Northeast Regional Biomass Program

Mission • Accomplishments • Prospects: 1991

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Table of Contents

Preface

This 1991 Report contains an update on the mission, goals and accomplishments of the Northeast Regional Biomass Program (NRBP). It describes the activities conducted during the past two years and incorporates the information contained in the 1989 publication of the NRBP Five Year Report. It describes the biomass projects conducted by the individual states of the Northeast Region, and summarizes the results from the Program's technical studies. Publications from both the state and regional projects are listed as well. An appendix lists the biomass-fired electricity generating stations planned or in operation in the region.

The NRBP began in 1983 by developing a five year plan to guide its work. Within that time frame, the NRBP undertook over 20 applied research and technology transfer projects, and supported and guided the work of its eleven member states. During and since that period, the NRBP has brought together public and private sector organizations to promote the use in the Northeast of biomass and municipal waste energy resources and technologies. The NRBP's long-range plan was updated in 1990.

In light of the accomplishments of the NRBP and the remaining challenges, this Report considers directions for future efforts. The Northeast has abundant biomass resources and markets for their use as energy. Meeting this potential will contribute to reducing the atmospheric greenhouse effect and dependence on imported oil.

Overview

The U.S. Department of Energy (DOE) administers programs in five regions to encourage the application of biomass and municipal waste-to-energy technologies throughout the nation. Because of the varied geography of the United States, with different potential and needs for biofuels development in each area, a regional biomass energy program has been developed to approach regional problems and opportunities with regional solutions.

Each region seeks to address the following issues:

- regional biomass fuels and availability;
- the costs of biomass compared to other energy sources;
- varied local requirements for energy from residences, commerce and industry;
- climatic and terrain differences and transportation limitations; and
- the needs of biomass energy suppliers, distributors and users.

The Regional Biomass Energy Program was established at the national level by Congress in 1983. The enabling legislation instructed DOE to support regional biomass energy programs, similar to one managed by the Bonneville Power Administration in the Northwestern United States since 1979, in other regions of the country for the development of appropriate bioenergy programs.

In fiscal year 1984, the Congress further defined the scope and direction of the Regional Program by specifying that it carry out activities related to technology transfer, industry support, resource assessment, and matching local resources to conversion technologies. Identical language has appeared in each year's legislation since that time.

The Northeast Regional Biomass Program (NRBP) was initiated in August 1983 with a grant to the Coalition of Northeastern Governors (CONEG), Policy Research Center Inc. from the U.S. Department of Energy's Oak Ridge Operations Office. The program is designed to promote the responsible use of biomass energy in the Northeast region which encompasses eleven states. This report provides a summary of NRBP activities over the last seven years, with an emphasis on the last two.

The program conducted by NRBP has three basic components. A state grant component provides funds (with a 50% matching requirement) to each of the states in the region to strengthen and integrate the work of state agencies involved in biomass energy. The Applied Research and

Technology Transfer Program component produces a series of technical reports and studies in areas that have been identified as important to the development of biomass energy in the region. The third component is a long range planning effort, with substantial involvement from the private sector, to identify activities necessary to spur greater development and use of biomass energy in the Northeast.

NRBP Member States

Connecticut
Delaware
Maine
Maryland
Massachusetts
New Hampshire
New Jersey
New York
Pennsylvania
Rhode Island
Vermont

The Biomass Energy Challenge

Biomass is the renewable feedstock most capable of displacing fossil fuels quickly in an emergency, and permanently in industrial utility boilers and in residential space heating applications. Municipal waste-to-energy facilities can make a substantial contribution to managing the waste disposal crisis in the Northeast.

The Congressional Research Service, the Office of Technology Assessment, and DOE's Energy Advisory Board have estimated the biomass potential by the year 2010 at two to three times current usage, and several times the expected energy impact of other renewable energy sources. When accompanied by appropriate forest management and air emissions controls, biomass energy use can make important contributions to more productive forests and simultaneously to reducing the release of greenhouse gases into the atmosphere. Co-firing wood with coal and municipal wastes also mitigates the growing constraints to the combustion of these fuels.

The unstable situation in the Middle East lends a fresh urgency to our efforts to displace fossil fuels. The Northeast used imported oil to meet 35% of its energy demand in 1990. Persian Gulf countries accounted for 7% of U.S. imports in 1985; through the first half of 1990, the number had grown to 26%. In addition, the emergence of global warming as a critical problem should accelerate our efforts to responsibly utilize biomass fuels.

Municipal Solid Wastes (MSW)

Management of municipal wastes, as well as commercial and industrial solid wastes, is a critical priority in the Northeast. The cost of disposing of these materials is escalating rapidly as a result of a shortage of landfill capacity and more stringent environmental controls. In some northeastern states it is doubtful whether new MSW landfills can be sited.

Because of these constraints, energy production from municipal wastes in resource recovery and anaerobic digestion facilities is emerging as a major solid waste management strategy. Municipal and commercial wastes are a significant biofuel resource in the Northeast. Methane gas recovery from landfills is another potential regional energy resource.

Wood Wastes

Wood wastes provide another abundant biofuel resource. While wood wastes from the manufacture of wood products are routinely used to produce energy in the forest products industries, urban and agricultural wood wastes are not widely used as biomass fuels.

Between 20% and 25% of the 150 million tons of solid wastes landfilled or otherwise disposed of annually in the United States are woody materials

from demolished buildings, land clearing, and from other industrial and commercial activities. An NRBP study finds that in the metropolitan Boston, New York, and Philadelphia areas, 6.5 million tons of wood wastes are generated annually. Limited landfill capacity and high disposal fees underscore the need to recycle these wood wastes as fuels.

Forest Resources

The Northeast has an abundance of biomass fuel resources that are not being utilized. There are 55 million acres of commercial forestlands in the eleven northeastern states. Surplus growth in these forests has the capacity to provide annually two to four times the volume of woodfuels than what is currently utilized, without jeopardizing the Northeast's vigorous pulp, paper and wood products industries.

This energy harvest can be accomplished without harm to forestlands. If sound forest management practices are used to keep residual stand damage to a minimum, woodfuel harvesting can generate positive impacts on the region's forests. Harvesting low quality, previously unmerchantable wood in thinning operations improves conditions for the growth of the higher quality trees which remain. Vigorous reforestation can make woodfuel resources entirely renewable as well as contribute to reducing atmospheric carbon dioxide.

Markets

The Northeast has significant markets for biomass fuels. The region is experiencing increased demand for electricity, and siting new central station generating plants is becoming increasingly difficult. The region is highly industrialized, presenting numerous opportunities for commercial and industrial conversions to woodfuels. At this time, over 380 industrial, institutional and commercial facilities are burning wood for energy.

After a five year decline in usage, residential heating with wood increased during the 1989-90 season. The sharp rise in heating oil prices sparked a surge in new stove purchases and a preference of many dual fuel households to return to wood burning. As a result of consumer education and technological innovations which have produced cleanburning, more efficient wood stoves, this trend towards wood may continue even after oil prices have stabilized.

Barriers

A traditional set of barriers impede the adaptation of innovative biomass energy technologies. These barriers include: financial risk for investors in new applications, inadequate information in the hands of decision-makers, and unknown social and environmental impacts. Lack of coordination among the decision-makers who have to work in concert to achieve results is also a problem.

In the solid waste management area, resource recovery facilities are becoming more difficult to site in spite of sharply escalating landfill disposal costs. Environmental concerns about combustion emissions are paramount in siting controversies. Yet emissions and their effects are not often adequately understood or communicated by developers, prospective neighbors, regulators, and professional environmentalists.

Potential users are uncertain about the supply of woodfuels as well as the infrastructure for harvesting woodfuels, recycling wood wastes, supplying end users, and supplying and servicing woodfuel handling and combustion equipment. While the technologies for efficient biomass fuels and municipal solid waste handling and combustion are available, they are not well understood by potential users.

Until recently relatively stable oil and gas prices have discouraged home use of biomass energy, and slowed institutional and industrial conversions. Regulation of woodfuel harvesting/forest management and air emissions from woodfuels combustion, especially wood wastes, is also an area of concern to potential users.

Goals and Objectives

The goal of the Northeast Regional Biomass Program is to increase acceptance and application of biomass energy technologies by the private sector and local governments. To achieve this goal, the Program seeks to identify and remove barriers to increased biomass energy use by providing information and technical assistance to private and public decision-makers.

In its technology transfer activities, the NRBP focuses heavily on "commercial" or nearly commercial biomass energy technologies. The products of biomass energy R & D, especially those carried out under the auspices of the DOE laboratories, are disseminated through NRBP channels. The Program also encourages the increase of biomass energy supplies and the development of a vigorous biomass energy supply infrastructure in the Northeast.

NRBP Objectives

- Identify and remove barriers to biomass energy development.
- Establish the availability of biomass resources in the Northeast.
- Encourage private investment in biomass fuels harvesting and processing.
- Promote investment in biomass and waste-to-energy facilities.
- Contribute to solid waste management solutions and biomass energy utilization goals.
- Contribute to understanding and mitigating environmental impacts of biomass harvesting and use.
- Improve the coordination among, and capabilities of, state agencies with biomass-related responsibilities.

In the past, state efforts to promote biomass and municipal waste energy projects have often been fragmented among a wide range of agencies involved in the various aspects of resource management, energy production, energy utilization and environmental protection. A key objective of the NRBP is to help member states coordinate efforts in these areas.

Program Strategies

The process of overcoming the barriers to increased biomass energy use involves first, analysis of the problem; second, information dissemination; and third, creation of networks. The NRBP's technical studies are the main instrument of problem analysis. In information exchange, the NRBP provides the most up-to-date technical, economic, environmental and institutional information to all potential users of biofuels by disseminating the results of its own work, as well as the work of other Regional Programs and the DOE laboratories and other national research institutions. Network creation is a function of both the state cooperative program and the technical studies portion of the NRBP.

Initial Planning

The NRBP's first step in 1983 was to convene committees of industry, government and academic leaders to identify problems in the Northeast with regard to biomass energy demand, supply and technologies. The NRBP used the committees' assessments and recommendations to develop a long range plan for its state programs and technical studies. This plan was updated in 1990.

The long range plan recognizes that to realize the potential contribution of biomass energy to the region's fuel needs and environmental goals, the NRBP should emphasize resource assessments, the development of biomass production and conversion technologies, and the transfer of information and technologies to potential users.

The Northeast Regional Biomass Program is divided into two interactive elements: cooperative activities with individual states, and region-wide technical projects. The goal of the state cooperative program is to match local opportunities with resources, and to address area-specific problems with local solutions. The technical projects are applied research and technology transfer efforts that provide a regional focus and address overarching issues.

State Cooperative Program

In the cooperative state program, the NRBP provides money for its eleven member states to pursue biomass energy assistance to industries considering a conversion and municipal waste projects of their own choice, subject to NRBP approval. A cost sharing commitment is required of each participating state. Additionally, state offices with responsibility for forestry/resource management, energy, and environmental quality are required to coordinate their activities with respect to biomass policies and programs.

Typical state activities are resource assessments, surveys of facilities that use biomass energy, technical assistance to facilities that are considering converting to biofuels, and dissemination of consumer information on subjects such as the safe installation and operation of wood stoves.

Each of the eleven state participants in the NRBP designates a representative who sits on the NRBP Steering Committee. The Steering Committee provides a forum for the exchange of information and consideration of regional biomass and waste energy issues. Steering Committee members advise CONEG on the focus of both the state cooperative program and the technical projects effort.

Technical Projects

The technical projects component of the Program involves contracting, generally through competitive solicitations, to conduct technical studies and develop information products. These activities are targeted to the biomass and municipal waste issues which have been identified by Technical Advisory and/or Steering Committees in a number of specific project areas.

In these projects, the NRBP seeks active cooperation and cost-sharing from the participating states, private industry, universities and other federal agencies.

The NRBP Long Range Plan was completed in 1984 and was updated in 1990. These plans have provided overall direction for the technical projects. Additionally, results from one NRBP technical project often suggest further issues that need to be addressed. For example, a broad study on the impacts of large scale fuel procurement on the forest resource base suggested two additional studies: waste wood as a feedstock in biomass energy facilities, and residual stand damage from wood fuel harvesting operations.

NRBP technical projects include information and technology transfer in workshop settings and in the form of targeted technical assistance to industry and institutional facilities.

The NRBP technical studies and information products are subjected to both internal and peer review before being published by the Coalition of Northeast Governors (CONEG) Policy Research Center. The NRBP disseminates its work through the Steering and Technical Review Committees, and through other industry, university and government contacts. CONEG maintains an inventory of reports and makes them available at a nominal fee on request. The NRBP also keeps biomass energy issues and information before the public through publication of articles in various periodicals.

NRBP Technical Areas

- Wood Fuel Harvesting
- Biomass Fuels
- Industrial/Commercial Wood Energy
- Residential Wood Use
- Solid Waste Management and Resource Recovery
- Environmental Issues
- Regional Impacts

Accomplishments

The Northeast Regional Biomass Program has sponsored over twenty technical studies and numerous technical assistance projects in the past seven years. These efforts have:

- assisted the conversion from fossil fuels to wood of dozens of facilities including greenhouses, schools, correctional institutions and sawmills;
- provided state and local decision-makers with data and criteria for determining the comparative health and environmental risks of new landfills versus waste-to-energy facilities as waste management strategies;
- developed principles and a model package of specific strategies to offer to host communities as equity adjustments for the siting of municipal waste resource recovery facilities;
- designed and helped to execute a field study of wood stove emissions that had a major influence on the shaping of an EPA standard requiring the manufacture and sale of cleaner burning stoves;
- successfully encouraged private developers to propose small power plants fueled with urban wood wastes; and
- helped to end the inappropriate practice of regulating wood-fueled boilers as coal combustion systems.

In these projects, the NRBP seeks active cooperation and cost-sharing from participating states, private industry, universities, and state and federal agencies. For example, the NRBP's four-year study of particulate emissions and wood use in advanced design residential stoves under actual operating conditions was co-funded by the U.S. Environmental Protection Agency, the Wood Heating Alliance, the New York State Energy Research and Development Authority, and the Canadian Combustion Research Laboratory. In this way, NRBP resources are highly leveraged, and the projects have broad support in both the public and private sectors.

Although NRBP technical studies specifically address barriers to biomass energy development in the Northeast, the results of these studies are often of interest outside the region.

Three recent technical studies are good examples of the NRBP's widespread impact: (1) the wood stove studies; (2) waste wood inventories and market studies; and (3) the examination of equity adjustments provided host communities for siting municipal waste recovery facilities.

Wood Stove Emissions

Six years ago concerns about wood stove efficiency, emissions, and creosote accumulation in chimneys prompted a two-year field study of conventional, catalytic and advanced technology appliances. Although laboratory tests and manufacturer claims promoted the perception that catalytic and advanced technology stoves were significantly more efficient and reduced particulate emissions by 70%-80%, the NRBP field studies in 68 homes revealed that catalytic and advanced technology stoves showed no significant improvement in emissions over standard air-tight conventional stoves. While 20%-40% improvements in efficiency and creosote accumulation were noted, the measurement of emissions expressed in grams of particulate per kilogram of dry wood combusted showed no statistically significant differences by stove type. The superior performance of a few advanced technology models did suggest, however, that some stove designs could reduce emissions by 50% or more.

