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Energy Plantations in the Republic of the Philippines

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Acronyms Appearing Frequently in this Paper

BFD	- Bureau of Forest Development
CASURECO IV	- Camarines Sur Electric Cooperative IV
FICELCO	- First Catanduanes Electric Cooperative
FSDC	- Farm Systems Development Corporation
INEC	- Ilocos Norte Electric Cooperative
ISELCO II	- Isabela Electric Cooperative II
ITP	- Industrial Tree Plantation
MHS	- Ministry of Human Settlements
NEA	- National Electrification Administration
PANELCO I	- Pangasinan Electric Cooperative I
PICOP	- Paper Industries Corporation of the Philippines

ABSTRACT

Development and management of plantations to support wood-energy programs have been aggressively promoted in the Philippines since 1979. Over 60,000 hectares of energy plantations have been planted under government-supported programs. This paper documents the problems and accomplishments of these programs, and describes plantation establishment, maintenance, protection, growth and yield, harvesting, and wood transport. Research priorities for improving energy farm operations are also suggested.

1. Introduction

Like most developing countries with large populations, the Philippines will be confronted with fuelwood shortages--possibly severe shortages--within the next two decades. Already, fuelwood is scarce in parts of the northern and central Philippines.

The largely rural Philippine population of 55 million depends heavily on firewood, especially for cooking. Surveying fuelwood consumption in Ilocos Norte, Hyman (1985) estimated annual wood use at 3,172 kg/household (about three-fourths of a solid m^3/person/yr). Estimates of 0.76 to 0.87 m^3/person/yr have been made for other rural areas in the Philippines (Wiersum 1982). Countrywide, household fuelwood use is conservatively estimated at 23.5 million solid m^3 annually and is expected to rise to 33.5 million solid m^3 by the year 2000 (Revilla 1985). Industrial fuelwood and charcoal use for generating electricity and steam, smelting, and drying is expected to rise even more dramatically. Total industrial use is projected to increase sixfold between 1985 and 2000, from 5.0 million to 30.0 million solid m^3/yr (Revilla 1985).

Projections made by the Philippine Forestry Development Center suggest that fuelwood supplies will lag behind desired demand by at least 8.2 million solid m^3 annually by the year 2000 if the present course of Philippine forestry is maintained (Revilla 1985). Continued low petroleum prices may mean industrial fuelwood demand will grow at a slightly slower pace than previously anticipated, but demand is still likely to outpace supplies by a significant margin.

Recognizing the fuelwood needs of the rapidly increasing population, and hoping to substitute wood for imported fuel in many industrial processes, the Philippine Government has expanded fuelwood plantations in recent years. Similarly, the private sector has responded to the increased demand for fuelwood. Tree farming has become profitable for a number of private investors with access to land.

This paper focuses on efforts by Philippine government agencies to develop energy plantations. First, institutional arrangements that support tree farming are identified, and planting accomplishments are documented. Plantation management, including establishment, maintenance, protection, harvesting, and wood transport, is then described in general. Particular attention is focused on harvesting, forwarding, and wood transport, because these activities have been poorly documented up to now. Finally, research priorities for strengthening tree farming operations are suggested.

2. Organizations and Accomplishments

The principal government agencies supporting energy plantation development in the Philippines are the National Electrification Administration (NEA), the Farm Systems Development Corporation (FSDC), the Ministry of Human Settlements (MHS), and the Bureau of Forest Development (BFD).

2.1 National Electrification Administration Programs

The NEA manages two major wood-energy programs. The Dendro Thermal Power Program uses wood to generate electricity for rural power grids. The TANGLAW Program produces wood for a number of markets and uses.

2.1.1 Dendro Thermal Power Program

The Dendro Thermal Power Program is the better known of the NEA's two major wood energy programs because its progress has been documented by several authors (Adriano 1982; Denton 1983; Durst 1986a, 1986b; Harlow and Adriano 1980). The program plans 60 to 70 wood-fired electricity-generating powerplants --each with supporting energy plantations of 1,100 ha or more.

Wood to supply the powerplants is grown by upland farmers recruited by the NEA rural electric cooperatives that manage the projects locally. Farmers are organized in associations of 10 families each. The tree farmer associations are eligible to lease up to 100 ha of land (10 ha/family) from the government at the concessionary rate of 0.50 peso (less than $0.10)/ha/yr. The NEA loans money to the rural electric cooperatives, who, in turn, loan farmers up to 3,500 pesos ($467 at 1980 exchange rates)/ha to help defray the cost of plantation establishment and management. The loans, which carry interest charges of 12 percent per year, are repayable in 12 years, including an initial 4-year grace period. Assistance is also given to farmers in the technical aspects of planting and managing trees. Other incentives include health and medical benefits, infrastructure development, and a guaranteed market for the farmers' wood.

Over 8,000 ha of plantations have been established under the Dendro Thermal Power Program (NEA 1984b). Although planting success has improved steadily since 1980 (table 1), survival and cost effectiveness vary dramatically among the 44 project sites (table 2). Thirteen sites have not yet established 100 ha of plantations, and five sites have survival rates below 10 percent. But six sites now have more than 400 ha of established plantations, and nine sites boast survival rates of over 80 percent.

