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Biomass Power Industry

Assessment of Key Players and Approaches for DOE and Industry Interaction

Final Report

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ACRONYMS AND ABBREVIATIONS

BPA	Bonneville Power Administration
CAAA	Clean Air Act Amendments
CCA	chromated copper arsenate
COE	cost of electricity
DFSS	dedicated feedstock supply system
DOE	Department of Energy
DTPD	dry tons per day
E&C	engineering and construction
EPACT	Energy Policy Act
EPRI	Electric Power Research Institute
GWe	gigawatts electric
IGCC	integrated gasification combined cycle
IOU	investor-owned utilities
IPP	independent power producer
IRP	integrated resource planning
kW	kilowatt
kwh	kilowatt hour
MMBtu	million British Thermal Units
MSW	municipal solid waste
MWe	megawatts electric
NREL	National Renewable Energy Laboratory
NYSEG	New York State Electric & Gas
NYSERDA	New York State Energy Research and Development Authority
ORNL	Oak Ridge National Laboratory
DOE/HQ	Department of Energy Headquarters
PG&E	Pacific Gas & Electric
PURPA	Public Utilities Regulatory Policy Act
QF	qualifying facility
R&D	research & development
SUNY	State University of New York
TVA	Tennessee Valley Authority
USDA	U.S. Department of Agriculture

BIOMASS POWER INDUSTRY
ASSESSMENT REPORT

1. INTRODUCTION

During September 1992 through January 1993, a review team established by the Department of Energy conducted an assessment of the U.S. biomass power industry. The review team, led by Michael Reed of the Solar Thermal and Biomass Power Division, and consisting of representatives of the Antares Group Inc. and Meridian Corp., visited with more than 50 organizations representing all sectors of the biomass power industry. These organizations included utilities, independent power producers (IPP), component manufacturers, engineering and construction contractors, agricultural organizations, industrial users and regulatory organizations.

1.1 Assessment Objectives and Approach

The "Biopower Tour" served many purposes. First, DOE was solicited industry input for the development of the Biomass Power Division's "Five Year Plan," which was issued in May 1993. The DOE believed there was a critical need to obtain industry's insight and working level knowledge to develop the near- and long-term plans of the program. At the heart of this objective was the desire to identify near-term initiatives that the program could pursue to help accelerate the further development of biomass power projects. Second, the tour was conducted to identify key players of the U.S. biomass power industry, and gain a better understanding of their needs and goals. Third, the tour served to inform industry about the mission and scope of the DOE's Biomass Power Program. Many of the organizations were unaware that a biomass power program existed within DOE. As such, it was important to discuss with industry the DOE mission, proposed DOE goals, and DOE willingness to work with them in the future.

As discussed in Section 2, the biomass power industry will probably never be a vertically integrated (fuel supply, equipment manufacture and installation, through project financing and operation) specialty industry like other renewable energy industries in wind, photovoltaics, solar and hydropower. As such, it was crucial to identify the key players in this industry, and work with them in identifying their needs. DOE consulted with industry associations and consultants to identify organizations that had active biomass power projects and equipment in operation. While the organizations contacted cannot be considered all inclusive of the parties with potential interest in biomass power, DOE obtained good cross-section of the industry. The geographic distribution of companies contacted is shown in Exhibit 1-1. In conducting the assessment, DOE presented a standard presentation as a frame of reference for the meetings, but allowed the discussions to focus on the issues and opportunities of most importance to the industry representatives. The basic intent was to be a good listener and to try to identify trends and consensus issues.

1.2 Overview of Assessment Findings

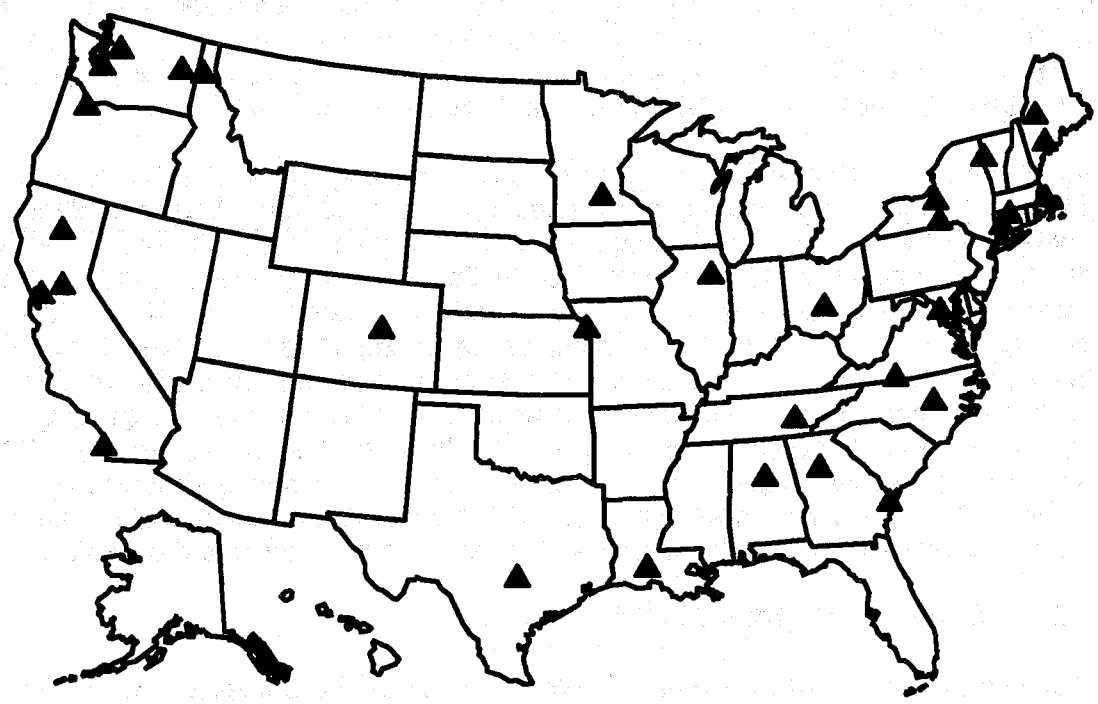
Biomass power already supplies 6 GWe of power to the domestic grid, and is the primary baseload technology among the renewables. Biomass power facilities have brought new industrial jobs to rural areas of the country and spawned several new regional businesses in biomass fuels procurement and delivery. The basic technology for producing power is proven for selected feedstocks in plant sizes from 10 to 50 MWe. However, many plants that have been

fueled by agricultural byproducts or low grade wood fuels have experienced operational problems. Fuel sources are currently limited to forest thinning materials, wood and agriculture industry byproducts or biomass In urban waste streams. The industry must generally rely on short term contracts or the spot market for fuel purchases. The infrastructure for fuel production, collection and transport is still in a nascent state.

Despite rapid growth in the 1980's, the numbers of active biomass power projects have decreased in the 90's. There are several reasons for the lack of current project activity. Power producers have often had to use a good deal of Ingenuity in their ability to acquire sufficient fuel feedstocks at reasonable costs. Competition for a limited feedstock source can drive up the price of the fuel substantially and limits the number of projects within a geographic region. In addition, use of feedstocks with characteristics that differ substantially from the fuel for which a given boiler was designed affects both unit performance and reliability.

The competition from natural gas fired generators has also dampened the market for biomass projects and many other fossil-fueled projects. End-use natural gas prices peaked in the 1980s and have generally declined since then. The magnitude of the change varies by end-use sector with prices declining most for on-system industrial sales and for electric utilities. The price of

EXHIBIT 1-1. GEOGRAPHIC DISTRIBUTION OF ORGANIZATIONS CONTACTED FOR THE ASSESSMENT



NOTE: MARKERS MAY INDICATE MORE THAN ONE ORGANIZATION AT THE LOCATION

power generated by natural gas combustion turbines has also often been the basis for the price for avoided costs on which most Independent Power Producers (IPP) power contracts are based. While production and availability of natural gas is expected to be maintained if not expanded throughout the 1990s, prices have risen since 1991.

Despite the current downturn in the market, members of the IPP industry believe that if the environmental benefits of biomass power are fully recognized through externalities and if natural gas prices once again return to prices consistent with the history of natural gas as a premium fuel, then the market will rebound. The utility industry, which has until now been a relatively small player in development of biomass projects, is poised to become a significant interest through cofiring wood at existing coal-fired boilers. This approach will allow them to reap the significant environmental benefits associated with biomass. For the near term, the IPP industry will survive by continuing to improve operations at current plants and exploiting niche markets for greenfield power plants. Although most project developers expressed interest in the international markets where capacity growth projections are Impressive, there was a practical appreciation of the difficulties of developing projects based on new technology or new fuel sources for that market.

Although many differing views were expressed concerning what needs to be accomplished and what role DOE should take to bring about a "green revolution" in power production, there was consensus on the major issues and opportunities:

- **Information and Education:** A high visibility information dissemination campaign needs to be undertaken to correct the most commonly held misconceptions about modern biomass-fired power facilities and to provide the public and decision makers with a well founded understanding of the environmental and economic benefits of utilizing biomass resources for power generation.

- **Environmental Assessment and Valuation:** Biomass could have the high tech image of photovoltaic power systems, but it will never be a zero emissions generating technology. Its environmental characteristics (both positive and negative) must be accurately characterized and fairly portrayed to the public. Environmental characterizations should be performed by independent industry sources. The environmental benefits must be valued in decision making with respect to power resource choices. Methods to properly value external benefits are still in a developmental stage.

- **EPACT 1992 Implementation:** The incentives provided in Sections 1212 and 1914 of the Energy Policy Act of 1992 (renewable energy production incentive and renewable electricity production tax credit) could be important stimuli to biomass power project development particularly for encouraging consideration of investments in sustainable dedicated fuel supply systems. Latitude in qualifying facilities for the incentives is needed to ensure transitional types of projects can be undertaken (i.e., cofiring).

- **Developing Cofiring Opportunities:** Cofiring biomass with coal represents the best near term opportunity to increase use of biomass fuels among utilities and quickly bring on line biomass fired generation capacity. The merits of this fuel switch option will have to be demonstrated at utility generating stations for several types of boilers to encourage widespread acceptance.

- **Expanding the Resource Base:** One general area of need and opportunity will be projects and activities that expand the current resource base available to power producers. Nearly all of the industry representatives for IPPs and utilities expressed the desire to be able to use a wider base of fuel resources economically. It was very clear from the meetings that the achieved survival of a nascent biomass power industry would depend on expanding the availability of diverse low-cost fuel sources.

- **Develop Repowering Opportunities:** Many of the generating units built by IPPs were constructed when available resources were cheaper and purchased power agreements were generous. As such, combustion efficiency was not considered a major issue at that time. As power purchase agreements expire and new contracts are negotiated, the ability of many of these facilities to continue to be productive will be in question. Repowering projects could improve the efficiency and availability of some of these plants to extend their useful life until a new generation of conversion systems becomes commercially available. Repowering aging utility-owned coal- and oil-fired plants to efficiently produce power from biomass is also a potential area for project development.

- **Develop Products for International and Modular Prepackaged Generation Markets:** For international markets in areas where power is frequently needed in smaller increments and biomass resources are plentiful, small-scale packaged biomass generators will be very attractive. On a larger scale several companies have targeted the existing agricultural processing industry as potential power producers. To open this market, new U.S. products will have to be demonstrated to meet performance (including cost), maintainability, and reliability claims of the manufacturers.

The power generation industry remains interested in the potential for biomass power but sees fewer opportunities to develop profitable greenfield projects under current market conditions. However, the experience gained in the 1980's is providing a solid base for developing successful projects in the 1990's for niche markets. Cofiring and repowering projects are expected to provide the best opportunities for continued near term growth in the use of biomass fuels.

As will be reported on the following pages, the current industry faces many hurdles and obstacles. The problems identified by the survey team, and the potential role that the DOE Biomass Power Program can fill to alleviate these problems will be outlined. However, it must be remembered that input was received from numerous organizations representing a diverse range of opinion. As such, this report should be viewed as DOE's analysis of the collective discussions held with industry.

