PART II BIO-ENERGY OPTIONS AND RURAL INDIA

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Global Energy Scenario

The world's increasing dependence on foreign oil poses problems for the economy that go far beyond those associated with oil deficits, oil prices, and volatility. Tenuous links to geopolitics have been made in the debate about our ability to quench our thirst for oil. The world is facing an energy crisis of immense proportions as cheap oil availability is coming to an end. Petroleum resources of most of the non-OPEC countries have already peaked or are going to peak in the near future (Figure 6.2.1).

Figure 6.2.1 suggests that the oil production from Indian facilities has already peaked in 1995 and the production will be lower while India witnesses steep increases in demand. The oil production from the non-OPEC countries is going to decline from now onwards and as a result, the world will be entering a regime dominated by OPEC countries. Most of the oil available in future will be from OPEC countries (Figure 6.2.2).

Global oil production on a per capita basis is consistently declining at a rate of 1.20 per cent per year since 1979 (Figure 6.2.3). This rate is bound to dip steeply in view of peaking oil resources around the world and soon the world may face a grim energy challenge as far as petroleum resources are concerned (Figure 6.2.4).

These trends emphasize that the energy resources based on petroleum are rather limited and it is high time for us in India to brace for the oil shocks in coming years. One of the ways to ensure energy security is to invest in developing renewable sources of energy.

Renewable Energy in India

Renewable energy sources offer viable options to address the energy security concerns in a country, especially in rural areas. There is significant potential in India for generation of power from renewable energy sources, such as wind, small hydro, biomass, and solar energy. Therefore, special emphasis has been laid on the generation of grid quality power from renewable sources of energy. In the past ten to twelve years, the capacity of small hydro projects up to 3 MW (megawatt) has increased fourfold from 63 MW to 240 MW. There exists an established potential of 19,500 MW, including 3,500 MW of exportable surplus power from bagasse-based cogeneration in sugar mills

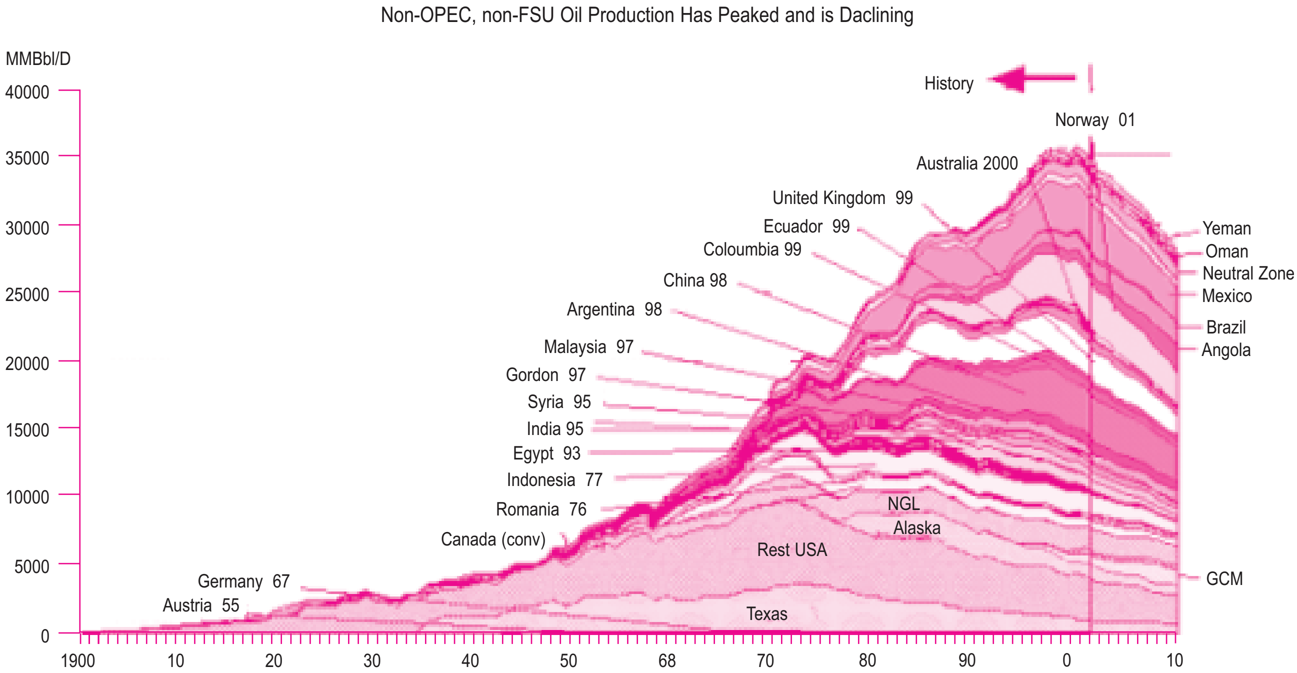


Fig. 6.2.1 Oil Production of most of Non-OPEC and Non-FSU countries

Source: ASPO (2006)

