PDWAL916

PRIVATE POWER GENERATION FROM CANE, RICE, AND WOOD RESIDUES

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John Kadyszewski
Project Manager
Bioenergy Systems and Technology
Office of Energy, Science and Technology Bureau
U.S. Agency for International Development

The Bioenergy Systems and Technology Project (BST) of the Office of Energy, U.S. Agency for International Development (A.I.D.), is the keystone of the Agency's efforts to develop biomass energy systems for future commercial power generation in many parts of the developing world. The BST Project concentrates on commercial application and applied research for energy and by-product systems based on crop residues, wood resources and solid wastes, to help developing countries lower their dependence on imports of energy and other critical materials and to establish better trade balances. In particular, diversification is becoming increasingly important for the traditional agricultural commodity industries of sugarcane, rice and forest products, and a number of avenues are promising today.

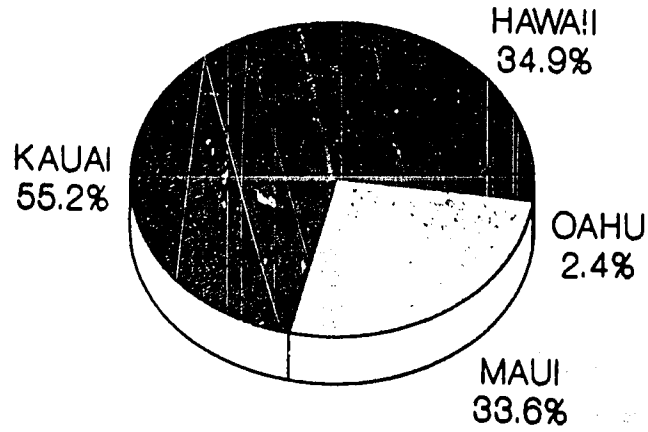
Within the U.S., private power derived from biomass sources has increased tremendously over the past 10 years. Two states that exemplify this increase are Hawaii and California.

I. Hawaiian Experience with Power Generation from Sugar Cane

Private companies in Hawaii historically have been an important source of electricity, particularly the sugar mills. The Hawaiian sugarcane industry provides over 10 percent of electricity statewide and remains the primary supplier of power generation to outer islands' grids, providing from 29 to 63 percent. Hawaii's cane electricity experience has seen a transition from producing only surplus or dump power to one in which almost all mills are providing baseload generation. Concurrently, with changes in the level and reliability of sugar industry power, the sugar industry utility contractual mechanisms have become increasingly sophisticated.

For nearly a century, the Hawaiian sugar industry has produced most of the steam and electricity needed to process sugarcane and to power its factories and irrigation pumps. It also played a major role in establishing electrical utilities on the three largest islands and

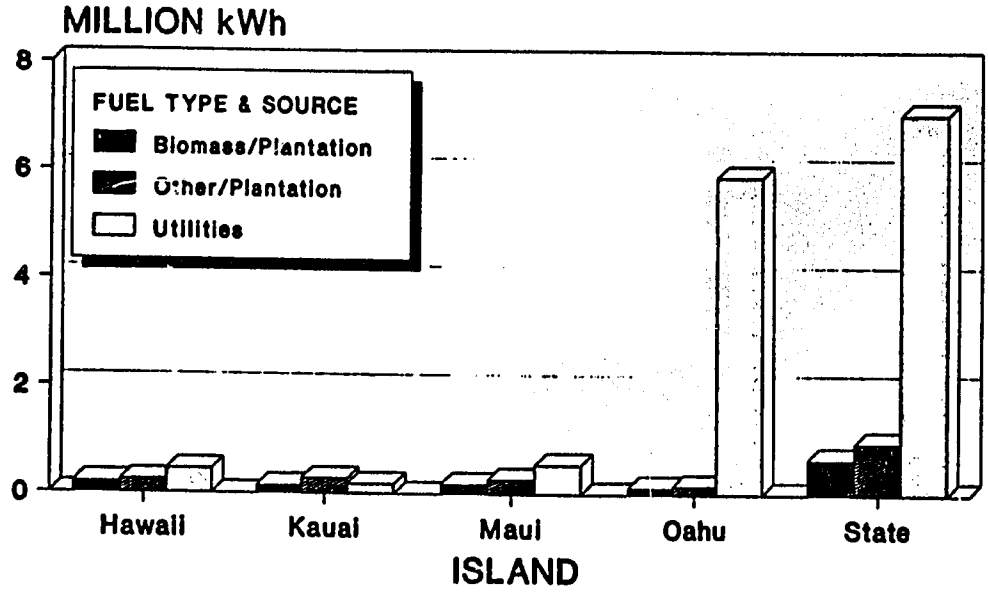
PLANTATION GENERATION
HAWAIIAN ISLANDS (1986)



% Total Elect. from Plantations

Source: HSPA. 1988.

