"development of this bio-mass energy potential is a highly complex task"

Energy Plantations *

by

Frank H. Denton, Ph D.**

National Bio-mass Potential

Bio-mass production is one means of capturing the energy of the sun in a form which can be stored and used when needed. The potential for bio-mass production is, in the limit, a function of the solar insulation on a given land area. The Philippines, located in the tropics, receives bountiful sunshine. A single square meter of land will receive, during one year, solar energy equivalent to about 2,000 kwh. A hectare will receive 20 million kwh of solar energy, or as much electrical energy as is used by 40,000 rural households during a one year time period.

Trees are one form of bio-mass which are particularly useful as a source of energy. Wood may be stored for extended periods and the technology for converting wood to usable forms of energy is well known. Trees can be produced on land which is not suitable for conventional agricultural crops, such as steep hills or very poor quality soil. It is estimated that the Philippines has between 5 and 7 million hectares of foothill land which has been denuded of its former forests and which is now lying idle. This represents almost 20 percent of the nation's land area. The solar energy falling on this land during a year amounts to almost 10 kwhs, or the equivalent of about 150,000 million barrels of oil. This is many times more than the total energy consumption of the country.

Not all of this solar energy can be captured, however. It is estimated, by scientists, that, with advanced tree production technology, up to 3 percent of the sun's energy can be captured in the form of usable bio-mass. Current program experience is that perhaps 0.1 percent of solar insulation may be captured in the form of harvestable wood. Thus, the current wood-energy production potential is on the order of 150 million barrels of oil equivalent per year. The annual import of oil now is in the vicinity of 80 million barrels per year. With improved tree farming technology, the bio-mass energy potential can be increased several fold. Thus, it can be concluded that bio-mass energy is potentially a major source of energy for the Philippines.

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** Consultant for Alternative Energy, National Electrification Administration.

Organizing Large Scale Bio-Mass Farms

Development of this bio-mass energy potential is a highly complex task. The hills which must be cultivated are in most cases remote from roads, power lines, schools and other public services. They are areas which are sparsely settled, if at all. Tree farming of the type required for energy production is not a well understood field. To develop the enormous bio-mass or wood-energy production potential requires planting of large tracts of land, the establishment of organizational structures to administer the planting, the cultivation and the maintenance of the trees until maturity.

For these reasons, the approach chosen by the National Electrification Administration (NEA) in the development of its tree farms has been to establish farmer associations to own and operate the tree farms. The land to be planted to trees is government owned. It is to be leased to the farmer associations for 50 years (initial 25 years, renewable for a second 25). Farm development loans, management assistance, negotiations for the sale of the wood to the power plants and so forth are all to be done through the associations. This gives a centralized point of contact and some central direction to farm management. Thus, some of the benefits of a single management unit for a large tract of land are obtained. At the same time, since the farmers own the trees and collectively make the decisions for farm development, the objectives of equity and a democratic approach are obtained. This compromise between allocating land to the individual farmer with its desirable social consequences and allocating the land in large blocks to efficient operators appears to be working quite well after three years of field experience.

A tree farm is organized around a wood processing unit such as an electric power plant or a block of charcoal kilns. For illustration purposes, I shall use the power plant model to describe the organizational structure. A 3 MW power plant requires a tree farm area of about 1,000 hectares to provide the necessary wood for its year-round operation. An area of about 10 hectares is required to provide enough income to support one family. Thus, a single dendro-power plant complex will involve about 100 farm families. In the standard model, the 100 farmers are asked to form associations of 10 farmers each. The associations will farm, on a collective basis, modules of 100 hectares. Each association will elect a set of officers to represent it and to make the management decisions. The ten heads of the associations will represent all the farmers at one tree farm.

A loan is made to cover the costs of developing the tree farms over the period from first planting to initial harvest, some 4 years later. The loan covers the expenses incurred in planting the trees and provides enough income for subsistence of the farmers and his family until he can sell his first harvest of wood to the power plant. The loan is made to the farmer association which is registered as a legal entity with the government. The money from the loan is released to the association on a work accomplished basis. The association must decide how to release the money to the individual members.

The loan is from the NEA and is coursed through the electric cooperative. The electric cooperative owns the power plant which is to use the wood being produced. The electric cooperative provides technical assistance to farmer associations and purchases in their name the supplies and equipment needed for farm development. The cooperative also provides general oversight direction of farm development. The farmers are guaranteed a price for any wood which they produce and in return they contract to supply the power plant with any wood required. In effect, the farmers are small owners operating as contract farmers to the power plant. The farmers are financed by the cooperative as the owner of the power plant.

NEA maintains general project oversight. It provides technical assistance on complex issues when they arise. It mediates such disputes as require its intervention.

The farmers are more or less self recruited with preference given to the poor who do not own land (or own very little). It has been found that it is important to have a few more motivated and skilled farmers to provide leadership within the associations. Typically, such farmer leaders are not from the poorest class since they have been able, through their own initiative, to make somewhat better lives for themselves and their families. In order to obtain this catalytic element of leadership among the farmers some provisions are made to recruit a quota of middle class participants.

Generally, this organizational structure appears to be working rather well. It is important that the associations elect at least a few good leaders at each farm site. The competition between modules for best performance will compensate for poor leadership for a percentage of the associations. Of equal importance is good leadership from the cooperative. It is the cooperative which releases the money, provides the necessary element of overall planning and provides the required technical assistance to farmers, many of whom know little about the farming of energy trees. The cooperative also provides for leadership in the relations with outside groups. This latter function is particularly important in areas where there are disputes over land rights, or where there is some group of more powerful persons who wish to become involved in what appears to be a relatively lucrative business.

