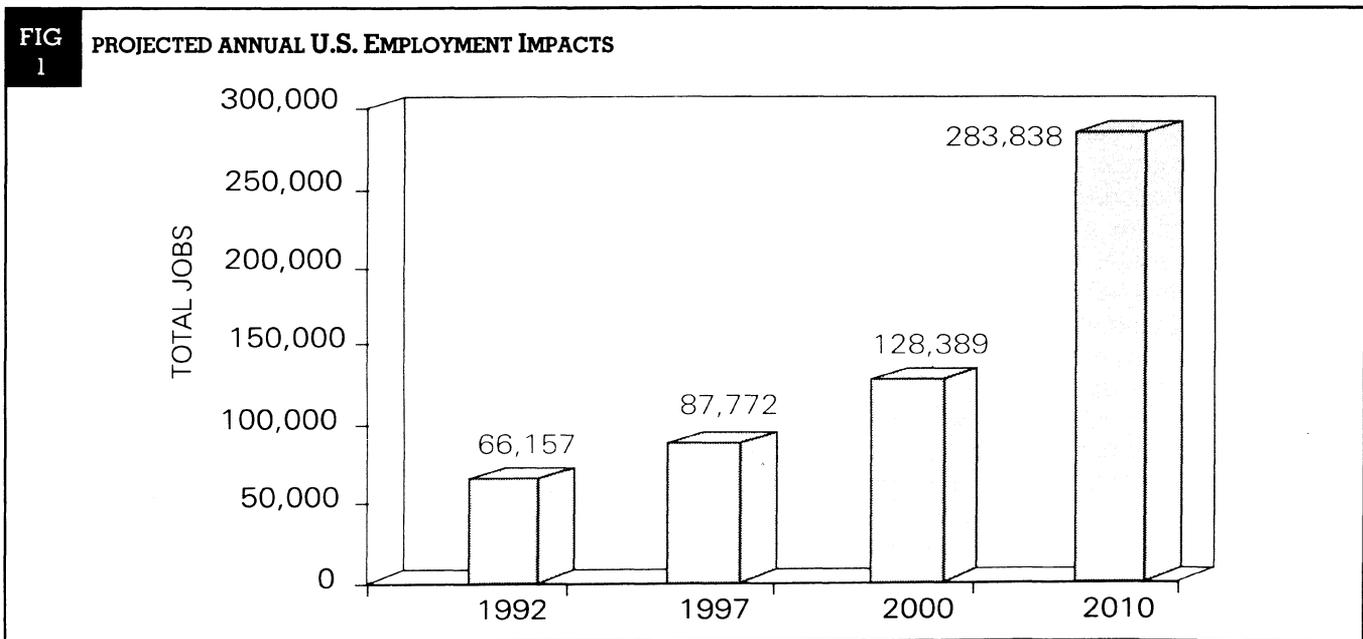


ECONOMIC BENEFITS OF BIOMASS POWER PRODUCTION IN THE U.S.

BY MERIDIAN CORPORATION AND ANTARES GROUP INC.

In 1992, the use of wood and other biomass resources to produce electricity resulted in a net impact of more than \$1.8 billion in personal and corporate income throughout the United States economy. More than 66,000 jobs are presently being supported by this income. By the year 2010, the economic benefits are anticipated to be far greater as advanced biomass power technologies and energy crops are commercialized, resulting in \$6.2 billion in personal and corporate income and 284,000 jobs annually. With much of this activity in the rural sector, biomass power can be a substantial pathway for revitalizing rural America. These were some of the key findings in a study just completed by Meridian Corporation and Antares Group Inc. for the U.S. Department of Energy's Biomass Power Program.

FIG 1 PROJECTED ANNUAL U.S. EMPLOYMENT IMPACTS



The study utilized an input/output model to characterize the net employment and income benefits from biomass power production. Input/output models allow an analysis of direct impacts as well as indirect impacts resulting from spending direct income in supporting industries and in the general economy. Estimated net annual employment and income impacts from biomass power are shown in Figures 1 and 2 for the years 1992, 1997, 2000, and 2010.