HAWAIIAN ELECTRICAL GENERATION
SUGAR PLANTATION vs. UTILITY (1986)



Source: First Quarterly Report to A.I.D Cane Energy Program, Hawaiian Sugar Planter's Association. Jan. 1988.

produced much of the electricity those utilities distributed in their early years. The association continues; today Hawaiian sugarcane plantations produce more than 815 million kWh annually, as much as two-thirds of the electricity produced in some areas is generated by plantations. About ninety percent of this electricity is produced by sugar factory cogeneration facilities (the remainder is produced by hydroelectric installations). Bagasse (the fibrous by-product of milled sugarcane) represents nearly ninety percent of all boiler fuel burned (First Quarterly Report to A.I.D., Cane Energy Program, Hawaiian Sugar Planters' Association, January 1988).

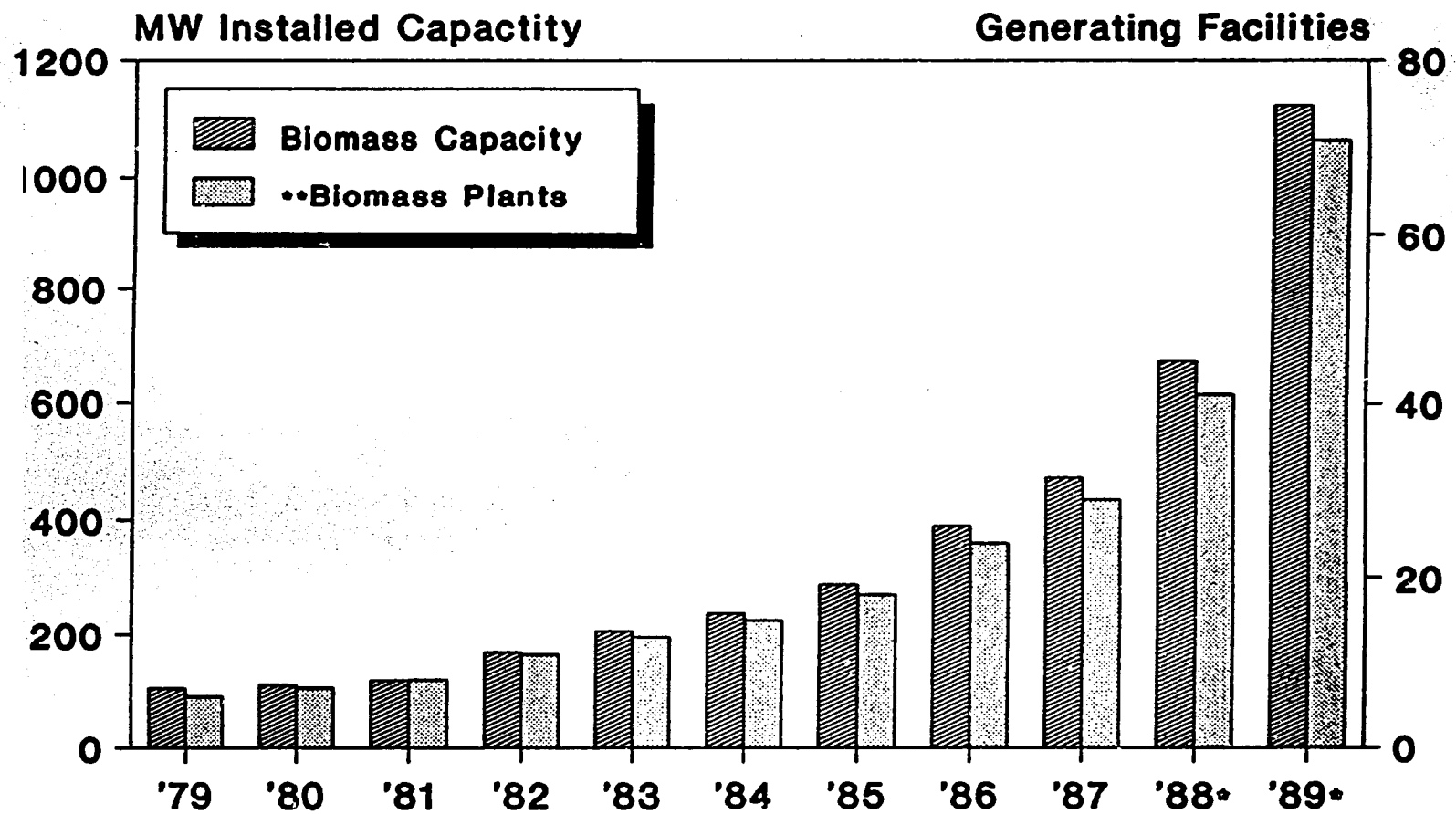
The sugar industry in Hawaii sold 815 million kWh to the utility and had a nameplate installed capacity of 213 MW. The capacity of the largest plant is 40 MW. The smallest plant has a 2 MW capacity. Six mills have contracts to provide firm power to the grid. Others provide power on an unscheduled basis. Power plants at sugar mills run 24 hours per day and in some cases are the most reliable power plants serving the grid. Revenues from sales of power provide approximately 20 percent of the net revenue to the sugar industry.