Economic Returns of Bio-Mass Production

The wood energy programs must produce energy at a price competitive with alternative sources of energy. Since oil is the primary alternative, comparisons are made with oil for this paper. Wood is a considerably less convenient source of energy than oil. Wood is of a lower energy density, meaning it is more bulky and expensive to handle than oil. In addition, being solid, wood is a less convenient fuel for most applications than liquid oil. Thus, on an energy content basis, wood must be cheaper than oil in order to be competitive in the market place.

NEA has used a planning figure for the price of wood, at farm gate, of $15 per dry ton. Oil contains about 37,000 BTU per kg., while dry wood has an energy content of roughly 17,000 BTU per kg. At $29 per barrel, oil costs roughly $192 per ton. Thus wood and oil costs per million BTU are as follows for the planning factor costs of wood at the farm gate.

	Cost per million BTU ($US)
Wood	0.88
Oil	5.19

Oil is, thus, some 6 times more expensive than wood on an energy content basis. However, oil can be converted to usable forms of energy more efficiently than wood can for many applications. Perhaps one half of wood's price advantage is lost because of this difference in efficiency in end use. Nonetheless, the economics of wood energy production looks attractive when the simple cost of fuel is examined.

In the dendro-thermal application, the wood is used to generate electricity. In order to be competitive, the electricity must be priced at, or below, the rate charge by alternative power sources. In most cases, the alternative power source will be the National Power Corporation (NPC). At the planning price for wood, the dendro-thermal power plants can produce electricity for about P0.52 per kwh. The current NPC price of electricity is about ₱0.54 on Luzon. In the Visayas, it is somewhat higher, in the range ₱0.63, while in Mindanao, the NPC price is under ₱0.20 per kwh. Thus, the dendro-electricity is competitive with the NPC on Luzon and in the Visayas, but not in Mindanao. However, Mindanao obtains most of its electricity from hydro-electric plants. Since one primary objective of the government in the dendro-thermal program is to reduce oil imports, Mindanao would not be a priority for dendro-thermal electricity, even if the price were competitive.

As for the farmer, at $15 per ton, he will earn a very attractive income for sites with reasonable fertility. If the farmer can produce 40 wet tons of wood per hectare per year, he will earn on the order $7 per work day, net of loan repayments. The loan for farm development is made for 10 years, with a four-year grace period and a 12 percent interest. In the 11th year, after the loan is repaid, the farmers income will increase by more than 50 percent. Thus, the basic economics of wood production looks very attractive. The results are similar, or even better, for the use of gasifiers. There is still limited experience in the field to firm up these numbers, but as will be shown in the next section, initial field results look quite promising.

Productivity Under Varying Conditions

The NEA program has started the development of tree farms at 37 locations throughout the Visayas and in Luzon. Tree planting has been extensive enough at over 20 of these locations to demonstrate the production of wood which can be expected. Currently, there is only one tree species which is being planted to any extent. That species is leucaena leucocephala, or giant ipil-ipil. Some sites are not suitable for ipil-ipil, and other species will have to be adopted for these sites. Consequently, we have found large variations in yields from site-to-site.

Using the planning figure for the price of wood, the minimum yield which will produce an acceptable income for the farmer is about 21 or 22 wet tons per year per hectare. At a production figure of 32 or 33 tons per hectare, or above, the farmers' income will be very attractive. There are a few locations, perhaps 20 percent of the total, which are generally achieving less than the minimum economic yield. A few sites, perhaps 30 percent of the total, reach economic yields throughout the planted area. More commonly, part of the plantation area will produce good yields and part will not.

After three years of experience we are beginning to have a better understanding of where we can produce acceptable quantities of wood and where we cannot. For example, in very hilly sites with steep slopes, it is often found that the yields obtained on the upper portions of the hills are unacceptably low. Further, the ipil-ipil does not produce well in highly acidic soils.

Yields are generally from 15 to 20 percent higher in the eastern areas where rainfall is more evenly distributed than is the case in the west, with its long severe dry season. This is so when all other fertility conditions are the same. We also find sharp differences in the growth rates for different trees under apparently identical growing conditions. It appears there is a considerable variation in the growth propensity for individual trees for the seed supplies we have access to at this time.

As we learn more about the factors influencing tree growth rates and as we develop a range of species adapted to the characteristics of particular sites, we will be able to significantly improve our average yields. Nonetheless, even with current limitations, we are producing generally satisfactory results. For example, in Isabela, yields close to 40 tons per hectare are being obtained as a plantation average, while the best areas are in the 50 ton region. At Bolinao, in Pangasinan, the best areas produce over 40 tons while the plantation average is about 34. Ilocos Sur, Iloilo and Bohol are in the 30 plus range.

At this stage of development, it has been demonstrated that there are large areas of the country where it is feasible to produce economic quantities of energy from a single species – ipil-ipil. Although we are not yet averaging the expected 0.1 percent capture of the sun's energy in the form of harvestable wood, we can produce meaningful quantities of energy. Currently, in a number of areas the wood energy production exceeds the equivalent of 20 barrels of oil per year per hectare.

Social Benefits

Apart from energy, a very attractive aspect of bio-mass energy production is the employment generation which results. About 1.5 jobs are created for each 10 hectares of trees planted. A program to plant 500,000 hectares, which might save 10 million barrels of oil per year, would also generate about 75,000 new jobs, on a direct employment basis. Since the land used would have been previously uncultivated, about 50,000 new farm units would be created as well.

The wood energy program involves the replanting of areas now denuded of trees. Consequently, the program involves reforestation as a side benefit. A target of 500,000 hectares would result in the reforestation of about 10 percent of the area of the country in need of tree cover.

The energy and non-energy benefits of the dendro programs are considerable. It appears from the initial field results that the economics of the wood energy has been proven for several applications. The question which remains is how rapidly implementation can take place.