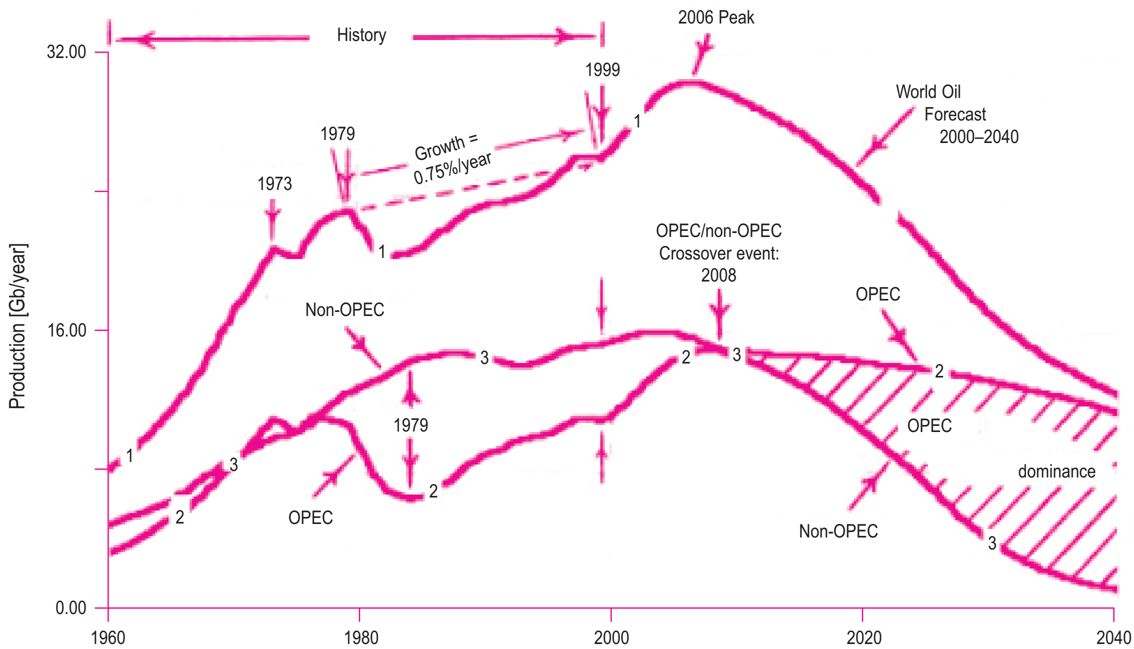


Fig. 6.2.2 Global Oil Production of most of Non-OPEC and OPEC countries

Source: ASPO(2006)

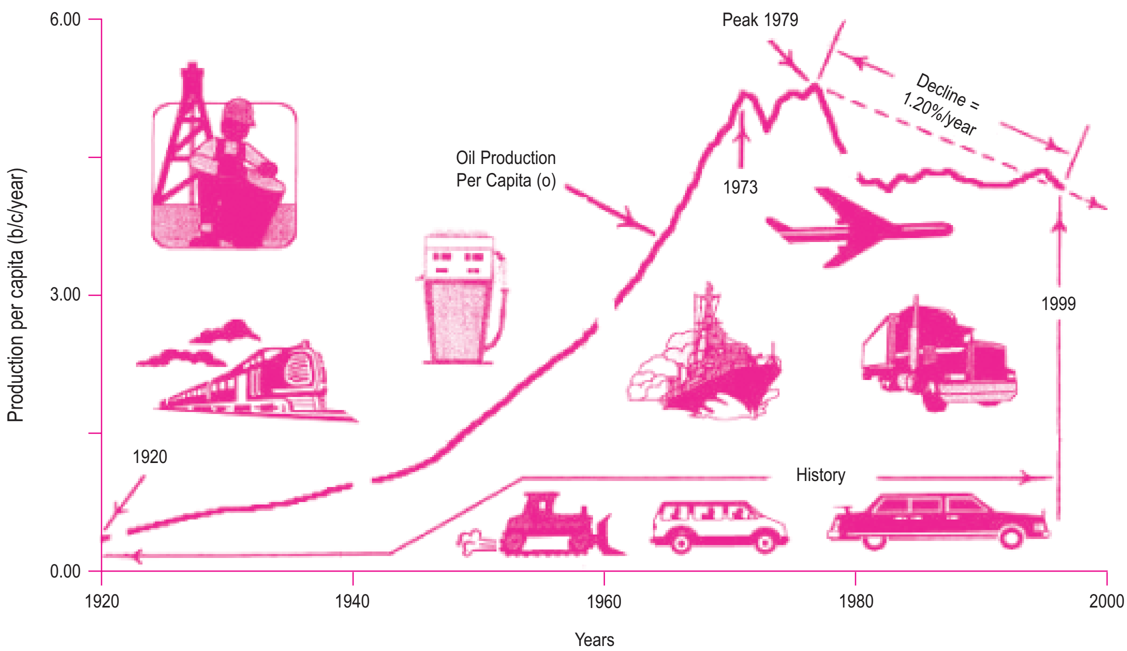


Fig. 6.2.3 Global Oil Production per capita per year

Source: ASPO (2006)

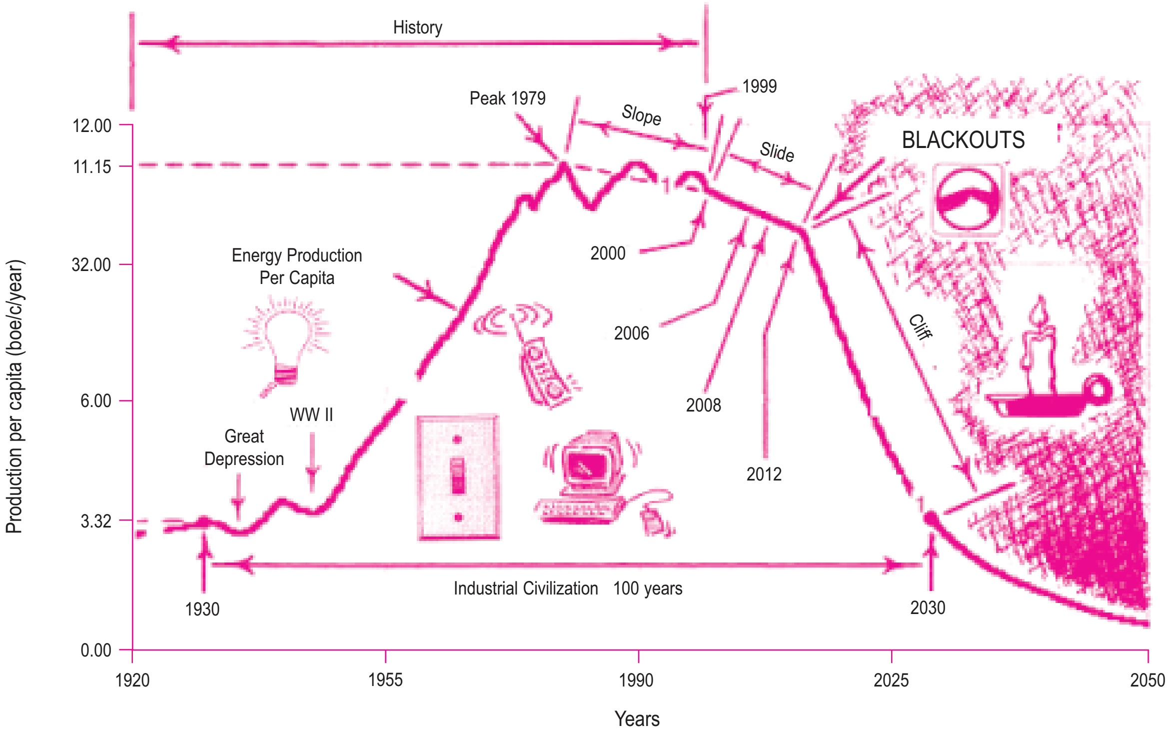


Fig. 6.2.4 Global Oil Production per capita per year and Future Projections

Source: ASPO (2006)