II. Californian Experience with Power Generation from Biomass

California has been a pioneer and leader in private power development in the United states, especially in contract negotiations, utility management, producer incentives, and financing. As a result of innovative financing, tax laws, and contract procedures, California is one of the most forward looking states in the U.S. in terms of power issues. Since systematizing its contract negotiations in the early 1980s under the Public Utility Regulatory Policies Act (PURPA), California has brought on line significant biomass-based electricity production.

In California, the on-line installed capacity from biomass power plants has increased from 104 MW in 1979 to an estimated 1123 MW for 1989. The number of biomass generating facilities (which are typically 15-20 MW) has also increased from six to over 70 plants during the same period. The California Energy Commission has conservatively estimated that by the end of this year, Californian biomass power plants will have generated more than 7.8 billion kWh for 1989 compared with less than 800 million kWh in 1979. Biomass power generating facilities contribute over 30 percent of all private power in the state. Over 95 percent of this biomass power is derived from lumber and pulp mill wood wastes, three percent is from urban wood waste, and two percent is from agricultural wastes.

BIOMASS POWER GENERATION
The California Experience



SOURCE: Estimates from California PUC
***Under Construction or in Planning**
****Most Facilities are 15-20 MW**

NOTES: 95% Biomass Power Generation is from lumber/pulp mill wood waste; 3% from urban wood waste; and 2% from agricultural waste

III. Results of Rice Residue Report for Indonesia

In 1987 a team from the Bioenergy Systems and Technology Project visited Indonesia to assess the potential for private investment in rice residue power generation. Team members studied the existing rice residue resource base in Indonesia; the technological options available; and the economic, financial and political backdrop under which privately owned, rice residue power installations would have to operate. The findings of that team were published in a report entitled Potential for Private Investment in Rice Residue Power Generation: Indonesia 1987 -- Preliminary Analysis, which is summarized here.

Resource Base Issues

Adequate husk is available in several areas for small (500 kW to 1.5 MW) power plants but there is a lack of adequate husk supply at most individual mills given decentralized milling capacity. Collection/transport of husk would be necessary to supply even small-scale plants.

Straw also is available in sufficient volume but like husk straw is widely dispersed and would require a collection/transport system that does not exist in most regions.

Due to a lack of alternative uses for husk and straw, energy systems could buy the residues but must create a reliable, low-cost residue collection and transport system. Seasonal and geographic production differences and logistics must be considered in plant location. Optimal initial sites may be on-Java.