The results were disappointing to the industry, and prompted the Environmental Protection Agency (EPA) to reconsider its approach to testing wood stoves. Midway through the study EPA commenced an administrative process for certifying new wood stoves. Beginning in 1988 all new wood stove sales would be regulated, and only stoves which met emissions levels 70% lower than conventional air-tights in laboratory tests would be certified. The results of the NRBP testing convinced the regulators to adopt two standards — one for catalytic and one for advanced technology non-catalytic stoves. The field performance of catalytic stoves and subsequent tests of the stove catalyst in the laboratory revealed a deterioration over time for many of these appliances. The advanced technology non-catalytic stoves showed a steadier performance over time.

The field study results prompted two other changes in the EPA certification and enforcement processes. First, the laboratory testing methodology was changed to simulate more closely observed operator practices. Second, the enforcement phase was modified to include a close inspection of gaskets, catalytic bypass door leaks and other critical areas where sloppy assembling practices or inferior quality parts might result in air leaks.

In the winter of 1989, one year after EPA approved its certification process, NRBP commissioned a second study. An extensive sampling of 25 EPA certifiable stoves was conducted for five one-week periods from January through March. Based on rigorous laboratory tests, three top performing catalytic models and two non-catalytic models were selected for the field monitoring. The average particulate emissions from the new technology stoves was 9.4 grams per hour, a 55%-60% reduction compared to the 21.3 grams per hour guideline for conventional stoves. While the two brands of non-catalytic stoves had average emissions of 9.3 and 11.3 grams per hour respectively, they failed to meet the EPA limit of 7.5 grams per hour for 1988 certification.

The second study demonstrated that the newer generation of EPA-certified stoves performed in the field closer to their laboratory results, but a considerable gap remained. Operator behavior, chimney conditions, and equipment design and integrity explain most of the difference between laboratory and field performance. Since a steady deterioration in catalytic stove performance was evident, attention focused on the variable which research could most readily influence: stove design and component failures. With the help of magnifying glasses, mirrors, flashlights and measurement tools, the researchers were able to identify the failure of a small number of critical components.

Loosely fitted bypasses, a lack of flame impingement shielding near baffles, warping of bypasses and bypass supports, and inadequate welds were found in many stoves. Many catalysts also failed, some of which were not detectable by inspection alone. To alert manufacturers to these findings, CONEG and the other study sponsors convened a meeting of stove manufacturers in August, 1989. Representatives from more than twenty companies nationwide attended the meeting, and all voiced satisfaction and appreciation for the research. Improved stove designs, stronger materials, and better manufacturing quality control processes have resulted, according to subsequent inspections carried out by researchers.

Recycled Wood Wastes

The nationwide solid waste crisis has led to overflowing and closed landfills, steeply rising waste disposal costs, and a strong push for recycling programs. Waste-to-energy facilities have also been built, although their siting has been slowed and even stopped recently in some states due to actual or perceived air quality problems. A study carried out by NRBP four years ago revealed that 20%-25% of the tonnage in landfills is comprised of woody wastes. Demolition, land-clearing, used pallets, railroad ties, and wood manufacturing industry wastes contribute to this total.

Closer examination of the waste streams in Boston, Philadelphia and New York revealed that millions of tons of wood wastes disposed annually provide large, untapped opportunities for its alternative use as a fuel. Wood waste haulers and processors, transfer stations, energy-intensive industrial facilities, and independent power producers are potential markets for these materials. At the time of the study only one New York City plant routinely accepted and burned urban wood wastes in their boiler to generate steam and electricity.

Since that time the NRBP research team has assisted the efforts of a Long Island, New York landfill and transfer station to construct a waste-fueled electricity generating station, and a landfill in New Hampshire to establish a waste sorting and processing operation. In 1991 there are proposed independent power plants (IPPs) in New England which would use wood wastes as their primary fuel. The NRBP research document is cited by all of them in their permitting documents. The NRBP research team and CONEG staff receive dozens of calls every year from prospective wood waste-to-fuel facility developers nationwide. Five years from now the generation of electricity from wood wastes should be commonplace throughout the country.

Equity Adjustments in Resource Recovery Siting

The Not-in-My-Backyard Syndrome is prevalent throughout the United States. Facilities for everything from hazardous waste processing to wood chip combustion plants have been vetoed by communities who perceive unacceptable environmental risks. One of the frequent victims of this widespread phenomenon is the resource recovery facility. Associated with stack emissions of dioxins, furans, trace metals and acid gases, heavy trucking, and odors, the resource recovery facility is vulnerable to opposition from informed and uninformed communities and interest groups throughout the Northeast.

The NRBP commissioned a study which categorized risks by: (1) health impacts; (2) safety; (3) environmental degradation; and (4) community fiscal well-being. The fourth category encompasses real estate depreciation and other unwanted economic risks associated with hosting a resource recovery plant. After organizing the risks by short versus long-term, extent of risk, and source of exposure, the report addressed the nature of each. Next, the study characterized the risks by geographic distribution, timing, predictability, and quantifiability. By such an organization of the risks, the establishment of appropriate compensating mechanisms proceeds more logically.

The strategy for facilitating acceptance of a facility is keyed by matching equity adjustments to the identifiable risks, taking into account the characteristics of each risk as outlined above. The strategy stresses the importance of a comprehensive and inclusive citizen participatory process from the very beginning of the siting process. A survey of equity adjustments from siting processes around the country revealed that monetary payments are the most prevalent. The provision of special services and grants, insurance and trust funds, property value guarantees, local hiring and procurement policies are additional tools developers can utilize to win community acceptance. The study relied upon case studies from other siting processes—low level radioactive waste facilities to hazardous wastes—to document its findings.

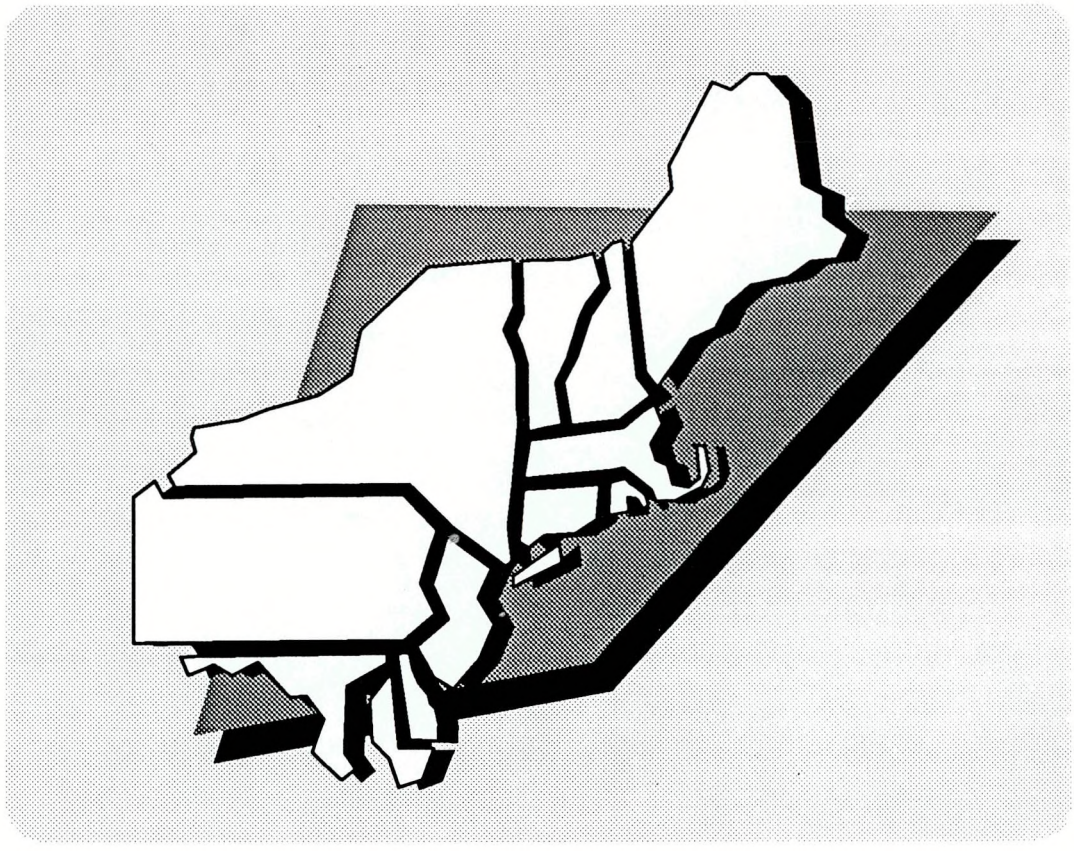
The first document of its kind to organize systematically strategies and mechanisms to compensate risks specifically for municipalities, state agencies, and developers of resource recovery plants, the publication has had a strong demand from officials and developers nationwide.

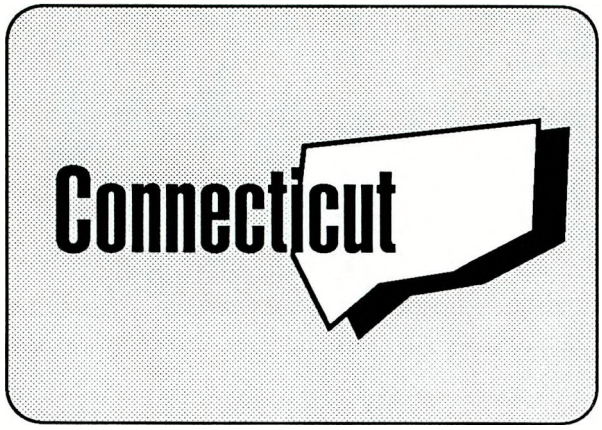
Grants to the States

The NRBP grants to the participating states have resulted in a large number of information products, technical studies, workshops and technical assistance efforts that address local issues and opportunities. In addition, the state cooperative portion of the program has had the effect of inducting forestry and energy officials in each state to work closely together. In general, the NRBP effort has, by focusing the biomass energy effort, fostered cooperation and coordinated activity among state officials responsible for solid waste management, environmental quality, energy and forestry.

Summaries of the NRBP state projects and the applied research and technology transfer products are presented in subsequent chapters of this Report.

State Biomass Energy Programs





Forest Acreage:	1.8 million acres
Industrial/Commercial Wood Fuel Use:	27,200 tons/yr in 1990 *
Residential Wood Fuel Use:	741,078 tons/yr in 1990 *
Wood-Fired Electricity Generation	
Existing:	<1 megawatt in 1990
Planned:	72 megawatts
MSW Resource Recovery Facilities as of March 1991	
In operation:	5,450 tons/day
Under construction:	600 tons/day
In planning:	2,400 tons/day

* Estimated

Overview

The use of wood for energy increased significantly during the 1970s in Connecticut, in response to the increasing cost of other fuels, particularly oil, during that period. Surveys conducted in 1979 and 1984 indicate that approximately 30% of residences in Connecticut used wood for energy.

Fuelwood use by industry in Connecticut has increased at a much slower rate due in part to the relatively low price of fossil fuels in the 1980s. Eight of the ten facilities that burn wood for energy are wood products manufacturers.

With 1.8 million acres of forested land, Connecticut has an adequate supply of wood. Research completed by professional foresters in the state indicates that substantial volumes of fuelwood could be harvested. Many foresters believe the use of wood for fuel can create markets for low quality wood that is otherwise unmerchantable. The use of integrated forest management techniques provides the opportunity to harvest low-quality wood while simultaneously improving the quality of the forest.

NRBP Supported Activities

Support from the Northeast Regional Biomass Program has provided the State with the opportunity to sponsor a variety of wood energy research projects, including market surveys to determine the extent of residential and industrial wood fuel use. Surveys conducted in 1984 resulted in publications on the availability of wood fuel in the state and in a guide to managing woodlots for wood fuel. In 1990-1991, Connecticut will again survey the residential sector to determine current levels of residential wood fuel use.

Other activities have included assessing the availability of forest and sawmill residues for energy, and sponsoring workshops to encourage the use of wood in small and mid-size industries. A study completed in 1989 analyzed the economics of producing wood chips as a result of forest management activities. Another 1989 study focused on identifying the availability of wood wastes for recycling, evaluating the economic cost of producing fuel from recycled wood, identifying environmental impacts, and providing information to regulatory agencies involved in reviewing and permitting proposed wood-fired facilities.

As the Biomass Program evolves in Connecticut, increasing attention is being paid to both wood energy and municipal waste issues. A roundtable discussion sponsored by NRBP was held in 1988 to explore important energy and municipal waste issues. Results of the discussion were used to develop regional and state program priorities for 1989 and beyond.

Future Trends

After the recent period of only modest increases in the amount of wood fuel used by industries, the use of wood may grow substantially in Connecticut firms during the next few years. This is primarily due to two factors: first, independent power producers have received favorable power sales agreements with electric utilities serving the state; and second, skyrocketing landfill costs are encouraging recycling of wood wastes. A third factor which may be expected to play a role is the price of oil.

There are currently three wood-fired power plants which are in the planning stages in Connecticut. Recycled wood products are expected to comprise a significant fraction of the total feedstocks. The output of the three plants will be 72 megawatts.

In November, 1990, the Connecticut Department of Administrative Services initiated a two-month test, introducing ethanol-blended gasoline into a broad cross-section of the state's fleet vehicles. The ethanol test program has attracted a great deal of interest – particularly since events in the Middle East have revived concerns about the transportation sector's vulnerability to oil price and supply disruptions.

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Forest Acreage:	376,400 acres
Industrial/Commercial Wood Fuel Use:	37 tons/yr in 1990 *
Residential Wood Fuel Use:	78,713 tons/yr in 1988
Wood-Fired Electricity Generation:	0 megawatts in 1991
MSW Resource Recovery Facilities as of March 1991	
In operation:	1,000 tons/day
Under construction:	0 tons/day
In planning:	0 tons/day

* Estimated

Overview

The use of woodfuel in the residential sector increased in Delaware from the late 1970s to 1984. According to a woodfuel survey conducted in 1984, 30% of residences in the state burned wood. By 1988, residential wood use had declined to 13.5% due largely to the relatively low price of fossil fuels.

Of those homes still burning woodfuel in 1988, only 3.5% used wood as the primary source of heat. 52% of residences obtain their wood for free. 75% of those who buy wood pay over $80 per cord.

There is minimal use of wood for fuel among industries and businesses in the state. Because no major facilities burn wood, there is little awareness of wood technologies among industrial and commercial managers. Although a few whole tree chippers operate in the state, wood chips are being used

primarily for paper/pulp production. Within the state there are recycling businesses that reclaim wastewood and tree stumps and convert them into mulch. Another recycling facility is reducing pallets to wood chips and selling these chips out of state for energy uses.