and 16,000 MW of grid quality power from other biomass resources. Grid-interactive solar photovoltaic power projects aggregating to 2.49 MW have so far been installed and other projects of 0.8 MW capacity are under installation. The wind power development in the country has been spurred by a mix of fiscal incentives and promotional measures. Consequently, generation from wind power projects has been increasing overtime from 0.03 BkWh (billion kilowatt hour) in 1970 to 2.2 BkWh in 2002 (Reddy, 2003).

Potential of Biomass for Rural Energy

Worldwide photosynthesis activities are estimated to store seventeen times as much energy as is consumed annually by all nations of the world. Even if the energy required for collection, processing, and conversion into other useful forms is taken into account, biomass still holds the promise to meet the complete energy needs of the world, if managed and used effectively in a sustainable way.

Biomass can be classified into two types: woody and non-woody. Non-woody biomass comprises agro-crops and agro-industrial processes residue. Municipal solid waste or MSW, and animal and poultry wastes are also referred to as biomass as they are biodegradable in nature. The main biomass sources are:

1. Wood and saw dust.
2. Agriculture residues: rice husk, bagasse, groundnut shells, coffee husk, straws, coconut shells, coconut husk, arhar stalks, jute sticks and so on.
3. Aquatic and marine biomass: Algae, water hyacinth, aquatic weeds and plants, sea grass beds, kelp, coral reef, and so on.
4. Wastes: MSW, municipal sewage sludge, animal waste, industrial waste and so on.

Due to the variety and diversity of biomass, sufficient data and documentation regarding availability and consumption/utilization patterns is not easily available. Although biomass meets a major part of the total energy requirement, it does not find an appropriate place in the overall energy balance of India.

Availability of agro-residues

Agricultural residues can be divided into two groups, namely, crop residues and agro-industrial residues. Crop residues are plant materials left behind in the farm after removal of the main crop produces. The remaining materials could be of different sizes, shapes, forms, and densities like straw, stalks, sticks, leaves, haulms, fibrous materials, roots, branches, and twigs. The agro-industrial residues are by-products of the post-harvest processes of crops such as cleaning, threshing, linting, sieving, and crushing. These could be in the form of husk, dust, straws, and so on. The major crop residues produced in India are straws of paddy, wheat, millet, sorghum, pulses, oilseed crops; maize stalks and cobs; cotton stalks; jute sticks; sugar cane trash; mustard stalks. The agro-industrial residues are groundnut shells, rice husk, bagasse, and cotton waste and coconut shells. The quantity of agricultural residues produced differs from crop to crop and is affected by seasons, soil types, and irrigation conditions.

Production of agricultural residues is directly related to the corresponding crop production and ratio between the main crop product and residues varies from crop to crop at times with the variety of the seeds in one crop itself. Thus, for known amount of crop production, it may be possible to estimate the amounts of agricultural residues produced using the residue to crop ratio. It may be noted that with improved agricultural farming techniques, production of crops is increasing consistently in the past three decades. Correspondingly, the availability of agricultural residues has also been changing with time. Some past and future projected data for various agro-residues at the national level are given in Table 6.2.1.

However, most agricultural residues are not found throughout the year but are available only at the time of harvest. This makes collection easy, but creates storage problems if the residues have to be saved for use during lean period, especially due to its low bulk density. The amount available depends upon the harvesting time, storage-related characteristics, storage facility, and so on. The broad periods of availability of some important agricultural residues are given in Table 6.2.2. In India, normally two crops—*kharif* and *rabi*—are taken into consideration. Therefore, availability of crop residues is expected to be spread evenly over the year. As a result, crop residues of one kind or the other are available throughout the year. Since crop production depends upon the agro-climatic conditions, all agro-residues are not available in all parts of the country (Table 6.2.3).

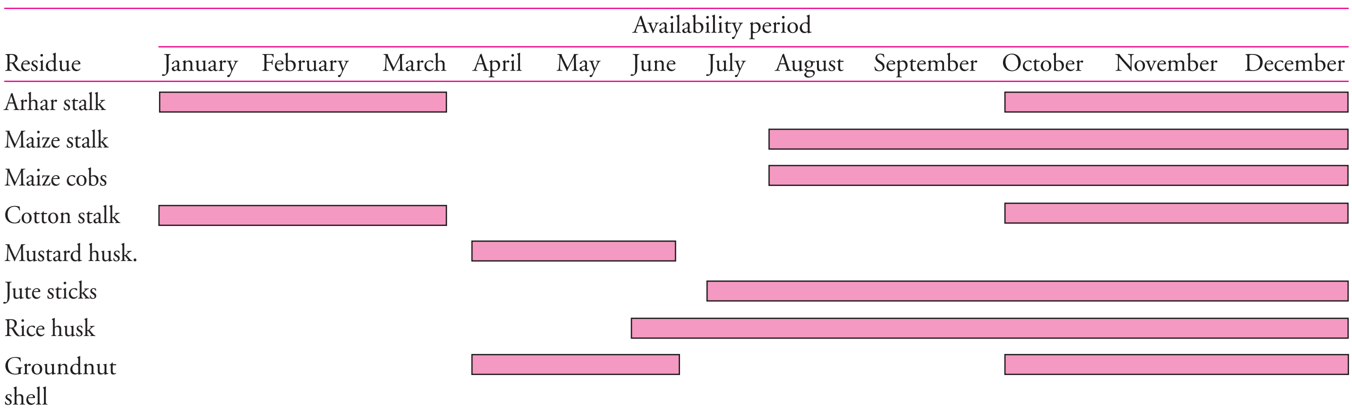
Agro-residues, however, do suffer from two major constraints: high moisture content and relatively low bulk density. These constraints inhibit their economical transportation over long distances, thereby necessitating their utilization near the sources of production. Unlike fossil fuels, which are concentrated sources of energy and chemicals, the management strategy