2. INDUSTRY STRUCTURE & KEY PLAYERS

2.1 Overview

The biomass power industry will probably never be a vertically integrated specialty industry, unlike renewable energy industries in wind, photovoltaics, and low head hydropower. The IPPs, utilities, and engineering and construction (E&C) firms which implement the technology are unlikely to dedicate all of their resources to a single fuel or technology, although they will often commit to a small group of technologies that are competitive in the power market. Despite the significant differences that the fuel characteristics of biomass impose on combustion and conversion technology, boiler and gasifier manufacturers will offer products that span the fuel market rather than focus on a dedicated fuel capability. As a result, biomass power will be a subset of the power industry with constituents in each of its major segments. On the fuel side, the agricultural interests are likely to present a similar picture with only a few growers dedicating their total resources to a single crop. The constituents for biomass power are likely to be organizations who see a profitable future for this generation resource and who have technology that is adaptable to the resource or project development experience that could give them a competitive advantage. In some cases, individual players may make an exclusive commitment to the biomass option, but they will probably be the exception rather than the rule.

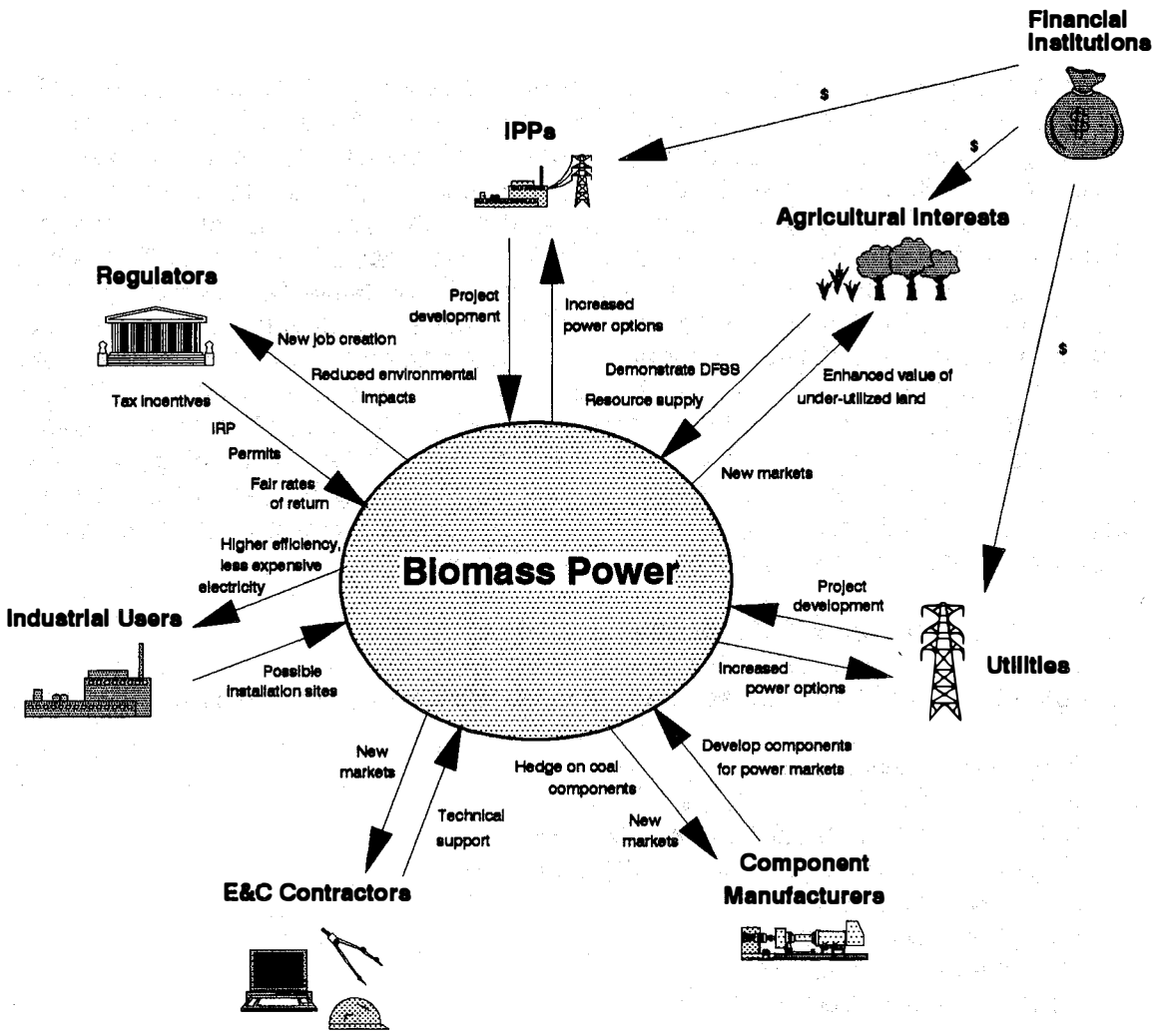
2.2 Components of the Industry

The components of the biomass power industry are depicted in Exhibit 2-1 and include:

- Regulated Electric Utilities
- Independent Power Producers (IPPs)
- Utility/Industrial Component Manufacturers
- Engineering and Construction (E&C) Contractors
- Agricultural Organizations
- Industrial Users/Producers
- Regulatory Organizations
- Feedstock/Fuel Brokers

Organizations in each of the above groups are likely to play a key role in the success or failure of biomass power both domestically and abroad. Shown as a second tier player in the diagram are the investment institutions/organizations which will be called upon to finance power projects. The importance of these organizations to the acceptance and development of biomass as a power resource is such that they can be considered on par with the first tier players in the decision making for power projects. Included in that category of interests are the insurance firms that provide efficacy insurance for projects. Without such insurance many projects would be to risky for investors to underwrite. The interests of these groups in the technology are discussed in the sections that follow (and the following Exhibit 2-2), concluding with an evaluation of the role they are likely to play in the development of the resource and implementation of improved technology in future biomass power stations in the U.S. and abroad.

EXHIBIT 2-1 COMPONENTS OF THE BIOMASS POWER INDUSTRY



2.2.1 Electric Utilities

A handful of utilities have built biomass power stations. These are mostly smaller utilities such as municipalities, and the stations are more often multi-fueled facilities rather than dedicated units.

The utilities are important constituents of the industry because they represent mainstream users of the technology for bulk power production at a utility scale. In addition, many utilities have experimented or continue to experiment with cofiring wood, municipal solid waste and coal. Their primary interests in the U.S. Department of Energy (DOE) Biomass R&D program will be the improvement of the current technologies or the demonstration of the next generation of technology. Regulated utilities are required to provide customers with safe, reliable, and economic service while earning an agreed upon return on investment. For biomass power, one

EXHIBIT 2-2 INDUSTRY RELATIONSHIPS TO THE BIOPOWER MARKET

UTILITIES

- REGULATED POWER PROJECT DEVELOPERS AND POWER PURCHASERS
- TRANSMISSION LINK BETWEEN POWER PRODUCER AND CUSTOMER
- BIOPOWER PROVIDES ADDITIONAL POWER OPTIONS FOR RESOURCE DIVERSIFICATION
- BIOPOWER PROVIDES A CO_2 NEUTRAL GENERATION OPTION

IPPs

- LESS REGULATED POWER PROJECT DEVELOPERS
- BIOPOWER FITS IPP CAPABILITIES TO DEVELOP ALTERNATIVE POWER SOURCES
- INCREASED INTEREST IN SULFUR-FREE RESOURCE DUE TO NECESSITY FOR SO_2 ALLOWANCES FOR OPERATION

AGRICULTURAL INTERESTS

- USDA IS RESEARCHING FEEDSTOCK SPECIES
- ORNL IS DEVELOPING A FUELS MODEL TO PROJECT RESOURCE AVAILABILITY
- MAY ENCOURAGE USE OF LAND UNDER ACREAGE REDUCTION AND CONSERVATION RESERVE PROGRAMS
- INCREASED LOCAL REVENUES AND JOBS

FINANCIAL INSTITUTIONS

- KEY SOURCE OF FUNDING FOR PROJECTS
- HESITANT TO DEAL WITH NEW OR "UNPROVEN" TECHNOLOGIES
- INCREASED REQUIREMENTS FOR EQUITY OWNERSHIP BY DEVELOPERS TO SHARE RISK

INDUSTRIAL USERS/COGENERATORS

- BIOMASS ALREADY USED FOR PROCESS HEAT AND SELF-GENERATION
- ALREADY KNOWLEDGEABLE IN FEEDSTOCK PRODUCTION, TRANSPORT, PROCESSING, AND HANDLING
- HAVE PRIMARY ACCESS TO FOREST RESOURCES

REGULATORS/LEGISLATION

- FAVORABLE VIEWS TOWARD ECONOMIC AND ENVIRONMENTAL BENEFITS WILL ASSIST MARKET
- UNFAVORABLE RULINGS WILL HURT PERMITTING, COMPETITIVE BIDDING, AND CONSTRUCTION AND OPERATION COSTS

COMPONENT MANUFACTURERS

- HARDWARE R&D WILL BENEFIT THE MANUFACTURERS, AS WELL AS THE WHOLE MARKET
- COST-SHARING WITH DOE
- COAL CONVERSION AND HOT-GAS CLEANUP EQUIPMENT VENDORS MAY SEE BIOMASS AS A HEDGE ON INVESTMENT

E&C CONTRACTORS

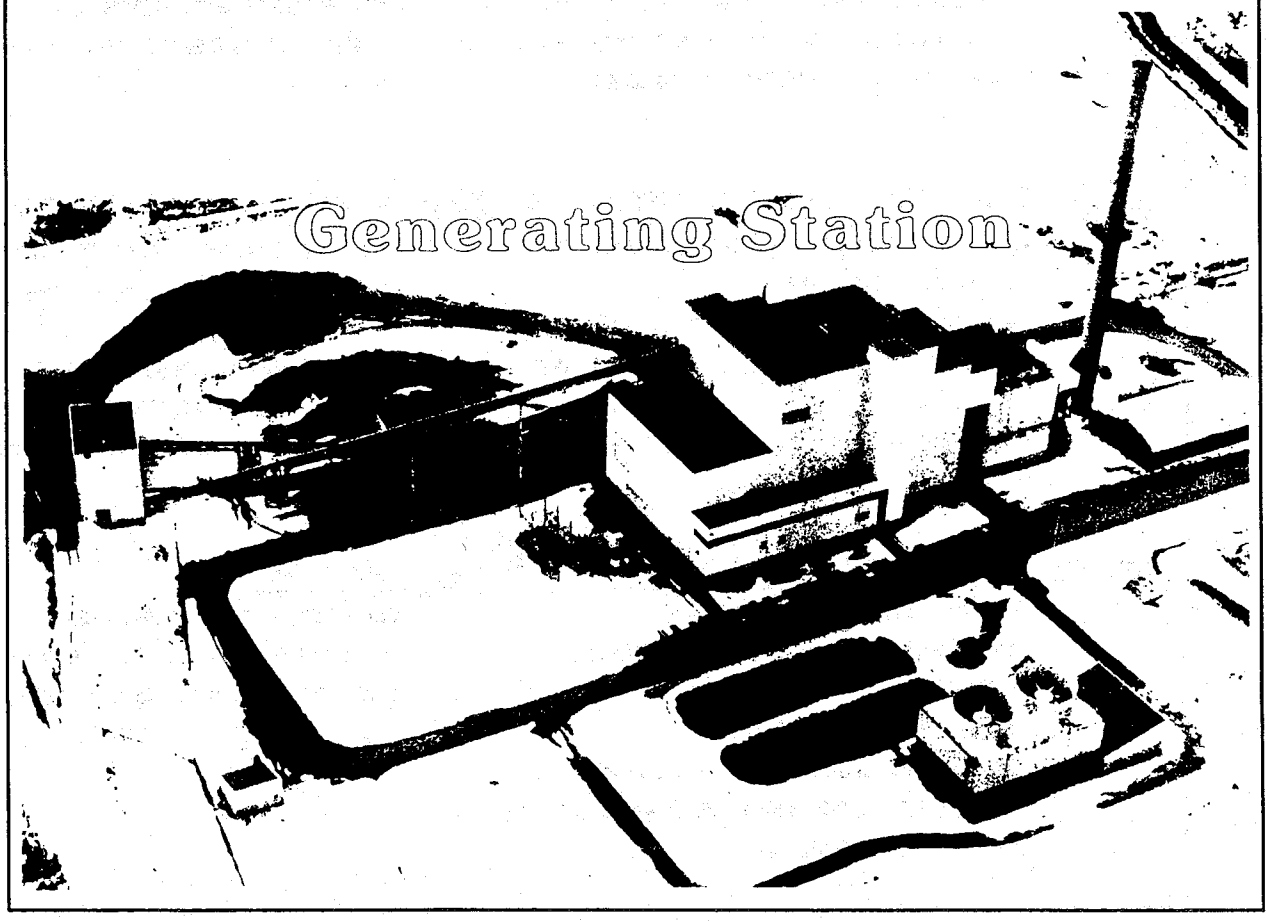
- RELIED ON HEAVILY BY IPPs AND UTILITIES, ESPECIALLY FOR TURN-KEY SERVICES
- SIMILARITY WITH COAL IGCC MAKES AN EASY TRANSITION TO BIOMASS

of the issues is the impact on the cost of delivery of economical power from a resource that is often not located near electric load centers. Since wheeling of power through systems at reasonably high efficiencies is an increasingly available option to generators, the concern is more one of access to transmission systems with available capacity. Utilities are more likely to support a biopower demonstration, if either can be accomplished through a relatively low capital retrofit of existing facilities, providing efficiency and reliability improvements. A major concern for such retrofits will be the effect on current permits for the facility. A review of current permits triggered by a possible demonstration of new technology would be a significant risk for the plant owners.