The term biomass energy in this study includes wood, agricultural residues, and energy crops. Use of municipal solid waste and landfill gas for power production were not included in the scope of the study. The category of wood includes both sawmill and papermill residues (in the form of wood solids and particles), residues and thinnings from commercial forestry operations, orchard prunings, and urban wood residues. Agricultural residues include items such as peanut hulls, rice hulls, straw, and other similar residues. These agricultural residues represent only a small portion of the biomass fuel used for power production. A number of varieties of trees and grasses such as hybrid poplar and

switchgrass, are currently being developed for use as energy crops.

Determining the economic impacts of biomass power production is important because there are considerable benefits for the national, state, and regional economies resulting from this activity. Employment and income opportunities are created, particularly in rural areas. In addition, biomass energy generates substantial revenues through taxes for federal and state governments.

AN EXPANDING INDUSTRY

Biomass power production in the U.S. grew rapidly after the oil price shock of 1973 and then slowed in the late 1980's, due in part to lower oil prices. Now, the industry is once again poised for significant growth due to environmental regulations, more attractive economic conditions, and promising new biomass power technologies. In the near term, utilities are showing increased interest in cofiring biomass with fossil fuels to lower sulfur emissions. Facilities which currently use biomass to produce electricity include papermills, sawmills, furniture manufacturers, small-power producers, and other industrial operations, as well as

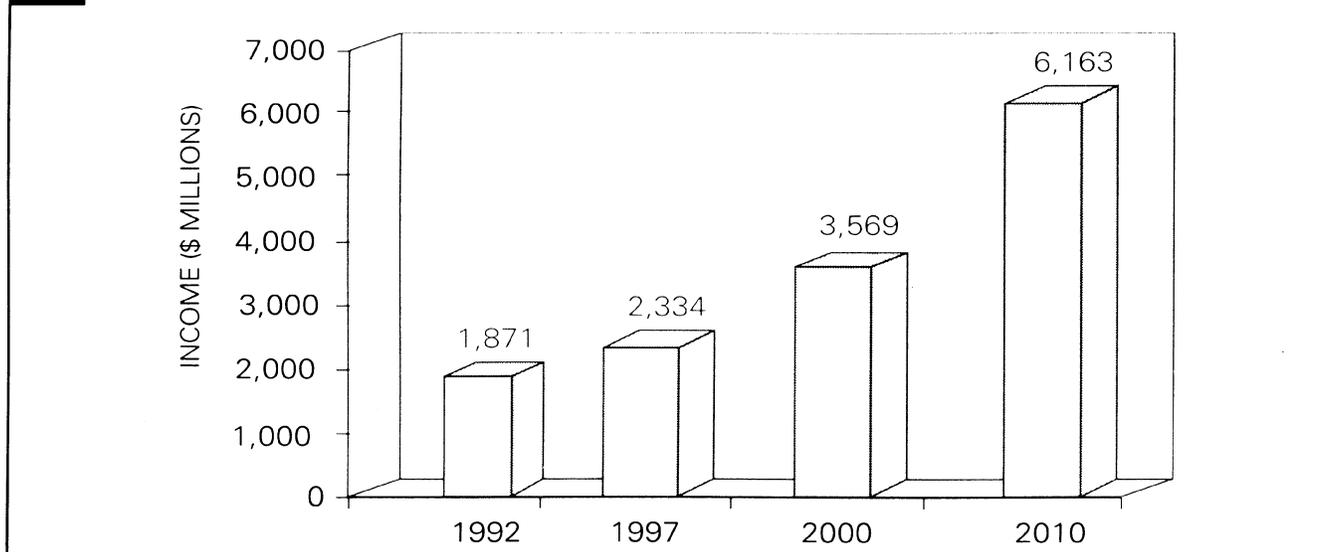
a few electric utilities.

In 1992, U.S. power plants fueled by wood and other biomass resources will account for approximately 6,500 megawatts (MW) of installed capacity. This approximates the capacity of six nuclear power plants, or the power required for six million people. The amount of electric power from biomass for 1992 will total approximately 42,000 GWh (gigawatt-hours or millions of kilowatt-hours) and require approximately 47 million tons of biomass fuel, representing a contribution to U.S. energy supplies equivalent to nearly 200,000 barrels of oil per day.