Table 6.2.1
Agricultural Crop Residue Production in India

	Production (million tonnes)	
Crop residue	1994	2010 (Projected)
Field-based residues		
Rice straw	214.35	284.99
Wheat straw	103.48	159.98
Millet stalks	19.42	17.77
Maize stalks	18.98	29.07
Cassava stalks	0.36	0.40
Cotton stalks	19.39	30.79
Soybeans (straw + pods)	12.87	34.87
Jute stalks	4.58	1.21
Sugar cane tops	68.12	117.97
Cocoa pods	0.01	0.01
Groundnut straw	19.00	23.16
Sub-total	480.56	700.22
Processing-based residues		
Rice husk	32.57	43.31
Rice bran	10.13	13.46
Maize cob	2.59	3.97
Maize husks	1.90	2.91
Coconut shells	0.94	1.50
Coconut husks	3.27	5.22
Groundnut husks	3.94	4.80
Sugar cane bagasse	65.84	114.04
Coffee husk	0.36	0.28
Sub-total	121.54	189.49
Total	602.10	889.71

Source:

Table 6.2.2
Seasonal Availability of Agricultural Residues



Source:

Table 6.2.3
Region-wise Availability of various Crop Residues in India

Region	Crop residues available
North (Punjab)	Sawdust rice husk, rice straw, and mustard stalk
North-east (Assam)	Jute and mesta sticks and rice husk
West (Gujarat)	Cotton stalks, arhar stalks, castor waste, groundnut shell, maize stalks, and maize cobs
Central (Maharashtra)	Sawdust, groundnut shell, arhar stalks, cotton stalks, sugar cane waste, and maize waste.
South (Tamil Nadu)	Rice husk, sawdust, groundnut shell, tamarind shell, coir pith, sugar cane waste, and coffee husk
South (Karnataka)	Rice husk, sawdust, groundnut shell, coffee waste, coir pith, and sugar cane waste.

Source:

for agro-residues utilization has to be different. These are, therefore, most appropriate for decentralized technological applications in rural environments. The processing of the agricultural produce and utilization of agro-residues, therefore, can contribute their maximum share to rural development.

With worldwide shortage of wood, especially in the developing countries, and the need for afforestation to maintain the global ecological balance, there is an increasing demand for proper utilization of agro—and forestry residues to replace wood. At present these residues are either grossly underutilized or completely unutilized due to *in-situ* burning in fields as a means of disposal. Development of technologies to utilize this major resource and its management need to be emphasized to meet the growing energy demands at the domestic level as well as of rural small-scale/cottage industrial sectors.

Monetary value of biomass

Biomass, both woody as well as agricultural, has acquired considerable importance as a biofuel, used directly in several applications such as domestic cooking, industrial process heating, electrical power generation, and also in briquetted form. In order to formulate and implement long-term strategies for efficient and economic utilization of biofuel as the energy source for energy conversion and utilization, it is important to estimate its monetary value for the end user. The following two approaches can be used for determining the monetary value of biofuel:

1. Supply-side approach or production cost method and
2. Demand-side approach or an opportunity cost estimation.

In the supply-side approach, the contribution of the costs of production, harvesting, collection, transportation, and storage is taken into account to arrive at a reasonable estimate of the minimum monetary value of agro-residue. This method does not take into account the quality of the agro-residue such as its energy content (calorific value) and the effect on efficiency for its utilization, during energy conversion to meet the energy requirements. Whereas in the demand-side approach, the maximum affordable cost (monetary value of opportunity cost) of agro-residue as biofuel for a given energy application is calculated based on the amount and the cost of fuel(s) that is likely to be substituted by biofuels. This MAC (maximum affordable cost) of the agro-residue is essentially the monetary value of an equivalent amount of fossil fuel that can be replaced by the use of agro-residue as biofuel. It is

1. a measure of equivalent monetary worth of agro—residues,
2. a basis for the comparison of the prices of two or more agricultural residues for a given application, and
3. an upper limit to the price of agro-residues beyond which the use of fossil fuel may be a better economical/financial option.

A rough calculation suggests that it makes a financially attractive proposition to use agro-residue by transporting it to a longer distance (say, 50 km) rather than transporting coal from 300 km for use as fuel. Similarly, if coal were to be transported over a distance of 1500 km for use, then it would be economical to transport agro-residue over a distance of 300 km distance by tractor trolley (Table 6.2.4).

Table 6.2.4
Comparison of Agro-residue Cost Estimation (Supply and Demand side approaches)

	Cost of agro-residue as biofuels (rupees/tonnes)					
	Production cost method			Maximum affordable cost method		
Agro-residue	On farm	50 km from farm	300 km from farm	At pithead	300 km from pithead	1500 km from pithead
Arhar Stalks	338	502	698	669	903	1840
Cotton Stalks	353	894	1089	622	840	1712
Groundnut Shell	145	564	759	720	972	1979
Jute Sticks	729	590	786	700	945	1926
Maize cobs	363	309	505	660	891	1816
Maize Stalks	426	517	713	652	881	1794
Mustard Stalks	288	528	723	703	949	1933
Rice husk	399	453	648	506	683	1391

Source:

Electricity from Biomass Technologies

The technologies used for producing power from biomass, range from the conventional to the cutting edge of research. The choice of technology can drastically affect the economics of biomass electricity and limit the size of the plant producing it. Table 6.2.5 summarizes various technological options available for biomass-based electricity generation.

Decentralized biomass-based power generation

Conventional biomass-based thermal power plants are normally suitable for large megawatt-level capacity. However, as biomass generally has low energy density, it favours small, dispersed plants for converting biomass into other energy carriers. Thus, a modern megawatt/gigawatt capacity conventional steam-cycle electricity plant is unlikely to be fuelled by biomass since it would draw its fuel from an enormous area, incurring prohibitive transportation costs. It is also clear from Table 6.2.5 that for decentralized small-capacity power generation using biomass, Otto or Diesel cycle IC (internal combustion) engines and Sterling cycle systems are more suitable.