The utilities are not a homogeneous group, and the subgroups within the industry have different needs and resources. The major subgroups are:

- Investor Owned Utilities (IOU)
- Municipal Utilities
- Rural Electric Cooperatives
- Federal Power Authorities

EXHIBIT 2-3 BURLINGTON ELECTRIC'S 50 MW BIOMASS FIRED MCNEIL STATION



Among these groups, the most active players in biomass projects are the municipal utilities. Few of the large investor-owned utilities (IOUs) yet own biomass fired facilities, but many are power purchasers from the IPPs. This may change as the scale of biomass power projects increases. None of rural cooperative generators or the Federal Power Authorities have built biomass power stations. The capacity growth needs of the smaller IOUs, the rural electric cooperatives, and the municipal utilities are well suited to the size of current biomass power facilities. However, when larger plants based on a dedicated fuel supply systems (DFSS) and advanced conversion cycles are ready for demonstration at full scale, the larger IOUs are likely to be the power purchasers and/or project developers.

Another possible DOE Biomass Program constituent is the coal-fired utilities for whom biomass cofiring might represent an attractive Clean Air Act Amendment (CAAA) compliance option. TVA has inaugurated a program of assessment and evaluation for these purposes in cooperation with DOE and the Electric Power Research Institute (EPRI). In addition, a set of utilities for which biomass cofiring appears to have merit was identified in a recent report prepared by Scott Piscitello and Christian Demeter of Antares for National Renewable Energy Laboratory (NREL) entitled "Biomass Cofiring Analysis Summary."

In summary, the utilities and their Research, Development, Testing, and Evaluation arm, the Electric Power Research Institute (EPRI), are an important constituent of the program. The utilities' interest In the program is likely to be in near term technical improvements to the technology. They offer potential for joint venture (cost-shared) retrofit demonstrations. They are also the ultimate customer for biomass power technology. Whether they build and operate their own plants or purchase power from the independent power producers (IPPs), they will be key decision makers with regard to technology acceptance and implementation. In some ways, they may be considered to have less at stake than other constituents since their investment is limited to the facilities they operate. Many of these facilities could be converted to other fuels if economics and other factors indicate it would be prudent to do so.

2.2.2 Independent Power Producers

A second key constituent for the biomass power industry is the IPPs. The IPPs are similar to the electric utility in that they will serve as project developers for the industry. Also, there are IPPs who already own and operate biomass fired power plants. Along with cogenerators, the IPPs represent the major portion of today's biomass generation capacity. Included in this category are JWP Energy Products, Thermo Electron, Wheelabrator, and HYDRA-CO (Exhibit 2-4). The independent power project developer segment is the most diversified in terms of the organizations involved ranging from the specialists, companies created solely to develop for this market, to the many subsidiary companies of the utilities, E&C contractors, and equipment vendors vying for a piece of the market. Many of the subsidiaries operate with a large degree of independence under the parent organization and are subject to the same market factors and interests driving the specialists in the industry.

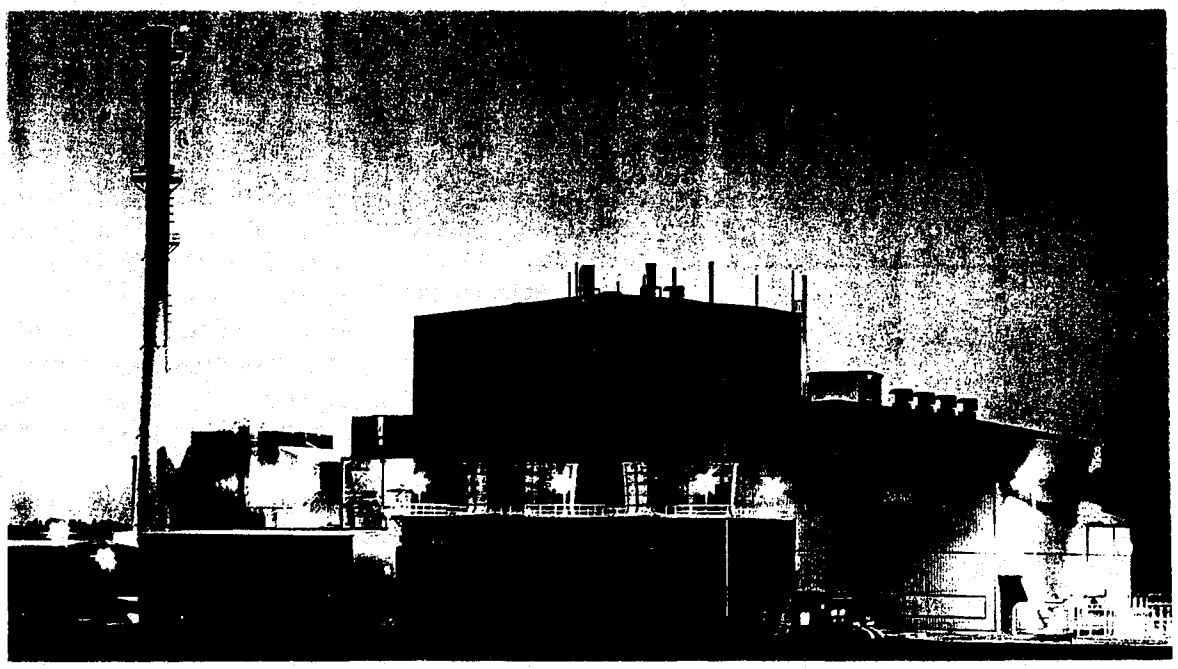
Under Title IV of CAAA, independently owned generating plants with capacities of 25 MW or more will be held to the same sulfur dioxide (SO_2) emission limits as electric utility plants. However, emission allowances will not be given to the IPPs (as is the case with the utilities) and will have

to be purchased on the open market or at emission allowance auctions. Therefore, IPPs' interest in the virtually sulfur-free biomass resource should increase as the regulation's deadline nears (January 1, 2000).

IPPs are well suited to respond to the utilities' current disposition towards smaller capacity additions which require modest capital outlays. The Public Utilities Regulatory Policy Act (PURPA), which mandates electric utilities to buy power from independent producers using renewable sources or cogeneration, sets an upper limit of 80 MW on the producer's capacity. This size fits the capacity addition range needed by many utilities. This range also matches the capacities of installed biomass power facilities. Thus, there often is a match between the size of plants which will be constructed by IPPs operating under PURPA, the capacity additions which the utilities desire, and the size associated with current biomass resources. The competitive bid process being utilized in many states for resource acquisitions is beginning to affect this market to some degree, increasing the size of many recent IPP projects. Scale-up of biomass technology will be more important as this trend continues.

Biomass can also be used to cogenerate electricity with process heat (steam). This creates opportunities for IPPs to work with industrial participants (such as the pulp and paper industry or the wood products industry) who can supply the biomass resource and also offer a host for the process heat. An interesting market for biomass-based cogeneration may be industrial participants who currently operate natural gas/gas turbine technology. For example, the Boise Cascade pulp and paper plant in Fort Francis, Ontario currently operates an 86 MW natural gas fired combined cycle unit. Biomass gasifiers could be installed at such locations and coupled to the existing combustion turbines.

EXHIBIT 2-4 HYDRA-CO'S 30 MW BIOMASS FIRED FAIRFIELD STATION

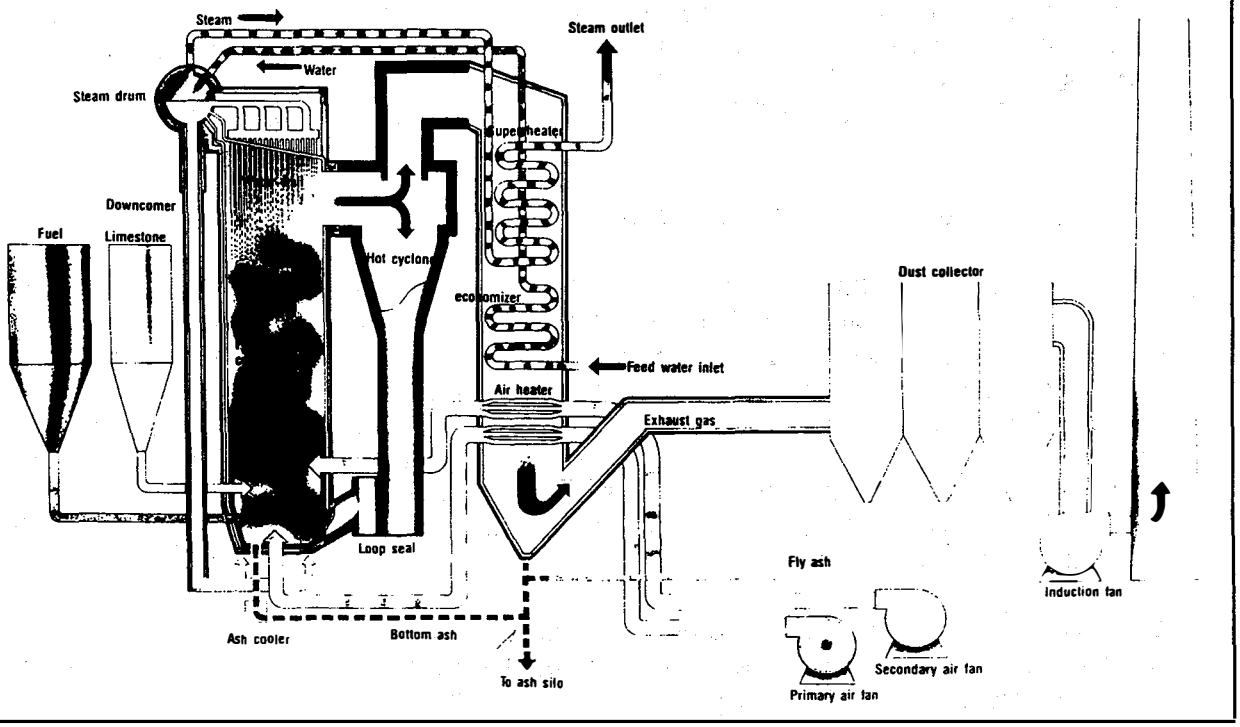


Underlying the success of the IPP industry is the advantage of operating under less regulatory burden than the electric utilities. Therefore, the IPP is less constrained in their generating technology options, and have a greater ability to take risks and earn healthy rates of return. In contrast to regulated utilities, the IPPs are dependent upon the capital investment markets for project financing. More recently, these investors are requiring greater financial exposure of the developers and other participants in the projects to ensure their interests in protecting the investment. This tends to result in a greater degree of conservatism in site, resource and technology choices for new projects. This is exemplified by the current emphasis on natural gas combustion turbine projects. For the IPPs to be successful they will need to work with utilities to identify locations for projects that can tap into existing transmission and distribution capabilities and that are near areas of increasing electric power demand.

2.2.3 Utility and Industrial Power Component Manufacturers

The traditional suppliers of utility power generation hardware are large, well-financed, heavy equipment manufacturers. Nearly all have international operations and compete in a global market. All of these companies also have product lines and services aimed at the industrial power market. In the industrial market, there are smaller specialty companies who also serve the market. Some of these firms, such as JWP Energy Products (JWP), may dedicate their product line to biomass and municipal solid waste (MSW), however, these firms are the exception. Nevertheless, the equipment vendors are important biomass program constituents since they are the most likely participants in hardware R&D, with a stake in the advancement of the state of the art. Pictured in Exhibit 2-5 is a Ahlstrom Pyroflow fluidized-bed boiler which is representative of state-of-the-art utility boilers capable of handling a wide variety of biomass fuels.