Technological Issues

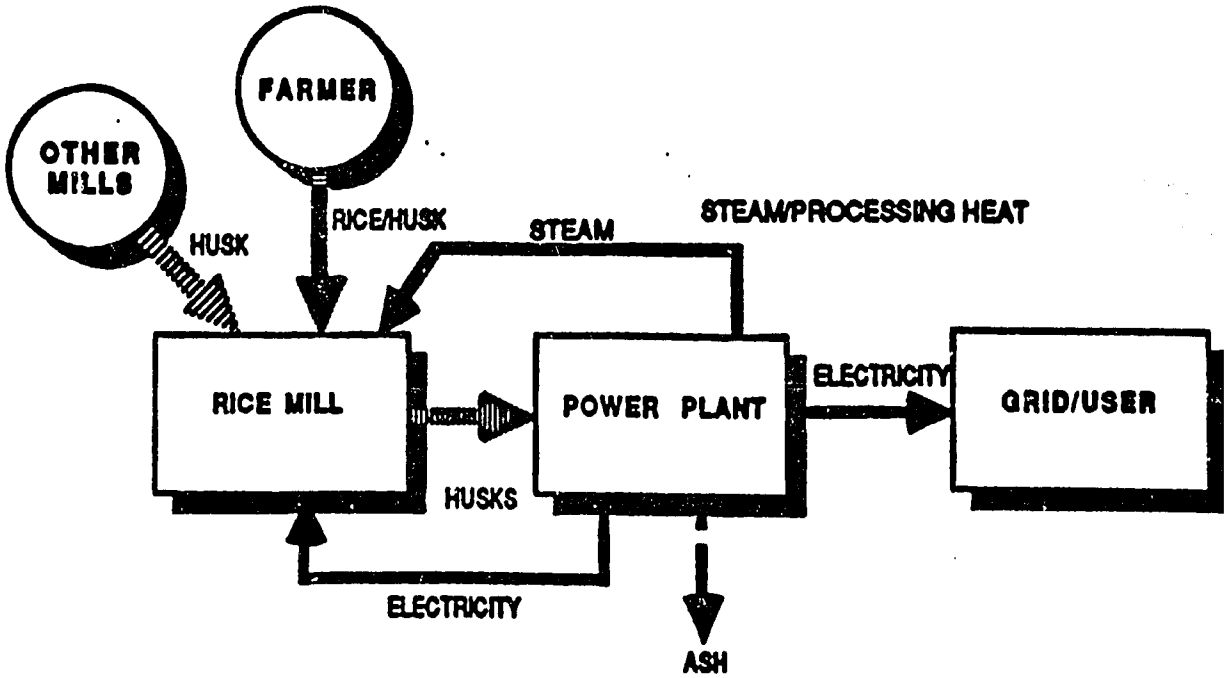
Due to small mill capacity, the current size of commercially demonstrated rice residue power systems is too large for Indonesia.

Downsizing of commercial power systems is needed and is underway by some foreign firms. New smaller systems will still require commercial demonstration.

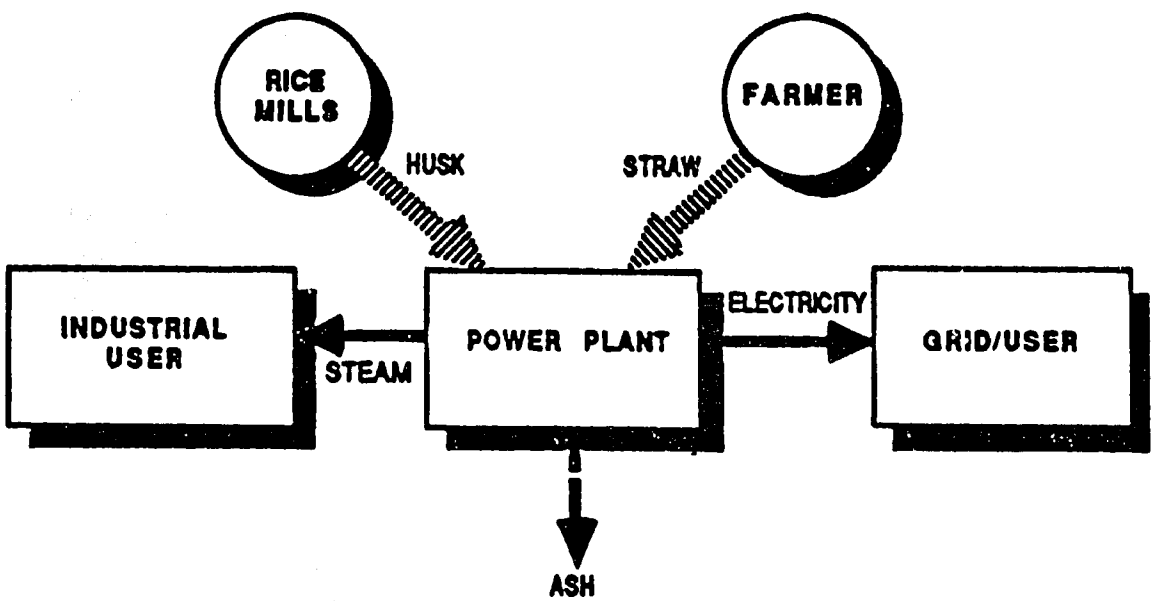
Economic Issues

Analyses of smaller model systems show positive returns over a range of feedstock prices and electricity purchase prices provided that there exists a reliable residue transport system, high load factors and a market for by-product (ash) sales. World markets for ash appear strong. Actual feedstock costs, while a small percentage of total costs, are highly uncertain.