Biomass gasifier based system converts solid biomass into the more user-friendly gaseous form, which can be used directly in IC engines to generate power. Table 6.2.6 compares biomass combustion with the gasification system for power generation, giving their advantages and disadvantages. It is seen that though biomass gasification is not right for grid interaction, it is more suitable for decentralized, small-capacity biomass-based power generation due to its many advantages over the combustion-based system such as low capital investment, higher operational process efficiency at smaller capacities and less power consumption.

Biomass gasification

In a gasifier, a solid fuel is converted into gaseous fuel (producer gas) by a series of thermo-chemical processes such as drying, pyrolysis, oxidation, and reduction. If atmospheric air is used as the gasification agent, which is the normal practice, the producer gas will consist mainly of carbon monoxide, hydrogen, and nitrogen.

The calorific value of the producer gas is about 1000–1200 kcal/Nm^3 (kilocalories per normalized cubic meter). Approximately, 2.5 Nm^3 of producer gas is obtained from the gasification of one kg (kilogram) of biomass. This gas can be used for the generation of motive power either in dual fuel engines or in diesel engines with some modifications. Engines operating on a spark-ignition system (such as petrol engine) can be made to run entirely on producer gas, whereas those using CI (compression ignition) systems (such as diesel engine) can be made to operate with about 60 per cent-80 per cent diesel replacement by the gas. Normally, for producing one kWh (kilowatt hour) unit of electricity, using the gasifier based system, about 0.9–1.1 kg of biomass is required in the dual-fuel-mode operation and about 1.5–1.8 kg biomass is required in 100 per cent gas engine operation. The gas can also be burnt directly for applications such as cooking in hotels,

Table 6.2.5
Comparison of Biomass Electricity Generation Systems

	Rankine cycle		Otto/Diesel cycle		Sterling cycle	
Alternative Technology	Steam	Organic	Wood based	Briquetted Biomass	Air	H_2/He
Acceptability of different biomass	Yes	Yes	No	Yes	Yes	Yes
Constraints related to installed capacity	Heavy	Moderate	Moderate	Moderate	Heavy	Mod-erate
Cost Constraints	Moderate	Heavy	Moderate	Moderate	Moderate	Heavy
Constraints related to collection of bio mass	Heavy	Not severe	Not severe	Not severe	Not severe	Not severe
Level of development within the country	Very little	Very little	High	Fair	Fair	–
Indigenous development	Good	Poor	Good	Good	Good	Very poor
Amenability for decentralized use	Poor	Good	Good	Good	Good	Good
Cost of maintenance	High	High	Moderate	Moderate	Moderate	High
Energy requirement for pre-processing	Low	Low	Moderate	High	Low	Low
Space requirement	High	High	Low	Moderate	Low	Low
Water requirement	High	High	Low	Low	Low	Low

Source:

Table 6.2.6
Comparison between Biomass Combustion versus Gasification-based Power Generation Technologies

Suitability parameter	Gasification	Combustion
Plant capacity	Economical at small scale levels (up to 500 KW electric)	Economical only at large-scale levels (1 MW upwards)
Biomass	Single biomass with less material handling system and quite efficient with wood chips	Multi raw material with expensive raw material handling systems
	Absence of deposition of metal vapours, oxides, etc., in case of pulverized fuels.	Deposition of metal vapours, oxides, etc., in case of pulverized fuels.
Investment cost	Higher on retrofit and low otherwise (average 25 million rupees per MW)	High (average 35–40 million rupees per MW)
Process and overall efficiency	High for small scale system	High for large-scale system
Maintenance	More	Less with standard Practices
Infrastructure	Small	Huge
Power consumption	Less	More
Emission control (NOx, SOx)	Superior	Possible
Grid interaction	Not recommended	Very good
Labour force	Small	Huge
Skilled personnel	Not very much	Required
Captive plant feature	Highly suitable for small-scale level	Suitable for large-scale level
Remote and rural application	Very well adapted	Not recommended
Operational experience in India	Quite common in India for thermal and rural electrification purposes on a small scale	Quite common in India on the large scale
	Inadequate experience for large-scale, grid-connected systems	Adequate experience for large-scale, grid connected systems
Technology status	Developing, near commercialization	Well developed, advanced, and commercialized

Source:

production of hot water and steam in small industries, and drying of a variety of agricultural and industrial products.

Biofuels

Biodiesel is a renewable fuel and technically speaking, biodiesel is vegetable oil methyl/ethyl ester. Biodiesel molecules are very simple hydrocarbons containing no sulphur, ring molecules, or aromatics associated with fossil fuels. Advantages of using biodiesel can be divided into technical and socio-economic categories. Technical advantages of using biodiesel are very low sulphur content, no aromatics, no net carbon dioxide addition to the environment, about 99.6 per cent biodegradability within twenty-one days. It is a renewable source of transportation energy.

Socio-economic advantages of using biodiesel are energy security, economic and social cohesion, healthy environment, upliftment of the rural communities, employment generation, rejuvenation of wasteland and so on. Although biodiesel offers several advantages, technical, environmental, and socio economic, it has some disadvantages such as slightly lower energy content (5 per cent-7 per cent less than the distillate fuel), slightly more deposit on engine components (olefins, traces of glycerides), relatively faster engine oil degradation and marginal increase (1 per cent-6 per cent) in NO_x (oxides of nitrogen) emissions from conventional compression ignition engines.

The economics and the price of biodiesel based on the long run marginal-cost principle are dependent on and sensitive to many factors like land area of seed production, per-hectare seed yield, by-product generation from the process, the sale price of the by-products, etc. Any policy directive should consider the proper channeling and marketability of the byproducts for a viable cost of production of biodiesel to make it competitive to other fuels for the benefit of end-users of this alternative fuel. The mandatory blending requirement and assurance of buy-back of biodiesel from the end-users can be a policy measure to support the economical and financial viability of biodiesel production. This has to be done through defining the role of each player in various segments of biodiesel production by addressing tax and import duty concessions, if necessary, to make the production of biodiesel sustainable, considering the future energy security needs of the country.