NRBP Supported Activities

NRBP support has been used for a range of research projects, including residential woodfuel surveys, an industrial energy survey and, most recently, a round wood and wood chip survey. These surveys are used to determine the extent of wood energy use and to identify potential areas for conversions in both forest and non-forest products industries. As landfill fees continue to increase, forest products industries more frequently express an interest in selling their wood waste for fuel. However, while a number of firms have expressed interest in converting to wood, concerns about payback have impeded the development of a reliable market.

The State Forestry Section, which administers NRBP funds for the state of Delaware, will produce an updated Primary and Secondary Wood Processors Guide in the summer of 1991. In the meantime, the Forestry Section continues to monitor and develop markets for wood chips. One such market is exemplified by Earthworks, a Dry Waste Recycling System which mixes wood chips and waste wood with humus leftover from Solid Waste Authority processing operations to create "super soils," a soil mixture which is being used to create sod-like mats of wildflowers for roadside planting and top soil blends.

The Delaware Forestry Section also uses NRBP funds to develop timber stand improvement projects in State forests. In 1991, the Forestry Section will begin looking at the impact of these improvements on stands where forest debris has been cleared, as compared with unimproved forest stands.

Other activities include providing information and technical assistance to residents and landowners, state agencies and private businesses on an ongoing basis. Educational efforts include wood stove maintenance, chimney cleaning and chainsaw safety in educational programs in cooperation with the State Extension Service.

Future Trends

Residential wood fuel use is expected to remain level in the state. Industrial and commercial wood energy use could increase because of greater availability of wood chips in the state and a growing industrial sector.

In 1990, Delaware appointed a Recycling Coordinator within the Department of Natural Resources and Environmental Control. In addition to setting up 100 recycling collection centers statewide, the program will target businesses with the aim of helping them to reduce the amount of waste they create and to find customers for some of their waste products – including wood wastes. For example, a Wilmington manufacturer currently seeking a permit to produce activated carbon (charcoal) and pyrolysis oil would require 50,000 to 100,000 tons of wood waste annually. The plant would most likely utilize pallets from two major automobile plants in northern Delaware.

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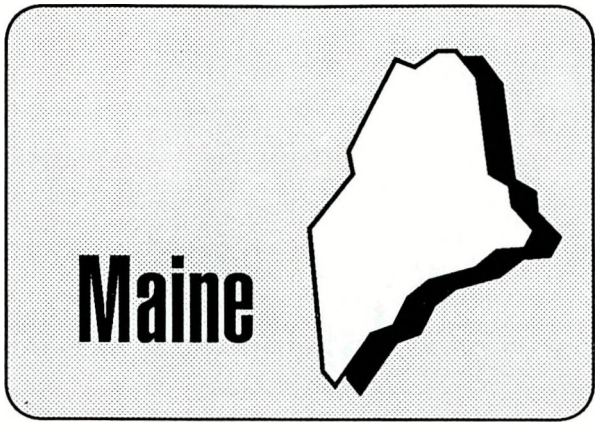

Forest Acreage:	16.9 million acres
Industrial/Commercial Wood Fuel Use:	3.9 million tons/yr in 1990
Residential Wood Fuel Use	< 2.5 million tons/yr in 1990 * (< 1 million cords)
Wood-Fired Electricity Generation	
Existing:	453 megawatts in 1990
Planned:	60 megawatts
MSW Resource Recovery Facilities as of March 1989	
In operation:	1,125 tons/day

* Estimated

Overview

Biomass fuel use peaked in Maine in the early 1980s, when as many as 55% of all households used wood for space heating, and numerous businesses and industries were also burning wood. Wood fuel use tapered off as oil prices fell, with just under 35% of residences burning wood in the 1987-88 heating season. Fuelwood consumption dropped below a million cords in 1989-90; however, an oil price spike that same year renewed interest in wood, and recent events in the Persian Gulf are expected to reverse the downward trend of the late 1980s. With a new generation of wood stoves available to consumers, the 1990-91 heating season is expected to bring about a significant increase in residential wood fuel use.

Except for the forest products industry, wood use penetration into the commercial, industrial and institutional sectors remains limited in Maine, although rising oil prices may effect a shift. There has been a renewed interest in wood pellets and wood gasification technologies.

Responding to opportunities created by the passage of PURPA, independent power producers continue to propose and build wood-fueled electric generating plants. Maine currently ranks second only to the state of California in the extent of wood biomass use, and ranks first in the nation in the percentage of its electricity produced from wood. Wood-fired power plants and industrial cogeneration facilities produce over 27% of the state's electricity. Over 500 megawatts of wood-fired power is either on-line or in the planning stages. Nine of the 21 existing wood-fired plants produce electricity exclusively; the rest are cogeneration facilities.

NRBP Supported Activities

The Maine Biomass program has operated from the energy division of the State Planning Office (SPO) since the Office of Energy Resources was eliminated by the Maine Legislature. This year, NRBP support will enable the State Planning Office to complete a report on the state's wood-fired electrical generating industry, to conduct a survey of whole tree chip harvesters, to survey residential fuel wood use, and to maintain a strong coordinating role with state forestry activities.

The primary emphasis of the Maine biomass program this year is on preparing a comprehensive report on the wood-fired electrical generating industry that has emerged over the past ten years. Site visits, interviews, and a literature review will form the basis of the report, which is scheduled for completion by June 1991.

Special attention continues to be paid to identifying the increasing number of wood chip harvesters, and to organizing workshops on environmentally acceptable harvesting practices. In cooperation with the Maine Forest Service, the State Planning Office will conduct a survey of whole tree chip harvesters. The survey instrument has been revised, and a computer-

operated data filing and management system has been created to store the data collected from chip harvesters active in 1989.

Other activities conducted under the auspices of the Biomass program include: a summary of wood energy consumption to update the State of Maine's energy plan; provision of information to energy extension agents and others on the results of in-situ wood stove testing, and some work on wood pellet issues, including pellet stove demonstrations. A boiler data base developed by the Maine Department of Environmental Protection allows the agency to track and record environmental permits issued for wood boilers. A wood contingency plan was developed for use in the event of a dramatic decrease in the availability of oil.

Future Trends

Because 89% of Maine is forested, wood is expected to continue to play a major role in the state's energy picture – with the support of both public and private decision-makers. The State Planning Office will continue to support research on the impact of wood chip harvesting on nutrient flows in the forest and harvesting rates that ensure Maine's forests will be harvested on a long-term sustainable basis, as well as research on wood ash disposal techniques and utilization options.

Other proposed NRBP-supported activities include: training of harvesting machine operators to minimize stand damage; development of pellet fuel use; contributions to Public Utilities Commission deliberations regarding the use of biomass as an alternative energy source; development of wood fuel technology and applications in commercial, industrial and institutional facilities; and the development of wood supply modeling capabilities.

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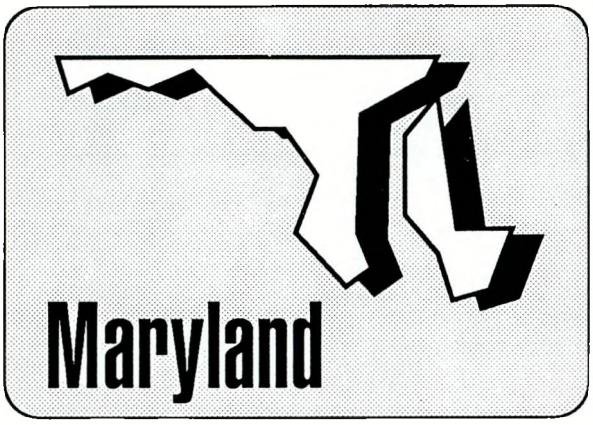

Forest Acreage:	2.4 million acres
Industrial/Commercial Wood Fuel Use	69,785 tons/yr in 1983
Residential Wood Fuel Use:	2.36 million tons/yr in 1984 (943,000 cords)
Wood-Fired Electricity Generation:	3 megawatts in 1988
MSW Resource Recovery Facilities as of March 1989	
In operation:	3,400 tons/day
Under construction:	0 tons/day
In planning:	1,800 tons/day

Overview

A variety of residences, businesses and industries use wood for energy in Maryland. Overall, however, wood energy use is not as widespread in southern portions of the Northeastern United States. This is due primarily to a warmer climate (compared to northern New England) and relatively low oil, gas and coal prices.

NRBP Supported Activities

In June 1990, the State of Maryland released *A Guide to Maryland's Regulation of Forest Products Industries: Energy Conservation, Energy Production and Environmental Protection Through Production and Utilization of a Renewable Resource.* The document covers all the laws, rules, regulations and policies to which forest products-based enterprises –

including wood-fired energy systems – must adhere. It is hoped that this comprehensive guide, the result of a broad collaborative effort involving over three dozen state agencies, will encourage and facilitate private sector development of wood energy projects, particularly on the part of the state's forest products industry.

Maryland NRBP staff participated in all phases (planning and design through construction and operation) of the wood-fired energy plant at the Eastern Shore Correctional Facility. Program staff also helped to publicize the plant, once it was built. The project has conducted studies on woodfuel suppliers and the availability of woodfuel in the state.

A guidebook to industrial wood energy equipment, researched and published by Maryland wood energy staff, is still available. NRBP funds have also supported several feasibility assessments in the state, and provided technical assistance to several potential commercial and industrial conversion candidates.

In 1991, Maryland will use NRBP funds to produce directories covering both what forest products industries use for fuel and the amount of surplus woodfuel remaining from their operations. Maryland also foresees conducting a new survey in 1991-92 of residential firewood usage throughout the state of Maryland as well as the northern Virginia metropolitan area.

Future Trends

The City of Baltimore was one of the first major cities in the United States to produce energy from combustion of municipal solid wastes. Significant solid waste disposal issues continue to confront Maryland, and recycling is going to be a major focus of state and local policy in the 1990s. The wood energy program will seek opportunities to demonstrate the potential for generating electrical and thermal energy through the use of waste wood products (e.g., land clearing debris and woody urban demolition debris).

In addition, there are portions of the state that are heavily forested, thereby providing the potential for a substantial wood chip industry if markets can be developed.

Finally, two private consulting firms are currently studying the state of Maryland for site locations for medium-sized wood-fired utility grade electrical generating plants. Each of the two firms is interested in siting medium-sized wood-fired plants.

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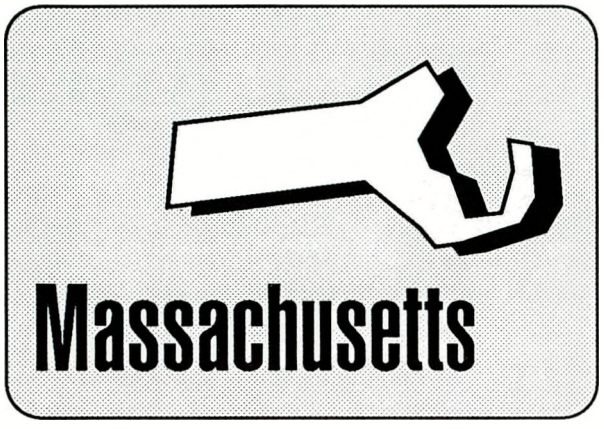

Forest Acreage:	3.2 million acres
Industrial/Commercial Wood Fuel Use	65,000 tons/yr in 1988
Residential Wood Fuel Use:	900,000 tons/yr in 1988
Wood-Fired Electricity Generation	
In operation:	<1 megawatts in 1990
Proposed:	16 megawatts
MSW Resource Recovery Facilities as of March 1989	
In operation:	10,400 tons/day
Under construction:	0 tons/day
In planning:	1,500 tons/day

Overview

Massachusetts features both substantial urban areas, such as Greater Boston, and significant rural areas, mostly in the western portion of the state. Approximately 64% of the state is forested. Wood-burning increased noticeably in the late 1970s and early 1980s in residences and industries. A decrease in fossil fuel prices since then caused some wood-burners to convert back to oil or gas, but this trend shows evidence of reversal.

NRBP Supported Activities

The Division of Energy Resources (DOER) directs NRBP activities. Attention has been paid in the Massachusetts program to both woodfuel and municipal waste technologies and issues since the program began. More recently, emphasis is being placed on exploring the potential of alternative fuels. An essential ingredient in the success of DOER's efforts has been the maintenance of a close working relationship with the Executive Office of Environmental Affairs, its Divisions of Solid Waste Management and Forestry and Parks, and the Department of Environmental Protection.

DOER has succeeded in passing enabling legislation which makes possible private ownership and financing of a cogeneration pilot project at a state facility. An RFP has been issued for a construction manager for the pilot project, which will be located on the University of Massachusetts, Amherst campus.

Working with a steering committee representing the Executive Office of Environmental Affairs, the Department of Environmental Protection, and the Department of Procurement and General Services, DOER has begun a one-year program to demonstrate alternative fuels for transportation. The use of propane, natural gas, and ethanol in state vehicles will be evaluated for their economic and environmental impacts, for safety, and for "wear and tear" on both vehicles and the road and highway infrastructure. The demonstration program is expected to yield recommendations for converting and replacing the state fleet's 8,000 motor vehicles.

DOER has provided assistance to the Division of Forestry and Parks in their effort to support the work of The New Forest Partnerships, an alliance between the Northeastern Area Association of State Foresters and the USDA-Forest Service. The program proposed by the Massachusetts Division of Forestry and Parks includes an updated brochure on "Residential Firewood Promotion and Information."

DOER continues its participation in the informally-organized Global Climate Change Task Force, a group consisting of representatives from several executive office level state agencies to coordinate policies to minimize the state's contribution to net emissions of the so-called "greenhouse gases." DOER's input to the Task Force consists of making available the results of both the Tellus study being funded by CONEG (see Section 7, "Applied Research and Technology Transfer Program") and the

Alternative Fuels Demonstration Program, and, in turn, seeking cooperation and policy guidance from other members of the group.

Future Trends

The combustion of wood and municipal waste may decrease, as public concern grows about air emissions and other environmental impacts. Two municipalities in Massachusetts now have local wood smoke ordinances, and there is a recent moratorium on construction of resource recovery plants.

On the other hand, decreasing landfill capacity and sharply escalating disposal costs are stimulating substantial interest in recycling wood for use as fuel at small power plants. At least five major wood recycling businesses are in operation or planned in the state. DOER has written a letter to the Department of Public Works supporting the development of an 18-megawatt wastewood-fired electric plant that would supply 14 megawatts to Fitchburg Gas & Electric Company. As of February 1991, the project has been granted final state and local environmental permits, meeting or exceeding all applicable standards.

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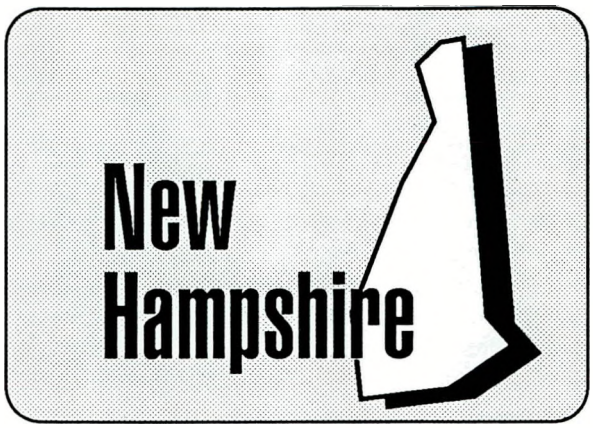

Forest Acreage:	5 million acres
Industrial/Commercial Wood Fuel Use:	2.7 million tons/yr in 1990 *
Residential Wood Fuel Use:	1 million tons/yr in 1990 *
Wood-Fired Electricity Generation:	155.8 megawatts in 1990
MSW Resource Recovery Facilities as of March 1990	
In operation:	800 tons/day
In planning:	500-1,000 tons/day

* Estimated

Overview

New Hampshire is a heavily forested state, with a long history of wood-burning. Numerous residences, businesses, industries and power plants in the state use wood for energy.