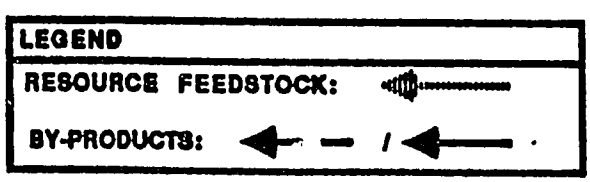
Power plant owners would need to ensure a husk transport network by guaranteeing prices for the feedstock. Firm power contracts for electricity prices must be negotiated and enforceable. Government must guarantee contracts.



Integrated Rice Mill-Power Plant System



Stand-Alone Rice Residue Power System



Financial Issues

Local Indonesian investors require extremely short (1 year) payback periods and high returns (35-45 percent) due to past instability and current conditions for alternative investments. Although firms invest in on-site captive energy use, most feel power generation has high risks due to tax and legal policies that discourage foreign and local ventures.

Incentives need to be provided for private energy investment on a selective basis.

Policy Issues

Rice Policy

Current government policy is to encourage small mills (1 T/hr) to stabilize employment and income benefits and food supply availability.

Production of rice residue power will require either large mills or substantial residue collection systems.

Electricity Policy

The 1985 electricity law allows sale of electricity by private producer, but few cases of private power generation for sale currently exist. The private sector is uncertain of legal and government support.

Further laws or guidelines must be established to ensure that both electricity sales and prices are guaranteed. Ongoing successes need to be publicized.

IV. Rice Industry Experience In Other Places

The rice industry has had a number of successes in implementing residue power systems. Examples of successful rice residue utilization include the Agrilectric power plant at Lake Charles, Louisiana; the PRM power plant in Stuttgart, Arkansas; Oxford Energy's Wadham Power Plant in Williams, California; and the three PRM Plants in Malaysia.

A. In 1984 Agrilectric Power of Lake Charles, Louisiana began producing and selling power from its 10.6 MW rice residue fueled power plant. The plant, which burns 250 tons/day of rice husks, was on-line 92 percent of the time its first year in operation. Eighty-four (84) percent of the power produced is sold to the local power company. The ash is sold to the steel industry for laddle and tundish insulation and as a toxic waste absorbent.

B. The PRM Energy Systems plant in Stuttgart which started operation in 1982, produces heat, process steam, ash, and electricity for internal use. PRM recouped its investment costs within the first 12 months of operation.

C. The Wadham Power Plant, which started its operations on February 24th of this year, will burn 185,000 tons of rice husk and straw a year. This 28 MW plant has a 30-year contract to provide power to the grid. In addition, it will produce 35,000 to 40,000 tons of rice husk ash a year. Husk delivery to the power plant is guaranteed by a 15-year contract with a local transportation company.

D. PRM Energy Systems has also built three rice residue plants in Malaysia for the Malaysian Padi Board. All three are used to produce heat for rice drying; with the addition of boilers and steam turbine generators, they will each produce 400 kW in the near future.

E. In addition to heat, steam and electricity, the burning of rice residues produces ash, which has a number of profitable uses. After burning, about 20 percent of the rice residue remains as ash, 94 percent of which is silica. The ash has a value to the steel industry as laddle and tundish insulation of $200/ton delivered. In addition, its highly absorbent qualities make it an excellent alternative to clay for toxic waste clean-up and for use as cat litter. This latter product is selling in the United States for $1.25 per pound.

The above mentioned U.S. rice husk power systems claim $1 million/year. savings in fuel displacement and equivalent earnings from ash sales.

V. Results of Wood Waste Study in Indonesia

In 1987 the BST Project, in cooperation with private industry and U.S.A.I.D./Jakarta, carried out a prefeasibility study of the prospects for the use of wood waste produced at Indonesian forest product industry sites, especially plywood factories, to substitute for diesel fuel for on-site power generation. The findings of this study were published in a report entitled A prefeasibility Assessment of the Potential of Wood Waste Power Systems for the Indonesian Wood Products Industry: Phase I Report. These findings are summarized here.

At present, wood waste represents up to 50 percent of the total raw lumber entering a plywood factory. This waste is typically piled in heaps and burned, used for landfill, or dumped in rivers and the ocean. Such waste material constitutes a potential energy resource for on-site power generation within the Indonesian wood products industry. Its use as a fuel in generating power at plywood industry sites would mitigate the environmental consequences of its dumping. Wood waste currently produced at Indonesian sawmills and plywood factories is sufficient to power some 1,000 MWe of distributed small steam power plants. Moreover, the widespread use of this technology ultimately could provide significant power for economic and social development on Indonesia's outer islands; establish new private sector initiatives for the production, sale, installation, and maintenance of wood waste power systems; increase the stability of the private wood products industry; permit an increase in diesel fuel exports; and improve the environmental and health conditions of the plywood manufacturing industry.