Project managers attribute successes to security of land tenure, provision of loans to farmers, suitable sites for growing trees, and guaranteed markets. Failures are usually attributed to free-roaming livestock or unfavorable soil conditions. Inadequate institutional support and poor organization are also responsible for failures at some project sites. Furthermore, the country's macroeconomic problems have forced the NEA to discontinue its farmer loan program (table 1).

Table 1.--Loan releases and planting accomplishments at 44 Philippine dendrothermal sites, 1980-84

Year	NEA loan releases	Area planted	Area surviving[a]	Survival
	Million pesos	- - - - ha	- - - -	%
1980	5.83	1,544	405	26.2
1981	23.67	6,050	1,821	30.1
1982	16.20	6,090	3,024	49.7
1983	8.21	3,801	2,495	65.6
1984	1.04	342	272	79.5
Total	54.95	17,827	8,017	45.0

[a]NEA computes area surviving based on number of trees per hectare relative to full stocking of 10,000 trees; thus, a hectare with only 5,000 live trees is counted as one-half of a surviving hectare.

Source: Dendro Thermal Development Office, National Electrification Administration, Philippines.

Table 2.--Cost effectiveness of reforestation expenditures at Philippine dendrothermal sites, 1980-84

Cost-effective group	Number of sites	1980-84 loan releases	Area planted	Area surviving[a]	Survival	Cost per planted hectare	Cost per surviving hectare
		Million 1984 pesos	- - - - ha - - - -		%	- - 1984 pesos - -	
Most effective[b]	14	29.55	6,525	4,737	72.6	4,529	6,238
Moderately effective[c]	13	40.17	7,860	3,057	38.9	5,111	13,140
Least effective[d]	17	25.66	3,442	223	6.5	7,455	115,067
All Sites	44	95.38	17,827	8,017	45.0	5,350	11,897

[a]See table 1, footnote a.

Sites are grouped according to peso expenditures per surviving hectare:

[b]Less than 10,000 pesos spent per surviving hectare.
[c]Between 10,000 and 20,000 pesos spent per surviving hectare.
[d]Over 20,000 pesos spent per surviving hectare.

2.1.2 TANGLAW Program

The TANGLAW Program, also administered by the NEA, has "Family Tree Farm" and "School Plantings" components. Under the Family Tree Farm component, farmer associations are similar to those in the Dendro Thermal Power Program, except that only minimal assistance is provided for plantation establishment and management. No financing is offered, and material support is limited to 2 kg/ha of giant ipil-ipil (*Leucaena leucocephala* (Lam.) de Wit) seeds. Success of the program depends on providing markets for the wood that is produced. Depending on the location of the projects, wood or charcoal may be sold to industries (e.g., smelters, drying facilities, cement manufacturers, and pottery makers), marketed in the cities, or exported. In addition, farmers may sell wood to dendrothermal powerplants with deficient fuelwood supplies.

By the end of 1984, after 2 years of operation, more than 360 tree farmers associations had been organized and 18,000 ha had reportedly been planted (Surtida 1984). Reliable surveys have not been conducted to determine the area of surviving plantations.

Under TANGLAW's School Plantings Project, 2,000 pesos ($154 at 1983 exchange rates)/ha are loaned to agricultural colleges, State colleges, and other schools for planting and managing tree farms. As with the Family Tree Farm component, marketing strategies depend on the location of the plantation. More than 1,600 ha had been planted by schools by the end of 1984 (Surtida 1984).

2.2 Farm Systems Development Corporation Programs

The FSDC is a government-operated corporation that provides technical and financial support for rural development. Since 1980, the FSDC has actively promoted tree farming as a means of increasing rural farmers' income.

In mid-1984, the FSDC reported 2,341 ha of surviving energy plantations, mostly in the western Visayas and Mindanao (NEA 1984a). The FSDC tree farmers are organized in associations similar to those in the NEA programs. The FSDC loans money, provides advice and funds for building charcoal kilns, transports wood, and makes market contacts for farmers. Wood from tree farms is converted to charcoal for sale in the cities or for export. The FSDC program has been less successful than the two NEA programs because loan resources are more limited and the FSDC lacks the organizational advantages of working with the rural electric cooperatives and schools.

2.3 Ministry of Human Settlements Programs

The MHS promotes energy plantations in conjunction with its housing and resettlement programs and the Kilusang Kabuhayan at Kaunlaran Livelihood Program. Over 2,700 ha had been planted by mid-1984. Eight hundred ha have been planted in Negros Occidental alone. Significant areas have also been planted in the Ilocos region, in central Luzon, and in southern and central Mindanao (NEA 1984a).

2.4 Bureau of Forest Development Programs

The BFD reports developing 22,750 ha of fuelwood plantations since 1979. More than one-fourth are in the province of Cagayan in northeastern Luzon (NEA 1984a). The BFD uses a "communal tree farm" approach that provides upland farm families with technical assistance, seeds and seedlings, and legal access to land.

The BFD also allows private companies to develop energy plantations on government land under its Industrial Tree Plantation (ITP) Program. Tax exemptions, credit priority, export privileges, and other incentives are provided along with low-cost 50-year land leases. Only a few ITP licenses have been granted, however, and little or no planting has been accomplished.

2.5 Other Government Programs

A few provincial, municipal, and barangay (village) governments are developing tree farms, usually in response to directives from Manila requiring local governments to establish energy plantations. Compliance is far short of universal, however, and successful local government plantations are seldom seen. The local programs usually lack financial resources, technical expertise, and a clear definition of target beneficiaries.