The pulp and paper industry is one of the major producers of biomass-fired electricity and a key player in the biomass power arena. In 1988, over half of the 45,000 GWh of electricity the industry consumed was self-generated, with 91% from cogeneration processes. Nearly 19,000 GWh was generated by qualifying facilities (QFs), and over 7,000 GWh was sold to utility and non-utility purchasers.

Abundant and low cost energy and fiber resources will help pulp and paper companies continue to prosper in world markets. New manufacturing technologies, and opening markets in

FIG 2 PROJECTED ANNUAL NET INCOME FOR U.S.



Eastern Europe and unified Germany, will contribute to future market expansion. New manufacturing facilities will create opportunities for advanced power generation systems, while efficiency improvement opportunities will come from existing locations. Together, these developments will allow the pulp and paper industry to continue to be a key element of the biomass power industry and a strong contributor to its economic impacts.

RURAL DEVELOPMENT OPPORTUNITIES

The economic benefits of biomass power are concentrated in rural areas, offering a unique opportunity for supporting rural industry development. As noted at the beginning of the article, the study estimated that by the year 2010, biomass power will create 284,000 jobs in the U.S. To gain a perspective on this issue, consider that the October 1992 unemployment figures for the East South Central region were 495,000 people; in the East North Central region the figure was 1,432,000 people; and, in the West North Central region, 434,000 people. These are areas which have either substantial forest residues or millions of acres of underutilized agricultural land highly suitable for energy crops. The maps in Figures 3, 4, and 5 illus-

trate where these unemployment areas are with respect to potential biomass resources. There are clearly considerable opportunities for growth in biomass power production, which will create a substantial number of jobs to offset unemployment in these regions.

The coal industry, another significant energy employer in rural regions, reduced its work force by about 70,000 workers between 1980 and 1990, and by about 280,000 since 1950. Increases in biomass power usage will serve to mitigate the detrimental employment impacts of automation in coal production.

By 2010, crops grown specifically for energy production are expected to deliver a significant portion of total biomass power fuel requirements. These energy crops will bring millions of acres of underutilized and set-aside agricultural land into productive use. Rural regions will be the primary beneficiaries of the resulting expansion in economic activity.

ADDITIONAL TAX REVENUES

The economic impacts of biomass power include the generation of considerable tax revenues for the federal and state governments. For example, more than \$467 million in federal and state taxes will be gener-

ated as a result of biomass power generation in 1992; and this number is projected to jump to more than \$1.5 billion by 2010.

"EXTERNALITY" BENEFITS/ CREDITS FOR BIOMASS POWER

Although the study focused on the economic impacts of biomass power production, important environmental impacts also occur. These economic and environmental considerations are increasingly receiving recognition as "externality" benefits in assessing energy supply options—this is occurring in federal and state legislation, as well as by public utility commissions as they establish criteria for setting electricity rates. Modest externality benefits were incorporated into the market penetration assumptions for biomass power. Some of these externality benefits are summarized below.

Using biomass residues for energy significantly reduces the volume of material that must be landfilled. By decreasing the volume of wastes that must be landfilled, disposal costs are also dramatically lowered. In some cases this can provide a positive cash flow if waste generators pay a "tipping fee" to dispose of biomass wastes. This volumetric reduction also conserves valuable landfill space. This increases the operating life of the land-

fill, which reduces the need for siting new landfills. Savings in landfill costs associated with the use of biomass residues for power production were specifically addressed in the study.

Biomass energy also benefits the quality of the atmosphere. When biomass (such as trees and grass) grows it absorbs CO₂ from the atmosphere. This same CO₂ is emitted up when biomass is burned for power. The result is no net increase in global CO₂