According to surveys conducted annually since 1983, the average length of time New Hampshire residences have been burning wood is 10 years. The percentage of homes using wood since the surveys began peaked in 1984, when 51% burned wood. By 1988, this had dropped to 26% of households. Currently 12.8% of homes burn wood as a primary source of heat.

More than 80 industries, businesses, municipal buildings and institutions burn wood in New Hampshire. In addition, there are seven wood-fired power plants in operation that produce 130 megawatts of electricity.

NRBP Supported Activities

The Governor's Energy Office (GEO) directs NRBP activities in New Hampshire. The agency strongly supports the use of wood energy. State forestry specialists believe wood fuel markets provide economic incentive to conduct silvicultural practices that improve forestlands while harvesting low quality wood that would otherwise be unmerchantable. This is important because many of the state's forests are overstocked. Low quality wood is competing with wood that could be of higher value, if properly managed.

With NRBP support, GEO conducts annual wood use surveys and tracks wood fuel harvesting and consumption statewide. In conjunction with the University of New Hampshire Cooperative Extension and the New Hampshire Division of Forests and Lands, GEO offers technical assistance to wood-burning households, power plant developers, local planning and zoning officials, state regulators, business people and loggers/chippers.

Future Trends

Residential wood use is expected to remain stable in New Hampshire, if oil prices do not fluctuate significantly. The use of wood by businesses, industries and power plants is expected to level off at 2.7 - 3.0 million tons per year. At the moment there are no serious proposals for new large wood-fired facilities.

Increasing activity is expected in the area of municipal solid waste, with a new plant currently under proposal for southern New Hampshire. GEO provides municipalities and project developers with assistance on solid waste disposal issues.

Ongoing projects include researching the flow of wood fuel into and out of the state and identifying the type of harvesting practices actually used during biomass harvesting. State biomass staff will work with state legislators to ensure that any harvesting regulations are based on up-to-date technical information on biomass harvesting. Efforts concerning residential wood-burning will focus on educating consumers and retailers on federal performance standards for wood stoves and providing information ensuring safe and clean wood-burning.

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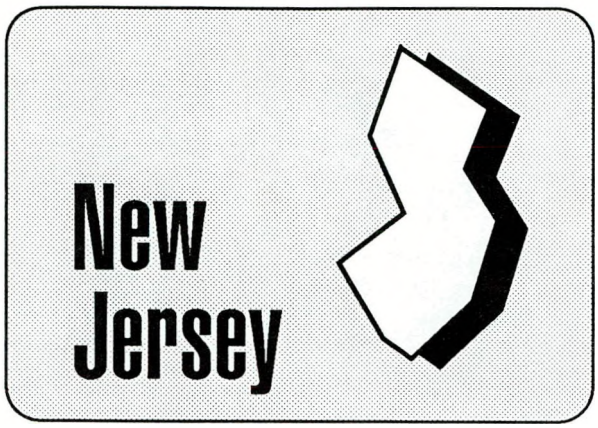

Forest Acreage:	2 million acres
Industrial/Commercial Wood Fuel Use:	70,000 tons/yr in 1990
Residential Wood Fuel Use:	2 million tons in 1990 *
Wood-Fired Electricity Generation:	0 megawatts in 1990
MSW Resource Recovery Facilities as of March 1991	
In operation:	5,225 tons/day
Under construction:	3,000 tons/day
In planning:	9,000 tons/day

* Estimated

Overview

Although New Jersey has large areas of developed land, 42% of the land area is forests. The mix of developed areas and forestlands provides substantial opportunity for wood energy use. During the 1970s and early 1980s, there was a noticeable increase in the amount of woodfuel used by residences. This has decreased recently, due to the relatively low price of oil. There was a negligible increase in wood-burning among businesses and industries until recently. Increasing waste disposal costs have inspired at least 28 wood products industries to burn wood wastes for energy.

Of the northeastern states, New Jersey is one of most affected by shrinking landfill capacity. Solid waste disposal is therefore a major issue. Planners and policymakers are emphasizing both resource recovery plants and recycling as management tools. Recent legislation mandates that 60% of all solid waste must be recycled by 1995. As support for recycling increases, so does interest in finding ways to recycle wood wastes for other uses.

NRBP Supported Activities

The New Jersey NRBP program is administered by the Bureau of Forestry Management. The Bureau has emphasized providing information and technical assistance to potential wood energy users, wood harvesting companies, forest products industries, regulatory agencies, equipment manufacturers, and energy consultants.

The Bureau has used NRBP monies to fund research projects on the amount of wood residues available for energy use and the potential for harvesting pitch pine for fuel. Listings of firewood dealers, wood chip suppliers, wood waste dealers and stumpwood grinding facilities have been published.

Future Bureau activities will include continuing to identify and assist facilities with a high potential for converting to wood. The Bureau will also continue to develop cooperation among state and local environmental and regulatory agencies involved in permitting wood facilities. A data base on woodfuel harvesting and wood residue production will be maintained.

Future Trends

Residential wood fuel use is expected to decline, if oil prices decrease in the future. The use of wood for fuel in forest products industries is expected to increase as more firms try to avoid disposal costs for wood waste. The use of wood to produce electricity by small power plants or commercial establishments will increase if favorable buyback rates become available.

Solid waste disposal issues will continue to have a direct effect on the availability of wood for energy. It is expected that an increasing volume of wood waste will be recycled. Recycled wood may be used for landscape mulch, compost products, sludge processing and as an energy feedstock.

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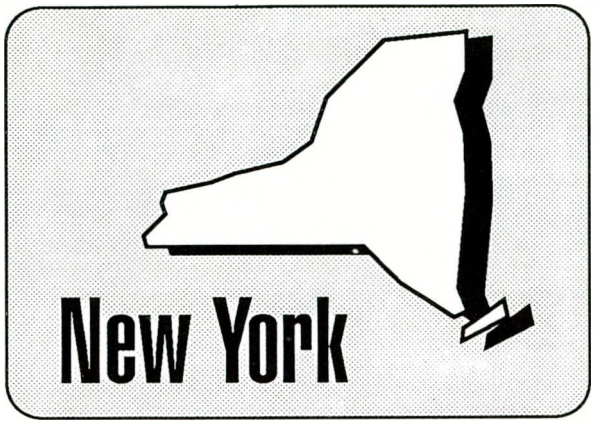

Forest Acreage:	3.1 million acres
Industrial/Commercial Wood Fuel Use:	3 million tons/yr in 1988
Residential Wood Fuel Use:	7.5 million tons/yr in 1988 (3 million cords)
Wood-Fired Electricity Generation	
In operation (early 1991):	11 megawatts
Expected to close in 1991:	8 megawatts (P&G)
Planned/in development:	33.5 megawatts
Proposed:	54 megawatts
MSW Resource Recovery Facilities as of March 1989	
In operation:	6,208 tons/day
Under construction:	4,069 tons/day
In planning:	21,215 tons/day

Overview

New York is a diverse state, ranging from urban New York City to the rural and wild Adirondacks State Forest. Wood energy use varies throughout the state. Overall, there are an estimated 700,000 wood stoves in use, and more than 75 industries, businesses, and institutions burn wood for energy.

In locations that are heavily forested, wood-burning is fairly common. Numerous forest products companies burn harvested wood and wood residues for fuel, and several of them also cogenerate electricity with their wood boiler.

In urban areas, there is increasing interest in recycling wood wastes produced by land-clearing, demolition, and construction. This is due to rapidly increasing disposal costs, particularly in the New York City area. Both waste producers and haulage contractors are seeking more cost-effective disposal options than tipping fees at landfills.

The Proctor & Gamble Port Ivory manufacturing Plant on Staten Island has used recycled wood as a major fuel since 1985. This demand for waste wood caused a number of waste contractors in the New York City region to install the equipment necessary for processing waste wood into fuel chips. Proctor & Gamble plans on closing its facility in the near future, but the loss of this market is stimulating waste contractors to develop their own power projects. Hubbard Sand & Gravel has been operating a 3-megawatt waste wood system on Long Island since November 1989; two other projects proposed or planned for Long Island will have a combined capacity of 15 megawatts. Elsewhere in the state there is a total of 31.5 megawatts in development at three upstate sites, and three other proposed plants with a capacity of 41 megawatts.

New York State electric utilities must now seek competitive proposals for additional planned electric power supplies. Bidding for lowest cost power supplies has resulted in a market primarily dominated by natural gas-fired systems. A major utility and state program has recently been initiated to determine the environmental costs of various electric power supply options. The ultimate impact of this study on the competitiveness of wood-based electric power production is speculative at this time. A recent study has concluded, however, that over 400 megawatts of competitive electric power could be generated by using the waste wood resources available in the state of New York.

NRBP Supported Activities

The New York State Energy Research and Development Authority (NYSERDA) directs NRBP activities in the state, in association with the State Energy Office and the Department of Environmental Conservation.

A major emphasis has been to offer assistance to small industries and businesses interested in burning wood for energy. As part of the program, trained advisors conducted surveys at 87 sites and prepared feasibility studies detailing energy options appropriate for each facility.

In addition to providing technical assistance to industries around the state, financial support from the NRBP has been used to: conduct a residential wood fuel survey; evaluate the impact of whole-tree harvesting on the forest; design a PC-based computer geographic information system to apply growth estimators to US Forest Service forest inventory statistics; and, in a recent project in New York City, to evaluate the energy impact of various municipal waste management options.

The environmental impact of burning waste wood is a major stumbling block. NYSERDA is managing a project for NRBP and a number of other cosponsors to estimate the emissions from burning wood contaminated with various products. Through this study, we hope to provide the environmental regulatory community with a resource base of sound technical information to better determine possible site-specific impacts, as well as a range of mitigation strategies.

It is important to note that NYSERDA operates an extensive biomass research program with projects in short rotation forestry, forest ecosystem modeling, the production of chemicals from wood fiber and risk management for wood-based electric power production. The NRBP has become an extremely useful resource for identifying high-priority research needs.

Future Trends

Relatively low oil and natural gas prices have been limiting economic incentives for converting to wood. However, new market development indicates other factors could increase wood energy use. The growing availability of wood waste, coupled with concern about decreasing landfill capacity, is resulting in substantial recycling of wood residue, demolition debris and construction waste. The availability of recycled wood could stimulate wood energy conversions in the commercial and industrial sectors.

In addition, substantial research is underway on the production of high-valued chemicals and materials from wood fiber. In the long-run, this could lead to new directions for biomass use.

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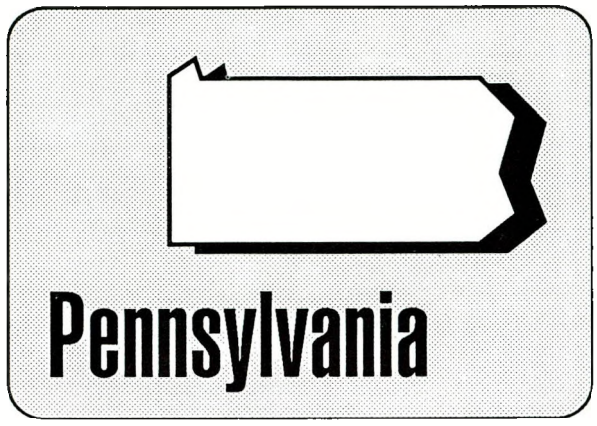

Forest Acreage:	16.7 million acres
Industrial/Commercial Wood Fuel Use:	800,000 tons/yr in 1990 *
Residential Wood Fuel Use:	3 million tons/yr in 1990 *
Wood-Fired Electricity Generation:	75 megawatts in 1990
MSW Resource Recovery Facilities as of March 1991	
In operation:	2,100 tons/day
Under construction:	6,088 tons/day
In planning:	5,800 tons/day

* Estimated

Overview

Pennsylvania is characterized by both large areas of forestlands and substantial urbanized areas, and thus provides both the demand for and supply of woodfuel. Residential wood use increased during the late 1970s and early 1980s. In 1981, approximately 1.2 million households in Pennsylvania burned wood. Although more recent surveys have not been conducted, state energy staff believe that residential use has declined approximately by half since the early 1980s due to declining oil and gas prices.

Industrial and commercial wood energy use increased during the last decade and continues to grow. Initially, woodfuel use by industry was due to the lower cost of wood compared to oil, gas and coal. More recently, the increasing cost of waste disposal is creating interest among facilities that produce wood residues to convert to wood energy.

NRBP Supported Activities

NRBP activities are directed by the Bureau of Forestry in cooperation with the State Energy Office. The Bureau has emphasized identifying opportunities for industrial and commercial wood energy use, and providing technical assistance to potential converters.

To meet this objective, the Bureau continues to offer industrial wood energy workshops and a boiler efficiency workshop. Among the target audiences for the wood energy workshops are energy engineering firms, which play a big role in advising institutions such as schools and hospitals whether and how to proceed with conversion to wood-burning systems. The Bureau currently has a grant program open to schools, hospitals, and non-profit institutions to help pay the capital costs of installing or converting to wood energy systems.

The Bureau also performs feasibility studies and provides direct assistance to projects. Examples include the installation of the first wood-fired cogeneration project in the state, a wood-fired conversion at a state facility, installation of a wood boiler at the largest commercial greenhouse in Pennsylvania, and the installation of a wood boiler in a new public school.

Additionally, the Bureau surveyed primary and secondary wood products industries and established a data base of wood residues available for use as fuel. The Bureau used NRBP funds to research opportunities for mixing wood chips with manure to produce compost; and have available five videotapes from a series of industrial wood energy slides shows prepared by NRBP.

Future Trends

Wood energy use is expected to continue to increase in industries and businesses in Pennsylvania, as evidenced by the two wood cogeneration projects that came on-line in August and November of 1988. More recent developments in the Middle East have generated numerous requests for information about wood fuel pellet manufacturing. Environmental concerns indicate opportunities for co-firing wood with coal at facilities in areas that do not meet state air quality standards. Concern about rising disposal costs should provide energy markets for recycled wood wastes.