2.6 Nongovernment Initiatives

Several foreign assistance organizations (e.g., U.S. Agency for International Development, World Bank, Asian Development Bank, and private voluntary organizations) now support energy plantation development with varying degrees of success. In addition, a growing number of private corporations and individuals are producing trees for fuelwood, especially in areas where dependable markets exist (e.g., Ilocos tobacco-growing region, western Visayas sugar-producing region, and areas surrounding dendrothermal plants, smelters, potteries, etc.). These private initiatives are often more successful than government projects because trees are planted on better quality land and more protection is given to young plantations. Because nongovernment plantations are so widely dispersed, however, no accurate estimates of their total area or standing volume are available.

3. Plantation Establishment

Plantation establishment procedures vary throughout the Philippines with climatic, edaphic, social, and economic differences. Nonetheless, common activities and experiences can be presented.

3.1 Plantation Location

With a population density of 184 people/km^2, intense pressures are placed on the Philippine land base. As a result, most quality lowland is occupied by agricultural fields, industrial facilities, houses, or roads. Energy plantations and associated forestry production activities are usually relegated to roadless sites, which are steep, rocky, and infertile.

Surveys of NEA and FSDC energy plantation sites reveal that trees are often planted on 40- to 60-degree slopes. Soils with pH below 5.0 predominate at some locations. Dry seasons typically last 5 to 7 months at many project sites. The lack of roads and trails at mountain sites complicates seedling distribution, silvicultural activities, and marketing of wood.

Most land now being developed by NEA, FSDC, and MHS programs was previously under the management of the BFD.

The BFD has frequently been accused of refusing to relinquish control of its better lands to other agencies.

In some areas, powerful politicians have influenced planners to locate projects so as to provide maximum employment and benefits for their constituents or hometowns. Not surprisingly, site selection based more on politics than on silvics has generally produced poor results.

3.2 Species Selection

Giant ipil-ipil is the most common species grown in Philippine energy plantations, making up at least 90 percent of the total area planted. The tree grows rapidly, fixes nitrogen in the soil, is easy to manage, and coppices readily after harvesting. In addition, its wood makes excellent fuel and charcoal, and its leaves make high-protein livestock feed (National Research Council 1984). Leucaena grows poorly, however, at altitudes above 500 m or where soil pH is below 5.5.

In the early years of energy plantation development, many sites planted with ipil-ipil were better suited for other species. The results were sometimes disastrous. Of 1,031 ha planted at one dendrothermal project site, for example, only 10 ha survive.

More effort is now being made to diversify. Trials have been established in four areas of the country to systematically assess the potential of 18 other species. After 2 years, *Gmelina arborea* Roxb., *Acacia auriculiformis* A. Cunn. ex Benth., *Acacia mangium* Willd., *Gliricidia sepium* (Jacq.) Steud., *Albizia lebbek* (L.) Benth., *Calliandra calothyrsus* Meissn., *Cassia spectabilis* DC., and several eucalypts are demonstrating the most potential.

3.3 Site Preparation

Although secondary forests are occasionally converted to energy farms, plantations are usually established on grasslands or brushy areas. Therefore, clearing can usually be accomplished without chain saws or heavy equipment.

Competing vegetation is removed from planting sites by slashing it with bolos (machetes). Slashing is often followed by burning. Although most sites are too steep or rocky to permit it, plowing has been successful in some areas (Cadaweng 1985). Plowing is costly, but it effectively reduces competition and allows farmers to grow food crops during the year following plantation establishment.

In some areas, farmers dig holes for the seedlings several weeks prior to the rainy season so that planting can proceed quickly when the rains begin.

3.4 Planting

Virtually all tree planting in the Philippines is done by hand. The spacing most often recommended for energy plantations is 1 m x 1 m, or 10,000 trees/ha. Best survival is attained when container-grown seedlings are planted, but direct seeding is more common at most plantation sites. Bare-root seedlings have been planted successfully at a few locations but are not used extensively. Where soil and water conditions are favorable, direct seeding can be just as successful as planting seedlings, and it is much more economical because nursery operations are unnecessary. Direct seeding sometimes results in stands that are overstocked, however, because farmers tend to plant several seeds at each hill. With good germination, a stand of 20,000 to 30,000 stems/ha may result, and few of the stems will grow to desired diameters.

In many places, a crop of upland rice, corn, beans, or root crops is planted before or simultaneously with the seedlings and harvested before the tree canopy closes. These crops provide food and additional income for farmers, which helps offset their outlays for planting. By cultivating crops simultaneously with trees, competing weeds and grasses are more effectively suppressed.

In addition, where such crops are planted, farmers tend to be more active in protecting their plantations from fire and grazing livestock.

3.5 Weeding

Plantations must be weeded frequently until trees reach a height of 1.5 to 2 m, or until the canopy begins to close and the trees are able to compete effectively with grasses and weeds. Tenacious grasses such as cogon (Imperata cylindrica (L.) Beauv.) and talahib (Saccharum spontaneum (L.)) are usually the most troublesome. At least three weedings about 2 months apart are necessary before trees overtake the grasses. On poorer sites, several more cleanings may be required.

Grasses and weeds are customarily cut by hand with curved grass-cutting blades or bolos, but at least one project is having considerable success with herbicides (Cadaweng 1985). After grasses and weeds are cut, they are placed at the base of the young trees for mulch.

