SHORT ROTATION ENERGY PLANTATIONS

By

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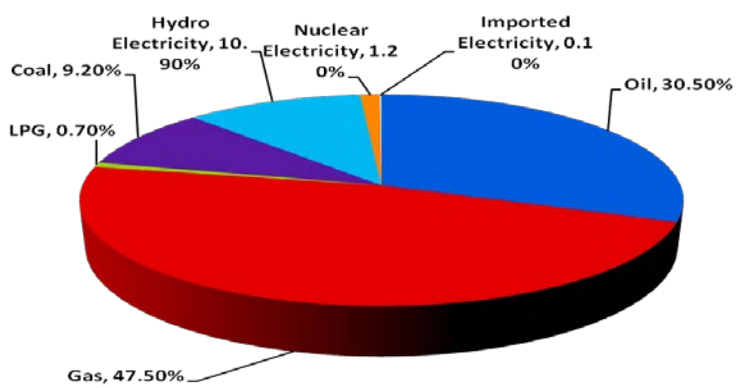
ENERGY CRISES IN PAKISTAN

Pakistan is facing acute energy crises in the form of shortage of electricity and gas supply. The electricity shortfall is continuously soaring and has crossed 6000 Mega Watt level. People are forced to stay without electricity for more than 12-14 hours in cities and around 16 hours in rural areas. Similarly gas supply is also short for commercial as well as domestic use. The country has suffered from worst power crisis during last few years which have forced many businesses to close down resulting the ten of thousand people have been rendered jobless and this number is feared to increase further. Generally these power crises are being associated with reduced oil and gas supply, financial constraints and shortage of water in two major dams.

Vested interests including powerful petroleum lobby are big hurdle in the development of power sector in Pakistan. Though, there were talks of exploiting alternative sources for power generation but practically the result still remains a big zero. Experts also associate current energy crises of Pakistan with Pakistan's current energy mix which is highly dependent on oil and gas. The country spends around $10-12 billion a year on the import of crude oil and deficit petroleum products.

PRIMARY ENERGY SUPPLY BY SOURCE 2007-2008



Pakistan heavily depends on natural gas, 47.50 % to generate electricity followed by oil, 30.50%, Hydro electricity, 10.90% and coal 9.20%. The power generation through nuclear means is only 1.20%.

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The primary energy consumption in Pakistan in 2008 was amounted to 62.9 million tons of oil equivalent with an average growth rate of 6.0% per annum. Besides non commercial fuels (fuel wood, crop residues and animal wastes) to the extent of about 20 million tons of oil equivalent (MTOE) were also used by the households and industry.

Based on historical and current trends in economics and energy growth in Pakistan, the Planning Commission of Pakistan envisages in its Energy Security Action Plan (ESAP) for 2005-2030 that the demand for energy will grow during the ESAP period at about 7.5 to 8.0 per cent per annum on the basis of a 7-8 percent sustained annual growth in GDP. Accordingly the primary commercial energy demand is projected to rise 6.5 folds from about 55 MTOE in 2005 to 360 MTOE by 2030. The corresponding requirements of power generation capacity have been projected to increase more than eight folds from about 19500 Mega Watt (MW) in 2005 to 162500 MW in 2030. These projections are based on the assumptions that GDP will increase from $109.5 billions in 2005 to $ 750 billions in 2030, while the population increase over the same period will be from 153.5 millions to 230-260 millions people. Accordingly the per capita commercial energy and electricity consumption in Pakistan is projected to increase from 0.36 TOE and 400 Kilo Watt hour (kWh) in 2005 to about 1.5 TOE and 2000 kwh in 2030.

However, the country had planed for revised energy mix by 2030. According to the Energy Security Action Plan for 2005-2030 power energy mix would be as shown in the table below.