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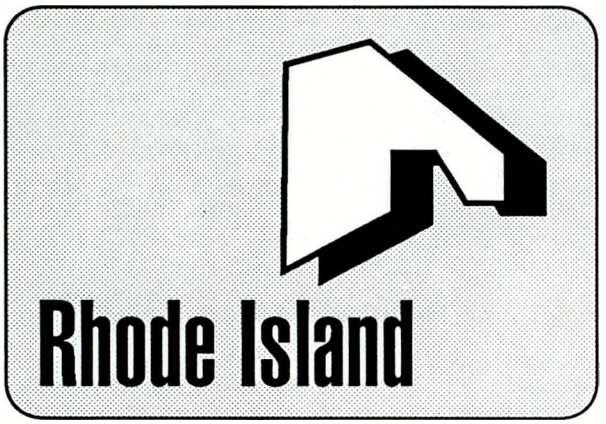

Forest Acreage:	371,700 acres
Industrial/Commercial Wood Fuel Use:	236,670 tons/yr in 1985
Residential Wood Fuel Use:	173,467 tons/yr in 1985
Wood-Fired Electricity Generation:	0 megawatts in 1990
MSW Resource Recovery Facilities as of March 1991	
In operation:	0 tons/day
Construction pending, 1991:	750 tons/day
Permits pending:	750 tons/day

Overview

Rhode Island is a small state that is 55% harvestable forests. Residential wood energy use grew during the late 1970s and early 1980s as oil prices increased. However, it is generally believed that fewer households burn wood now than five years ago. A residential survey completed in 1986 found only 13% of households burning wood.

There are no major businesses or industries known to use wood as a primary fuel in Rhode Island. This is due to the relatively low cost of other fossil fuels. However, increasing disposal costs are encouraging wood waste producers to find other ways to dispose of residues. In addition, there are an increasing number of wood recycling operations on-line or planned in Rhode Island or in nearby states.

NRBP Supported Activities

The Governor's Office of Housing, Energy and Intergovernmental Relations (GOHEIR) directs NRBP activities in Rhode Island. To encourage private forest landowners to properly care for forestland, GOHEIR produced a videotape on woodlot management. A publication on wood stove safety was produced and distributed to retailers, consumers and the media. GOHEIR also used NRBP funds to research small commercial and industrial cordwood boilers, and identified industrial parks with a high potential to use wood boilers. The feasibility of developing wood fired cogeneration facilities was examined at several potential sites, but none of these projects have materialized.

During 1989-1990, NRBP funds were used to produce a primary wood producers directory and complete a study on "Wood Waste Available for Fuel in Rhode Island." A study of the potential for recovering methane gas from small landfills in Rhode Island was supported by NRBP funds. One landfill, at Bristol, was selected to perform a gas analysis survey and to develop a plan to mitigate the hazard of landfill gas in a cost-effective energy project. This project was completed in 1990.

Activities planned for 1991 include identifying and developing end-use markets for recycled construction and demolition waste in Rhode Island and to research and evaluate factors affecting market development. In addition, Rhode Island's wood stove manual will be revised to comply with new standards and data made available through regional CONEG studies.

Future Trends

Important factors affecting future wood energy demand are the relative price of wood and other fuels, and the cost of waste disposal. Woodfuel use will increase if oil and gas prices increase or if waste disposal costs continue to climb. This will be particularly true for industries and businesses that produce wood residues, demolition debris and construction waste. A new landfill for demolition debris and construction waste is proposed by a private developer, but the Rhode Island Solid Waste Management Corporation is seeking alternative disposal or recycling options.

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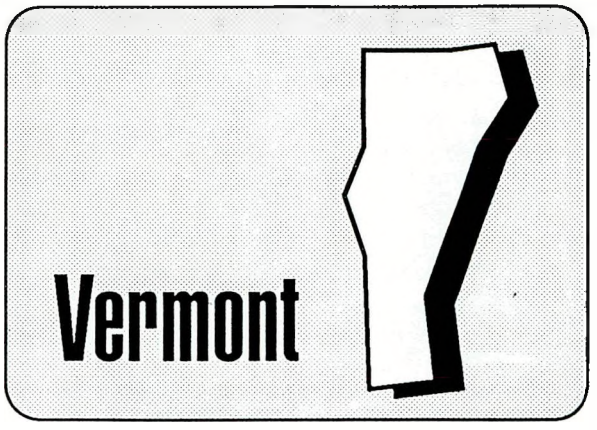

Forest Acreage:	4.5 million acres
Industrial/Commercial Wood Fuel Use	890,000 tons/yr in 1990
Residential Wood Fuel Use	732,500 tons/yr in 1989-90
Wood-Fired Electricity Generation	
Existing:	53 megawatts in 1990
Planned:	58 megawatts
Proposed:	80 megawatts
MSW Resource Recovery Facilities as of March 1991	
In operation:	250 tons/day
Under construction	0 tons/day
In planning:	0 tons/day

Overview

Vermont is a primarily rural state, with over 75% of the land area forested. Wood is commonly used as fuel by residences, businesses and industries. The largest municipally-owned wood-fired power plant in the country is located in Burlington, Vermont. Overall, an estimated 37% of homes currently use wood for heat, at least 75 state buildings burn wood, and approximately 100 industries and businesses rely on wood energy.

State foresters and energy specialists are convinced woodfuel harvesting has positive impacts on the state's forests. The use of integrated forest management techniques includes harvesting low quality wood while simultaneously improving growing

conditions for higher quality trees. An increased market for wood chips created by the Burlington Electric Department 50-megawatt power plant has provided economic incentives for harvesting previously unmerchantable wood. Burlington Electric's plans to increase the plant's output to 90 megawatts in the summer of 1991 will enhance these incentives, as will the establishment of an 18-megawatt wood-fired plant at East Ryegate, recently permitted and scheduled to come on line in November 1992.

NRBP Supported Activities

The Public Service Department directs NRBP activities in Vermont. Within the Energy Efficiency Division (formerly the Conservation and Renewable Energy Unit), a state forester and energy engineer work as a team on biomass initiatives. Emphasis is placed on researching and documenting successful wood installations and helping to develop new markets for wood fuel. Information and technical assistance are provided to current and potential wood energy users in Vermont.

Recent Energy Efficiency Division accomplishments include: organizing a major wood energy conference and exhibition in 1989; completing the 1989-90 (biennial) residential woodfuel survey; releasing a paper documenting three public schools' conversions to wood-fired heating systems; and creating a list of firms which make or install automatic wood chip-fired systems.

The Energy Efficiency Division also has available videotapes documenting successful industrial and commercial wood-fired facilities, and continues to update its list of wood energy installations in the state.

Future Trends

While wood energy use is higher in Vermont than many Northeast states, the percentage of residences and businesses burning wood declined during the late 1980s. This trend is largely in response to the relatively low price of oil and gas, and could reverse itself quite significantly if world events cause other fuel prices to increase.

Two recent local developments are expected to boost the utilization of wood chips for fuel in Vermont. The establishment of "ChipTech," a fabricator of residential and light commercial wood chip gasifiers, in Bristol, Vermont has dramatically lowered the cost of this technology. Previously, the only wood chip gasifiers on the market were imported from Europe, at a cost of $100,000 apiece. Domestic production of these systems has reduced the cost to consumers by two-thirds, bringing it within the reach of schools and other potential users.

A second development, known as the "Bennington Project," may have an even more dramatic impact on the way Vermonters – and others – generate electricity. The 20-megawatt wood chip gasifier jet engine generator design is expected to be 45% efficient, a significant improvement over the 33% efficiency levels achieved by current steam generators. The design will undergo early testing by General Electric in April 1991. Pending successful test results, the Energy Efficiency Division will issue a Request for Proposals from firms interested in building the 20-megawatt prototype.

Municipal waste management issues continue to pose a critical challenge for Vermont. The State Solid Waste Bill, passed in 1987, establishes a goal of recycling 40% of all solid wastes in the 1990s. In addition, most landfills must have liners by 1991, or they will be closed. Consequently, there is growing interest in opportunities for recycling wood and for managing wastes in innovative ways. To help identify potential recycling opportunities, the Department of Forests, Parks and Recreation surveyed all sawmills and secondary mills in 1990 to find out the amount and types of wood waste they generate.

Methane recovery will increase at the Brattleboro landfill from 250 kilowatts to 800 kilowatts in 1991.

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Applied Research and Technology Transfer Program

Wood Fuels Harvesting

Impact of Large Biomass Demand Centers on the Forest Resource Base

Public perception that large demand centers will have negative impacts on forest management is a barrier to further development of wood-fired electric power plants. To address this question, NRBP sponsored a project to examine the impacts of four wood-fired power plants on wood procurement systems and forest management in the plants' "woodsheds." The facilities evaluated were the Proctor & Gamble plants on Staten Island and in Baltimore; Scott Paper Company's S.D. Warren plant in Westbrook, Maine; and BED's McNeil power station in Burlington, Vermont. Together these facilities have a potential capacity to consume more than 1.5 million tons of chips annually.

The study methodology depended primarily on interviews with people involved in wood chipping for energy, and to a limited degree, on examination of forest management activities in the field. Interviews were held with 45 foresters, 20 loggers, 12 private, nonindustrial forest landowners, and 21 wood-chip brokers, haulers, and suppliers. The field studies included post-harvest stand examinations of 37 logging sites in northern New York, Vermont, New Hampshire and Maine. Interview protocols and tabulations, and the results of the field studies are reported in an appendix volume of the project report.

The report describes wood procurement systems for each of the four power plants. The study revealed that a significant portion of wood supply for each of the plants comes from private, nonindustrial forest land outside the previously accepted limit of a 50- or 75-mile supply radius. The P & G Staten Island facility used a large amount of processed and unprocessed wood waste from urban demolition. All four plants received large amounts of wood from agricultural and development clearings: 17% at Burlington, 35% at S.D. Warren, 67% at P & G Baltimore and 76% at P & G Staten Island.

The study found that integrated harvests, which include product separation and the sorting of higher-value products (sawlogs, veneer logs, pallet wood, etc.) in association with fuelwood chip harvesting, are an integral part of the fuelwood chip harvesting business. Chip suppliers are subject to constant change in demand for chips by both the energy and pulp and papermaking sectors. The survival of the harvesting and supply business, requires flexibility, firm commitments, and a broad range of clients.

The study showed that the wood chip market created by wood-fired power plants has had a beneficial impact on the forest industry by serving as a market for excess chips, stabilizing the market in

some regions, and increasing employment in the wood industry. Changes in the costs of competing fuels and uncertainties of power demand offset these generally positive impacts.

The study found no dramatic change in the intensity or quality of forest management due to fuelwood chip harvesting, which does not appear to differ from chip harvesting for pulp and paper or composite board production. Foresters are involved in 80%-90% of all chip harvests in Maine and Vermont. There has been no increase in "loggers choice" or destructive, uncontrolled chip harvesting since increased demand was created by the four wood-fired facilities. Loggers and foresters generally do not believe that fuelwood harvesting significantly increases soil erosion, although 42% of foresters and 30% of loggers do see an increase in residual stand damage. The study also found no indication that regulations specific to chip harvesting have had an impact on the quality of forest management, although 85% of the loggers and 36% of the foresters surveyed believe chip harvesting should be regulated. There was no evidence that any major improvement in the quality of forest management had occurred through thinnings or improved regeneration associated with chipping.

The study concluded that two important issues remain to be resolved: larger and more stable chip markets need to be developed, and public acceptance of chip harvesting is hampered by the absence of information on its impact on forest management.

Residual Stand Damage In Whole Tree Partial Cutting Operations

The preceding study examining the impacts of wood-fired power plants on forest management practices underscores the importance of investigating the extent of residual stand damage following partial cutting operations. Furthermore, earlier studies conducted on residual stand damage from partial cutting in the Northeast have reported widely varying degrees of damage.

The objective of the NRBP study of residual stand damage in northern hardwoods was to perform a controlled, replicable field study to determine the extent of residual stand damage from harvesting with the equipment most commonly used to supply fuelwood chips: drive-to-bunch fellers and grapple or cable skidders. Eighteen sites were studied in Maine, New Hampshire and Vermont. All study sites were upland hardwood or mixed hardwood-conifer forests harvested mechanically within the previous three years.

The study was completed in January 1990. The assessment of residual stand damage in the study sites used a new classification system developed by the University of Maine. The study used a logistic regression model to evaluate the relationship between the extent of residual stand damage and site, stand and harvest management practices. Using the model as a predictive tool, recommendations addressed harvest management practices so as to minimize residual stand damage to less than 10%.

Damage on the study sites averaged 9.6 percent; only five sites revealed damage in excess of 10 percent. This represents a reduction in residual stand damage for machines versus conventional chainsaws, resulting in significant economic benefits as a result of increased timber quality. The damage encountered on trees within any one site was not related to location within the site, distance from skid trails, nor distance from the landing. The variation in damage from one site to the next was relatively large. Forest cover type, rockiness, and season of harvest in combination were responsible for only a small portion of the site-to-site differences in damage.

Residual stand damage appeared to be most influenced by the care taken in planning the harvest and in the experience of the feller buncher operator. The study concludes with a recommendation that appropriate training for equipment operators, perhaps in concert with a certification program, could improve forest quality and productivity.

Biomass Fuels

Wood Chip Supplies And Markets

The emerging wood chip supply industry can benefit greatly from dissemination of information about availability of woodfuel. This is particularly true of wood chips, which can be perceived as an unreliable fuel supply for large demand centers such as wood-fired power plants.

To investigate the basis for this perception, and to provide comprehensive information on the industry to potential users, NRBP sponsored a project in 1984 to identify specific wood chip supply and market sources. Completed during the first year of NRBP-sponsored technical studies, it was the first region-wide study to address opportunities and problems associated with harvesting and supplying wood chips for fuel in the Northeast. The objective of the project was to determine whether there was an adequate supply of wood fuel available; to identify wood chip suppliers in operation; and to analyze the costs associated with starting a wood chip harvesting business.

The report on the project presents three case studies of wood chip supply businesses as well as case studies of markets for fuelwood chips: a residence, apartment building, hospital and manufacturing company. The report includes an annotated list of chip suppliers in each Northeast state. Approximately 375 wood chip suppliers are identified. The report also includes a list of equipment suppliers available to harvest, handle, dry and burn whole tree chips. These lists have been expanded, updated and published separately.

The report discusses factors affecting development of the supply market, suggests strategies for developing successful businesses, and presents hypothetical business plans for three supply businesses. The report emphasizes the need for educating potential woodfuel users about the availability of wood and the capability of suppliers to deliver wood on a reliable basis.

Recycled Wood Wastes

Between 20% and 25% of the almost 150 million tons of solid wastes disposed of throughout the United States in 1987 were woody materials from demolished buildings, land clearing, and from other industrial and commercial activities such as replacement of wooden pallets and railroad ties. Limited landfill capacity and high tipping fees have focused attention on recycling these materials as fuels and for other uses. To encourage recycling of wood wastes as fuels, NRBP sponsored a study to provide a comprehensive analysis of existing and future markets for recycled wood wastes in the Northeast. The objective of the study was to estimate the availability of wood and woody materials in the solid waste stream and to determine the economic and technical viability of separating and recycling them for use as fuel.

The report on the study includes an annotated list of companies that recycle wood waste as well as a list of power plants, industries and businesses that use recycled wood for fuel. Detailed assessments of market opportunities for wood recycling operations in Boston, New York City and Philadelphia are presented. Information on air emissions and ash disposal regulations for facilities that burn recycled wood is included. A decision-making process for firms interested in recycling and burning wood wastes was included.