3.6 Fertilization

Various fertilizer formulations and application rates are recommended at plantation sites. The recommendations are often ignored, however, because of the high cost of fertilizer. A partial solution suggested by Johnson (1985) calls for more careful matching of species to sites, thus minimizing the need for fertilizer.

3.7 Labor and Material Requirements

Labor and material requirements for plantation establishment vary considerably with conditions at each planting site and with the method of establishment. Based on 4 years' experience at 44 project locations, the NEA Dendro Thermal Development Office has estimated the average requirements for establishing leucaena plantations (table 3). Similar requirements have been observed for other species.

4. Plantation Maintenance and Protection

After trees reach 2 m in height, a minimum of maintenance is required. A member of the tree farm family may occasionally visit the plantation to guard against wandering livestock, wildfires, and illegal woodcutters, but plantations are seldom checked more than two or three times a week after the first growing season.

In areas of high fire danger, some farmers build firebreaks around their plantations, but most do not. Firebreaks are seldom more than 2 or 3 m wide and are rarely adequate for stopping major fires.

Serious psyllid (Heteropsylla cubana Crawford) infestations are now being encountered in many leucaena plantations. Although the defoliators can be controlled by spraying with systemics (Nitrogen Fixing Tree Association 1986), most farmers are reluctant to invest in insecticides to protect trees. They prefer to allow the infestation to run its course, confident that the trees will survive. Most trees do survive, but growth is severely curtailed by the defoliations.

Planners and project managers have frequently discussed thinning options for plantations (Dugan 1985; Forest Engineering Incorporated 1984; Paper Industries Corporation of the Philippines 1985). Thinning would be beneficial, especially where direct-seeded stands have over 10,000 stems/ha. To date, however, very little thinning has occurred. Many managers are afraid that encouraging farmers to thin will lead to overcutting. Conversely, many farmers are reluctant to cut any trees before they reach final harvest age, since they believe that all stems--even those in dense stands--will reach a desired large diameter if allowed to grow. Others feel the returns will not offset the labor and marketing costs associated with thinning.

Table 3.--Labor and material requirements per hectare for three methods of establishing leucaena energy plantations in the Philippines

Activity	Direct seeding	Container-grown seedlings	Bare-root seedlings
	- - - - - - -	Worker-days	- - - - - - - -
Nursery Establishment			
Clearing/brushing	--	1	1
Nursery bed preparation	--	1	2
Top soil collection	--	3	--
Bagging/potting	--	10	--
Sowing	--	--	1
Maintenance and care	--	5	5
Lifting	--	--	1
Trimming	--	--	1
Mud puddling/packing	--	--	1
Plantation Establishment			
Clearing/brushing	25	20	25
Staking	4	4	4
Hole digging	26	21	21
Planting	15	15	15
Transporting seedlings	--	10	10
Plantation Maintenance			
Fertilizer application	5	5	5
Pesticide application	2	2	2
First weeding	25	25	25
Second weeding	25	20	20
Third weeding	20	15	15
Firebreak construction	15	15	15
Total	162	172	169
Materials			
Seeds	2.5 kg	1.5 kg	2.0 kg
Plastic bags	--	12,000 pieces	--
Fertilizer	1 bag	1 bag	1 bag
Pesticide	1 qt	1 qt	1 qt

Source: Dendro Thermal Development Office, National Electrification Administration, Philippines.

5. Growth and Yield

Growth rates of energy plantations vary tremendously, depending on the quality of management and the site. On experimental plots, growth often averages well over 100 m^3 (40 t)/ha/yr (Bawagan and Semana 1977), and this level has been approached under operational conditions on favorable sites (NEA 1985).[1] Experience at NEA plantations indicates growth rates range from less than 20 m^3 (8 t)/ha/yr to 90 m^3 (36 t)/ha/yr (table 4). Growth averages between 40 and 60 m^3 (16-24 t)/ha annually (Gaudie and Moore 1985; MacDicken 1985; NEA 1985; Van Den Beldt 1984).

[1]Unless otherwise indicated, m^3 refers to a stacked cubic meter, or stere, of wood. The weight of a stacked m^3 of giant ipil-ipil wood averages 400 kg.

Table 4.--Estimates of growth at selected National Electrification Administration energy plantations in the Philippines

Name and location	A	B	C	D	Mean
	m^3/ha/yr[1]				
ABRECO, Abra	42	55-73	NA	60	55
ANTECO, Antique	53	33-50	38	40	43
BOHECO, Bohol	27	25-35	NA	23	27
CAPELCO, Capiz	53	50-65	NA	38	51
CASURECO IV, Camarines Sur	NA	80-98	50	83	77
FICELCO, Catanduanes	31	48-63	NA	20	36
INEC, Ilocos Norte	33	25-43	25	28	29
ISECO, Ilocos	82	61-80	75	63	73
ISELCO II, Isabela	53	45-50	50	NA	50
OMECO, Occidental Mindoro	NA	50-60	63	50	56
PANELCO I, Pangasinan	39	63-75	63	88	57
Mean	46	49-63	52	49	50

NA = Not available.

[1]Stacked m^3 (steres) averaging 400 kg green weight.

Sources: Column A, Gaudie and Moore (1985); Column B, MacDicken(1985); Column C, NEA (1985); Column D, Van Den Beldt (1984).