EXHIBIT 2-5 THE AHLSTROM PYROFLOW FLUIDIZED-BED BOILER



Among the larger vendors, there are sufficient resources to support, through cost-sharing, the DOE R&D program if the corporate commitment exists. Those companies that have invested in the coal gasification option may be inclined to make a serious commitment to the biomass gasification alternative if they see a strong potential market and view the biomass conversion option as a hedge on their investment in developing coal conversion equipment. For this reason, the companies involved in coal gasification should be viewed as potential partners in the biomass power program. A similar argument can be made for the manufacturers of hot gas cleanup equipment.

In contrast, the gas turbine manufacturers are less likely to commit resources to develop a new turbine tailored to biomass derived fuels. Manufacturers of turbo-machinery designed for the low-Btu gases supplied by coal will likely already have a product for the biomass gasification process. However, the fuel of choice for the foreseeable future is natural gas and motivation to invest in alternative fueled turbine development is nil.

2.2.4 Engineering and Construction Contractors

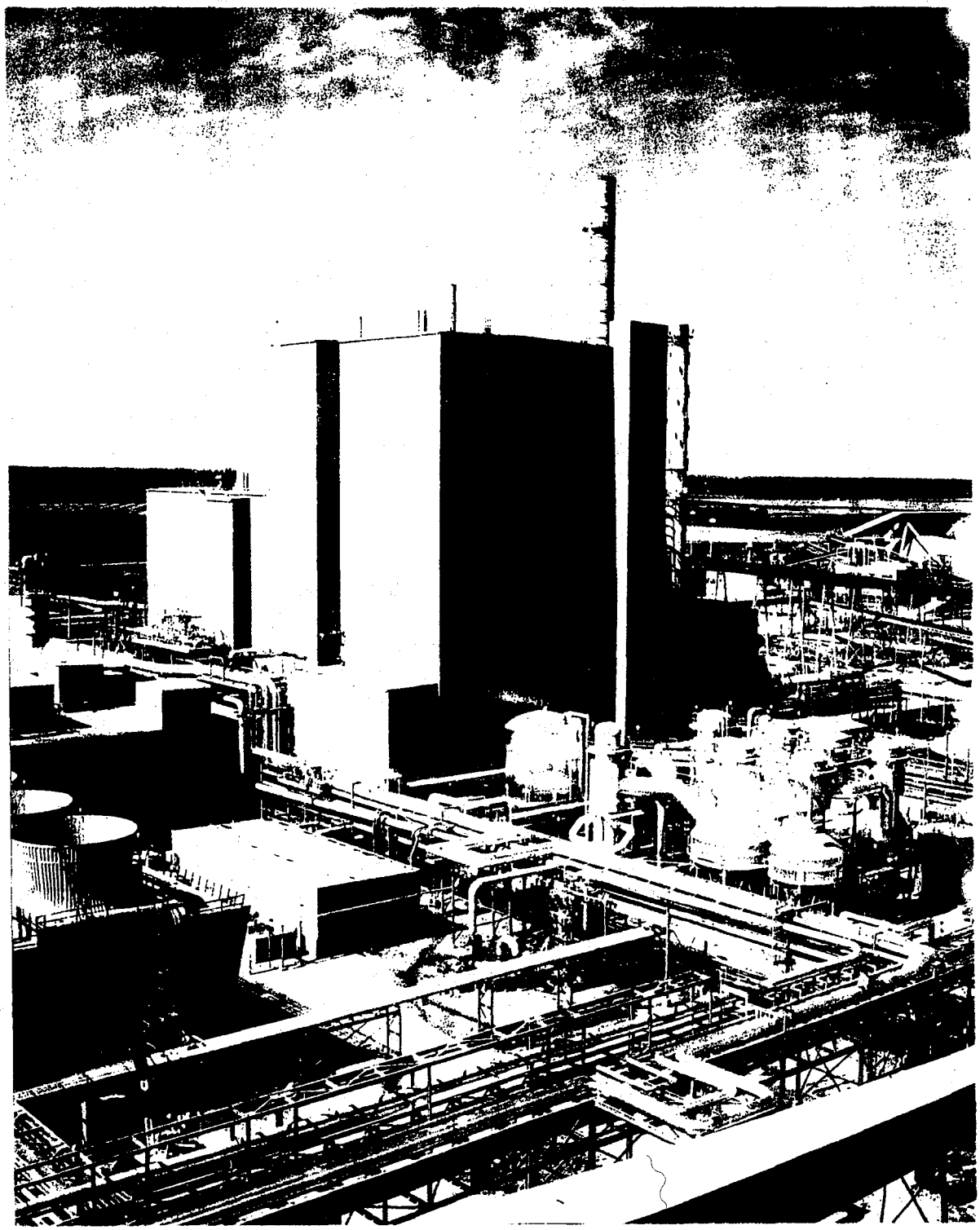
Often power equipment manufacturers, such as General Electric, Westinghouse and ABB Combustion Engineering, take on the role of E&C contractor. In other situations, companies are dedicated to E&C and are not involved with component manufacturing (e.g., Black and Veatch, Stone & Webster). In either circumstance, electric utilities and IPPs rely on E&C contractors for large tasks which may be beyond the responsibilities that they wish to bear. For this reason, the E&C firms must be kept abreast of, and involved with the Biomass Power Program. The most important of these firms' capabilities is turnkey services, in which they are responsible for coordination of feasibility, design, procurement, construction, start-up, and operation. Some of these firms even assist in financing. Often the contractor can supply some or all of these individual services in addition to the coordination. Due to the similarities between biomass power technologies and more traditional technologies (e.g., biomass IGCC/coal IGCC similarities) E&C contractors can easily make the transition to the biomass power industry. In fact, several manufacturers, including Babcock & Wilcox and Foster Wheeler, have already provided turnkey services at biomass fired facilities, generally for the pulp and paper and sugar processing industries.

2.2.5 Industrial Users and Cogenerators

The wood products industry and pulp and paper mills have used biomass fuels on a broad scale for process heat and self generation. PURPA brought in a new set of players building biomass fired cogeneration systems supplying industry with process steam and electricity, and also feeding power back to the grid as a qualifying facility. However, the primary objective of the mills is to dispose of the unused byproducts; heat and power generation are generally secondary benefits. With the trend in the industry toward waste minimization and alternative uses for unused byproducts of higher value than fuels, the availability of these sources will tend to decrease in the future. For the cogeneration project developers, the number of attractive sites with hosts for process steam have dwindled.

Currently the wood products industry is the primary supply source for biomass fuels for power projects. That role is expected to continue throughout the 1990s. The importance of this group to the development of biomass power is probably their knowledge of large scale feedstock

EXHIBIT 2-6 PULP AND PAPER INDUSTRY - FOURTH LARGEST ENERGY USER IN THE U.S.



production, transportation, processing and handling systems and their holdings or rights to large areas of potential feedstock production, which might give them a competitive advantage in entering the production phase of the business. Nearly all of the major businesses involved in the wood and paper products industry have had power generation experience including Georgia-Pacific, Boise-Cascade, and Weyerhaeuser.

2.2.6 Biomass Fuels and Fuel Feedstocks

The U.S. Department of Agriculture (USDA) has ongoing programs that are looking at specialty crops for biomass fuel production, for example, rapid growth poplars and switch grass, and has signed a Memorandum of Understanding with DOE to pursue these programs jointly. Oak Ridge National Laboratory (ORNL) has a current project focused on the development of a biomass fuels model that can project resource availability based on plant type, soil characteristics, water availability, climate and other characteristics. However, from a less technical viewpoint, what also needs to be investigated is to what extent current agricultural subsidies and allowances will enhance or slow the transition by the agricultural sector to biomass fuel crops. It may be appropriate to look in detail at the economics of biomass fuels production to insure the resource availability at a cost-competitive price. The analysis should consider the environmental costs as well as the national/regional economic benefit of relying on a domestically produced fuel. These economic benefits would include an increase in jobs, reduction in energy imports, and an increase in federal, state and local tax revenues.

2.2.7 Regulatory Agencies

The decisions of the regulatory agencies affect nearly all aspects of power production and can be pivotal in the development of the biomass power industry. A favorable view toward the environmental and economic benefits of biomass power could lead to changes in the competitive bidding process and integrated resource planning (IRP) being instituted in most states in the U.S. and potentially foreign jurisdictions as well that might give biomass a competitive advantage. Equally, an unfavorable ruling on biomass environmental impacts could hurt biomass projects across the board - permitting, competitive bidding, cost of construction and operation and generation efficiency. Generally, regulatory agencies will not champion technology or resources, but they certainly have the power to influence resource choices by penalizing the perceived negative impacts of specific resource and technology choices. From this standpoint, DOE cannot afford to ignore the information needs and technical concerns of the regulatory bodies. In effect this may be an important way in which the Biomass Power Program can assist industry toward near term implementation of biomass projects. The degree of objectivity shown by DOE in presenting its lab and field test findings with respect to biomass power technology will have a profound affect on their acceptance by the regulators. A number of regulatory agencies at the national (EPA) and local (e.g. South Coast Air Quality Management District, CA) level have R&D resources for evaluation of environmental characteristics of new energy technologies and could be contributing partners in the Biomass Power Program. A number of the PUCs nationwide have been or are in the process of commissioning analytical studies of the use of environmental adders (externalities) in the resource selection process and other important refinements to the IRP process.

3. DYNAMICS OF THE MARKETPLACE

The marketplace for biomass power projects is influenced by many factors. Some of these factors, such as the low cost of natural gas in the past several years, make it difficult for the biomass power option (and many other conventional or renewable fuels) to compete on a simple production cost bid basis. Other influencing factors, such as negative public perception, can be overcome with increased information dissemination. Meetings with industry representatives focussed on the following issues as being the areas of greatest challenge.

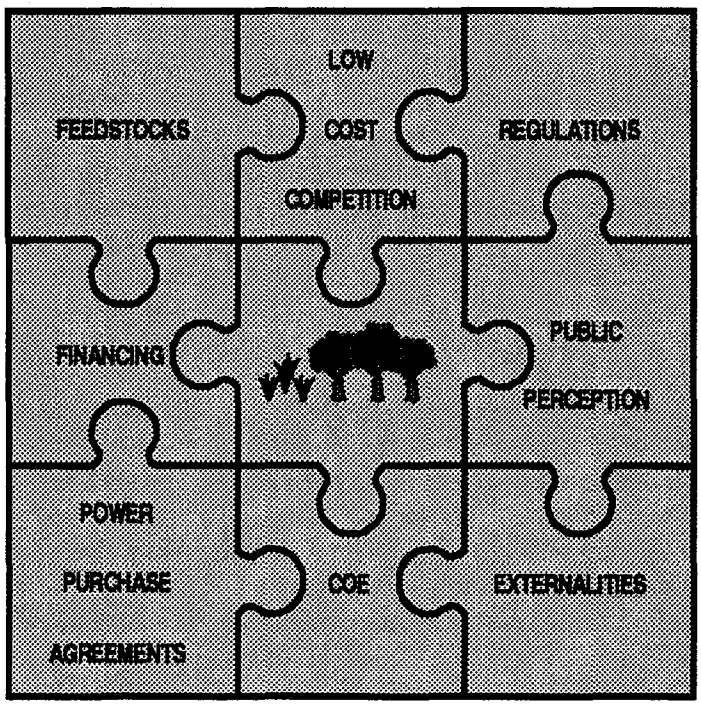
3.1 Cost of Electricity

Biomass power projects are relatively capital intensive (comparable to coal, but less than nuclear) and must generally be operated as baseload stations to make the investment economic. The busbar cost-of-electricity (COE) is a common figure of merit used to compare generation alternatives. A high capacity factor reduces the impact of the capital cost component of the plant COE. This increases the relative importance of fuel and other operating costs as components of COE. Once a project is operational, the plant will be dispatched solely on its relative cost to operate compared to other plants in the system. Thus for a biomass power project to contribute value to the utility system, operating costs must be competitive with other choices. The primary drivers for operating costs are station heat rate and fuel cost with low heat rate and fuel cost being the winning combination. (IPPs generally have contracts requiring the utilities to buy as much electricity as the IPP can produce, but the price paid for power is fixed. Thus, the IPP has a similar motivation to minimize fuel costs and heat rate, though it is driven more by profitability rather than dispatchability.)