Overall, the study identified significant volumes of wood wastes disposed of in landfills in the region. The report concludes that high tipping fees and a shortage of waste disposal capacity in metropolitan areas are creating incentives for recycling wood for fuel and other uses. According to the study, there were nine wood recyclers in operation in 1987. A single 43-megawatt wood-fired plant on Staten Island purchases recycled wood waste from six of the nine wood recycling plants. Another two chipping facilities provide fuel to a paper company and a refuse-to-energy plant. The ninth recycled wood processing firm serves landscaping firms and commercial wood-fired facilities in the Philadelphia area. At least four other companies were planning facilities to come on-line in the near future. Market

Limited landfill capacity and high disposal costs underscore the need to recycle wood wastes as fuel.

opportunities exist for landfill operators, transfer stations, waste haulers and stand-alone recycling businesses.

The study reports that there is presently a greater supply of recycled wood than there is demand. However, this may change if new wood-fired power plants proposed in New Hampshire, Massachusetts, and Connecticut are successfully sited and permitted. Other markets for recycled wood could also develop. Recent experience with using recycled wood for landscaping mulch, soil amendment, sludge stabilizer, farm bedding and wood supply for wood products industries indicate the range of opportunities.

Industrial Wood/Coal Co-Utilization

Industry concern about fuel supply, emissions regulation, and price stability has prompted installation of multi-fuel boilers in the Northeast region. Recognizing that few of these installations have elected to use wood and coal combinations, NRBP initiated a study in 1986 to examine the opportunities and constraints for wood/coal co-utilization in industrial boilers in the Northeast. The study uses previous research and technology studies, the results of a user survey, and a case study of the S.D. Warren Company's Westbrook, Maine wood/coal facility to examine advantages and disadvantages of developing a wood/coal multi-fuel facility.

The study found that wood/coal combinations are few and recent in the East Coast Region. There are two major installations in northeastern states: the S.D. Warren plant in Westbrook, Maine (wood chips and pulverized coal) and the GlatFelter Paper Company of Pennsylvania (bark and pulverized coal). These wood/coal facilities as well as most others around the country are forest products facilities or electric utilities within 50 to 100 miles of large volumes of wood residues. The S.D. Warren plant was a former oil-burning facility newly equipped to co-fire wood chips and pulverized coal to control energy costs and achieve fuel versatility. S.D. Warren is a pulp and paper manufacturing company.

The study points out that in the absence of low or no-cost wood residues on or near the point of use, the incentive to co-fire wood in coal boilers is negligible unless state regulations create new requirements to lower sulfur emissions, and/or on-site wood supplies are inadequate to meet total energy requirements. The study reports that wood and coal are compatible but not identical fuels to handle and burn. Although the study concludes that technological constraints to wood/coal co-utilization are minimal, cost differentials are substantial. For example, fuel handling for wood is more costly than for coal. Wood requires larger storage areas and more complex handling systems since it contains only 40% of the BTU value/ton of coal and is only 70% as dense. Multi-fuel combustion equipment is more costly than wood- or coal-only boilers.

The study concludes that the decision to blend fuels will in large part be governed by the incremental costs of accommodating both fuels compared to offsets achievable by less costly environmental controls on wood/coal operations. In New England and New York, wood/coal co-utilization will be most attractive as a form of fuel diversification and to achieve greater combustion efficiency in wood-only boilers. In Pennsylvania, Maryland and Delaware, where coal and gas are the major industrial fuels, wood/coal co-utilization conversions are most feasible in the form of a wood supplement in coal operations to meet increasingly stringent emissions standards imposed by state regulators.

Industrial/Commercial Wood Energy Use

Guidebook for Industrial Wood Energy Conversion

Lack of technical information and experience performing feasibility studies is a barrier to the cost-effective use of wood energy in industrial and commercial (including institutional) facilities. To address this problem, NRBP sponsored a project to provide facility managers and other decision-makers with information necessary to make preliminary decisions on the feasibility of using wood for fuel.

The Guidebook produced for the project is a sourcebook for potential wood energy users and includes information on economics, fuelwood procurement, equipment options, air pollution regulations, and worksheets for calculating cost-

effectiveness. It has been distributed to over 600 potential wood energy users throughout the Northeast.

The Guidebook includes descriptions and drawings for wood-fired watertube boilers, firetube boilers, direct-fired furnaces, indirect-fired furnaces, multi-fuel boilers and boiler retrofit equipment. The Guidebook also includes information on wood fuel unloading, storage, conveying and drying equipment. Options for air pollution control equipment that are discussed include cyclone separators, scrubbers, and electrostatic precipitators.

Two financial worksheets are presented and explained as part of the Guidebook. The worksheets provide a quick and easy way to estimate fuel cost savings from using wood. The worksheets are for preliminary analysis only and do not replace more detailed engineering and financial feasibility studies.

Targeted Industrial Conversion Assistance

NRBP initiated the Conversion Assistance Program in 1985 to encourage industries and businesses to evaluate wood energy conversion, and to continue facilitating information exchange.

The Conversion Assistance Program was designed to provide information and technical assistance in workshops, and to develop more specialized information on converting to wood. The Program offered ten industrial wood energy workshops at various locations in the Northeast. Case studies and slide shows of successful wood conversions were presented. The Program developed lists of wood energy engineers and equipment manufacturers; researched and documented the decision-making process used by industries that successfully converted to wood; and provided an information referral service for facility managers.

Information developed for the Program is compiled in a Resource Notebook containing nine fact sheets describing each step in the decision-making process; eleven case studies of wood-fired industries, businesses and institutions; a users guide to computerized preliminary feasibility assessments that can be performed in-house; a list of wood energy associations; and resources for further information. The list of wood energy equipment vendors was updated in 1988 and is published separately as a directory which includes wood chip suppliers.

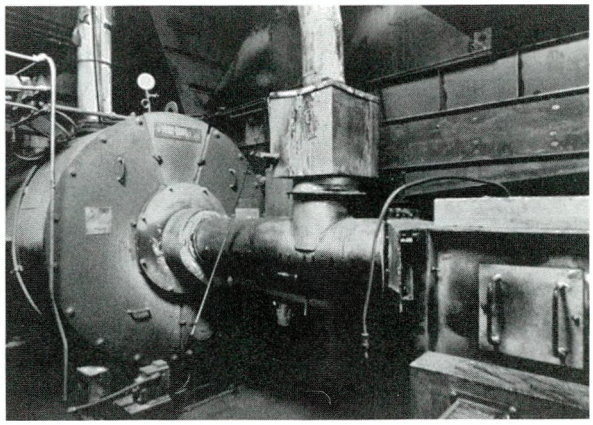
Cogeneration And Wood Energy Slide Shows

As part of an effort to assist industrial, commercial and institutional facilities in making informed decisions about conversion to wood, NRBP sponsored a project in 1985 to develop slide programs showing successful wood fuel operations in different types of facilities: manufacturing industries, commercial greenhouses and nurseries, primary and secondary wood industries, and institutions such as schools and hospitals.

Each 30-minute slide program includes three case studies of wood-fired facilities in the particular industrial/commercial sector covered in the show. The slide programs and their scripts present detailed information on equipment costs, fuel cost savings and payback. A fifth slide program provides an overview of industrial wood energy use and summarizes the experience of successful wood-fire installations. This program is narrated and is appropriate for use during the introductory session of a workshop or conference.

Northeast Directory Of Biomass Energy Facilities

To facilitate exchange of technical information and to demonstrate the use of biomass for wood energy, NRBP published a directory of biomass energy facilities in the Northeast in 1987, and an updated version in 1989.



Over 400 power plants, industries, businesses, and institutions use wood for fuel in the Northeast.

The comprehensive directory identifies over 400 power plants, industries, businesses and institutions that use wood for fuel in the Northeast. Information is presented for facilities that use wood chips, mill residues, or sawdust in automated energy systems rated at 3 MMBTU/hr or larger. Hand-fired systems burning cord wood are not included.

The Directory includes an overview of wood energy use in the Northeast, a list of wood energy users by state, detailed descriptions of over 200 of the facilities, and indices organized by industry type, cogeneration use, and heating plant output.

Directory Of Wood Chip And Wood Energy Equipment Suppliers

Industrial and commercial facilities which could potentially benefit from conversion to wood energy often have the perception that fuelwood supply is uncertain and that the equipment and service infrastructure for wood combustion is not well developed. NRBP work has shown that this is not generally the case in the northeastern states. NRBP accordingly sponsored development of a directory to demonstrate the large number and wide distribution of wood chip suppliers and wood energy equipment venders in the Northeast. The Directory was updated in March 1989.

The Directory contains over 250 entries for wood chip suppliers and brokers. They are listed by state and are categorized as loggers-chippers, forest products industry chippers, brokers, and complete service companies. The list does not include pulp and paper mills that produce chips solely for their own use in pulp manufacturing.

The annotated directory of wood energy equipment suppliers includes 85 entries and is national in scope. Each entry includes an annotated list of the company's products and services.

Characterization of Waste Wood Products And Their Emissions

Waste wood represents an increasingly attractive alternative to fossil fuels in many regions of the country. Environmental regulators and citizens in communities which might potentially host facilities utilizing waste wood as a fuel raise concerns that the waste may be "contaminated" with paints, resins, preservatives, etc. Given the rising cost of disposing of the waste, the difficulty in separating it, and the volume of the resource, it is important to accurately characterize the categories of wood wastes and to determine which products may be environmentally acceptable as a boiler fuel.

Together with the Canadian Combustion Research Laboratory, the EPA, New York State Energy Research and Development Authority, the Commonwealth of Virginia and the other four regional programs, the NRBP proposed a project to identify potential impurities in the wood waste resource and test the emissions from various types of wood waste in the laboratory. The project also will characterize the wood waste stream in several states and a Canadian province to determine the volume of various wood waste products. Information on waste wood generation, management and disposal shall be researched and presented on a state or provincial basis. Current waste management and disposal practices will also be examined for their possible regulatory implications. A second phase of this project will feature the testing of selected waste wood resources in field boilers which vary in size and type. The impact of appropriate control technologies will also be assessed. This work is expected to be completed in 1993.

The goal of the project is to identify combustion system operation parameters and air pollution control technologies that can minimize the emissions of identified air contaminants from the combustion of waste wood.

Residential Wood Energy Use

Performance Monitoring Of Advanced Technology Wood Stoves

In 1985, NRBP undertook a three year study of fuel savings, creosote build-up and emissions from advanced technology wood stoves in use in homes. Widespread concern about pollution, safety, and wood stove efficiency prompted the research. The objectives of the project were to determine the effectiveness of catalytic and non-catalytic advanced technology stoves in reducing wood use, creosote accumulation and particulate emissions.

The project monitored wood stove performance in 68 homes for a two-year period (1985-1987). Twelve stove manufacturers donated a total of 26 catalytic low emission stoves to home owner volunteers in Vermont and upstate New York. Conventional air-tight stoves were operated in 28 homes to provide baseline data for at least one year of the two-year effort.

Creosote and volumetric wood pile measurements were conducted on all 68 homes. Creosote accumulation was measured two to three times annually by sweeping the chimney system and weighing the collected material. Researchers measured woodpiles during the heating season, normalizing for moisture content and fuel species. Particulate emissions were sampled three to four times each winter in 34 homes. These homes had computer-assisted data logging systems to record stove temperatures, flue gas oxygen concentrations, and wood weights. Particulate samples were collected continuously for one minute every half an hour during each week-long sampling period.

The catalytic and non-catalytic low emission stoves generally performed only marginally better than the conventional air-tight stoves. While individual models and individual stoves demonstrated significantly lower emissions and creosote accumulations and greater efficiency than conventional models, the results for the advanced technology categories as a whole were disappointing. While laboratory testing on particulate emissions reveals that catalytic and non-catalytic advanced technology stoves can achieve 70% - 80% reductions over their conventional air-tight counterparts, the field studies revealed emissions only a few grams per hour lower for catalytic stoves and seven grams lower for non-catalytic stoves in reducing emissions. Stoves which had lower emissions, however, generally also enjoyed lower creosote build-up and lower wood use. Average reductions by stove group ranged from 10%-35% for creosote and 15%-30% for wood use.

Large variations among stoves of the same model, and of the same stove during different testing periods, made conclusions difficult. There appear to be many factors influencing stove performance. These include firebox size, burn rate, fuel loading procedure, catalyst operation time, chimney conditions, catalyst durability, stove design and proper installation.

Operator behavior is also a key factor, but measuring its dimensions was not an objective of the project. Volunteers for the study received no special instructions or training. Catalyst durability proved to be quite variable among the stoves used in the project. Several experienced rapid deterioration; others did not. For one stove model, replacement with a "second generation" combustor model virtually eliminated the problem. In the second year of testing, emissions from this stove model equipped with the "second generation" combustors were reduced by one-third.

Results from stove inspections conducted after the second heating season revealed that significant leakage of smoke around combustors may be a cause of high emissions. Gaskets around the bypass damper and combustor were the component in greatest need of maintenance to reduce leakage.

The U.S. Environmental Protection Agency (EPA) and the New York State Energy Research and Development Authority (NYSERDA) co-sponsored the research with NRBP. The study has had a significant impact on testing methodology for certifying wood stoves under the new EPA Source Performance Standard. The research also justified setting a different standard for non-catalytic stoves and prompted EPA to require periodic inspections for gaskets and welding leaks in new stoves.

In the third year field testing, the Wood Heating Alliance and the Canadian Combustion Research Laboratory joined in sponsoring the research. The research objective for the 1988-89 heating season was to identify particular factors associated with low particulate emission in EPA-certified stoves. Tests were completed on three brands of catalytic stoves newly installed in 15 households, and two brands of high-tech, non-catalytic certified stoves newly installed in 10 households. These stoves were monitored for emissions, fuel loading, catalyst bypass damper usage and fueling door activity, and catalytic temperatures. The purpose of the field study was to determine the adequacy of the EPA standards in reducing emissions under optimal field conditions.

The five-week sampling of 25 stoves demonstrated a 55%-60% reduction in emissions among these stoves versus the guideline attributed to conventional air-tight standards. The average particulate emissions level was 9.4 grams per hour. The two brands of non-catalytic stoves averaged 9.3 and 11.3 grams per hour

During the 1988-89 heating season, 25 EPA-certified residential wood stoves were monitored for emissions and other performance factors.

respectively. Both failed to meet the EPA standard of 7.5 grams per hour for 1990 certification. Two of the three catalytic stove models did not perform up to expectations. One experienced gradual performance degradation, beginning one month after stove installation. The other had elevated emissions throughout the testing period.

The 1990-91 testing season has moved back to the laboratory. The sponsors, joined by Oregon's Department of Environmental Quality, are striving to construct a "stress test" methodology to simulate conditions found in the field. To help manufacturers design stoves which persist in achieving good performance, the stress testing methodology features high burn rates, hot fires, more extensive drafts, and round-the-clock loading and combustion for periods of two weeks or more. To date the research effort has yielded a preliminary stress test method which has produced results comparable to that found in the field. This research should be completed in the fall of 1991.