Under average conditions, trees that are to be utilized for firewood or charcoal can be harvested after 3 years. Subsequent coppice crops are harvestable after 2 years. Plantations producing fuel for dendrothermal powerplants are allowed to grow 3 to 5 years before the first harvest. By then, trees normally range from 5 to 13 cm in diameter at breast height (d.b.h.), depending on stand density, site quality, and growing conditions. Coppice crops reach harvestable size in 2 to 4 years.

6. Harvesting

Most energy plantations are clear-cut 15 to 25 cm above the ground at time of harvest. Small branches and tops are trimmed from the stems and left in the field where the trees are felled.

If the trees are sold directly as fuelwood, they are carried or dragged to the roadside where they are bucked and stacked. If charcoal production is desired, trees are forwarded to kilns before bucking.

6.1 Tools and Equipment

Harvesting of energy plantations in the Philippines is nearly always done with chain saws, bolos, or both.

Many of the larger operations employ chain saws, primarily to speed up harvesting activities when contracts require wood to be delivered by a specific date. Chain saws may also be used when labor is temporarily in short supply.

At some plantations (e.g., CASURECO IV, Camarines Sur), trees are felled by chain saws, then limbed and trimmed by laborers using bolos. At FICELCO (Catanduanes), trees are felled and limbed by bolo; chain saws are used only to buck logs to the length desired by the buyer.

Original plans called for farmers at all dendrothermal project sites to harvest their trees with rented chain saws. At PANELCO I (Pangasinan), however, where the most harvesting experience has been gained so far, farmers have abandoned the use of chain saws in favor of bolos. The high costs of fuel, along with unfamiliarity with chain-saw operation and maintenance, are identified as the main reasons for wanting to return to bolo harvesting. Chronically dull and improperly adjusted chains, broken chains, and poorly tuned engines are common problems.

Studies by Hodam and Associates, Inc. (1985) and the International Labor Organization (Laarman and others 1981) support the use of handtools over chain saws for harvesting small trees. Hodam and Associates, Inc. (1985) recommend the following guidelines for harvesting fuelwood plantations:

- Trees up to 8 cm in diameter should be felled, topped, and bucked with bolos.
- Axes should be used to fell and top trees with diameters greater than 8 cm.
- Bow saws should be used for bucking trees larger than 8 cm in diameter.
- Cutting with chain saws is much more expensive than cutting with bolos, axes, and bow saws; therefore, the use of chain saws should be avoided.

Although in the International Labor Organization studies, handtools were found to be cost competitive with small chain saws, bow saws were recommended over axes or bolos because of faster cutting speed and smaller kerf (Laarman and others 1981). The International Labor Organization studies were conducted in plantations of *Albizia falcataria* (L.) Fosb., where tree diameters are somewhat greater and wood is less dense than in most energy plantations, however. Additional research with

small-diameter trees and denser species is necessary to reconcile apparent inconsistencies between the recommendations of the Hodam and Associates, Inc., and International Labor Organization study teams.

Citing results of the Hodam and Associates, Inc., studies, the NEA has provided some cooperatives with bow saws and axes. These tools have not been widely distributed, however, and it remains to be seen how well they will be accepted by tree farmers and laborers.

Costs of harvesting tools and equipment are shown in table 5. At this time, only bolos are readily available throughout the country.

Table 5.--1984 purchase prices of tools and equipment used for harvesting energy plantations in the Philippines

Equipment	Purchase price	
	Pesos	Dollars
Bolo (machete)	50	2.70
Ax	150	8.11
Bow saw	200	10.81
Chain saw		
Small (14 to 16 in. bar)	6,000	324.32
Large	14,000	756.76

Source: Hodam and Associates, Inc. (1985).

6.2 Production Rates

Harvesting production rates vary with the skill, strength, and stamina of operators and laborers; the equipment used; the topography of the plantation; the density and size of the trees; the climate; and other factors.

Studies conducted by Hodam and Associates, Inc., (1985) indicate that a laborer can cut, top, buck, and stack an average of 2.5 m^3 (1 t) wood/day with handtools. Field experience at PANELCO I, however, has shown that laborers average only 1.5 m^3 (600 kg)/day if harvesting with bolos alone (Bedano 1985). Harvesting stands of average yield (200 m^3/ha after 4 years of growth) requires about 135 worker-days/ha.

At FICELCO, laborers using bolos fell an average of 120 trees (8 to 13 cm in diameter)/day. About 50 trees are limbed and topped per day by each laborer.

At CASURECO IV, each worker fells an average of 30 m^3 wood/day with a chain saw. Other workers then trim and stack the wood by hand.

6.3 Labor Costs

Laborers who harvest energy plantations are paid in one of two ways: (a) based on a daily wage scale, or (b) according to work performed ("pakyao" system).

Daily wages for wood cutters most often reflect the prevailing rates for unskilled labor. This rate ranges from 20 pesos ($1.08)/day, or less, to as much as 35 pesos ($1.89)/day. Some government-supported projects pay their laborers according to minimum wage standards (36 pesos or $1.95, per day in 1985), even though such rates are often significantly higher than those paid by private enterprises, which often ignore legislated wage standards in rural areas. Chain-saw operators are considered semiskilled and command daily wages ranging from 5 to 15 pesos ($0.27 to $0.81) above those for other laborers.