Revised energy mix under Energy Security Action Plan for 2005-2030 (MW)

Year	Nuclear	Hydel	Coal	Renewable	Oil	Gas	Total	Cumulative
2005	400	6460	160	180	6400	5940	19540	-
% age	2.04%	33.06%	0.81%	0.92%	32.75%	30.39%	-	-
Addition to be accomplished								
2010	-	1260	900	700	160	4860	7880	27420
2015	900	7570	3000	800	300	7550	20120	47540
2020	1500	4700	4200	1470	300	12560	24730	72270
2025	2000	5600	5400	2700	300	22490	38490	110760
2030	4000	7070	6250	3850	300	30360	51830	162590
Total:	8800 5.41 %	32660 20.1 %	19910 12.2 %	9700 5.97%	7760 4.77 %	83760 51.5 %	162590	-

The major shift planned in the 2005-2030 Energy Plan is decreased dependence on oil and increased dependence on coal, nuclear, gas and renewable sources.

RENEWABLE ENERGY SOURCES

Renewable energy is energy which comes from natural resources such as sunlight, wind, rain, tides, geothermal heat and biomass which are renewable (naturally replenished). About 16% of global final energy consumption comes from renewable, with 10% coming from traditional biomass, which is mainly used for heating. Renewable energy sources provide a sustainable and carbon dioxide neutral source of heat and power and improve the security and diversity of supply. The increasing interest in renewable energy and its projected potential is a result of following factors:

- A general worldwide acceptance that emission levels of carbon dioxide is urgently needed to be reduced to mitigate their effect on global warming;
- This has resulted in a number of internationally binding agreements under the Kyoto Protocol to limit carbon dioxide emission levels to agreed limits by 2012;
- The dwindling reserves and spiraling costs of fossil energy, in particular oil and gas, and their vulnerability to political events on a worldwide scale;
- The need to reduce dependency on imported energy with the security of supply that indigenous sources bring.

BIOMASS ENERGY

Biomass energy is a form of renewable energy source and it is derived from living or dead organisms like plants, waste and alcohol mostly. With the exception of tidal and geothermal, all other sources of renewable energy ultimately gain their energy from the sun. In the case of biomass energy the radiant energy from the sun is converted into stored chemical energy in the plant tissues through the normal photosynthetic growth processes. This can be in the form of cereal grains or oil seeds, the stems of the annually harvested energy grasses, such as Elephant Grass (Miscanthus) or in the case of biomass from woody stems. These woody stems represent approximately 60% of the total biomass of plant, the remainder being in the stool which remains after harvesting, the roots, and leaves.

Biomass energy is getting widespread popularity nowadays. Biomass energy source is most often derived from plants either to generate electricity or to produce heat. Biomass can make major contribution to the global commercial energy economy in ways that help to promote rural development, reduce local environment problems and reduce green house gas emissions through fossil fuel substitution, if the biomass is produced sustainably with modernizing the biomass energy systems.

An assessment made by Johansson et al. (1993) of the potential of renewable energy (part of a major study prepared as an input to the 1992 UN Conference on Environment and Development in Rio de Janeiro) indicates that sustainably produced biomass energy could be the largest single contributor to global energy supply in a renewable intensive global energy scenario (RIGES) providing 35% of the total demand for primary energy by 2050. In the RIGES, the majority of biomass energy supplies come from dedicated, high yielding energy plantations. Three quarters of the plantation biomass would come from developing regions and five sixth of this would be accounted for by Africa and Latin America. A “Global energy prognosis” scenario analysis carried out by the Shell

International Petroleum Company's Group Planning Division envisages the same magnitude of biomass use in 2050 as the RIGES (Kassler, 1994).

Total biomass supplies for energy (Exajoule (EJ) per year) for RIGES

Region	2025				2050			
	Forests	Residues	Energy Crops	Total	Forests	Residues	Energy Crops	Total
Africa	2.43	6.81	18.94	28.18	2.43	9.38	31.81	43.62
Latin America	1.59	10.92	32.30	44.81	1.59	13.59	49.60	64.78
S & E Asia	3.13	13.61	--	16.74	3.13	20.42	--	23.55
CP Asia	1.21	3.85	5.00	10.06	1.21	4.16	15.0	20.37
Japan	--	0.89	--	0.89	--	0.95	--	0.95
Australia/NZ	0.02	1.14	--	1.16	0.02	1.39	--	1.41
USA	0.61	5.86	9.60	16.07	0.61	5.68	9.60	15.89
Canada	0.04	1.43	1.20	2.67	0.04	1.42	1.20	2.66
OECD Europe	0.31	4.85	9.0	14.16	0.31	4.86	9.00	14.17
Former CP Europe	0.58	5.28	4.0	9.86	0.58	5.68	12.0	18.26
Middle East	0.02	0.18	--	0.20	0.02	0.23	--	0.25
Total	**9.94**	**54.82**	**80.04**	**144.80**	**9.94**	**67.76**	**128.21**	**205.91**