3.1.1 Low Cost Power Generation Options

Natural gas prices have remained relatively low in recent years, while natural gas combined cycle plants have increased the efficiency of power production dramatically. This price moderation for what is usually viewed as a premium fuel has allowed electricity generation costs to approach 4 ¢/kw-hr with this fuel source. Although more regional in nature (i.e. in the northwest U.S.), low-head hydropower costs are in this range as well. Relicensing issues surrounding existing hydro sites are expected to significantly constrain the use of this resource. Since the natural gas

EXHIBIT 3-1 THE BIOMASS POWER MARKETPLACE



option is widely available it has become the standard for many utilities in setting a floor on resource bids. More recently, gas prices have begun to rebound and will probably escalate at a moderate level during the rest of the decade.

3.1.2 Feedstock Availability and Cost

Feedstock availability and cost strongly influence the COE associated with biomass power facilities. Biomass feedstock collection can be labor intensive, especially when obtained from the forest floor. Also, because biomass has a higher bulk density per unit heat input than coal, it has higher associated transportation and handling costs. In the northwest, environmental concerns (i.e. spotted owl habitat) have greatly affected the timber industry. This directly affects the feedstock availability for biomass power plants in that region. In California, the rapid development of biomass power facilities in the 1980's (as a result of PURPA legislation), created a high demand, causing biomass fuel prices to skyrocket. Furthermore, as pulp and paper mill operations become more efficient there is less byproduct resource available. Competing end-uses for biomass resources, such as for landscaping mulch, maintain demand-side pressure.

Countering those forces to some degree are trends such as the restrictions on landfilling which may increase the availability of process byproduct resources in the market. As electricity prices increase, pulp and paper mills will want to become more self-sufficient in power and repowering with high efficiency biomass fueled power systems will be more desirable.

3.2 Financing/Lending Institutions

Another obstacle encountered in the today's markets for new power is securing financing. Securing financing for biomass projects can be more difficult than for conventional projects due to higher perceived risks. For all IPP projects, the recent trend of requiring a higher equity stake on the part of the developer is forcing technology toward the tried and true. Lending institutions are very reluctant to finance the construction of biomass power plants without an established long term fuel supply infrastructure. A power plant will not be financed without a fuel supply infrastructure, and the fuel supply infrastructure will not be created without a market for the biomass fuel. In addition, despite the need for the use of higher efficiency conversion systems to make biomass power fuels competitive, most lenders are uncomfortable with new or unfamiliar power generation technology. Thus perceived risks in financing can be a significant hurdle to the introduction of the technology that is needed to move the industry forward.

3.3 Environmental and Permitting Regulations

A recurring concern echoed throughout the industry is dealing with variable and changing permitting requirements. Federal, state, and local regulations present a veritable maze to the biomass plant developer, Exhibit 3-2. In addition, biomass power is seen as a relatively new technology concept where many regulators are concerned. Therefore, whenever a developer is applying for permits for a biomass plant, he must first educate the appropriate regulators concerning biomass technology. This has the practical effect of sending the permitting process back to square one for every new biomass plant, where each aspect of the plant must be documented and/or proven, over and over again. This approach may also be seen as unnecessarily burdensome, given the potentially beneficial environmental aspects of biomass power compared to some conventional plants. It is hoped that once regulators are educated as

to the benefits of biomass power, some of this repetition could certainly be eliminated (placing biomass on at least an equal footing with conventional power sources), and perhaps even some informal streamlining could take place. An example presented to the survey team indicated that the permitting process for a new plant took three years and cost $3 million. Streamlining the permitting process would be a logical step for organizations hoping to encourage the use of biomass power.

3.4 Power Purchase Agreements and Externality Considerations

Competitive bidding practices pit IPP generation options against each other and utility-financed options. This practice is gradually replacing the avoided cost power contract. On a simple first cost basis, gas combustion turbines tend to have a clear advantage. However, some jurisdictions are beginning to value externalities such as environmental and economic impacts in the competitive bid process. These factors tend to level the playing field for biomass power and other alternatives. In bids where these factors have been given significant weight, biomass power projects have proven to be competitive. Exhibit 3-3 indicates the potential effect of a several externalities as they might be applied to a cofiring retrofit project for an existing coal fired facility. While the trend is toward giving these considerations more weight, the process and methods are still controversial and far from being widely used. One approach favored by several states has been the use of set-asides of blocks of power for acquisition of renewables. This approach lets renewables compete among themselves and avoids the use of a complex system of cost adders in the bid process.

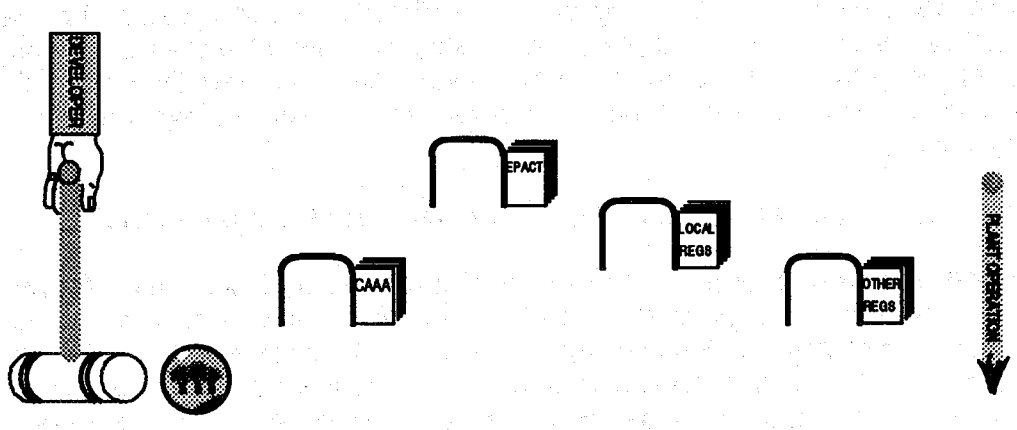
In February 1993 the Administration proposed a broad-based energy tax covering fossil fuels, nuclear fuel, and hydroelectric power. "Non-conventional" fuels, including biomass, were excluded. The Administration stated the objectives of the tax were to increase energy efficiency, improve the environment, enhance national security, and strengthen domestic economic performance. The tax was to be indexed to the energy content of the fuels and was proposed at 25.7 ¢/MMBtu. Although it is unlikely that the conference committee bill will include the Btu tax in this form, it is expected that the trend toward valuing externalities in tax measures will be an approach given serious consideration by legislators.

3.5 Public Perception

It appears that as a whole, the biomass power industry suffers from a public relations problem. Much of the general public (and to some extent the regulatory community) views biomass combustion as an old (1930s) style combustion technology, or worse, as a cover for waste incineration. Environmental and economic benefits of the technology are not often taken into account. Public awareness about today's biomass power generation, on a national level, is essentially nonexistent. This lack of awareness and/or misconceptions about biomass power often causes unfounded community concerns regarding the siting of biomass power facilities.

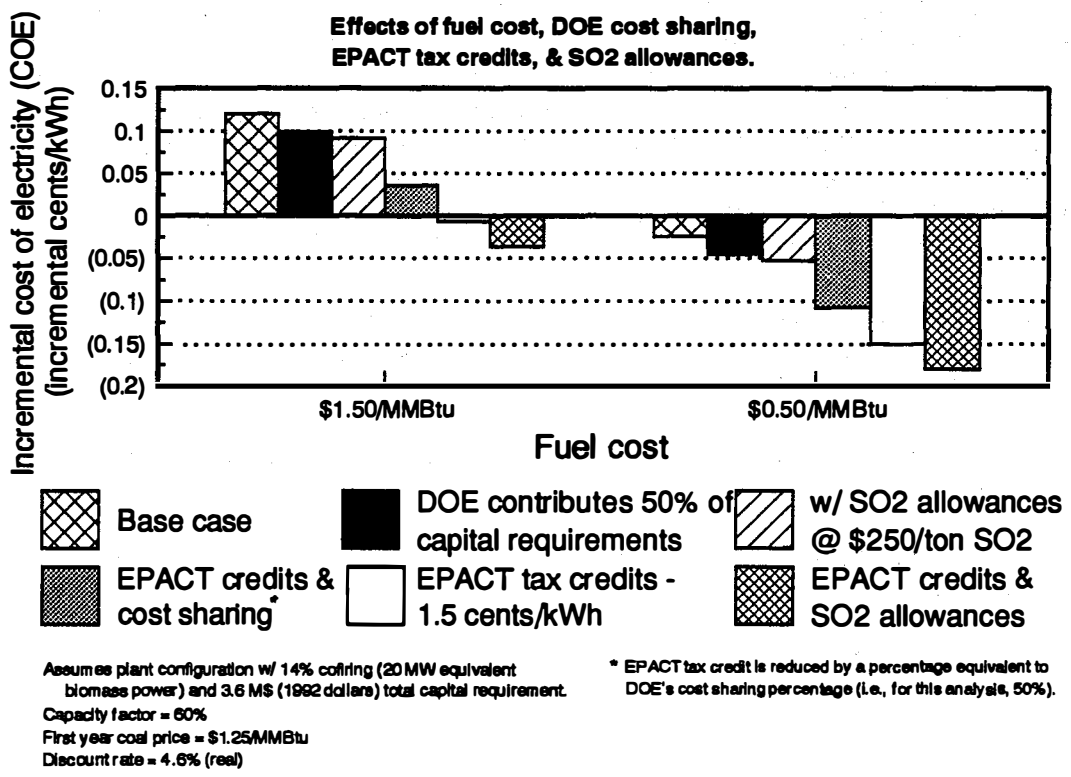
Industry perceives a further complication of this problem by the government's failure to take a firm stance with regard to developing biomass as a national resource for its economic and environmental benefits in power generation. Industry lacks the independence to evaluate and promote these benefits to the public. Thus the burden of reaching the public on the need for

EXHIBIT 3-2 THE REGULATORY PROCESS FROM THE DEVELOPERS PERSPECTIVE



biomass power falls to DOE which in conjunction with the USDA and EPA must present a united or at least coordinated front on the issues to be resolved and benefits that can be achieved through promoting biopower.

EXHIBIT 3-3 INCREMENTAL COE FOR COFIRING RETROFITS



Assumes plant configuration w/ 14% cofiring (20 MW equivalent biomass power) and 3.6 M$ (1992 dollars) total capital requirement.
Capacity factor = 60%
First year coal price = $1.25/MMBtu
Discount rate = 4.6% (real)

* EPACT tax credit is reduced by a percentage equivalent to DOE's cost sharing percentage (i.e., for this analysis, 50%).

4. OPPORTUNITIES

As a result of the assessment team's discussions, a number of important opportunities for coordinated efforts and possible joint ventures between DOE and industry were apparent. Each of these areas can produce important near term results that will spur the continued development of the biomass resource and generation capacity in the 90's. These opportunities received strong consideration in the development of the DOE Five-Year Plan.

4.1 Cofiring Biomass and Coal in Utility Boilers

Cofiring alternative fuels, such as biomass and coal (or other fossil fuels), has been conducted on an experimental basis by utilities without much fanfare throughout the U.S. (See Exhibit 4-1) Experience has varied with boiler configuration. In pulverized coal boilers, cofiring has been limited to a few percent of heat input. In coal stokers, the percentage cofiring has been increased into the 25 to 50% range while fluidized bed boilers have been fired with mixtures that span the full range.