The pakyao method of compensation is preferred by project managers and administrators at most sites. The system allows laborers to work at their own pace and set their own hours of work. At PANELCO I, where farmers are paid 43.33 pesos ($2.34)/$m^3$ by the cooperative, some farmers reportedly subcontract the harvesting of their trees to other laborers. Using a pakyao system, tree farmers pay laborers 15 to 20 pesos ($0.81 to $1.08)/$m^3$ for harvesting. Laborers cutting 1.5 m^3/day therefore earn 22.50 to 30.00 pesos

($1.22 to $1.62). The total labor cost of harvesting a hectare yielding 200 m^3 is 3,000 to 4,000 pesos ($162 to $216).

All of the cooperatives operating dendrothermal powerplants now use the pakyao system to purchase wood on a volume or weight basis. Prices range from 25 pesos ($1.35)/$m^3$ at CASURECO IV to 60 pesos ($3.24)/$m^3$ at INEC (Ilocos Norte), delivered to roadside or cable-side loading points. These rates increase to 30 pesos ($1.62) and 85 pesos ($4.59), respectively, if wood is delivered to the powerplants. Payments compensate both the stumpage value of the wood and the labor required to harvest and move it to assembly points or the powerplants.

7. Forwarding

Rugged topography, and the lack of roads and trails, makes forwarding wood from its point of harvest to loading stations along roads or cableways one of the most challenging tasks at energy plantations.

7.1 Initial Forwarding Plans

The government's early plans for forwarding called for the use of motor-driven skylines at several plantations. These portable "feeder winches" were to forward wood to loading stations along the primary wood transport systems. The NEA made an initial purchase of 20 winches from Austria in 1981 and 1982. The cost, in 1985 terms, was nearly 500,000 pesos ($27,000) each.

CASURECO IV is the only cooperative using the winches at this time. Project managers report forwarding an average of 50 m^3 wood/day/unit. However, experience at CASURECO IV has shown that the winches take considerable time and skill to set up; that they are not easily transported to rugged, roadless areas; and that fuel and maintenance costs are significant.

7.2 Current Practices

Currently, most forwarding depends on manpower alone. Workers carry or skid logs down mountain slopes without any animal or mechanical assistance. The process is difficult, time consuming, and often dangerous. Moreover, the difficulty of manual forwarding means that tree farmers are reluctant to cut trees located far from pickup points or in locations that require crossing adverse terrain.

Only a few exceptions to the common practice of manual forwarding have been observed. At the CASURECO IV dendrothermal project, three operations are sometimes used to move wood to a truck loading point. From where it is harvested, wood is first carried a short distance to a hand-winch cable system. The hand winches, which have a capacity of about one-third of a m^3, feed to motor-driven skylines (described above). Each skyline carries between 1.5 and 2 m^3/trip and deposits wood directly at a truck loading point.

At Bolinao (PANELCO I), the cooperative uses trucks to help forward wood to loading stations along the monocable loops which serve as the primary transport system for the plantation. The potential for forwarding wood by trucks is limited, however, by the opportunities to construct roads within the plantation.

7.3 Future Alternatives

Several proposals have been advanced to help solve the forwarding problem. The most notable include suggestions for hand winches, carabao (water buffalo) skidding, polyethylene pipe slides, carabao-powered cable yarding, and small low-cost motor-driven "swing" winches (Forest Engineering Incorporated 1984; Hodam and Associates, Inc. 1985).

In Masipiquena's detailed studies (1982), carabao skidding proved attractive. His studies determined skidding standards for various distances, load sizes, gradients, and skidding devices (sledge, cone, pan). Skidding production ranged from 2.80 m^3/day under adverse conditions (skidding distance of 500 m, adverse slope of 20 percent, load size of 0.2 m^3) to 17.94 m^3/day under

favorable conditions (skidding distance of 50 m, favorable gradient of 20 percent, load size of 0.4 m^3). Under most conditions, production of at least 5.0 m^3/day was attained. Carabao forwarding is not practical on steep adverse slopes or unstable soils, and carabaos cannot work in midday heat, but carabao skidding may prove to be a low-cost forwarding option at many sites.

At Barbaza, Antique, plans call for tests of hand-operated and carabao-powered cable systems capable of handling the forwarding needs of a 24-ha FSDC plantation. The system is expected to cost less than 60,000 pesos ($3,250).

Polyethylene pipe slides are suggested for moving wood down especially steep or rugged mountain slopes (Hodam and Associates, Inc. 1985). The 50-cm pipes come in 12-m lengths that can be cut lengthwise to form two sections of the slide. Sections can be bolted together to form chutes as long as needed. Wood is placed in the chutes at any point and slides downhill by gravity. The chutes are portable, since sections can be moved and reassembled wherever needed. Initial investment for the chutes is relatively high (460 pesos, or $25, per m), but the slides are expected to last for at least 20 years.

Opposition to implementing the alternative skidding proposals focuses on five arguments:

1. Farmers and project personnel are unfamiliar with the new forwarding technologies, and considerable training might be required before they could be implemented.

2. The technical and economic feasibility of several of the proposed technologies is unproven.

3. Cables, polyethylene pipe slides, and other equipment may be stolen if left unguarded in the plantations.

4. Resources needed to implement the proposals are not always locally available.

5. Feed stocks to support large herds of carabao are insufficient at some sites (for animal skidding proposal).

Despite these obstacles, many of the proposals will probably be implemented in the future simply because the present methods are inadequate.