The A.I.D. report indicates that even with the present 50 percent subsidy of diesel fuel in Indonesia, small (ca 2.5 - 3 MWe) integrated standardized wood waste-fired power plants could be economically attractive. Wood waste at the plywood plants would be sufficient to support approximately 150 MW of distributed captive power which would be consumed entirely on the individual sites. Wood waste produced at sawmills would be more difficult to use as a fuel for power generation, but the resource could support ca. 800 MWe of distributed capacity, most of which would not be required for the sawmills themselves.

Preliminary financial analysis suggests that even under the present conditions of highly subsidized diesel fuel prices such installations are commercially attractive. Several alternative approaches to introduction and commercial diffusion of the technology are possible. One approach is for a U.S./Indonesian joint venture firm to build, own, and operate such plants on-site, using wood waste supplied under a long-term contract by the plywood mill as the fuel for modular power generation units. A second approach is for one or more firms to build, operate, and transfer these plants to those mills interested in ownership of the power generation units. In both cases several financing approaches are possible, including a mix of debt and equity financing from sources including the Asian Development Bank (ADB), the International Finance Corporation (IFC), and the private investment arm of U.S.A.I.D.

Project Economics

The analysis conducted as part of the Indonesian Wood Power Study suggests that even with the present 50 percent subsidy of diesel fuel in Indonesia, a 2.5 MWe wood waste-fired power plant would be fully paid for in six years or less, with a 25 percent return on equity. This return would be earned through savings in diesel fuel costs alone, assuming that the wood waste is available at no cost for use as fuel. If the operation and maintenance costs and short life of diesel generators are also included in the analysis, the effective payback time becomes even shorter. If the Indonesian government were to phase out the present diesel fuel subsidies over a five-year period (starting in 1990 - the projected first year of plant operation), the payback time would decrease to three years and the return on equity would be 60 percent.

VI. Use of Wood Waste for Energy in the U.S.

In the United States, direct combustion of wood now rivals hydroelectric and nuclear power in energy produced. Over the past decade, wood energy consumption in the United States has increased in all four sectors: commercial, industrial, residential, and utility.

During the 1970s, dramatic growth in wood energy use occurred as high-priced oil was displaced in many predominantly industrial and residential thermal applications. By the end of the 1970s, there were over 3000 commercial, institutional, industrial, and utility combustors in the United States using wood as the primary fuel source.