Cofiring, as a strategy element of the Biomass Power Program, provides one of the best opportunities to quickly bring the utilities into the fold of biomass resource users. IPPs that build or own coal-fired stations may also be interested. From the utility point of view, cofiring is attractive for several reasons. Cofiring of inexpensive byproduct fuels solves two problems. It

helps mitigate a waste wood disposal problem that is becoming increasingly burdensome for industrial customers, municipalities and its citizens. As landfill restriction are tightened and operating costs spiral upward, the diversion of waste wood from landfills to the power generator as a low/no-cost fuel resource can provide direct consumer benefits. Not only is landfill space preserved, but consumer waste disposal costs and customer power rates may be lowered. If the byproduct fuels can be procured at a near zero cost, it may provide the only opportunity to revitalize some smaller capacity coal units that are no longer economical to dispatch as base or intermediate load plants. Cofiring is also a low risk, low capital cost option. This makes it a much easier sell to both utility management and the Public Utilities Commission. Other cogent factors favoring cofiring from the utility perspective include:

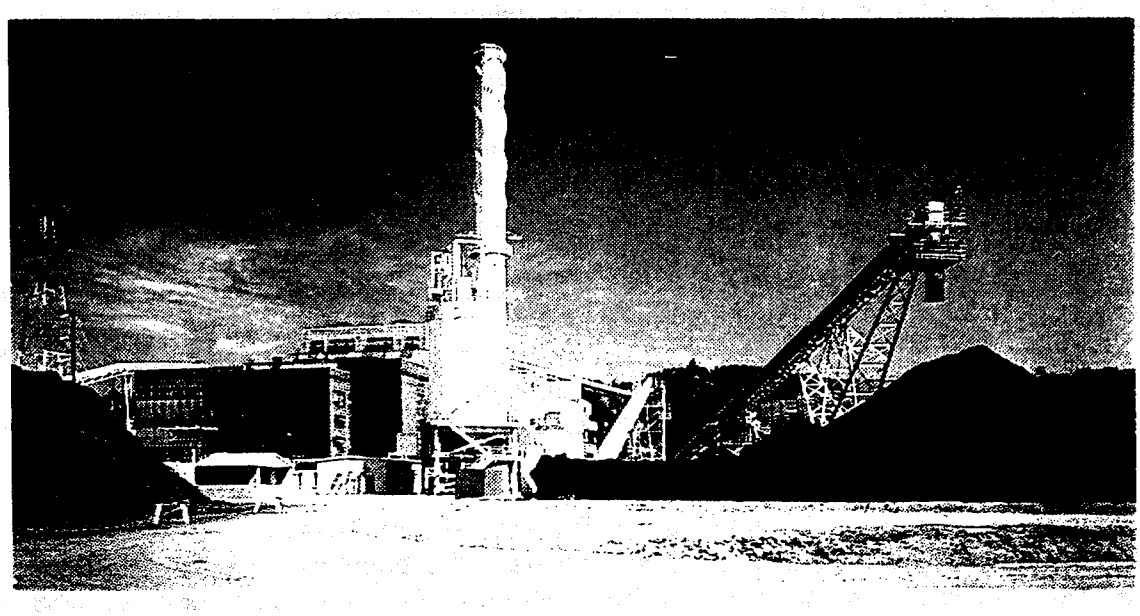
- direct environmental benefits of both reduced air emissions (lower SOx, NOx and CO_2 emissions) and reduced solid waste streams. Thus biomass provides power while demonstrating corporate commitment to a cleaner environment.

- possible economic benefits accruing to SO_2 allowances and avoidance of potential carbon taxes.

- fewer permitting problems by introducing this "new" fuel on a partial basis at existing permitted facilities.

- fuel flexibility providing negotiating advantages in fuel procurement for coal and biomass.

EXHIBIT 4-1 TACOMA CITY LIGHT'S STEAM PLANT #2 COFIRES BIOMASS AND COAL TO GENERATE 50 MW



From the DOE perspective several factors make this strategy attractive:

- this strategy element is also a low risk to DOE on both the investment and technical ends.

- cofiring offers the best near-term opportunity to bring the traditional utility companies into the biomass power arena providing them with fuel procurement, permitting, and operational experience.

- environmental regulators and the public are afforded the opportunity to evaluate the use of biomass fuels in a permitting setting that is far less threatening.

- cofiring is a technology choice that can deliver its share of the power generation capacity goal set for the biomass power program in SOLAR 2000.

- cofiring can provide the lower risk transition step to DFSS development.

Only two utilities have cofired coal and biomass on a continuous basis. These are Tacoma Public Utilities and Northern States Power (NSP). Burlington's McNeil plant was designed to operate solely on wood fuel but was later converted to cofire natural gas (at low summer rates) and biomass to improve plant economics and dispatchability.

In the Southeast and mid-Atlantic region, several utilities have experimented with cofiring biomass and coal in existing utility boilers. Santee Cooper has successfully fired a 5% mix of biomass and coal on a temporary basis. Others, including Delmarva and Carolina Power and Light, have run wood/coal cofiring tests. TVA is undertaking a year long study of retrofit options for its coal fired power stations as well as resource assessments. Early results indicate that there are units that could be adapted for pulverized wood firing with minimal impacts on boiler operation. The Southern Company is in the midst of a similar assessment and is already cofiring wood and paper processing byproducts on a limited basis at several facilities in the system. In fact, the Southern Company affiliated utilities have expressed a desire to implement pilot plant conversions at several smaller stations in the system.

In the Northeast, Niagara Mohawk is investigating opportunities to cofire a number of alternative fuels in its coal-fired facilities primarily to take advantage of very low cost byproduct fuels to improve the dispatchability of existing coal-fired stations on an economic basis. NYSEG is already cofiring wood chips on a limited basis (less than 1%) and has expressed similar reasons for its interest in cofiring.

It is important to note that utilities did not feel that SO_2 reductions alone will have a significant enough benefit to make cofiring a good investment. It is clear that other factors will have be present to make a cofiring retrofit worthwhile. In some discussions, previous attempts to cofire more difficult biomass fuels such as peat or cofire by directly mixing minimally processed biomass on the coal pile led to operational problems that has left some plant operators skeptical. A cofiring initiative on the part of DOE will have to consider these concerns in addition to the other concerns typically raised for use of biomass fuels.

Several strategy elements and issues are evolving from these and other similar assessments in the region. For interested utilities, the unknowns and concerns that need to be addressed include:

- potential boiler operation impacts: efficiency losses, increased slagging potential, boiler capacity derating, fuel feed control and boiler response, downtime for retrofits, combustion instability and unknown levels of emissions (NOx, VOCs, CO, SOx, PM10).

- fuel delivery, handling and stocking concerns: fuel deliveries (access and congestion), on site fuel storage area required for low density fuel, fuel pile emissions, fire hazards and decomposition, separate on-site fuel processing equipment needs, fuel feed and boiler interconnections, fuel processing and handling safety, system flexibility for coal/biomass interchange and systems reliability.

- fuel procurement: availability, price and its impact on plant dispatchability, fuel contract administration, fuel quality assurance and variability.

- impacts on environmental controls: ESP, baghouse, or scrubber performance impacts and their consequences for permit compliance or review.

- impacts on plant staffing.

In addition, plant managers will want to know if the positive benefits of cofiring outweigh the possible problems of plant and operational modifications to accommodate the use of the fuel. To convince system and plant managers to pursue cofiring projects, joint venture activities must address the issues in three ways. First and foremost, there is a desire to see that retrofits can be made with minimal impacts on plant capacity, operations and dispatchability. Second, the benefits of cofiring must translate into meaningful incentives. This could include:

- achieving NOx or SOx compliance through cofiring without further modifications.

- increased run-time (capacity factor) due to reduced operating costs and/or environmental dispatch incentives such as carbon dioxide caps on generation.

- reductions in loadings of local municipal landfills from industrial sources due to diversion to cofiring facilities.

Third, the fuel procurement systems must be demonstrated to assure plant managers that a sufficient long-term source of known quality fuel will be available to the plant.

The types of projects that are required include generic design studies for each of the major boiler configurations, demonstration projects designed to address all aspects of the retrofit and cofiring operations. Specific joint venture hardware tests might include:

- evaluation of preprocessing equipment capability to meet desired fuel specifications that minimize boiler modifications (fuel dryers, and mills).

- evaluations of alternative boiler retrofit options to optimize combustion stability, completeness, and minimize regulated emissions.

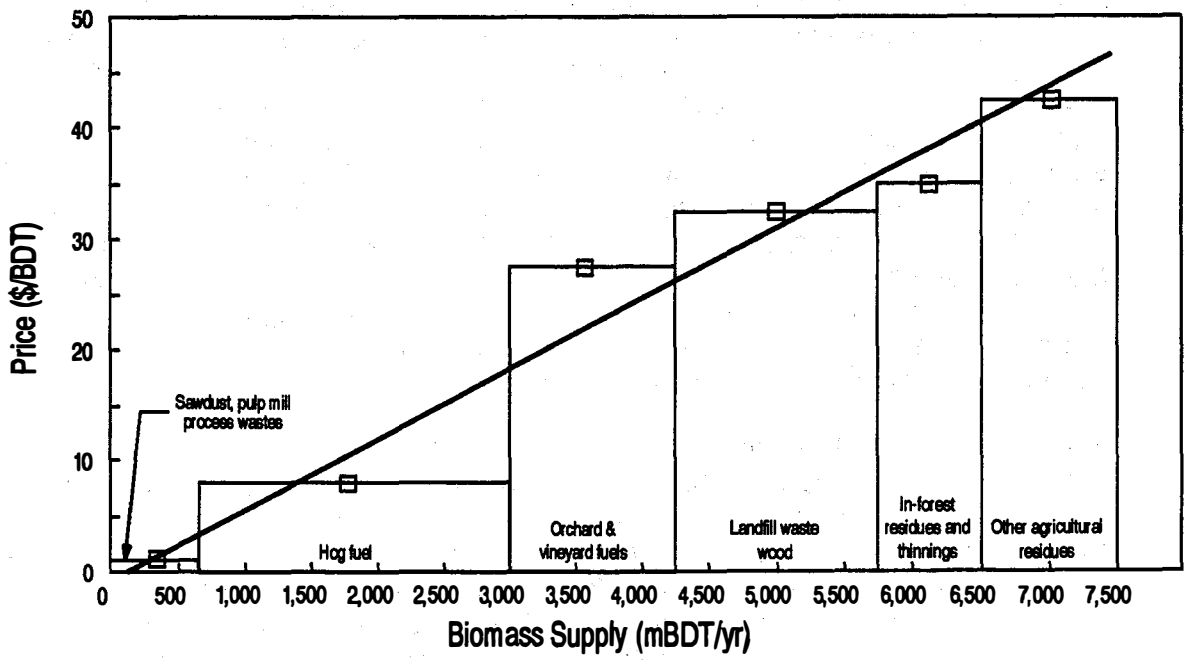
- evaluations of boiler and fuel feed equipment configurations that permit a high degree of flexibility with respect to fuel mix and boiler response to load changes.

- on the institutional side, initiatives that address possible evaluation of changes in dispatch rules, and system operations and accounting that provide incentives based on the demonstrated benefits of cofiring.

4.2 Expanded Resource Availability

One general area of need and opportunity will be projects and activities that expand the current resource base available to power producers. As can be seen in Exhibit 4-2, byproducts such as agricultural residues represent the upper end of the current supply curve in California. The possibilities raised span the potential market from wood and paper byproduct streams to energy crops as a supplemental source. Nearly all the IPP and utility representatives expressed the desire to be able to use a wider base of fuel resources economically. It was very clear from the meetings that the continued survival of the nascent biomass power industry would depend on the expansion of availability of diverse, low-cost fuel sources. Each potential resource has a specific set of issues to be addressed although environmental, collection and permitting issues pervade them all. Many of the potential feedstock sources are byproducts of industrial or agricultural

EXHIBIT 4-2 CALIFORNIA'S BIOMASS SUPPLY CURVE, 1990



Source: Turnbull, Jane, The California Biomass Energy Industry in 1990: Supply, Demand, and Outlook for Biomass Fuels, May 1991

operations. It will be more efficient for the Biomass Power Program to work jointly with DOE Industrial Energy R&D Programs and USDA Product Development Programs to develop these resources.

Efficient collection of agricultural residues. Orchard prunings, and wheat and rice straw are a few of the sources that the IPPs and utilities expressed interest in utilizing as a fuel source. However, these residues can be costly to collect and their availability is seasonal. The further tightening of open field burning restrictions could prove to be a strong motivating factor for these efforts. Estimates of the farmer's cost to collect and ball wheat materials range from $17 to $30 per ton. Furthermore, the resource is low density, on the order of 1 to 3 tons per acre per year. The desirable solution appears to be the development of collection processes that are integrated with harvesting. By densifying and collecting the material as a part of the harvesting process, these fuels could be affordably collected. Collection must then be augmented by an efficient delivery system to transport fuels to the plant.

Increasing the availability of residues from improved forest management practices. In California and the Pacific Northwest, concerns for habitat protection continue to be strongly supported. However, the economic downturn coupled with recent experiences with forest fires and the desire to use forest resources to benefit economic growth have spurred efforts to institute forest management practices that consider the benefits of removing salvageable materials that would otherwise be tinder for forest fires. The industry that must operate in this region generally feels that the level of emotion that pervades the forum on the use of forest lands is hamstringing productive and environmentally sound uses of the resource. The initiative that the industry is seeking here is to involve DOE and the Forest Service in efforts that would gain acceptance for good management practices that provide for the health of forests while permitting economic use of the available resources. Opportunities to demonstrate these practices are being developed by the owners of Biomass One in eastern Oregon at a 5 MWe site. PG&E has indicated its willingness to offer a renewable generation rate for such projects and BPA could also be a player in this process. The situation in Vermont is similar, but the driving force for access to forest resources has been towards management programs designed to cull the low value species that predominate in Vermont woods to allow high value species to make a comeback. Burlington considers its fuel harvest management approach to be a model for the industry. Burlington Electric suggested that one area where Federal support could be of direct assistance would be in providing resources to the state forestry and agriculture programs to underwrite the costs of surveying forest resources, developing harvest management plans and providing manpower for inspection to assure compliance with authorized harvest plans. This would directly reduce costs born solely by the utility that increase fuel procurement costs.