8. Wood Transport

Debate continues over the most appropriate technologies for transporting wood from pickup points to utilization areas. Only two transport technologies are presently used--truck hauling and transport by cableway. Both have been criticized as expensive and inadequate for Philippine energy plantations.

8.1 Truck Hauling

Trucking is the most common method of transporting wood. The size and type of trucks used are determined by the quality of roads at each plantation. At ISELCO II (Isabela), for example, 6-wheel-drive logging trucks with 15 to 20 m^3 capacity are best for negotiating the narrow, steep, and muddy roads. At other locations (e.g., INEC, Ilocos Norte), better roads are able to accommodate 10-wheeled flatbed trucks with capacities of 30 to 40 m^3.

Trucks are loaded and unloaded manually. The driver is usually assisted by three or more helpers who receive standard laborer wages. Drivers are considered semiskilled laborers and enjoy somewhat higher salaries.

Local truck prices vary with the age, condition, and size of the vehicles. Small used trucks can sometimes be purchased for 100,000 pesos ($5,400) or less. Larger trucks that have been reconditioned command prices of 250,000 pesos ($13,500) or more. Due to import restrictions resulting from

the Philippines' financial crisis, new large-capacity trucks are nearly impossible to obtain.

Private truckers are hired to haul wood at several plantations. Contractors are paid 6.00 to 8.00 pesos ($0.32 to $0.43)/m^3 for loading and unloading. Transport charges are 2.00 to 3.00 pesos ($0.11 to $0.16)/m^3/km for short hauls and about 1.00 peso ($0.05)/m^3/km for long hauls.

8.2 Cable Transport

Both the NEA and the FSDC expect to use light cableways to transport wood in rugged, roadless areas. After studying transport options in 1979-80, the NEA approved the use of a Swiss-manufactured monocable system because of the following features (Sevilla 1985):

- The system transports light bundles of wood which are easily handled by laborers.
- The system is flexible; it can be relocated as conditions demand.
- Repairs are easily made.
- The system can be powered by electricity produced by the NEA dendrothermal powerplants. Therefore, financial costs are lower than for systems powered by gasoline or diesel engines.

In 1981-82, the NEA purchased 10 cableway units from Switzerland for approximately 5 million pesos ($270,000) each (1985 pesos). The system uses 14-mm-diameter cable in loops up to 13 km in length. The cable is strategically erected to allow loading of wood at several points throughout the plantation. Wood is bundled in slings accommodating about 0.25 m^3 each and hooked to the continuously moving monocable. The cable can be driven by either diesel or electric power and is capable of transporting 12 to 15 t wood/hr.

Despite its reputed advantages, the monocable system has been strongly criticized by independent observers for its high investment cost, inflexibility (despite planners' anticipations), and inappropriateness for the administrative and physical settings at some plantations. Furthermore, the NEA and the FSDC lack personnel with experience to install, operate, and maintain the systems.

Only at PANELCO I has one of the units been fully installed and operated. Eleven laborers are needed to operate the system, but extra workers are sometimes hired on a pakyao basis (at 1.00 peso/sling loaded and hooked to the monocable) to speed loading operations. Although the system is capable of transporting 15 t (37.5 m^3) of wood/hr, production rarely surpasses 11 t (27.5 m^3)/hr (Hinayon 1985). A major problem is forwarding sufficient wood to the monocable to ensure efficient operation.

8.3 Hauling with Carabao Carts

Among the unconventional transport proposals is one to use four-wheeled carabao carts as an alternative or supplement to trucks and cableways. The carts are equipped with mechanical brakes and rubber tires, and have a capacity of at least 2.5 m^3. Similar carts tested by PICOP commonly haul 4.0 m^3 or more. Using all new materials, carts can be fabricated for about 15,000 pesos ($810) each (Hodam and Associates, Inc. 1985).

8.4 Cart and Truck Roads

If trucks or carabao carts are used for hauling wood, adequate road networks must be developed and maintained. At some plantation sites, construction of new roads is necessary. At others, existing roads can be rehabilitated. Recommended road specifications are shown in table 6.

Hodam and Associates, Inc. (1985) estimate the following financial costs for road construction and maintenance:

New truck road construction	70,000 pesos ($3,784)/km
Truck road rehabilitation	13,000-63,000 pesos ($703-$3,405)/km

Truck road maintenance	7,500 pesos ($405)/km/yr
Carabao cart road construction	38,000-50,000 pesos ($2,054-$2,703)/km
Carabao cart road maintenance	5,000 pesos ($270)/km/yr

These estimates assume that heavy equipment can be borrowed from Provincial Engineers' Offices or the Ministry of Public Highways, with the energy projects paying only for fuel, oil, labor, and maintenance. If the cost of renting heavy equipment is included, truck road construction costs increase to about 500,000 pesos ($27,000)/km and cart road construction costs increase to 125,000 pesos ($6,750)/km. Costs were derived from a study by the International Labor Organization (1983).

Table 6.--Specifications for cart roads and truck roads at energy plantations in the Philippines

Features	Cart roads	Truck roads
Design speed	--	45 km/h
Formation width	4 m	7 m
Travel width	3 m	5 m
Turnouts	10 x 2 m	15 x 3 m
Gradients		
Adverse	7% max	7% max
Favorable	10% max	10% max
Curve radius, min.	25 m	100 m
Sight distance, min.	--	40 m
Surface	gravel	gravel
Weight capacity	3 t	20 t

Source: Hodam and Associates, Inc. (1985).