Energy crops and forestry

Energy crops are grown specifically for use as fuel and offer high output per hectare with low inputs. In countries with large areas of existing forest and woodland there tends to be little interest in establishing dedicated energy crops. This is because although conventional forestry produces much lower levels of biomass output per hectare compared to many energy crops, the costs of producing each ton of biomass in the forest are also significantly lower. Consequently there is little attraction in establishing energy crops on high quality agricultural land.

In countries like Pakistan, where there is extremely low level of forest cover the demand for biomass fuels could exceed the rate of production of biomass in the existing forest. It is necessary to consider whether it is appropriate to use forest and agricultural land for biomass production. If this is required, purpose grown energy crops become an attractive option as high yields of biomass can be produced in a short time.

Characteristics required for Energy Plantations

To make the energy plantations a viable entity, it is necessary to associate following characteristics with the crops to be raised as energy plantations:

- Energy plantations should be raised of fast growing, high yielding species.

- The tree species should have good coppicing ability.

- Method of propagation should be easy i.e. through seeds or branch cuttings.
- Those species should be raised which do not need intensive care.

If the primary purpose is not the production of timber for saw logs, but for energy, then to operate on such a long time scale. In addition, the annual rate of increase in biomass per hectare tends to be greater at early stage of trees, although this varies from species to species. Consequently, there is considerable interest in short rotation operations that harvest fast growing trees for biomass when they are just a few years old.

Short rotation coppice (SRC)
Some fast growing tree species can be cut down to a low stump (or stool) when they are dormant in winter and go on to produce many new stems in the following growing season. This practice is well established in many countries, having been a traditional method of woodland management over several hundred years for a variety of purposes including charcoal, fencing and shipbuilding.

Species Suitable for Energy Plantations
A number of different species are suitable for coppicing, with different optimum cycle periods. In many countries different species have been coppiced in the past as energy plantations but in Pakistan no such energy plantations have been raised. However the potential species which can be used for short rotation coppice for biomass production are:

1- Willow

2- Eucalyptus

3- Poplar

4- Gumhar

5- Tun

6- Iple Iple

7- Sweet acacia

Among the above mentioned species, Willow and Eucalyptus have been found as most promising species for short rotation coppice crop used for energy production. The species and their management system are briefly described here.

Willow (*Salix babylonica, tetrasperma, alba*) as Energy Plantation
Willow has not been grown as energy crop on short rotation coppice in Pakistan, so data is not available for yield per acre under different climatic conditions. Most of the work on

willow as short rotation coppice has been done in UK and it has been proved as most successful short rotation coppice crop. As willow is not a demanding species in terms of its site requirements so it flourishes on a wide range of soil types and environmental conditions. Keeping in view this characteristic of willow and suitability of Pakistani climate to willow, the yield pattern will not be much different as in UK. The crops productivity will be determined by site fertility, temperature, availability of water and light.

Water availability

Willow coppice requires more water for its growth than any other conventional agricultural crop and hence requires a good moisture retentive soil. Areas with an annual rainfall of 900-1100mm are best or areas where the crop has access to ground water. The crop can tolerate occasional inundation but this may have implications for harvesting.

Planting Design

To facilitate mechanical harvesting and machinery access, the crop is planted in double rows 2.5 ft apart with double rows spaced at 5ft. An in-row spacing of 2ft gives an initial planting density of approximately 7000 per Acre.

Harvest Cycle

The crop is established from cuttings prepared from one-year-old wood produced by specialist nurseries. The cuttings are inserted into the ground in spring and at the end of the first growing season they are cut to ground level (coppiced) to encourage the development of the multi-stemmed stool. Growth is rapid after cut back and can be as much as 4 meters in the first year increasing to 6-8 metres at harvest in three years (short rotation) following cutback. A willow coppice may be harvested six to eight times on a three-year cycle giving the plantation a life of 19-25 years allowing for the first or establishment year.