Tapping treated mill byproduct materials. In addition to untreated wood byproducts, the industry would like to access other mill byproduct streams such as pulping process byproducts or treated wood byproducts (fiberboard, plywood). The ability to economically process these byproducts into transportable fuel forms and burn them without environmental permitting repercussions is the primary issue. JWP Energy Products, Inc. is concluding a project in Virginia that burns paper mill sludges at a rate of 32 DTPD. Wheelabrator expressed interest in processes that would pelletize pulp and paper sludges for fuel. These fuels are potentially of most value to the mills for cogeneration.

Tapping low value paper byproduct streams. Treated paper products such as newsprint, colored or finished paper and chemically impregnated cardboard byproducts are difficult to recycle into new paper products. Rather than landfill these materials, recycling them as fuels would be desirable. One of the industry contacts pointed out that the recycling of low value paper sources to produce paper often generates more mill sludge than paper. For these materials, fuel uses may be the higher value use with the least environmental impact. JWP Energy Products, Inc. Is particularly interested in developing a multi-fueled energy project in Northern Idaho to demonstrate low emissions from today's fluidized bed combustion technology.

Tapping urban wood materials from the solid waste stream. Several efforts are being pursued which tap into the urban wood materials supply, thus diverting it from the solid waste stream. Burlington is accepting yard and tree trimmings at the McNeil station. Wheelabrator is In the process of building a 39 MWe energy facility in Polk County, Florida, that will burn a combination of yard and tree trimmings, used tires and landfill gas. Thermo Energy has three operating facilities and is completing a fourth that use urban wood as a fuel source. Use of urban wood has been extensively evaluated by New York State and others as an important source of fuel for power production. Use of urban wood directly reduces landfill loading and provides low cost fuel for power production. The primary issue has been concern with air emissions from the use of treated wood products. The NYSERDA work generally indicates that with the exception of CCA treated wood, the exposure risks of combusting most treated wood are very slight or insignificant and meet state guidelines. NYSEG is particularly interested in specialized used wood streams and is evaluating fuels such as railroad ties and telephone poles. Forced recycling goals for California and other jurisdictions may make these fuel sources more accessible.

Early development of DFSS projects to supplement other fuel sources. Possible use of DFSS as a source of fuel is being considered for projects in Alabama, Minnesota, Virginia, Wisconsin, New York, the Tennessee Valley, and California. EPRI is very supportive of this approach for two reasons: long term supply assurance and disassociation of biomass from the potential environmental problems of misusing forest resources and limitations of byproduct or waste fuels. Two things appear to be necessary for the DFSS concept to be accepted as economic for current industry projects - assurances that the EPACT 92 production tax credits can be used by the project and the ability to serve several markets with the biomass products (e.g. white wood going to paper production, bark and lesser grades of wood harvested going to fuel uses). In New York, NYSEG, Niagara Mohawk and SUNY (Syracuse) are pursuing a trial DFSS project based on hybrid willow clones. The fuel produced would be test co-fired in utility coal-fired boilers. In Virginia, poplars grown on existing farm acreage are being considered as a potential fuel supplement option for obtaining a secure long term fuel supply required by lenders for a wood-fired IPP project. In California, the DFSS option is being given consideration as a supplemental fuel source to provide an alternative to current sources that are in high demand by competing uses. Ag West Resources has proposed a DFSS project to support the Thermo Energy project at Woodland, CA. SMUD is working with UC Davis to identify the four most productive DFSS species for the Sacramento valley. With passage of the North American Free Trade Agreement (NAFTA) pending, California is very concerned about the decline in state agriculture with the opening of markets to products produced in Mexico. In the Tennessee Valley, DFSS projects offer the ability to expand the use of biomass fuel sources needed to implement TVA's coal and wood cofiring strategy without

recourse to harvests from environmentally sensitive resources. Another interesting concept put forth is the dual purpose use of energy crops as erosion control and ground water filtering systems. This increases the value of the DFSS as a dual purpose system. In the San Joaquin Valley, 600,000 eucalyptus and casuarina trees (some poplars also tested) have been planted to control erosion and absorb Selenium salts from irrigation runoff[1].

4.3 Repowering Existing Steam Turbine Stations

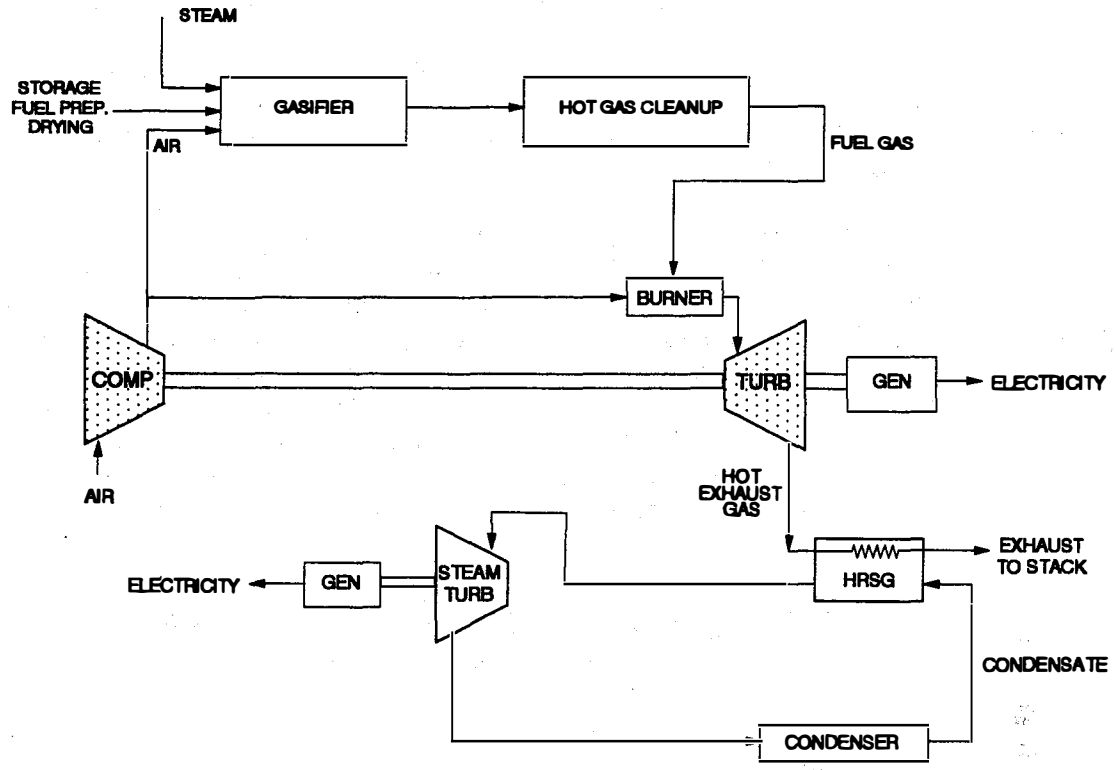
Many of the generating units built by IPPs were constructed when available biomass resources were inexpensive and purchased power agreements were generous. As such, combustion efficiency was not considered a major issue at that time. As power purchase agreements expire and new contracts are negotiated, the ability of many of these facilities to continue to be economically productive will be in question. In addition to tougher power contracts, stricter environmental regulations and a tighter wood supply situation are threatening the economic health of the industry. In California, IPP and QF biomass power stations now account for approximately 4% of total generation for Pacific Gas and Electric. Repowering projects can improve the efficiency and availability of some of these plants to extend their useful life until a new generation of conversion systems becomes commercially available. This is also true for two other classes of power facilities: wood fired units operated by the pulp and paper industry and aging coal fired plants operated by the utilities or industry. The pulp and paper industry would benefit from a greater degree of self sufficiency while the utilities could upgrade and extend the life of older units. Options include:

- Gasification of agricultural biomass fuels to fire boilers previously plagued by slagging problems. Low temperature gasification can produce a fuel gas that will be free of slagging materials and can be fired in existing boilers at relatively high efficiency and with increased plant availability. There are a number of plants which have plentiful resources of agricultural byproducts but cannot keep the boiler in operation due to severe slagging problems. Gasification could provide the solution to reintroduce the agricultural byproduct fuels into the operation.

- Gasification combined cycle retrofits to increase efficiency and reduce operating costs. Repowering existing boilers with a gasification combined cycle offers the potential to salvage projects where fuel costs have made biomass operations uneconomic (See Exhibit 4-3). Green Mountain Power, with assistance from EPRI, is giving this option consideration. Burlington Electric's McNeil Station is currently dispatched on an economic basis at a low capacity factor and is a possible candidate for repowering. Approximately 40% of generated power is currently produced using gas available during the summer at very low cost. Gasification combined cycle would reduce fuel operating costs by as much as 25%. Paper and wood products industries such as Weyerhaeuser have expressed interest in the gasification combined cycle with the intent of being even more self sufficient in terms of self producing power for plant operations.

[1]Biomass yields can be up to 5 tons per acre.

EXHIBIT 4-3 BIOMASS INTEGRATED GASIFICATION COMBINED CYCLE



4.4 Modular Scale Prepackaged Generating Systems and Custom Built Agripower Systems for International Markets

For international markets in areas where power is frequently needed in smaller increments and biomass resources are plentiful, small scale packaged biomass generators will be very attractive. Several companies are evaluating the market and the technology that would best serve the market. One company, Energeo, is committed to development of those markets with the intent to offer a line of prepackaged indirect-fired gas turbine generators sized from 200 kW up to several Megawatts (See Exhibit 4-4). PGI is also developing a product (direct-fired small gas turbines) well suited to this market. The opportunity exists for small scale, modular biomass systems to compete in the international marketplace with diesel-powered generators. By using an inexpensive indigenous resource, biomass power systems reduce dependence on high cost, imported fossil fuels. Other companies have indicated interest in offering prepackaged systems for biomass fuels based on more conventional conversion equipment.

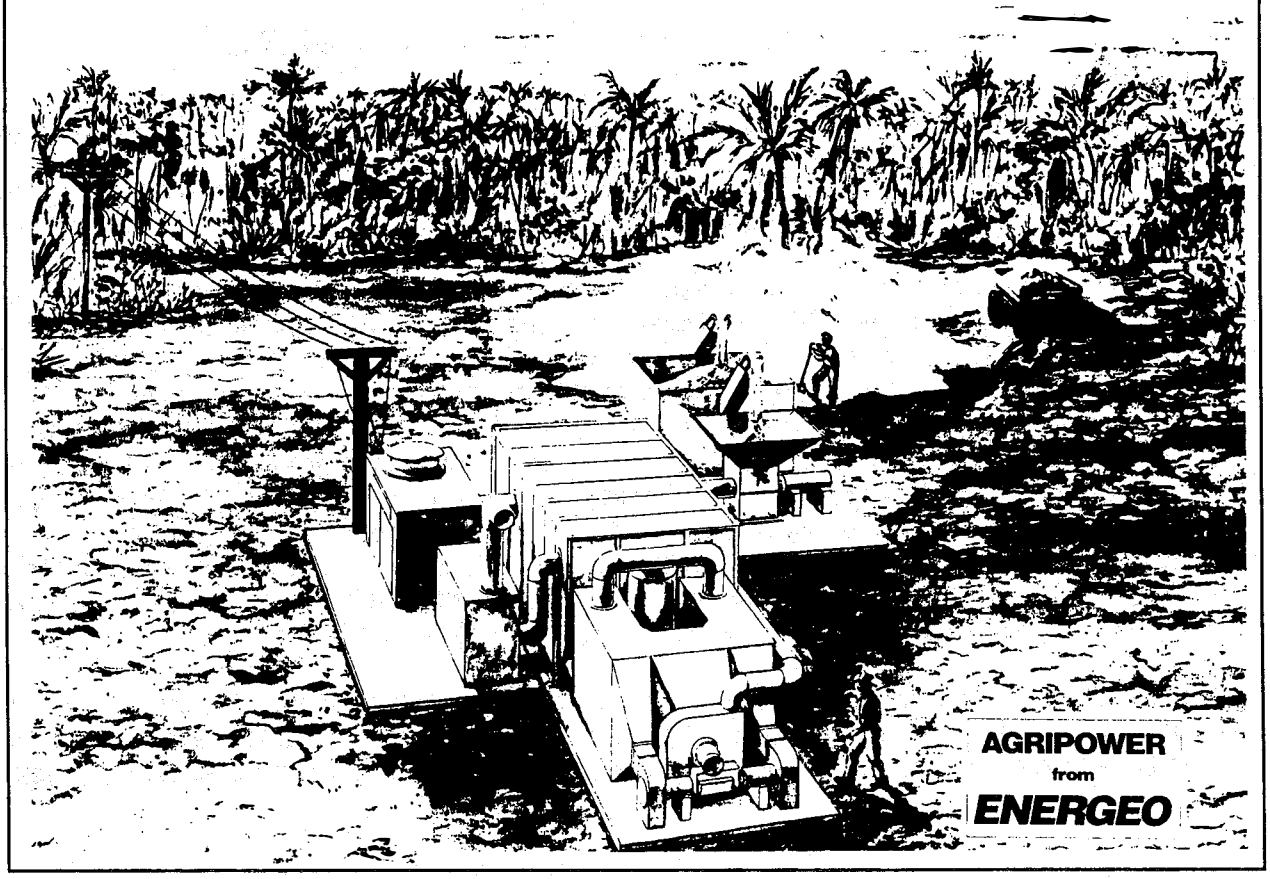
On a larger scale, Agrilectric, JWP and other companies have targeted the existing agricultural processing industry as potential power producers. The sector that has attracted the most initial interest is the sugar industry, which typically uses its byproducts to produce process heat. By

converting to higher efficiency cogeneration equipment at these facilities, the industry and local economy stand to benefit by the additional income generated by power sales. Both JWP and Agrilectric offer products that are suited to the combustion of agricultural fuels.