Workshop On Residential Wood Stoves

The residential wood stove monitoring field studies revealed that wood stove retailers, installers and users need information on proper installation and operation of the new high efficiency, low-emission wood stoves to meet fuel savings and air quality objectives. Changes in air emission standards for wood stoves promulgated by EPA are creating significant changes in the design, operation and performance of wood stoves and catalytic retrofits. To address these issues, NRBP sponsored a major workshop in October 1988 on the standards and on new, clean-burning wood stoves.

The workshop was attended by over 160 wood stove retailers, chimney sweeps, housing and weatherization specialists and state energy staff from throughout the Northeast. Additional workshops were held in 1989 and 1990. A workshop "Notebook," published by NRBP, includes information on new emissions standards and changes in wood stoves. Notebook materials include a "Shopper's Guide to the New Wood Stove Law," questions and answers on indoor woodsmoke, a review of certified wood stoves, a description of low-emission, catalytic and non-catalytic stoves, information on catalytic retrofits, a guide to stove installation and safety, a guide to chimney construction and maintenance, and a resource list for further information.

Videos On Residential Wood Stoves

The issues that prompted NRBP to develop a residential wood stove workshop also provided impetus to co-sponsor production of a series of videos on wood stove safety, maintenance and operation. The Wood Heating Alliance and Wood Energy Institute-West co-sponsored production of the videos which focus on the high efficiency catalytic and non-catalytic stoves certified by the U.S. Environmental Protection Agency.

The three videos have different subjects and audiences. The first is a series of 10-30 second public service announcements highlighting the safe, efficient and clean-burning advanced technology wood stoves. The second video is a seven-minute educational documentary produced for retailers and consumers. It is intended for use in wood stove retail outlets. The video covers the same subjects as the short public service announcements in more depth. It also presents information on proper stove sizing and installation, chimney design, wood purchase, and stove operation and maintenance.

The third video is a twenty-minute production expanding on themes in the seven-minute video. This

documentary was produced for cable television, public television stations, and as background material for news features. The video includes information on the history and evolution of wood stove use and development of high efficiency catalytic and non-catalytic wood stoves. The video also discusses the chemistry of wood combustion and the importance of using combustor bypass valves properly.

Approximately 100 retailers have purchased the seven-minute video and a number of television stations have aired the public service announcements and/or the documentary. The productions have received exposure in every region of the country.

Solid Waste Management and Resource Recovery

Wood Fuel Feedstocks In Resource Recovery Facilities

As part of continuing work exploring new markets for wood wastes, NRBP sponsored a study to examine the technical and economic feasibility of mixing solid waste with wood chips in resource recovery facilities. The purpose of the study was to identify the circumstances under which adding wood fuel to municipal waste is economical. The study sought to determine if there are limitations to supplementing the waste stream with wood chips, bark and sawdust; and to identify examples of resource recovery projects in the Northeast which demonstrate economic and technological feasibility of wood/MSW co-utilization.

The study identified five reasons for supplementing municipal solid wastes with wood fuels in resource recovery facilities. These include circumstances in which threshold fuel volumes from MSW alone cannot be achieved; interim, stopgap fuel sources need to be used; diversifying fuel sources is an appropriate strategy; or emissions need to be reduced to meet environmental concerns or requirements.

The report profiles three projects that chose to co-fire MSW and wood. These plants include two facilities in Maine (one a 22-megawatt plant and the other a 24.6-megawatt facility). Both facilities are designed to burn refuse-derived fuel processed on site with a supplement of wood chips, natural gas and fuel oil.

The study examined wood procurement requirements and infrastructure for resource recovery facilities that co-fire, and analyzed woodfuel availability in New Jersey, New York, Pennsylvania, and Maryland. A model for doing financial analysis was created and applied to four scenarios that illustrate application of the model for different size facilities using varying MSW/wood ratios.

The study concluded that wood and MSW are compatible solid fuels and that co-utilization presents no major technological barriers. Either co-firing in the same boilers or co-utilization in parallel boilers can address a number of circumstances which can impede implementation of resource recovery facilities. Probable short-term incentives are meeting threshold fuel volumes and mixing wood with the MSW stream as an interim fuels strategy.

The financial analysis of co-utilization under varying assumptions demonstrates the sensitivity of project economics to electricity purchase rates. Power purchase rates, not the presence or extent of fuel mixing, is the critical determinant of feasibility in the analysis conducted as part of the project.

Comparative Risks Of Landfill And Resource Recovery Facilities

The crisis in municipal solid waste management – a combination of rising disposal costs, landfill exhaustion and environmental degradation – has spurred much public debate over preferred courses of action. NRBP sponsored a study in 1988 to provide policy guidance to state and local officials in comparing health, safety and environmental risks of state-of-the-art resource recovery and landfill facilities. These two disposal options will be necessary even after aggressive source reduction and recycling. The study objectives were to inform decision-makers and the public on what is known and not known about the relative health and environmental risks of these disposal options, and to suggest how such information can be used in formulating local and regional MSW management strategies.

To compare risks, the project synthesized studies which provide quantitative and qualitative analyses of the nature and magnitude of various risk sources. As a starting point, the study developed a demographic and waste profile of a typical area of the Northeast. The scenario assumed an aggressive

recycling program which reduced the waste stream by 25%. For the remaining wastes, two disposal options were offered: a state-of-the-art, mass-burn resource recovery facility including an ashfill for handling residual materials after burning; and a landfill designed to meet all existing state and federal regulations.

The study evaluated risks to public health, risks to public safety, and risks of environmental degradation. For each type of risk, the risk assessment included identification of the hazard; an assessment of the nature and size of populations exposed to the hazard and the magnitude and duration of such exposure; an estimate of the quantitative relationship between the amount of exposure and the likelihood of disease occurrence; and a comparison of the estimated outcome against some benchmark. Typically, the benchmark is incremental or additional cancer cases and/or other health outcomes.

The study results underscore the fact that estimates of potential disease in risk assessments must be interpreted with great caution. Not only is the transport and transformation of chemicals in the ambient environment complex, but there is great uncertainty in translating particular exposure levels to human doses and responses. Because of uncertainties, risk assessments should only be interpreted as relative. That is, absolute numbers such as ten excess cancer deaths per million population exposed from operation of a resource recovery facility or landfill should not be used as a precise predictor of health outcomes. Rather, its value lies only when 10 is compared to 5, 15 or any other number derived from a risk assessment of a different facility.

The study found that landfills fall into two types with widely divergent risks. Uncontrolled landfills – those without leachate and air emissions control systems – comprise the vast majority of the nation's 9,000 active and inactive facilities. Excess cancer risks from these facilities are in the range of 50 - 400 per million population exposed from air toxins alone. However, new landfills will have appropriate controls capable of collecting and flaring fugitive emissions. Risk estimates attributable to air pathway exposure from controlled landfills generally fall below 20 cancer risks per million and often less than 10 per million.

This figure is within the range of cancer risks associated with state-of-the-art resource recovery facilities. For both operating and planned resource recovery facilities under optimal operating conditions, risk levels are in the range of 1 to 10 cancer cases per million population exposed. The degree of risk is derived from a number of published assessments ranging from single medium/single pathway to multi-media/multi pathway analyses on facilities with a variety of air emissions control equipment. Despite this wide variation, the relatively narrow risk range creates a reasonable degree of confidence that actual risks fall within these boundaries.

The study lists additional considerations concerning cancer risks that decision-makers may consider in developing solid waste management strategies. Information will need to be considered on the number of people at risk from alternative strategies, differences between strategies in monitoring and regulating emissions, whether environmental and safety risks are roughly comparable, and how risks from different types of facilities change over time.

The report concludes with guidelines on communicating comparative risk information effectively. The most acceptable way to discuss risk comparisons with the public is to compare the same risk at two different times (e.g., retrofitting a resource recovery facility with additional air emissions controls, and comparing the pre- and post-retrofit risk levels); to compare relative to a standard (e.g., comparing state-of-the-art landfill risks of exposure to a particular pollutant with EPA or state standards for the same chemical pollutant); and, to compare different estimates of the same risk (e.g., the project developer's estimate of risk is "x" whereas the community group's estimate is "y").

Equity Adjustments In Resource Recovery Facility Siting

Resource recovery facilities in the Northeast are increasingly difficult to site. Underlying siting problems are equity controversies between those who benefit from a facility and those who bear the risks. NRBP sought to contribute to resolving these problems by examining host community equity adjustments and by providing guidelines for formulating workable equity adjustments for host communities.

The study, published in May 1989, begins with a description of actual and perceived risks of resource recovery facilities that must be addressed in an equity adjustment program. The study examines different types of equity adjustment measures to offset risks. These include community participation and empowerment, public service payments, payments in lieu of taxes, monetary payments based on facility use, insurance and trust funds, special services and grants, property value guarantees, and local hiring and procurement policies.

The study conducted a survey of resource recovery facilities in the northeastern states to determine which of these equity adjustment measures had been or were being used in negotiations with host communities. Of the eleven northeastern states, the report notes that four have regulatory requirements for host community compensation. The survey shows that monetary payment to the host community based on a facility's use is the most prevalent compensation measure. Other frequently used compensation practices are payments in lieu of taxes, provision of special services and grants, and public service payments. Measures such as formal community participation are rare; and insurance and trust funds, property value guarantees and local hiring are not used at all in the Northeast.

Drawing on experience in equity adjustments for resource recovery facilities in California and other hard-to-site facilities, the study recommends procedures, principles and measures. The study concludes that there are three principles which should guide the formulation of a model package: cover only unavoidable risks; link adjustments to identifiable risks; and present equity adjustments early in the process as integrated packages, not as discrete and unrelated components.

The study recommends that a citizens negotiation and monitoring committee be formed as a permanent part of the siting process. The Committee should have specific but broad responsibilities and authority. The study recommends that public service payments should be part of the equity adjustment package. These might be for additional equipment and material for host community agencies such as police, fire, etc.; additional personnel connected to public service functions; utility expenditures; and road construction and maintenance funds.

The study concludes that payments in lieu of taxes are a logical, though infrequently used, type of equity adjustment and that monetary payments of approximately $2 per ton should be paid by the facility operator to be expended at the discretion of the host community.

The study suggests that sufficient uncertainty exists in the future availability and cost of environmental impairment insurance to warrant assignment of ultimate financial responsibility for environmental and health contingencies to the one entity capable of guaranteeing coverage under any contingency – the host state. The study also recommends that the facility owner establish a property value guarantee procedure. Finally, the study considers the costs of these equity adjustments and who should pay them.

Modeling Future Waste Streams

Planning for future resource recovery facilities must take into account the changing nature of the waste stream and the impact of recycling and source reduction requirements increasingly in place. Determining the energy value of a given ton of municipal solid waste depends a great deal what assumptions one makes about paper recycling, packaging requirements, composting opportunities or mandates, recycling provisions and landfill disposal costs. To help municipalities, resource recovery facility operators, developers and solid waste management officials at the state levels understand the current configurations, and estimate future energy balances, NRBP commissioned a consultant to construct a user-friendly software model to project the volume and energy value of future waste streams.

By varying the assumptions for each attribute of the waste stream and by varying cost projections for disposal and combustion technology parameters, the planner can determine the cost-effectiveness of alternative waste management strategies. The models, designed for application on personal computers, and running on Lotus 123 spreadsheets, is called WastePlan. Every state in the NRBP territory has an application which models that state's current and projected waste stream.

Environmental Issues

Regional Strategies To Mitigate The Accumulation Of Greenhouse Gases

The growing concern about the global climate changes effected by the accumulation of carbon dioxide, methane, and other gases in the atmosphere has occasioned renewed interest in the role of biomass. To combat a common perception that links biomass energy development to deforestation and the exacerbation of "the greenhouse" effect, NRBP initiated in 1990 a secondary literature review and policy analysis aimed at developing strategies to mitigate the region's net contribution to the atmospheric accumulation of carbon dioxide and methane through the careful utilization and management of biomass resources.

The potential for utilizing biomass resources to address the global climate change crisis is twofold. First, biomass combustion – especially wood – can displace coal and oil, both of which emit carbon dioxide into the atmosphere in greater quantities per unit of energy produced. Second, where appropriate, reforestation practices and prudent forestry management policies can increase forest growth, which in turn increases the region's carbon-fixing capacity.

The first phase of research entails estimating the Northeast region's current and projected net contributions of carbon dioxide and methane to the atmosphere, taking into account both gross annual emissions from energy production and use and the gross annual uptake – primarily of carbon dioxide – by the region's forests. This "reference case scenario" begins with the base year 1988 and extends over a 30-year period, assuming a continuation of current energy and forestry practices. The key factors that make up the reference case – land use, energy demand and supply sources, forest growth rates – are mounted on computer, to facilitate the testing of alternative strategies capable of impacting the factors that contribute to net emissions.

Strategies to be analyzed will include: intensive forest management of privately owned and publicly owned lands; development of short rotation intensive crops and energy plantations; planting on marginal lands; urban forestry; and solid waste recovery. For each biomass resource development strategy identified, the study will assess the approximate size of the potential resource and its technical potential for displacing fossil fuels in various applications. The next step will be to estimate the range of net impacts on energy and "greenhouse gas" emissions, and the relative cost-effectiveness of various strategies with respect to reducing net emissions. The final phase of the project will be to recommend policy initiatives that may be taken both regionally and locally to implement the most promising strategies.

The primary objective of this project is to produce a document to guide local, state, and regional policymakers in developing policies affecting the growth and utilization of the region's forests; the use of marginal agricultural lands; the extent of our reliance on fossil fuels; and the utilization of landfills. A secondary objective is to educate the general public about the opportunities and constraints posed by biomass resources and their energy applications. NRBP will publish a report detailing the findings of this project, and major findings and conclusions will also be summarized in an article suitable for publication in a lay periodical. A third objective is to generate research priorities for further investigation (see Section 8, "Future Directions"). The study is expected to be completed in June 1991.

Wood Ash Disposal And Recycling

To facilitate development and implementation of low-cost, environmentally acceptable uses for wood ash, the NRBP initiated a project to summarize disposal options, utilization options, state and local wood ash disposal regulations, and related research on wood ash conducted in the United States and Europe. The project report is published as a "Sourcebook".

The Sourcebook begins with a characterization of wood ash. Approximately 2% of the weight of dry wood remains as ash following combustion. Calcium, potassium, and sodium are the chief elements in wood ash; the carbon content can range from 1% to 30% or more. The efficiency and type of combustion, pollution controls, and wood species determine the percentage distribution of various elements. The elements include nitrogen, magnesium, aluminum, iron, cadmium, chromium, copper, manganese, nickel, lead and zinc.

The Sourcebook reports that 80% of the approximately 125,000 tons of wood ash produced annually in industrial and commercial boilers in the region are spread on agricultural lands. Landspreading is useful because ash is an effective liming agent on soils which are acidic. Generally crops respond more favorably to neutral soils than the acid soils common to the Northeast. The trace metals in the ash are also beneficial to plant growth.