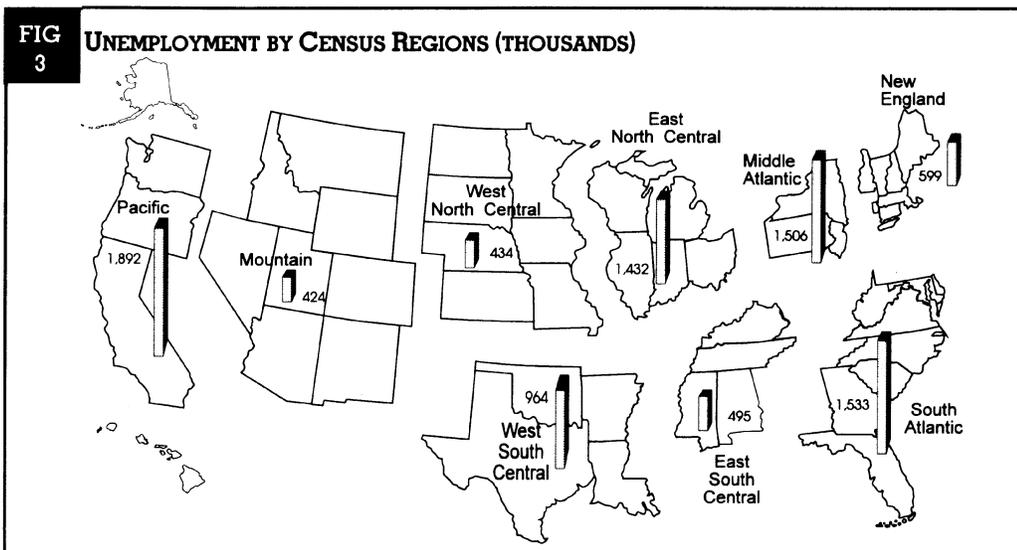


FIG 4 AGRICULTURAL RESIDUES AND FOREST RESOURCES

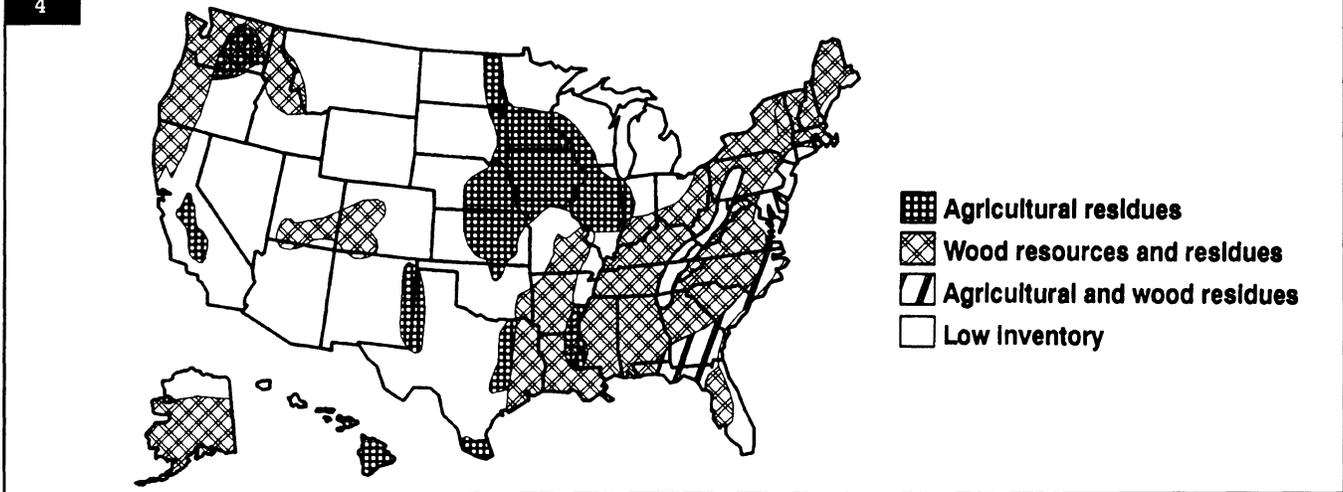
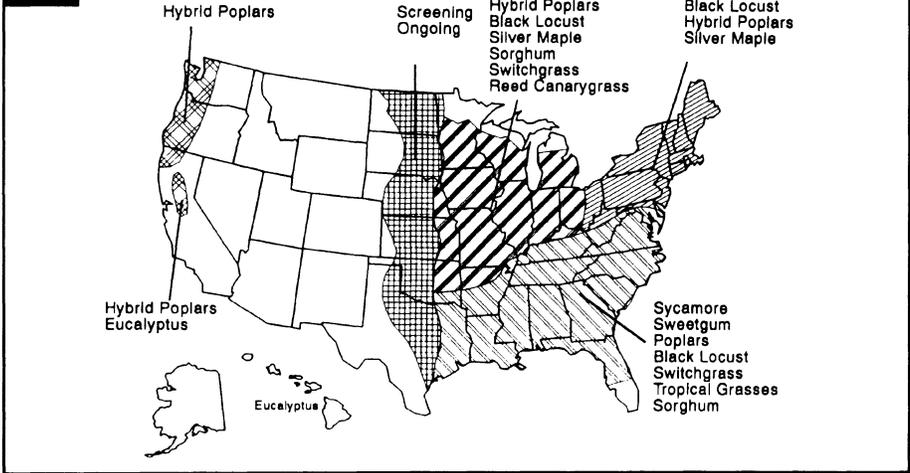