Industries actively pursuing international markets are aware of the programs sponsored by USAID and Winrock and in several instances are already benefiting from these "technical assistance missions" to developing nations. The industry generally felt that these programs were helpful and should not be duplicated by DOE.

One element these programs do not address is the need to demonstrate performance, maintainability, and reliability claims of the manufacturers. The need to see, first hand, a system operating on local feedstocks for an extended period of time (up to one year) and to realize the projected cost savings for replacing aging diesel equipment, is commonly expressed by the purchasing agents of the governments of developing nations. An opportunity exists for DOE to pursue joint venture projects in strategic locations worldwide that make it easy for representatives of developing nations to see U.S. built systems in operation. A second issue that is clearly of concern to U.S. firms is the protection of the company's technology rights. Reverse engineering of the patented portions of U.S. equipment is commonplace. Once a product is available from

EXHIBIT 4-4 MODULAR INDIRECT-FIRED COMBUSTION TURBINES FOR VILLAGE POWER



in-country or regional sources, there is little market left for the U.S. product unless the company licenses the technology to in-country manufacturing concerns and competes with local manufacturing labor.

4.5 Developing Markets for Biomass Power Byproducts

Potential productive uses of biomass ash include: liming agents and nutrients for agriculture, landfill caps, sewage sludge stabilization, and structural fill. The issues for application of biomass ash are regulatory. In the State of Washington, wood ash is classified as a hazardous waste based on pH>12. This restricts both the handling and application of the ash for agricultural uses. A far more difficult problem has arisen in California where rice straw ash has been declared hazardous due to its high silica content. One project has been stockpiling the ash on site with the potential of becoming a hazardous waste clean-up site unless appropriate disposal arrangements are made. For urban wood materials, the presence of heavy metals and other contaminants from chemical treatment pose a problem for ash disposal. The approach recommended by industry to overcome some of these regional restrictions is to develop environmental consensus standards for biomass ash based on the real risks posed for transport, application and use.

Coproduction of chemicals and power make it possible to operate plants at full capacity to generate two product streams. For gasification, methanol production is a logical coproduct. Methanol can be used as a turbine fuel, a transportation fuel, or a chemical feedstock for other processes. Development of coproduction facilities was discussed only as a future option.

4.6 Capturing Legislative and Regulatory Incentives

The cofiring and niche opportunities described above may be enhanced considerably by legislative and regulatory incentives that encourage the use of renewable resources and resources which have positive environmental attributes unlike conventional fuels. The picture for the biomass power industry is still somewhat unclear, however. For example, industry is generally aware of the nature of the incentives provided under the recently-passed Energy Policy Act of 1992, but is unsure of the direction of implementation. Thus, the influence of these factors can be potentially positive for development of biopower projects, but may also lead to a "wait and see" approach that would postpone projects until a clear direction for implementation is assured. In addition, a number of state organizations and utilities have instituted programs which provide incentives for renewable technologies, and the Clean Air Act Amendments also may provide for improved opportunities.

Energy Policy Act of 1992

The Energy Policy Act of 1992 includes several incentives for renewable energy power production, including a renewable power production incentive (section 1212), a tax credit for renewable energy electricity production (Section 1914), and joint venture funds for renewable projects (Section 1201). The renewable energy production incentive provides for a payment from DOE of 1.5 cents per kWh produced. The coverage for this incentive, however, is limited to plants with ownership by a governmental entity (such as a state, political subdivision of a state, or an instrumentality of a state) or a nonprofit electrical cooperative. The tax credit is to be part of the General Business Credit, and applies only to qualified closed-loop biomass (and wind)

plants, and is set at a maximum of 1.5 cents per kWh. A closed-loop biomass plant is defined as utilizing crops specifically grown for fuel for an electricity plant. The amount of the credit is reduced if the average power purchase rates for biomass power facilities exceed 8 cents per kWh or if there is Federal or other government cost-sharing (grants, subsidies, etc.). Both incentives (sections 1212 and 1914) cover the first 10 years of the plant's operation, and are indexed for inflation. A 1.5 cent per kWh production incentive is equivalent to a $.90 - $1.25 /MMBTU subsidy for the biomass fuel at a plant heat rates ranging from 16,000 to 12,000 Btu/kWh. This incentive could make a difference for marginal projects. The industry could easily see the benefits for project development but seemed skeptical about being able to realize the potential benefits. Issues rased by the industry include:

- The law specifies that the credit applies to "new facilities" built after 1992. Many of the real opportunities are repowering or cofiring retrofit projects which are by definition upgrades to existing facilities. As such, the law bypasses some of the most realistic near term opportunities available for biopower development.

- Early DFSS projects are likely to serve two markets simultaneously: fiber and fuel. Extension of the definition of DFSS to cover these projects will increase the chances that DFSS will be considered by plant developers.

The renewable energy joint ventures program seems particularly attractive to utilities or project developers who are considering use of DFSS as a supplemental fuel supply. There is also interest in the use of joint venture funds for both cofiring and gasification demonstrations.

Externality Valuation and Regulations

Many jurisdictions of the U.S. are giving consideration to the recognition of externalities in the utility resource planning process. The impetus for this consideration comes from many sources, including implementation of the Clean Air Act Amendments of 1990, state and local legislation/regulations, and a number of other sources. In addition, this recognition comes in many forms, but there is no consensus concerning methodology or the degree to which externalities should impact decision making. In its broadest sense, any credit or debit based on social or environmental interests that is used to alter decisions that would normally be based on a purely economic and technical risk assessment serves as an externality. An immediate example is the proposed BTU tax which provides a favorable treatment for biomass fuels for power generation by exempting them from the tax. The biomass IPP industry generally favors the use of externalities since they believe that they will tend to favor renewable energy projects and, more specifically, biomass fuels. The utilities, on the other hand, generally favor the traditional economic assessment approach with qualitative consideration given to other factors. While some utilities are adamantly opposed to the quantitative use of externalities, others have developed and used them in their resource planning process. Some examples include:

- Vermont has issued an executive order for 20% CO_2 reduction for energy uses and has instituted a renewable power purchase program.

- Puget Power provides a 10% credit for renewable regeneration sources in bidding.

- Idaho offers 6.5 cents per kWh for renewable generators less than 10 MWe.

- The CAAA have instituted allowance trading for SO_2 emissions. The low sulfur content of biomass fuels permits utilities to earn allowances when they substitute biomass for coal fuels.

- The California Assembly directed the state PUC to set aside 50 percent of future generating capacity for renewables.

- New York established a program to procure 300 MW of new renewable capacity by January 1, 1994 if it could be procured at an acceptable price premium.

- Iowa established a statewide renewable capacity procurement of 105 MW at a contract rate of approximately 6 cents per kWh.

- Wisconsin's PSC approved an investment/purchase incentive of 0.25 cents per kWh for biomass-generated electricity for up to 20 years if projects are on-line by December 1998.

At the level of current externality valuations, most in the industry felt that the gap between biopower projects and gas turbine projects could not be made up. There is, however, a good deal of concern about the possible imposition of carbon taxes or carbon limits. Most of the industry seemed to feel that this could make the difference as long as the "no net CO_2" principle for biomass is accepted. Until the rules for valuing reduced CO_2 emissions are in place, the industry has suggested that a systematic approach for "banking" credits for reductions would provide some initial incentive for companies considering biomass cofiring or repowering projects. These early reductions would be credited to the utilities' CO_2 accounts pending the imposition of caps and allowance trading. Without such a system there will be some inertia against reducing what may become the baseline emissions under future regulation.

5. RECOMMENDATIONS FOR DOE AND INDUSTRY JOINT ACTION

From the DOE perspective the industry meetings provide the best avenue for direct input from industry to the DOE blueprint for action - the National Biomass Power Program Five-Year Plan. The following recommendations present specific alternative courses of action designed to capture the opportunities discussed in the forgoing section. Each course of action is a distillation of the industries comment, while specific actions are generally representative of the many suggested approaches to program follow-up.

5.1 Implement an Information Dissemination Campaign

- Key players - Regional Biomass Programs, Industry Associations.
- One page summaries on key topics disseminated to key decision makers, industry and other interested parties. (What is biomass power?, environmental benefits and issues, Cofiring options).
- Biomass power report providing the latest information on the biopower market and technology via fax.
- Commercial quality video production highlighting the operations of modern biomass facilities and key aspects of the future role for biopower as envisioned by the biomass program strategy.
- Continue efforts to cosponsor several national conferences and forums on Biomass Power.

5.2 Support Implementation of EPACT and other Legislative Incentives

- Key players - DOE/HQ, Industry Associations, Key Industries.
- Provide technical input to rule-making for EPACT production incentives, especially definition of qualifying facilities and feedstocks.
- Channel information on status of credits and incentives to industry through the associations.
- Encourage and develop mechanism for the implementation of CO_2 credit banking.

5.3 Assist Utilities and IPPs to Implement Cofiring of Biomass and Fossil Fuels

- Key Players - Utilities, IPPs, NREL, Regional Programs.
- Sponsor prefeasibility studies for cofiring retrofits.
- Cosponsor test burns and cofiring demonstrations for major classes of utility boilers.

5.4 Support Industry Efforts to Expand the Base of Fuel Sources

- Key Players - Industry, NREL, ORNL, Regional Programs.

- Cosponsor limited scope feasibility studies of new feedstock sources including gradual introduction of energy crops.

- Support limited R&D on feedstock collection and processing methods that improve feedstock combustion characteristics and/or lower costs.

- Support R&D for safe byproduct uses of wood ash, and wood-coal mixed ash.

5.5 Support Industry Efforts to Demonstrate Advanced Biomass Conversion Systems

- Key Players - Industry, NREL

- Co-sponsor feasibility studies and demonstrations of repowering existing power stations with high efficiency biomass conversion systems.

- Co-fund feasibility studies and selected demonstrations of commercial scale power projects that integrate sustainable, dedicated fuel supply systems with high efficiency power generation systems.

5.6 Support Industry Efforts to Demonstrate New Modular Generation Technology

- Key Players - Industry, NREL, USAID, Winrock.

- Cosponsor demonstrations of new U.S. modular generation systems fueled by biomass niche domestic and international markets.

Under the current budget scenario for biomass power it is unlikely that all of these recommendations can be implemented. As such, a continuing dialogue between industry and DOE will be an important program building block. As the program moves forward there will be room for course corrections and review of priorities in light of changing market and regulatory conditions.

APPENDIX

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During September 1992 through January 1993, a review team established by the Department of Energy conducted an assessment of the U.S. biomass power industry. The review team, led by Michael Reed of the Solar Thermal and Biomass Power Division, and consisting of representatives of the Antares Group Inc. and Meridian Corp., visited with more than 50 organizations representing all sectors of the biomass power industry. These organizations included utilities, independent power producers (IPP), component manufacturers, engineering and construction contractors, agricultural organizations, industrial users and regulatory organizations.

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