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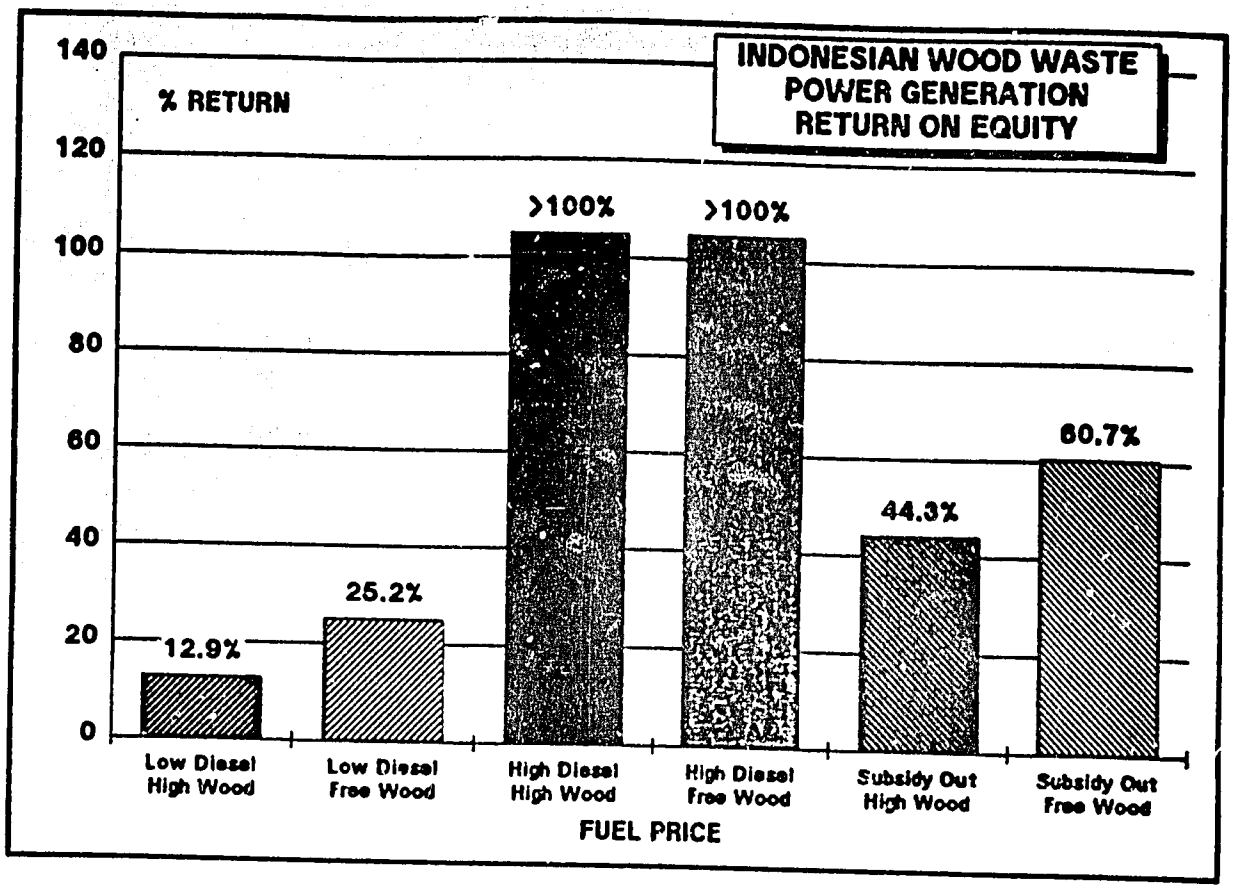
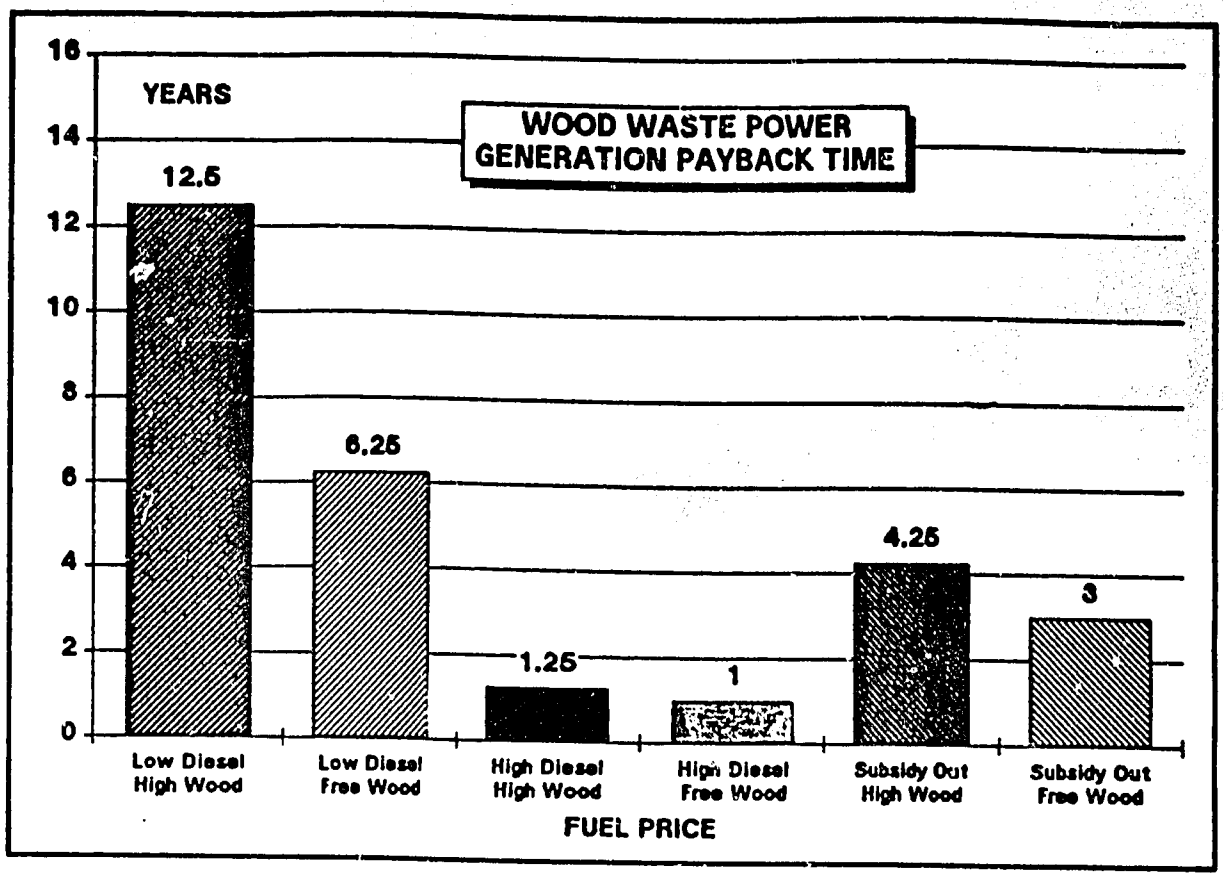
RETURN ON EQUITY FOR AN INVESTMENT IN
WOOD WASTE-POWER GENERATION SYSTEMS
IN INDONESIA*