Development of Jatropha as biodiesel crop

Jatropha curcas has been identified for India by many experts as the most suitable TBO (tree-borne oilseed) for the production of biodiesel, in view of the non-edible oil available from it, shorter gestation period, hardy nature, high seed/oil yields, and the possibility of its plantation throughout the country. However, as Jatropha is not a native species of India, no systematic studies were undertaken earlier regarding tree improvement. Initiatives have been taken during the last two years to increase the compact area under genetically improved Jatropha species, which can produce better quality and quantity of oil besides being high-yielding. But these initiatives have to be more result-oriented and should focus on state-wise survey and collection of Jatropha seeds, tree improvement/variety diversification for desirable characteristics, multi-location trials for agronomical studies in rain-fed, irrigated, alkaline soils, standardization of agro-forestry models to make Jatropha plantation economically viable, disease and pest management, and intercropping with other value-added crops, that is, medicinal plants, fruits, and so on.

Recognizing access to energy by the poor as a major barrier to the rapid growth prospects of India as well as its vulnerability to volatile international oil prices, the Government of India has, in recent times, laid major emphasis to biofuels, in particular, Jatropha-derived biodiesel. Public sector oil companies have offered an assured buy-back price for biodiesel at 25 rupees per litre. A detailed project report recently prepared under the Ministry of Rural Development (MoRD) identified various end-uses for non-edible straight vegetable oils (SVOs) produced from plants, such as Jatropha, including their direct use for transport applications and power generation on a decentralized basis apart from conversion of the SVOs to biodiesel for purposes of blending with petro-diesel.

Large tracts of wasteland can be placed under such plantations for production of biodiesel. Under alternate assumptions of productivity of such plantations and efficiency with which oil could be extracted, biodiesel could meet as much as 40 per cent of India's diesel requirements by the year 2030.

As such, prima facie, biodiesel seems to have the potential to contribute significantly to India's energy security. However, a clear choice needs to be made on priorities of use of the SVOs produced from plants such as Jatropha. The use of SVO for decentralized applications, with R&D (research and development), could go a long way in securing access to energy in the remote rural areas, either in the form of a fuel providing motive power or for conversion into electricity to feed into local mini-grids. Alternately, the SVO could be converted into biodiesel for purposes of blending into petro-diesel, thereby saving foreign exchange. Irrespective of the end-use application, there is an urgent need for the government to support a targeted R&D programme that should address plantation models, enhancing plant productivity and resilience, of oil extraction, environmental and social impact assessments and institutional models to maximize local socio-economic benefits.

The National Mission on Biodiesel (NMB)

The report of the Planning Commission (2003) highlighted the increased acceptance and usage of biodiesel worldwide as a solution to the problem of environmental pollution and energy security, reducing the imports of petroleum, rural unemployment, and the demands of an agricultural economy. A number of new initiatives have been taken up by many corporate organizations, NGOs and individuals for the promotion of biodiesel. However, in the absence of a national policy on biodiesel, these efforts have not yielded tangible results.

The MoRD has been designated as the nodal ministry for implementation of the recommendations of the committee, especially for launching the NMB to look into Jatropha plantation throughout the country. As part of the demonstration project under the NMB, Jatropha plantations are to be raised on 0.4 million hectares of land in various states across the country with funding from the GOI as against a target of 11.19 million hectares of land required for achieving 20 per cent biodiesel blending with diesel. Seed-collection centres/oil expellers are required to be established to procure seed and extract oil. The oil produced in these centres will be transferred to transesterification plants to produce biodiesel. Thereafter, the biodiesel will be blended with petrodiesel by oil companies and marketed through their retail outlets. The demonstration project is planned to be implemented by involving various stakeholder ministries of the government, dealing with agriculture, rural development, environment and forests, petroleum and natural gas, and so on. Phase II of the mission may consist of self sustaining expansion of the programmes, and is thus proposed to be people-driven with the government playing the role of a facilitator. All stakeholders in the mission, including private entrepreneurs, are aggressively preparing themselves to strengthen the important links in the biodiesel manufacturing chain, that is plantation sector, oil expelling, transesterification, marketing and distribution, R&D, capacity building, and education and awareness.

Current status of biodiesel in the country

The Ministry of Petroleum and Natural Gas (MoPNG) announced a biodiesel purchase policy in October 2005. It prescribes that companies shall purchase biodiesel of standard quality through its notified centers at Rs 25 per litre. Depending upon the market conditions, the oil companies will be free to review the price every six months. The policy recognizes the vital role that PRIs can play in the promotion of biodiesel.

The Petroleum Conservation Research Association (PCRA) has opened the National Biofuel Centre (NBC) at its headquarters in New Delhi that has 'root-to-canopy' information to educate the masses. The PCRA has also introduced a biodiesel bank that recognizes the efforts of various bodies in promoting biodiesel. The bank awards credit points for work done on propagation, promotion, R&D (research and development) efforts, imparting training, and developing plants and machinery to promote biodiesel. Uttaranchal has constituted the Uttaranchal Biofuel Board for the promotion of biodiesel in the state. Chhattisgarh has formed the Chhattisgarh Biofuel Development Authority, and the Andhra Pradesh government has set up a task force for the same (Box 6.2.1). Several other states have either formed task forces or promoted NGOs to take up plantation. The National Oilseeds and Vegetable Oils Development Board has implemented an R&D network programme in the country to develop practices for cultivation in nearly 1800 hectares in the country. The Department of Biotechnology has initiated the Biofuel Mission and the Jatropha Mini Mission to select good germplasm, develop quality planting material, and standardize agro techniques. The Council of Scientific and Industrial Research has initiated a network programme for genetic enhancement in association with the industry under its prestigious New Millennium Technology Leadership Initiative programme. The National Botanical Research Institute, Lucknow, in association with Biotech Park, Lucknow has initiated efforts to educate farmers, industry, and entrepreneurs to develop a model nursery, and model plantation; and to effect certification of seeds for their oil. It has also partnered with the Indian Institute of Petroleum, Dehradun, for providing end-to-end technology to industry. TERI, New Delhi has been involved with the cultivation of Jatropha on degraded sites, and the promotion of Jatropha for biodiesel on an industrial scale.

lIT Kanpur is involved in testing engine efficiency, long-term durability test, vehicular field trials, particulate, and pollution issues related to biodiesel while lIT Delhi is working on the protocols of machines for various operations involved in producing biodiesel. Several NGOs and the industry have plunged into the biodiesel programme and are cultivating Jatropha for seed production.