FIG 5 POTENTIAL HERBACEOUS AND WOODY ENERGY CROPS



levels, which is in stark contrast to the vast amount of CO_2 released from fossil fuel combustion. In addition, since biomass feedstocks are low in sulfur, their combustion results in virtually no SO_2 emissions. This makes biomass attractive to utilities, since displacing coal with biomass can help them comply with Clean Air Act requirements. The study assumes some expanded market penetration for biomass power due to cofiring of biomass and coal in utility boilers to meet Clean Air Act requirements.

STUDY APPROACH AND METHODOLOGY

Expenditures on biomass power have a major positive influence on our economy as they are respent and ripple

through the U.S. economy. In addition to the jobs generated directly within the biomass power industry, jobs are also created in many other sectors. These ripple effects include benefits to employment in a broad range of sectors and at various skill levels, from high-technology industries such as engineering design, turbine and boiler manufacturing, electrical machinery, construction, and conveying equipment industries, to more unskilled workers involved in assembly, installation, and maintenance. As the income from these jobs ripples through the economy, additional jobs are created in a host of consumer-oriented sectors such as retail, health services, finance, insurance, food, real estate, apparel, and others.

As a guide to the following discussion, Figure 6 serves to illustrate the "ripple effects" caused by various expenditures as they flow from initial biomass energy purchases to final payments made for personal consumption items.

As a result of purchases made for biomass power facilities, primary (direct) expenditures are made by the harvest, transportation, and end-use (e.g., boiler and turbine construction) sectors. These expenditures support the personal and corporate income immediately associated with those sectors as well as the direct employment of a number of workers. The study assesses net jobs from biomass power by subtracting the income and jobs that would have occurred if the power had been produced using conventional fossil fuels instead of biomass fuels.

To meet the demands associated with biomass power production, the fuelwood industry requires harvesters, foresters, transporters, local suppliers, fuelwood handlers, and other players directly involved in the provision and use of industrial fuelwood. The direct impacts calculated in the study thus involve the cash flow and employment directly related to expenditures made for harvesting, transporting, and consuming wood energy in biomass power facilities.

As a result of the initial expenditures for wood harvesting, transportation and utilization, the wood energy