9. Research Needs

A sense of urgency motivated Philippine energy planners in the late 1970's and early 1980's. Action-oriented alternative energy programs were favored over those demanding extensive preliminary research. FSDC, NEA, and MHS programs with ambitious goals were established and funded generously. Planners realized that mistakes would occur but believed that corrections could be made as programs evolved. Serious problems have already emerged, and additional research is needed for programs to remain viable.

9.1 Species Trials

The almost exclusive use of giant ipil-ipil for energy plantations has resulted in very poor stands at some sites. The need to diversify is apparent, but little research of alternative species has been completed. Trials established in 1983-85 must be maintained at least 2 more years to be useful. Moreover, trials should be expanded to encompass a greater variety of climatic and edaphic conditions.

9.2 Economics of Plantation Stocking

Optimal plantation density and rotation age are critical issues for plantation forestry in the Philippines. Most wood-energy specialists agree that the greatest biomass yields are obtained from very densely stocked plantations. But because plantations are usually located on steep slopes and wage rates are relatively low, nearly all aspects of plantation management are performed manually. Therefore, dense stocking means increased expenditures for planting, weeding, thinning, harvesting, transport, and handling.

Several observers have suggested that plantation costs could be reduced significantly by planting fewer seedlings per hectare, intensifying thinning regimes, and lengthening rotations (Dugan 1985; Forest Engineering Incorporated 1984; PICOP 1984). Research in this area must integrate silviculture, biometry, and engineering economics to derive yield and cost functions within an optimizing multirotation framework (Laarman and others 1986).

9.3 Economic Evaluation of Plantation Inputs

Market prices are most often used for the initial analyses of energy projects and alternatives in the

Philippines. Subsidies, taxes, trade restrictions, price ceilings, and minimum wage legislation all distort market prices from the true economic value of commodities and services, however. Since taxes and subsidies are merely transfer payments within society, they do not increase or diminish the total wealth of the country and should not be included in economic analyses. Similarly, price controls and minimum wage laws prevent prices from stabilizing at true economic values. Where unemployment and underemployment are high, workers might gladly accept wages far below legislated minimum rates. In such instances, the opportunity costs of hiring labor are less than the minimum wage rate because laborers will remain relatively unproductive in the absence of the project--society gives up little or nothing when laborers become employed by the new project.

More effective project decision-making can be made if all economic evaluation is based on "shadow prices" that reflect the true social opportunity costs of project impacts. Shadow prices are not always easy to estimate, however. Research is needed to accurately determine what society gives up by committing land, capital, and labor resources to energy projects instead of alternative projects. Only when realistic shadow prices have been estimated for all project inputs can planners be sure of making sound economic decisions.

9.4 Harvesting Studies

The NEA and the FSDC are now encouraging farmers at some sites to harvest with bow saws and axes, in combination with bolos. In light of the differing recommendations of Hodam and Associates, Inc., and International Labor Organization study teams, further research is needed before large investments are made for new harvesting tools.

Studies of the optimum size of trees for harvesting are also needed. These should be coordinated with spacing and rotation studies described above. Woodcutters now seem most productive when harvesting trees that are 4 to 7 cm d.b.h., but harvesting larger stems may be more efficient if bow saws and axes are accepted by farmers.

9.5 Nutrient Cycling Studies

The long-range impacts of repeated biomass harvest on soil fertility are not well understood. The species that is planted, the frequency of harvests, the intensity of removals, and other factors may all influence nutrient cycling. Studies should be implemented immediately to monitor the long-range effects of plantation management on soil nutrient levels. These studies should be coordinated with similar studies in other parts of the world.

9.6 Forwarding and Transport Studies

Considerable testing of proposed forwarding and transport alternatives is needed before the alternatives can be implemented on a large scale. Tests are needed most for technologies that are still largely unproven (e.g., carabao-powered yarders, polyethylene chutes, carabao carts).

Studies of the effects of log length on the economics of transport are also necessary. Currently, most logs are bucked into 1-m lengths at the farm gate. This length permits easy scaling of the wood, but increases handling costs. Consultants (Forest Engineering Incorporated 1984; PICOP 1984) have suggested increasing standard log lengths to 3 to 4 m, or retaining logs in tree-length form. If handling costs can be substantially reduced by transporting longer logs, new scaling techniques should be developed that would allow projects to purchase and transport longer logs.

10. Concluding Observations

Unfortunately, the future of energy farming in the Philippines is largely outside the control of the tree farmers or the sponsoring government agencies. Continued low oil prices will depress the market for industrial fuelwood and charcoal, if not domestic firewood. Also, it is still unclear what type of energy policy will be promoted by the new Aquino government. Furthermore, the country's severe macroeconomic problems may halt the progress of biomass-energy programs even if the new government is strongly committed to the programs.

Philippine wood-energy programs have weathered considerable difficulties already. Many tree farms have failed. For those that remain, income and yields are often less than expected. Harvesting and transport are difficult and expensive. Despite these problems, however, many farmers and administrators have demonstrated the flexibility needed to maintain their programs. If exogenous conditions improve and if programs are supported by additional research, most of the remaining tree farmers are likely to succeed.

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KEYWORDS: Electricity generation, establishment, growth and yield, harvesting, transport, economics.

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