The country has nearly 63 million hectares of wasteland, out of which 33 million hectares has been allotted for tree plantation. The collective efforts of farmers, NGOs, contract farming, industry, and international promoters can produce sufficient feedstock to achieve a biodiesel mix of five per cent in conventional diesel. This is a sustainable development process leading to large-scale employment of rural human power. Also, it will reduce the foreign exchange outflow for importing crude oil, the cost of which is continuously rising in the international market.

Issues in Large-Scale Plantation

Many government departments, multinational oil companies, NGOs, rural communities, and large and small farmers have undertaken large scale plantation in the last decade. The government sector has started many initiatives to encourage and support such plantations by different stakeholders on private, community, and government wastelands. Subsidies

Box 6.2.1

Biofuels in Chattisgarh, Uttaranchal and Andhra Pradesh

Chhattisgarh

In line with the National Mission on Biodiesel the Chhattisgarh state government took up an exhaustive programme for planting Jatropha on almost one million hectares of fallow land available in the state by 2012. This includes the land lying unused for want of desired soil character or irrigation. To start with, the Government of Chhattisgarh set up a Chhattisgarh Biofuels Development Authority, in January 2005 for the promotion of biofuels programme in the state.

The state has about 44 per cent forest cover, which produces numerous types of underutilized TBOs (Tree Borne Oilseeds) such as Jatropha, *karanja, mahua,* and *kusum* in abundant quantities. This provides ample opportunities for the promotion of the biofuels programme in the state. It is projected that by undertaking the plantation of Jatropha/*karanja* on one million hectares of fallow land in Chhattisgarh, the following production will accrue.

1. Jatropha seed: 10 million tonnes
2. Biodiesel: three million tonnes
3. De-oiled cake (bio-manure): seven million tonnes
4. Glycerol: 0.5 million tonnes
5. Biogas: 3500 million cubic metres
6. Electricity: 700 MW (megawatt)

Though the above are only estimated figures, they reflect the huge potential available in Chhattisgarh for setting up biofuel projects through private investments.

Policy initiatives of Chhattisgarh government

The Government of Chhattisgarh is targeting fallow land as well as barren/unused land belonging to farmers for the plantation of TBOs so that the set objectives are achieved in the minimum possible time. The various policy initiatives taken by the state government included supply of Jatropha saplings to farmers, land allotment policy for investors and support price for purchase of TBOs. To ensure that the farmers planting Jatropha on fallow land get proper price for their TBO produce, the state government has declared a support price for procurement of the same. The support prices are fixed for Jatropha seed (Rs 550 per quintal), *karanja* seed (Rs 450 per quintal) and *Jatropha/karanja* oil (Rs 18 per kilo).

Once the targeted area of one million hectares is brought under Jatropha plantation by the year 2012, various socioeconomic benefits accruing out of biofuel programme to the state will see improvement of the environment, improved soil fertility of barren land, achievement of energy security goals locally, and saving of the appreciable costs being incurred on transportation of fuel at present. Besides, it will also generate employment at the village level through extensive installation of oil expeller/ transesterification units.

Uttaranchal

Of the total geographical area of the Uttaranchal state, 65 per cent is forest land. Of this, approximately 45.74 per cent is under forest cover and the remaining 19.26 per cent, including that of *van Panchayats,* is partly degraded. The degraded forests are leading to massive soil erosion and ecological imbalances. Thus, there is a need to implement the biofuel programme in totality.

The state has undertaken an ambitious scheme of biofuel species plantation in an area of 200 000 hectares. For managing the biofuel species plantation, the state has constituted the Uttaranchal Biofuel Board on public-private partnership basis.

The biofuel programme has been divided into two phases. First phase starting from 2005–6 will cover 100,000 hectares of Jatropha *(Jatropha curcas)* plantation. The second phase in which another 100,000 hectares of Jatropha plantation will begin from 2011–12, will be completed in the next four years.

It is estimated that one rural family with two hectares of Jatropha plantation can generate Rs 28,000 per year (after five years of plantation), which is sufficient to run the household. Unlike diesel and kerosene subsidies running into several hundred crore rupees, biodiesel is not subsidized and it is one of the best fuels for remote villages. Jatropha plantation provides a net annual energy yield that is equivalent to about one tonne per hectare of crude oil imports and 2000 units of electricity generation through gasification of oil cakes. Jatropha plantation will impact positively 100,000 rural families, revitalize unproductive land, and generate carbon credits in the Uttaranchal state and other significant revenues by offsetting the social costs of fossil fuels. It also has a potential of providing employment in the far flung areas of the state.

Andhra Pradesh

In Andhra Pradesh, the plan of action for biofuel programme started with identification of areas, which have not received rainfall beyond 600 mm during nine of the last eighteen years. The government has listed out ten such districts namely Anantpur, Chittor, Kurnool, Mahbubnagar, Medak, Nalgonda, Nellore, Ongole, and Ranga Reddy. The share of wasteland here is about 53 per cent. The required oil-expelling and transesterification capacity is 9600 TPD (tonnes per day) and 3000 TPD, respectively. The state has a total of about 15,714 hectares of land earmarked for plantation purpose, and the total cost for the programme is about Rs 45 crore. Of the 15,714 ha earmarked, irrigated land comprises 7400 ha and rain-fed area extends up to 8000 ha. Seedlings are being supplied to the farmer free of cost. In addition, the government is also providing adequate land preparation facilities. AP has enabled seed procurement by adopting a committee approach involving the best institutes in the country. About 37 tonnes of good quality seed from across sixteen sites have been collected. About 178 000 seedlings in the ten districts have been raised, which go directly to the farmers from the nurseries of the research institutes.