Cost of Planting and Maintenance

Per acre cost of raising of Willow coppice plantation up to first harvesting

Year	Activity	Cost in Rs.
First year	Raising of Plantation	20000/-
Second Year	Maintenance including cut back	10300/-
Third Year	Maintenance	8300/-
Fourth Year	Maintenance including final harvesting	12900/-
	Total	**51500/-**

Yield

A wide range of yields can be expected depending on site, weather conditions and all the other factors which normally determine yield from conventional crops but can be expected to be in the range 3-5 tons dry matter (tDM) per Acre per year (9-15t DM on a three-year harvest cycle). In energy terms short rotation coppice willow dry matter has energy content of approximately 19MJ per kg or 45% of the energy in an equivalent volume of light fuel oil. This gives a mean annual production equivalent of 1300 - 2300 liters of oil per acre per year.

Income from firewood

A minimum of 9 tons of dry matter are expected from first harvest from one acre of willow coppice. The fresh volume will be 18 tons of wood. If current market rate of fire wood is taken as Rs.300/- per maund, then an income of 135000/- per acre is expected from first harvest.

Eucalyptus as Energy Plantation

Eucalyptus species are most widely cultivated worldwide. It is accepted as energy crop as well as industrial wood. Different methodologies have been devised for its cultivation depending upon the requirement of end product. In Pakistan Eucalyptus has been cultivated on large scale especially for pulp wood industry. Unfortunately pulp industry depending upon Eucalyptus wood has not yet started production of eucalyptus wood pulp on large scale but the demand of eucalyptus wood is increasing day by day for its other commercial and domestic uses. Eucalyptus has not been cultivated as energy crop on short rotation coppice system in Govt. sector in Pakistan, although Eucalyptus coppice plantations have been raised in private sector on limited scale.

Eucalypts are generally responsive to coppicing, though there is a range in this ability throughout the genus. Certainly for *E. grandis, E. saligna, E. tereticornis* and *E. camaldulensis* this would be the preferred management technique for biomass production. Those Eucalypts reported to be poor at coppicing include: *E. astringens, E. botryoides, E. cloeziana, E. pilularis* and *E. regnans*. The crop is coppiced at intervals of less than 4 years depending on the size of material required and it should be possible to obtain at least 5 crops before replacement of the stools would be required. The frequency of coppicing is related to both the size of produce required and the original espacement. For short rotation coppice (SRC) crops grown at 1 x 1 m, it would be expected that a coppicing regime of 2-3 years would be required. The more traditional approach to fuel wood production would be to establish the crop at around 2.5-3.0 meter espacement and to operate on a 4-8 year rotation aiming to produce fuelwood of dimensions closer to 20 cm diameter and requiring extensive cross cutting and splitting before use. The choice of size of material and hence the management regime would therefore be dictated by the kiln unit being used. There is very little difference between the Eucalypts as far as their heating quality is concerned and calorific value is within the range of 4,700 -4,800 calories/kg. Similarly good quality charcoal can be made at an average yield of 9.3 m3 of wood per ton of charcoal.

Coppicing is normally carried out at around 20 cm above ground level with a sloping cut, to ensure that rainwater does not cause rot. Following the development of successful coppice shoots, reduction of the number of shoots might be necessary. For pole production this would be down to 1-3 shoots, for biomass production, the upper limit is more flexible. After the shoots reach a utilizable size they are normally removed in a single operation, throughout the crop. In Sri Lanka, a biomass production regime of continuous cropping has been tried, whereby shoots are removed as they reach an utilizable size, which is a little over 2 cm diameter. This regime is popular with Gliricidia but it is probably less suitable for Eucalypts. However, it is a modified regime that might be worth consideration.

Pole and Timber Production

Eucalypts make excellent poles (however they require chemical preservation treatment for most uses) and are used for the production of low-medium grade timber. It would be relatively easy to manage an area of Eucalypts for a range of uses – both as a pole crop and for biomass production. This could be done through the division of the forest area into specific production zones, using close-planted SRC for biomass and a separate area of wider planted (3 x 3 meter) for pole/timber production. Another alternative would be to manage the crop on the basis of coppice with standards. In this management system, better formed individuals (spaced roughly at 5 x 5 – 8 x 8 meters) would be allowed to grow on until they reach the desirable size, whilst the bulk of the crop would continue to be managed on a frequent cutting SRC system. After felling the standards, there regeneration would be encouraged through coppicing supported by vigorous singling to concentrate growth onto a single stem.