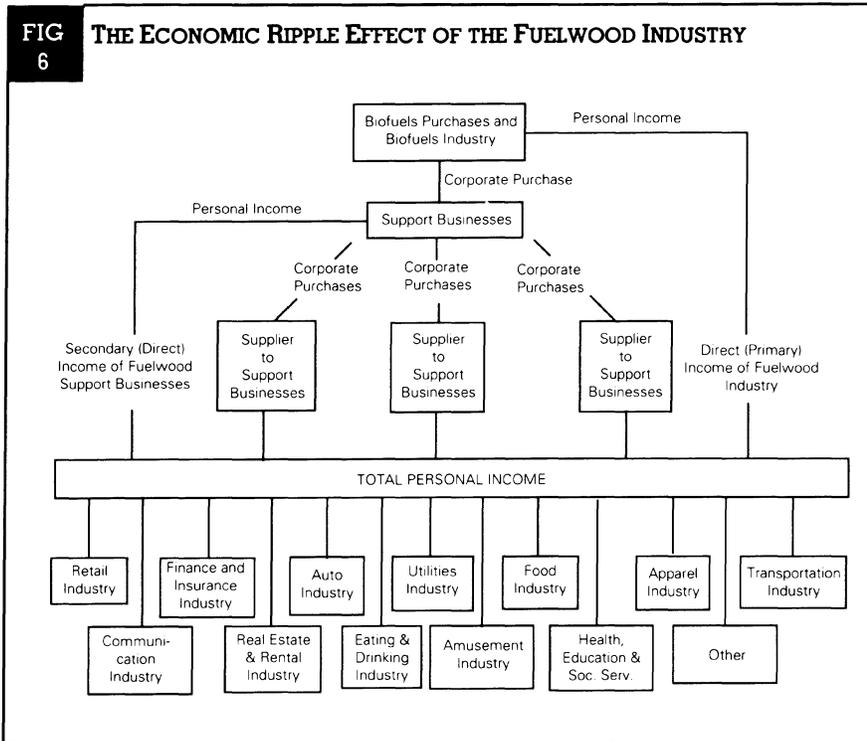
industry must purchase various goods and services from support industries; and these industries must pay their employees. Re-spending then occurs that gives rise to secondary, or "trickle-down," economic impacts in

other sectors of the economy. These revenues are partially offset through displacement of conventional fuels (which are mainly fossil fuels) by biomass power. Additionally, taxes are generated by the use of biomass power

both in the power industry and in supporting industries.

All of these factors were accounted for in this study to produce estimates of the net economic impacts of biomass power. An input/output model known as IMPLAN, developed by the U.S. Forest Service, was used to develop multipliers which reflect the income and employment effects of expenditures in a given sector as they ripple through the economy. These multipliers were entered into a spreadsheet-based model which calculated the total effects of biomass power use on the U.S. economy. Estimates were made for 1992 economic impacts as well as for the years 1997, 2000, and 2010. Projections are based on estimates of current biomass energy use for power production, and the forecasted growth rate of the biomass power industry with anticipated technology improvements and market conditions.