Research and development is under the auspices of premier research institutions like Central Research Institute for Dryland Agriculture, International Crops Research Institute for the Semi-Arid Tropics, Hyderabad, Directorate of Oilseed Research, Hyderabad, National Bureau of Plant Genetic Resources, New Delhi, Indian Institute of Chemical Technology, Hyderabad, and Acharya N G Ranga Agriculture University, Hyderabad. The institutes are involved in the collection of high-quality germplasm and carrying out other necessary experiments within a mandate period of three years to bring out the best plant material and also the best agricultural practices.

As Jatropha is a cash crop, failure can have a devastating effect on farmers. A step forward in providing safeguards has been taken by involving ICICI Lombard, which has already covered about 2800 farmers with weather insurance. A risk fund is proposed to guarantee minimum income to Jatropha growers in case of yield loss. Guaranteed buy-back price (with an adjustment clause) for farmers through tripartite agreements to cover income/market risks is also proposed to be drawn between growers, industry, and biodiesel board.

for purchase of seeds, planting stock, planting operations, and a buy-back policy for biodiesel are some such incentives to support a successful biodiesel mission. However, initial efforts produced mixed results due to lack of information and systematic research, as also knowledge gaps. Subsequently, many research organizations have undertaken programmes to standardize technical and biological aspects such as nursery techniques, planting models, cultural operations, harvest methods, and genetic improvement programmes to identify superior genetic material to maximize yield.

These research findings and on-hand field experiences have resulted in significant improvements in knowledge related to commercial production from large-scale plantations. For example, the myths on irrigation requirements, and their correlations with seed yield have been cleared. Bio-fertilization with the use of mycorrhiza and protection from pests and diseases also enhance yield even on marginal and highly degraded soils. However, more efforts are required to answer questions related to variation in yields, and refinement of plantation models and cultural operations.

Limitation of vegetable oils as diesel fuel

Vegetable oils when used as diesel fuel have various technical limitations such as high viscosity, poor atomization, poor volatility, thermal cracking in diesel engines, poor oxidation stability, polymerization in combustion chamber leading to deposits, injection fouling by deposits, fuel line and filter clogging, polymerization of triglycerides in lube oil and so on. Hence, modification of vegetable oils is necessary for efficient and trouble-free engine operation. One way to modify vegetable oils to produce diesel is to transesterify them.

Bio-ethanol Programme

Society as a whole will benefit from an ambitious, global ethanol introduction as a renewable alternative to diesel. However, many myths such as lower calorific value, cetane number, production potential of ethanol, associated with sugar cane ethanol are impossible to ignore. Predictably, staunch opposition comes from fossil fuel industry. Ethanol fuel is an option which can cohabit with traditional fossil fuels, improving long-term security of supply. Although the US Environment Protection Agency declares that temporary use of such fuels will not cause major damages to engines, the same cannot be said regarding tailpipe emission control systems as the ethanol fuelled vehicles emit significantly large quantities of unregulated pollutants such as aldehydes.

Biofuel programmes in developed countries are very often treated as a domestic issue: a deficient strategy that provides ammunition for the defenders of fossil fuels in terms of reliability and potential. The real issue is that there are import barriers in developed countries to introducing biofuels, as with many other agricultural products. Biofuels such as alcohol are energy sources produced in rural areas to primarily service the energy needs of cities that can afford to pay. Often, biomass programmes are established to produce energy for the poor living in rural areas. These programmes have their merits but are limited economically because of size, given that the buyers have little purchasing power or are not even involved in the commercial market.

Although incentives to domestic production act in the learning curve effect, there is also a need to counteract the pressure from inefficient suppliers and to increase production efficiency worldwide, including progressive trade liberalization. This will allow developing countries to produce biofuels not only for domestic consumption but also for obtaining revenues from biofuel exports.

Way Foreward

Biomass gasification is one of the upcoming renewable energy technologies in India and its contribution to overall energy supply is likely to increase rapidly in future. Though biomass can offer a decentralized and environment-friendly (with net zero carbon-di-oxide emissions) option of energy, biomass gasification is still perceived as a cumbersome and unreliable technology for decentralized power generation. Therefore, in spite of the government's programme for its promotion, since 1984, vast potential still lies untapped. The major problem faced in the acceptability of the biomass gasifier as a decentralized power plant is due to its cumbersome and unreliable long-duration operation, the main reasons being fuel bridging and clinker formation within the gasifier and the hampering of smooth fuel movement calling for constant attention of the operator. Also, ineffective cooling of gas results in lower efficiency and the presence of high tar and particulate content in gas calls for frequent shutdowns for maintenance. Therefore, there is a need to develop low-tar gasifier designs and gas cleaning-cooling systems with minimal waste water generation. Unfortunately, there is no organized market for biomass trading and this is a major barrier in developing biomass-based energy systems on a large scale. A key factor that can influence the future of biomass energy is the development of a market for biomass energy resources and services. Long-term penetration of biomass energy in the industrial and power sector depends on the cost of delivered energy as well as reliability of technologies. The future of biomass energy lies in its use with modern technologies.

India needs to take separate approaches for successful implementation of biofuels programme in the country's different segments. Vegetable oils can be utilized as they are or by converting them to methyl/ethyl esters i.e. biodiesel. Agricultural engines like pump-sets and farm machinery engines are simpler engines in construction and they can be very well maintained by villagers, hence, they may be subjected to use SVOs with modified maintenance schedule whereas more sophisticated engines like transportation engines may use more refined fuel such as biodiesel. Transportation engines are expensive engines and affect the urban air-quality. Their population is quite large and concentrated in urban areas, hence, they may use biodiesel, which is a more refined and standardized fuel.

For production of biodiesel, a multi-pronged approach seems more practical where the transesterification may be carried out by oil refineries in an organized manner and the biodiesel premixed with diesel at the refinery before the distribution. The process of transesterification can also be carried out by cooperatives at district headquarter level, which will cater to the district, thus generating employment in rural areas and avoiding the fuel transportation related costs. This will also reduce the energy dependence of rural areas. SVO can, however, be used in villages for decentralized power generation as well as agriculture farm machinery in remote areas and rural areas. Bio-mass based energy options have the potential to change rural areas, especially, those having large tracts of fallow and barren land.

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