Productivity

Eucalypts can be highly productive providing care has been taken to match the species / provenance to the site and site preparation and establishment operations have been completed to an acceptable standard. Production rates in excess of 550 Cft / Ac / year are not unusual and for SRC, production can exceed 700 Cft or even 850 Cft / Ac / year on the better sites not subjected to long periods of drought. For planning purposes however, production figures closer to 200-280 Cft / Ac / year would be more realistic for most instances and on poorer sites where rainfall and soils are more questionable and management is not as tight as it should be, then 140-180 Cft / Ac / year would provide a more conservative guide.

Income Generation

Estimates have been made for the cost of production and the potential income generation from the growing of Eucalypts.

Per acre cost of raising of Eucalyptus coppice plantation up to first harvesting

Year	Activity	Cost in Rs.
First Year	Raising of plantation	53500/-
Second Year	Maintenance of plantation	10300/-
Third Year	Maintenance of plantation	8300/-
Fourth Year	Maintenance of plantation	2900/-
	TOTAL	**75000/-**

Income generation different management systems

Management	Per acre per	Productivity	Productivity	Rate per	Amount

System	year average productivity	for four years	in maunds	maund Rs.	Rs.
Short Rotation Forestry	240 Cft	960 Cft	600 Maunds	200/Maund	120000/-
Short Rotation Coppice	500 Cft	2000 Cft	1250 Maunds	200/Maund	250000/-

Eucalyptus camaldulensis is one of the principal eucalypts grown for fuelwood over the world. The wood of most eucalypts burns well when air dried and leaves little ash; it carbonizes easily, providing good charcoal. Charcoal yields more calories per kg than raw wood, about 7,900 calories per kg for charcoal against 4,700 calories for wood. Charcoal production, however, uses $1^1/4$ to 3 times as much wood to deliver the same amount of energy, as there is considerable loss of energy/heat during conversion into charcoal.

Eucalyptus camaldulensis is quite comparable in calorific value with the commonly preferred fuelwood species of shisham (*Dalbergia sissoo*) and kikar (*Acacia nilotica*). However, the former has slightly lower wood density than the latter; the density of Eucalyptus wood is 705 kg/m^3, shisham (*Dalbergia sissoo*) is 801 kg/m^3 and of kikar (*Acacia nilotica*) is 833 kg/m^3. On the other hand considering growth rate of these species, a hectare of Eucalyptus plantation could produce up to 10.86 tons of air dry of wood per annum which is more than that of shisham (*Dalbergia sissoo*) (5.21 tons of air dry wood per ha per annum) and kikar (*Acacia nilotica*) (10.08 tons of air dry wood per ha per annum).

Poplar as Energy Plantation

Poplar displays more apical dominance than willow and is therefore less ready to develop multiple stems following coppicing. Shoots can reach up to 8 m by the end of the first rotation. It therefore tends to develop fewer, thicker stems than willow, and consequently has a lower bark to wood ratio. Individual shoots can reach up to 8 m by the end of the first 3 year rotation.

Planting

Poplar is planted in spring, from cuttings. These cuttings must have an apical bud within 1 cm of the top of the cutting. Because of this it is difficult to use poplar in equipments developed for planting willow short rotation coppice.

Planting density is lower than for willow, typically 10,000-12,000 per ha. Cut back takes place late in the following winter.

Yield

Yield is very site dependent, and in some sites can out perform willow. Average yield on a suitable site is likely to be in the region of 8 oven dry tons per hectare per year.

Harvesting

Poplar responds well to harvesting cycles of around four or five years which is slightly longer than the 3 years often recommended for willow. This is because growth in the first year following cutback or harvest is generally not as rapid as in subsequent years. Combined with a very up right growth habit this means that the crop may not develop a closed canopy, and hence maximum light interception, until the second or third year.

Harvesting requires similar equipment to willow; however, owing to the tendency of poplar to form fewer, heavier stems, it must be slightly more robust.