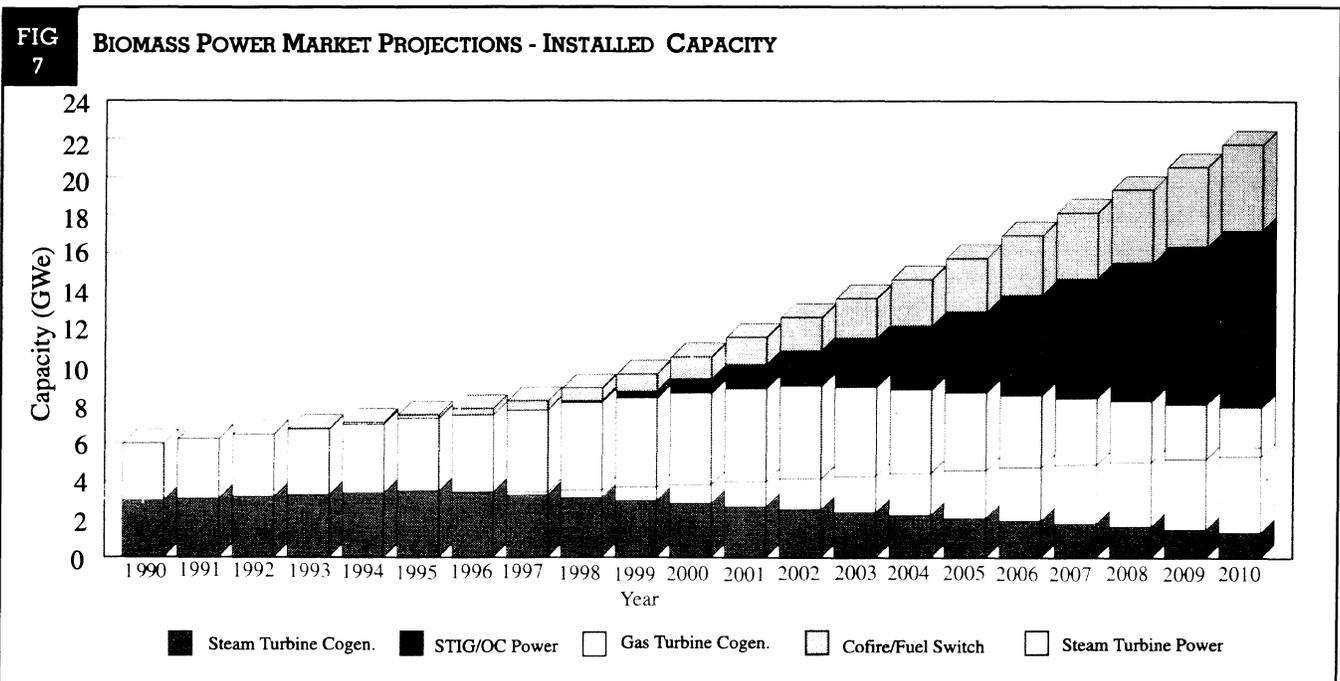
FIG 6 THE ECONOMIC RIPPLE EFFECT OF THE FUELWOOD INDUSTRY



DATA SOURCES

The methodology used in this study is similar to a 1990 study which focused on the southeastern region of the U.S.

FIG 7 BIOMASS POWER MARKET PROJECTIONS - INSTALLED CAPACITY



This 1990 study was conducted by the Meridian Corporation for the Tennessee Valley Authority (TVA), titled *Economic Impact of Industrial Wood Energy Use in the Southeast Region of the U.S.* (Nov. 1990). The spreadsheet-based model developed for the current study is a modified version of the model used for the 1990 TVA study. Data on the fuelwood supply sector, including details such as wages, production rates, and insurance requirements, were taken from the 1990 model. Where appropriate, costs were escalated to reflect inflation to 1992 dollars.

Technical inputs to the model are based on the biomass power capacity addition projections presented in the DOE Office of Solar Thermal and Biomass Power document titled *Biomass Power-A Development Strategy* (April 1991). Technology assumptions concerning power cycle, efficiency, capacity factor, capital cost estimates, and personnel requirements, were based on this DOE Strategy document. Cost estimates for energy crops were derived from *The Costs of Producing Biomass in the United States for Selected Land Resource Regions* (1990) by Burton C. English and Sean Coady.

TECHNOLOGY ASSUMPTIONS

Biomass power technologies addressed in the study included Rankine-based stand-alone and cogeneration units, cofiring with coal in existing utility units, and thermochemical conversion processes (i.e., gasification and pyrolysis) with simple and advanced gas turbine cycles for stand-alone power and cogeneration of power and process steam. Figure 7 shows the anticipated capacity additions for 1990 through 2010, assuming an aggressive DOE/industry effort to develop and commercialize the advanced technology systems.

TABLE 1 PROJECTED INCOME IMPACTS OF BIOMASS ELECTRIC POWER USAGE

	1992	1997	2000	2010
State Taxes Generated by Biomass Electric Activity	93,573,822.86	116,707,359.62	178,452,342.95	308,181,341.29
Federal Taxes Generated by Biomass Electric Activity	374,295,291.43	466,829,438.49	713,809,371.81	1,232,725,364.17
Direct Income Generated	486,226,924.99	560,413,145.20	664,633,075.64	1,151,412,160.21
Indirect Income Generated	1,443,949,864.13	1,596,211,568.44	2,771,746,277.80	5,154,750,192.74
Income Impacts from Energy and Landfill Savings	1,422,221,591.61	2,387,663,902.83	3,367,926,153.11	9,956,924,668.99
Total Income Generated	3,352,398,380.72	4,544,288,616.47	6,804,305,506.55	16,263,087,021.94
Income Displaced by Biomass Electric Activity	1,480,921,923.57	2,210,141,424.02	3,235,258,647.50	10,099,460,200.10
Net Income Generated by Biomass Electric Activity	1,871,476,457.15	2,334,147,192.45	3,569,046,859.05	6,163,626,821.84

TABLE 2 PROJECTED EMPLOYMENT IMPACTS OF BIOMASS ELECTRIC POWER USAGE

	1992	1997	2000	2010
Direct Jobs Generated	14,435.63	16,758.52	19,888.07	32,839.35
Indirect Jobs Generated	33,608.10	37,186.25	62,279.73	121,208.94
Job Impacts from Energy and Landfill Savings	36,651.50	61,531.53	86,793.47	256,584.47
Total Jobs Generated	84,695.23	115,476.31	168,961.27	410,632.76
Jobs Displaced by Biomass Electric Activity	18,538.32	27,703.89	40,572.53	126,795.26
Net Jobs Generated by Biomass Electric Activity	66,156.91	87,772.42	128,388.75	283,837.51

The assumptions used for Figure 7 are listed below.