* The six fuel price scenarios shown are defined in Table 1-2 and discussed further in Section 5 (Project Economics and Financing)

PAYBACK TIME FOR AN INVESTMENT IN WOOD WASTE-POWER GENERATION SYSTEMS IN INDONESIA*



* The six fuel price scenarios shown are defined in Table 1-2 and discussed further in Section 5 (Project Economics and Financing)

During the 1980s, an equally dramatic growth has occurred as electricity is being produced from wood to offset the high price of electricity from nuclear plant overruns or oil fired plants. Several hundred wood and biomass power production plants are coming on-line in the mid-1980s with over 1000 MW of wood energy in California alone.

Other uses for wood energy are expanding as well. Wood gasification is being used in agriculture, industry, and commerce. Wood liquifaction into methanol, an alcohol fuel which can be blended with gasoline or used in its pure form, serves as an important transportation fuel of the future. Even a 10 percent market penetration of methanol fuels would displace one million barrels of petroleum per day at current consumption levels.

The major markets in the United States that have contributed to the development of the wood energy industry are the lumber and pulp and paper sectors in the 1960s and 1970s; the residential and non-forest sectors in the 1970s; and the utility sector in the 1980s.

Pulp & Paper

In the 1980s the U.S. pulp & paper industry remains the largest consumer of wood fuel in the industrial sector. Almost 50 percent of all wood fuel is consumed by this industry, and wood supplies approximately 70 percent of this industry's energy needs. There exists a strong correlation between wood consumption and the out-put of the pulp & paper industry.

Lumber

The U.S. lumber industy has been the second largest consumer of wood fuel in the industrial sector in the 1980s, using almost 20 percent of wood fuel primarily for thermal applications.

Non-Forest Industries

Nearly 10 percent of the nation's wood fuels goes to the non-forest products industry which amounted to 51 trillion BTUs of wood consumed in the early 1980s. In some instances electrical energy was produced from biomass resources and sold to local utilities on a cogeneration basis.

Utilities

Some utilities burned wood for electricity in the U.S. between 1980-1983 with the largest facility generating 56 MW. Over 200 utility-interconnected plants (PURPA QF's) have been coming on line since 1983 in the 10-50 MW range.

Presentation to Indonesia Private Power Workshop
March 7 - 9, 1989

I. Hawaii experience with power generation from sugar cane (2 slides)

A. Technical data
1. Installed capacity
2. Number of generating facilities
3. Total number of kWh generated by year
4. Reliability

B. Financial Data
1. Total revenue earned by sugar industry from power sales by year
2. Power revenue as percentage of total sugar industry revenue

II. California Experience with power generation from biomass (2 slides)

A. Technical data
1. Increase in installed capacity over past ten years.
2. Increase in number of generating facilities
3. Increase in total number of kWh generated by year
4. Distribution of biomass power facilities by fuel source

B. Financial data
1. Contribution of independent power generators to state economy
2. Estimated investment in biomass power facilities

III. Results of rice residue report for Indonesia

A. Slides of Indonesian rice facilities

B. Slides with findings from study
1. Technical conclusions
2. Economic/financial conclusions

IV. Rice industry experience in other place

A. Agrilectric (2 slides)
1. Picture of plant
2. Data on plant

B. PRM (2 slides)
1. Picture of plant
2. Data on plant

C. Oxford (2 slides)
1. Picture of plant
2. Data on plant

D. PRM Malaysia (2 slides)
1. Picture of plant
2. Data on plant

E. Mah Boon Krong - Thailand
   1. Picture of plant
   2. Data on plant

F. Byproduct slides (ladle insulator, kitty litter, Enviroguard, etc.)

V. Results of wood study for Indonesia

A. Slides of plywood factories in Indonesia (Jezek)

B. Slides with findings from study
   1. Technical conclusions
   2. Economic/financial conclusions

VI. Use of wood wastes for energy in the United States

A. Growth of installed wood-fired electric capacity

B. Any slides of existing wood installations we can find

C. Percentage of energy for wood products industry provided by wood wastes