Removal of a poplar crop at the end of the useful life of the plantation can be more difficult than for willow as poplar often forms a large taproot which will generally require a large excavator to remove or more time to decay naturally.

Gumhar (*Gmelina arborea*) as Energy Plantation

Gmelina arborea is moderately sized to large deciduous tree with a straight trunk. It is wide spreading with numerous branches forming a large shady crown, attains a height of 30 m or more with an average diameter of 60 cm. The genus was named after J.C. Gmelin, an 18th-century German botanist. The specific name means treelike, from the Latin ‘arbor’ (tree).

History of Cultivation

Gmelina arborea was first introduced from Myanmar as a fast-growing tree species into forest plantations of Peninsular and East Malaysia. It was also introduced to other ASEAN countries, such as the Philippines and Indonesia. *G. arborea* has since been introduced into many countries worldwide and large-scale plantations are found in Central and East Africa, West Africa and South Africa. It has not been grown as energy plantation before in Pakistan, but its growth characteristics reveal that it can be easily grown as energy plantation.

Natural Habitat

The species occurs in a variety of forest habitats, including tropical semi-evergreen, sub-montane, very moist teak forests, deciduous, sal and dry teak forests. The tree is a light demander, although it can with stand some shade. It is moderately frost hardy and recovers quickly from frost injuries. *G. arborea* occurs in the western Himalayas. Its choice of site is wide, but it shows a preference for moist fertile valleys with sandy loam soil; in west Bengal, this species grows best on high silt deposits near rivers. It does not thrive where the drainage is poor, while on dry, sandy or otherwise poor soil it remains stunted and is apt to assume little more than a shrubby form because of repeated dying back through drought.

Tun (*Cedrela toona*) as Energy Plantation

Tun is a large deciduous tree with a spreading crown, commonly attaining a height of 20-30 m and a girth of 1.8-3 m.

Natural Habitat

A tree of subtropical climates, Tun grows in moist localities such as ravines, banks of streams and even swamps. It grows best in fire-protected savannah, abandoned cultivation and in small gaps in forest, and does not do well on dry hill slopes.

Biophysical Limits

Altitude : 0-1500 m, Mean annual temperature: -1 – 40 deg. C. Mean annual rainfall: 750-4000 mm Soil type: Prefers well-drained, deep, fertile soils and does not do well on wet, compacted or poor sandy ones.

Propagation

Natural regeneration is profuse even in areas outside its natural range. Good natural reproduction can be induced by clearing the ground in the vicinity of seed bearers. For a high germination percentage, the seeds are best collected off the tree. It is best propagated artificially by planting 2-season-old stumps. Germination takes 8-15 days and fresh seed have a germination rate of 50-80%. Seed germinate quicker and better under shade and should broadcast thinly on raised and shaded nursery beds soon after collection.

Tree Management

Tun is a moderate light demander; however, the young plants require some side protection from direct sun. . The tree is frost hardy. It coppices well and produces plentiful root suckers. It has a spreading superficial root system, which may have adverse effects on the growth of agricultural crops. If tended and watered in the early stages it is capable of growing in comparatively dry areas, such as those with rainfall as low as 750 mm, and with maximum temperatures as high as 49 deg. C. Good drainage is necessary for optimum development of the seedlings, as excessive moisture restricts root development. It can also be grown as energy crop on short rotation coppicing system.

Iple Iple (*Leucaena leucocephala*) as Energy Plantation

Leucaena leucocephala is a small variably shrubby and highly branched (sp. leucocephala) to medium-sized tree with a short, clear bole to 5 m, upright angular branching and a narrow open crown

Tree Management

L. leucocephala vigorously coppices and responds well to pollarding and pruning. Coppiced stems sprout 5-15 branches, depending on the diameter of the cut surface, and 1-4 stems dominate after a year of re-growth. Wood yields from *L. leucocephala* over short (3-5 year) rotations compare favourably with other species, ranging from 3-4 m in height/year and 10-60 cubic m/ha a year. . High plant densities are recommended for solid fodder. Fodder yields range from 40 to 80 t/ha when moisture is not limiting

***Leucaena leucocephala* as Fuel**

L. leucocephala is an excellent firewood species with a specific gravity of 0.45-0.55 and a high calorific value of 4600 cal/kg. Wood burns steadily with little smoke, few sparks and produces less than 1% ash. The tree makes excellent charcoal with a heating value of 29 mJ/kg and good recovery values (25-30%).