- Improved stand-alone steam units continue to be installed through the turn of the century, but eventually are replaced by integrated gasification / advanced turbine systems (i.e., steam-injected gas turbines, combined cycles). Older stand-alone Rankine units are retired.
- Although it comprises a significant portion of today's capacity, inefficient Rankine-based cogeneration is eventually replaced by biocrude-fired combustion turbine cogeneration. (Biocrude is a liquid fuel similar to petroleum which can be made from biomass.) Older cogeneration units are retired.
- Cofiring biomass with coal in existing utility boilers gains growing acceptance through 2010, initially as a solution to several site-specific problems (e.g., waste wood disposal), and eventually as a bona-fide sulfur dioxide (SO₂) reduction method for Phase II units under the Clean Air Act.

Figure 7. Projected Biomass Power Installed Capacity. As the efficiency of biomass power plants improve, the number of workers required per megawatt of generating capacity decreases. Despite this improved productivity, the model predicts a substantial increase in the number of direct and indirect jobs generated by biomass power from 1992 to 2010. This is because the reduced number of jobs due to improved productivity is more than offset by the increasing market penetration of biomass power and the associated jobs created in supporting industries.

RESOURCE ASSUMPTIONS

There are three basic fuelwood types used in the industrial and commercial sectors: mill residues, cord wood, and

whole-tree chips. In analyzing the impacts of fuelwood use for power production, the economic effects of burning mill residues and whole-tree chips are considered; cord wood is used in quantities too small to have a noticeable impact.

Mill residues are by-products of wood processing used for purposes other than energy production. While most mill residues are either used at their source for energy production or disposed of in landfills, a certain amount is sold to other parties for energy use. The economic impacts of this transaction, including the sale of mill residues and its transportation to the end-user, are important components of industrial fuelwood use examined in this study.

Whole-tree chips are not a by-product like mill residues, but are produced specifically for biomass power and industrial process heat. The burning of whole-tree chips and wood residues involves the activity of many participants including foresters, truckers, fuelwood handlers, boiler operators, and operations and maintenance staff at cogeneration facilities and stand-alone wood-fired power plants. The model also addresses biomass power plant construction and installation, which is done to satisfy new plant requirements caused by the expiration of old plants, and increases in demand for power, which creates demand for new biomass power facilities.

As conventional fossil fuels increase in price, and the competitive economics of biomass electricity production improve, crops grown specifically for energy production (also known as dedicated feedstock supply systems or DFSS) are expected to become a significant portion of total biomass fuels used for power production. "Energy crops," such as fast-growing hybrid trees (e.g., poplar and sweet gum) and certain grasses (e.g., switchgrass) can be grown on land which is considered marginal for food crops or

land which is not farmed for other reasons. The energy crop industry will have some structural similarities compared to whole-tree chipping, but will also require expenditures for planting and other crop maintenance. Consistent with the assumptions in the *Electricity from Biomass* development strategy, biomass resources are assumed to be dominated by wood use through the end of the century. However, by the year 2010, energy crops are assumed to comprise 30% of the total biomass consumed for power generation.

The results of the study are summarized in Tables 1 and 2. Table 1 presents the projected net annual income generated by the use of biomass for power generation for the selected years. Net income includes income displacement due to switching from conventional fuels to biomass power and the savings accrued from avoiding landfill costs. Net annual employment impacts resulting from biomass power usage are given in Table 2.

These results demonstrate that in many regions of the country where the cost of biomass power is competitive with fossil fuels, biomass power is clearly the preferable option. In addition, as the demand for electricity in rural regions around the world continues to grow, the market for biomass power systems will increase. A strong U.S. biomass power industry will be well-positioned to serve this global market. **B**