993
Diesel, Petrol etc.	1200	kL	11.502	1.072

mU: million units (million kWh), kL: kilo litres

Status of Bio Resource availability and demand for Kolar:

The ratio of productivity and fuelwood demand is computed to get an idea of level of bioresource availability in Kolar taluk. Total bioresource available from various resources is about 3058 lakh kWh per year. The availability to demand ratio ranges from 0.33 (if fuelwood demand is taken as 2.5 kg/person/day) to 0.64 (if fuelwood demand is taken as 1.3 kg/person/day). The ratio being less than one indicates that there is bio resource scarcity.

Integrated renewable energy: some issues in Kolar

Study of renewable energy options and status in Kolar indicates that Kolar lacks integrated approach in energy use. Though renewable energy in the form of firewood is the major energy source in domestic sector, its use is not on sustainable scale. Use of farm grown firewood is significant progressive step. In many areas of the district biogas is being used effectively. Current trends in energy use shows that biogas can tackle rural domestic energy need provided Government continues its subsidy policies and also take care of social lacunae in biogas spread. Use of community biogas is feasible option for many villages/communities in the district and can help cattle-less households but unfortunately there is no wave in this direction. Table: 6 describe present energy contribution and ability to support energy system on sustainable basis.

Table - 6:

Resource Type	Availability	Potential to support energy system in sustainable manner	% Contribution
Bioresource			
Forest	VP	VP	35
Other Plantation	G	G	40
Agriculture Residue	G	G	8
Animal waste	VG	VG	5
Oils			

Kerosene	P	P	2
Diesel	G	P	0.2
Petrol	G	P	0.1
Others			
Electricity	P	P	0.5
LPG	P	P	0.05
Solar	VG	VG	0(Negligible)
Wind	G	VG	0
Hydro	P	P	0

VP: Very poor, P: Poor, G: Good, VG: Very Good

Bioresource in the form of firewood contributes as much as 84% of the total domestic energy consumption. Farm grown firewood if grown with region specific diversified plant species can yield healthy results in all respect. Forest, which is degraded to large extent, can be taken up for afforestation program involving the concept of social forestry, energy plantation which can improve socio-economic and environmental condition, satisfying energy needs of the population. Agriculture residue can be used more effectively by minimising waste.

Fuel-efficient stoves can bring reduction in firewood consumption to significant extent. Therefore, use of these stove should be made mandatory in order to provide healthy indoor as well as outdoor atmosphere. Earlier studies reveal that by switching over to fuel-efficient improved stoves the energy saved is about 33 - 42%. [9] In many possible cases use of kerosene can be minimised or replaced by electricity, which can be generated from biogas. Mix of different energy sources can be used for various activities as shown in table 7, taking in to consideration the end use efficiency aspects.

Table - 7 :

Activity	Current use	Possible replacement/use/options
Cooking	Firwood, biogas	Biogas, Firewood, solar cooker
Water heating	Firewood, Bioresidue	Solar heaters, firewood, Bioresidue
Lighting	Electricity, Kerosene	Electricity, biogas, Kerosene
Water lifting	Electricity, bullock power	Wind power, electricity, solar power, bullock power

Conclusions :

Kolar depends mainly on non-commercial forms of energy. Non commercial energy constitutes 84%, met mainly by sources like firewood, agricultural residues and cowdung, while commercial energy share is 16%, met mainly by electricity, oil etc. Based on this investigation of biomass

resource availability and demand, Kolar can be categorised as bioresource deficit region. The present inefficient fuel consumption could be brought down by the usage of fuel-efficient stoves.

Framework of the integrated energy plan proposed for a district is shown schemetically below (Fig.3).

Availability of animal residues for biogas generation gives a viable alternative for cooking, lighting fuel and a useful fertiliser. However to support the present livestock population fodder from agricultural residues is insufficient in these Taluks. Various alternatives such as fuel-efficient stoves, biogas, energy plantations are proposed for improved utilisation of bio resources and to enhance bioresource stock in a region with techno economic analyses.

Renewables such as solar has good potential in the area, but the spread is hampered by economic constraint. Small-scale use of wind turbine can be promoted for water lifting and such other purposes. Solar energy is available and can be used for water heating and water lifting need effectively provided it is subsidised to affordable cost. Integrated approach in energy use involves diversity in energy use, keeping environmental and social criterions.

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