Leucaena leucocephala can be raised as energy crop which can be expected to yield highest biomass per acre in Pakistan.

Sweet Acacia (*Acacia farnesiana*) as Energy Plantation

A shrub which attains a height 4 meter having smooth brown bark with persistent white spines growing as weed in many areas of the world .

Habitat/ecology

Dry habitats between sea level and 1000 m. This thorny, deciduous shrub grows to 4 m in height, sometimes forming impenetrable thickets, although in most areas it forms a more open cover. Although the aerial portions may be killed by fire, it soon regenerates from basal shoots. Sweet acacia is a drought-hardy, fire-resistant species that does not tolerate frost and grows well in areas receiving between 500 and 750 mm of rainfall. Its best growth occurs on well-drained soils.

In Fiji, naturalized near sea level along roadsides, in cultivated areas, pastures, on beaches and dry river banks. In Hawaii, formerly cultivated for an attempted perfume industry, now naturalized and common, sometimes becoming a pest, in dry, open, disturbed areas.

Propagation

Seeds are dispersed by ungulates which eat the pods. Natural reproduction is abundant, particularly on disturbed sites and in active pastures where cattle readily consume the pods. It also coppices well and many branches come out when cut above ground which makes it a suited species for energy plantations.

Uses

In Pakistan it grows as weed but if managed properly, it can be utilized as a good fuel wood crop grown on coppice based cultivation.

Biomass energy system technology

All the tree species described above are suited for energy plantation. The raising of energy plantations is a new concept in Pakistan because technology has not yet been established in Pakistan to produce energy /electricity from biomass except Sugar Mills which use ‘bagas’ as biomass. If modernized biomass energy systems are introduced in Pakistan, then the raising of energy plantations can reduce unemployment and energy crises in Pakistan. A brief overview of the technology/mechanism used in biomass energy production is described as under.

CONVERSION OF BIOMASS ENERGY IN TO USABLE ENERGY

There are three thermo chemical processes, which can be used to convert energy stored in the biomass in to usable energy i.e. heat, or electricity.

1- Combustion

2- Gasification

3- Pyrolysis

At the small-scale, the direct combustion technologies are largely available ‘off the shelf’. However, small-scale Gasification technologies have yet to complete their commercial development and Pyrolysis is still at the research and development stage.

Combustion

Generally, this is the most efficient way to produce heat from wood chip. It involves burning the wood chip with sufficient oxygen to complete the combustion process converting the majority of the fuel to carbon dioxide and water. It is an established technology with many systems available 'off the shelf'. There are inevitably efficiency losses in all combustion systems but modern, well maintained chip boilers will have conversion efficiency in excess of 80%. There is a wide range of equipment available ranging in size from a few kilowatts to multi-megawatts. The generated heat can be used directly to produce hot water or air, or it can be used to raise steam to drive a turbine to produce electricity.

Gasification

This is a form of partial combustion where the stored energy in the wood chip is released in the form of combustible gases, principally hydrogen and carbon monoxide. This is achieved by heating the fuel to high temperatures (>1000 °C) in a controlled deficit of air so full combustion to carbon dioxide and water cannot be completed. This is a relatively simple chemical process and can be completed in a range of systems – updraft, downdraft, fluidized bed – depending on where the air is introduced and its direction of passage through the gasification vessel. Wood gas has a low calorific value of between 4 and 5 MJ/m3 and is not economically practical to store. It is therefore used as it is generated. Gasification is not yet commercially viable and requires further R&D before it will reach market maturity.

Pyrolysis

This is a technology which is still in the research and development phase. It involves the heating of the wood chip to temperatures varying from 400-700 °C, in the total absence of air, to release energy in the chip as liquid pyrolytic oil, a solid char and/or combustible gasses. The relative proportions of these products depend on the temperatures used and on the residence time of the chip in the reactor. The main advantage of this process is that it produces liquid oil, which can be stored and transported relatively easily. It has a calorific value of 16MJ/kg but is acidic and has significant water content so is corrosive and tends to be unstable.

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