An estimated 15% of wood ash is landfilled. Increasingly, landfilling requires a liner to allow recovery and treatment of leachate. This environmental protection measure increases disposal costs from $10 - $12 per ton to $40 - $50 per ton. Additionally, transportation costs to suitable landfills add $.15 per ton per mile. Therefore, a facility producing 5,000 tons of ash annually and trucking it a distance of 40 miles to the landfill pays $230,000 - $255,000 for disposal. By contrast, agricultural use of ash costs one-third to two-thirds less than landfill disposal. Typically, application costs are borne by the landowner receiving the ash.

The Sourcebook identifies additional utilization options for ash: spreading on forest lands, use as a sewage sludge composting agent, use in cement production, and as an additive to roadbase materials. Forest spreading and sewage sludge options will be the most attractive options in the 1990s. Wood ash may also find useful applications as an additive in fertilizer, charcoal production, hazardous waste treatment, treating potato processing wastes, and in pretreatment of landfill leachate.

In areas outside northern New England and New York, there are no state regulations governing disposal of wood ash. The four states with ash disposal regulations are also areas of greatest ash production. Maine has the most stringent requirements. Special permits are required for ash landfilling, and prior state environmental agency approval is required for landspreading. Site, soil and ash analyses are required to meet agency criteria for toxicity and acidity before permits are issued. Vermont and New York subject ash to the same criteria as other solid wastes, thus rendering landspreading a less attractive option.

Two major factors limit the rate at which ash may be spread on agricultural lands: ash increases soil pH; and toxic compounds such as those containing cadmium must be monitored for possible contamination of the food or water. Ash landspreading is usually done without prior treatments. Occasionally, ash for landfilling is mixed with lime or paper mill sludge prior to application.

The Sourcebook provides abstracts of 45 American and European research articles published on wood ash and its applications. Interviews with large producers of ash and disposal contractors provide detail on the experiences and costs associated with the landfilling and landspreading options. The Sourcebook identifies research and government and commercial contacts who might assist those interested in disposal options for wood ash.

Air Emission Regulations For Small To Moderate-Sized Wood-Fired Boilers

One reason the full potential of fuel savings from using wood energy is not being realized fully is the perception among potential commercial wood burners that air pollution regulations pose special difficulties. Therefore, in 1984 NRBP initiated a project to review air quality standards in the eleven Northeast states and to identify those regulations applying to small and medium size units. The objective of the study was to provide potential wood burners with information to evaluate the technical and economic feasibility of meeting the state emission standards.

The study found that emissions regulations that apply to small and moderate sized boilers vary from state to state. This is true for both allowable emission rates for different boiler sizes and the minimum boiler sizes regulated. In most states, applicable emission rates were not developed specifically for wood-fired boilers. Many regulations apply specifically to coal, wood and heavy oil while others apply uniformly to all fuels. In general, the study concludes that rules and regulations are complicated, and that case by case consultation with regulatory agencies is the only way to insure that the specific requirements are understood.

The study notes several generalities. As of 1985, boilers less than 1 MMBTU/hr are exempt from filing in all states except Connecticut and Maryland. Multiclone collectors should provide acceptable particulate control on small boilers (<10 MMBTU/hr) in all states except Connecticut, New Jersey, Maryland and Rhode Island.

The largest boilers (>100 MMBTU/hr) are expected to install high efficiency control equipment – wet scrubbers or baghouses – in all states except Vermont where multiclone collectors are acceptable. However, in a number of states, boilers >60 MMBTU/hr are subject to formal review procedures where "best available control technologies" will be applied. These are often more stringent than state emission regulations.

The report includes an overview of particulate control operating strategies and equipment, and cites particulate control requirements by the individual state.

Stack Emissions Standards For Industrial Wood-Fired Boilers

Uncertainty surrounding state air emission regulations has led to confusion for small to moderate-sized industries considering conversion to wood. To address this problem, NRBP sponsored a project in 1985 to address fundamental technical, economic and regulatory issues associated with the control of pollutant emissions from wood-fired boilers in the Northeast. The objective was to provide the best current emission test data available for industrial wood fuel combustion. Until the NRBP study, this information was not available in a single document. This resulted in an inconsistent and sometimes inappropriate data baseline on which state emission standards were developed or modified.

The study identified the current distribution of wood-fired boilers in the Northeast, pollutants of concern from wood-fired boilers, and relevant federal and state emissions regulations. The study projected expected emission rates of pollutants of concern, identified state-of-the art industrial wood combustion and emission control technology, and evaluated the economic impact of federal and state regulations on wood-fired boilers.

On the distribution of wood-fired boilers in the Northeast in 1985, the study finds that the use of wood as a boiler fuel is typically limited to industries generating wood residue. Most of these have capacities of less than MMBTU.

The study concludes that particulate matter is the major pollutant of concern. Federal air pollution regulations (in 1985) do not generally apply to small wood-fired boilers which meet state emission standards. State emission standards vary substantially in content, purpose and impact on industry. Compliance with stringent emission standards can be achieved through application of controls. The study found, however, that innovative methods of operation can eliminate the requirement for air pollution control equipment or at least reduce the cost of control equipment. The study finds that the economic impact of using emission controls becomes greater as boiler capacity decreases.

The study found that potential users of biomass are not aware of applicable air pollution regulations or the permitting process. The study did not find a correlation between the wood-fired boiler population in a state and the state's particulate emissions standard.

The report includes a detailed discussion of federal air emissions standards as they might apply to wood-fired boilers (generally they do not apply), and a state-by-state discussion of air emission regulations. Specific attention is paid to particulate emission determinants including the combustion efficiency of various species of woodfuel, the size and shape of wood burned, and the mechanics of particulate production and entrainment. The report discusses in detail the equipment design and operating practices, as well as control technologies, that will reduce particulate emissions.

Appendices to the report include data on emission analyses – especially particulate emissions – referenced in the main body of the report. The data include reports on emissions testing of wood-fired boilers using different wood fuels, composition of ash, and summary information from state air quality bureaus as well as air emissions standards of the northeastern states.

Particulate Emissions From Residential Wood Combustion

In response to increasing community and regulatory concerns about air quality impacts from residential wood combustion, NRBP initiated in 1985 a study to analyze the impact of residential wood combustion on ambient air quality and public health in the northeastern states. Strategies to control the impact of residential wood combustion had recently been implemented in Oregon and other western states. NRBP sought to discover the appropriateness

and feasibility for similar strategies in the northeastern states. A secondary objective of the project was to provide a resource document for the states when pursuing the analysis of localized problems resulting from residential wood combustion.

Subsequent to NRBP's completion of this study, the U.S. Environmental Protection Agency promulgated standards for emissions from wood stoves and began a program of stove certification. A subsequent NRBP study on the performance of low-emission wood stoves certified by EPA under actual operating conditions has made a major contribution to the specific dimensions of that standard.

The study assessed emission rates for total suspended particulates (TSP) and benzo(a)pyrene (BaP) from wood burning stoves, estimated the impact on ambient air quality, and identified the policy options available to the states. The report also includes a comprehensive review of emissions characterization, impact analysis methodologies, relevant health effects, indoor air quality, and toxic air pollutant studies related to residential wood combustion.

The study used the contractor's national air quality data system to determine which counties in the eleven northeastern states have exceeded the primary or secondary national ambient air quality standards (NAAQS) for TSP and B(a)P. For the years 1980 - 82, the study found that 30 counties exceeded the secondary TSP standard. Six of these counties exceeded the primary TSP standard. Most of the counties are highly industrialized and the study concludes that the contribution of residential wood combustion to TSP levels is very low compared to other point sources. The study estimated emission rate values for TSP and B(a)P for each of the 30 counties by first estimating annual wood fuel usage and then using a simple model of meteorological dispersion to estimate pollutant concentrations due to residential wood combustion sources for TSP and B(a)P.

The study reviewed public health studies of exposure to TSP and B(a)P emissions. The study also considered indoor air quality, noting that an Oak Ridge Laboratory study of indoor air quality found that correct operation of residential wood sources has a significant effect in lowering TSP emissions.

The report includes a detailed description and evaluation of control strategies. These include education; firewood seasoning; home weatherization to reduce the amount of space heating required; pollution control devices (catalytic afterburners, air supply controls, and stack gas temperature gauges); and wood stove certification and restricted use. The report gives examples of the application of these controls in other parts of the country, the costs of the strategies and describes in detail the certification programs in Oregon and Colorado.

The report concludes that as of 1985 no study demonstrates with any degree of confidence that controlling residential wood combustion on a region-wide basis in the Northeast would significantly reduce ambient TSP levels. The study notes that where ambient TSP levels exceed NAAQS, residential wood combustion is not a significant source of particulate emissions.

Regional Impacts

Economic Impacts Of Wood Energy In The Northeast

To encourage a vigorous wood energy industry in the Northeast, NRBP recognizes the need to determine the impacts of wood energy use on employment and income. The NRBP project gathered data on the volume of wood energy used and the fuels displaced in each of eleven northeast states, and used this information to determine direct employment and income effects. A U.S. Forest Service input/output model was used to assess the indirect impact of wood energy use on the economy of each state and the region as a whole.

The study estimated direct employment impacts from wood energy activity in three categories: harvesting, transport and end-use operations. Indirect impacts arise from purchases by employees in the wood energy industry. Induced impacts result from the spending of income earned directly or indirectly by employees of wood energy enterprises.

The report identified 78,000 jobs created in the eleven northeastern states by the wood energy industry. This estimate includes jobs displaced in

conventional fuel industries affected by the substitution of wood energy as well as jobs lost outside the region.

The net employment gain from wood energy activities created $1.8 billion of personal income annually. The residential woodfuel industry, serving over 5 million homes in the region, generated an estimated 54,300 jobs and $1.3 billion in income for the region in 1985.

The study reported that two-thirds of the 8.9 million tons of fuelwood consumed in the region's industrial sector is a manufacturing by-product, and so of negligible cost to the end-user. Therefore, this sector generates relatively few new jobs and less personal income. The net impact in employment for the industrial wood energy sector was 23,800 jobs and $541 million in personal income in the region.

A major economic impact is the savings which accrue to residential and industrial users who have displaced more expensive conventional fuels with wood. Wood displaced over 1 billion gallons of oil, 37 million cubic feet of natural gas and propane, 138,000 tons of coal, and 1,858 million kilowatt-hours of electricity in 1985. Selection of wood over other fuels saved households and businesses in the region $1.2 billion in their 1985 fuel bills.

Companies which utilize wood wastes for energy also benefit from avoiding the costs of landfilling those wastes, assumed in the NRBP study to be $22/ton in 1985. Additionally, almost $6 million in state and federal tax revenues were generated by wood energy related economic activity in the region in 1985.

Published reports from the project include a report for each of the eleven Northeast states, a regional summary, and a technical appendix. The project also produced a spread sheet computer model to tabulate employment and income effects. Each state received a copy of the spreadsheet model to use in estimating the impacts of proposed developments on the area economy.

Future Directions

The Challenges

The near term prospects for biomass technologies depend in large part on the nation and the region's motivation and commitment to addressing three pressing problems:

1. **The achievement of an energy mix which relies successively less on imported oil.** The substitution of biomass, energy efficiency and other indigenous, non-polluting energy technologies takes on greater importance in the context of war in the Persian Gulf.

2. **The increasing harm to our atmosphere brought about by global warming, acid rain, smog, and ozone depletion** – problems largely rooted in fossil fuel used by utilities, industry and the automobile.

3. **The near-intractability of our current solid waste disposal crisis.** The closing of landfills, rapidly increasing disposal costs, and difficulty in siting additional landfills and resource recovery plants have placed an exceedingly high, and unrealistic, burden on recycling and source reduction strategies.

The abandonment of the nation's earlier resolve to curtail our dependence on Middle Eastern oil has contributed to the tensions in the Persian Gulf. The Northeast's reliance on foreign oil for 35% of its energy is the result of an upward trend over the last three years. The decline in real oil prices during the 1980s undermined the national determination to displace oil with alternate technologies and energy conservation. In the Northeast, the upsurge in the use of wood for residential heat and industry steam and electricity needs slipped; only utility-fired biomass production increased during the past five years.

The solid waste crisis has spurred the planning and siting of several resource recovery plants during the past half-decade, but the Not-In-My-Backyard (NIMBY) syndrome and an increasing regional sensitivity to the dangers of air and groundwater pollution has slowed this momentum. Some smaller municipalities have tapped landfill gases to generate methane for industrial steam and electricity use, but a great deal of potential remains untapped. As additional public health studies reveal more comforting results regarding air emissions from resource recovery plants, optimism will rise about the prospects for waste-to-energy plants as an integral part of the solid waste disposal business of the 1990's.

The 1990 Clean Air Act enacted by Congress reflects the emerging concern for reducing the emission of greenhouse, acid rain, and ozone-formation gases. Utility offset credits for reducing gases associated with fossil fuel combustion should reinvigorate the biomass technologies, whose life cycle CO_2 emissions are zero or negative. The EPA

has shown great interest in short rotation intensive crops, the use of ethanol and methanol as transportation fuels, and other strategies which utilize biomass feedstocks.

The region's particular vulnerability to an oil shortage, its skyrocketing waste disposal costs, and its environmental sensibilities underscore a strong commitment to accelerating the responsible utilization of biomass feedstocks and technologies. Over the next two to three years NRBP applied research will focus upon many of the following project concepts.

Residential Wood Use

NRBP will share with manufacturers the results of its current work in developing a laboratory "stress test" which simulates the operation of stoves in the field. To the extent that manufacturers apply this or a similar test to their new stove designs, we can expect new products which lower emissions under typical home conditions. Earlier research sponsored by NRBP has revealed structural failures and design flaws which cause a significant deterioration in the performance of EPA-certified "low emissions" stoves.

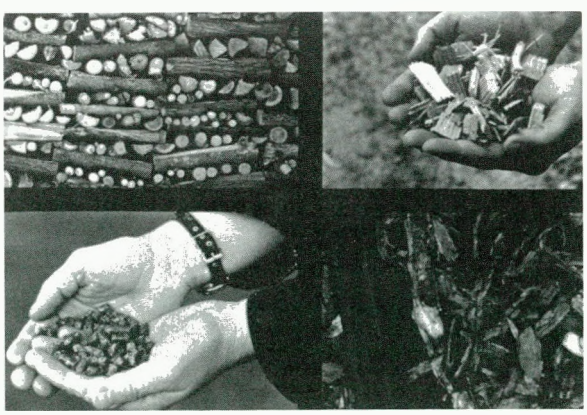
This research and ongoing work also suggests that the EPA certification testing methodology leads to the development of stove designs which do not minimize emissions in field conditions. In forums and publications the NRBP will encourage EPA, manufacturers, and the research community to examine closely the gaps between laboratory results and field performance. Over the long run, the advocacy of a certification procedure which facilitates the manufacture of appliances which minimize emissions in the field will remain a priority.

The prospective new buyer and operator of the newly certified catalytic or advanced technology stove requires education and training to operate it appropriately. While EPA has a consumer brochure available explaining the proper sizing and some features of the new appliances, there is not available a short publication which orients new stove buyers to the nuances of the current stove technologies. Because effective operation of the so-called "high technology" stove is different in several respects from that of the conventional airtight stove with which most consumers are familiar, an informative, attractive guide is needed. Inspecting catalysts and examining the stove for other indicators of deteriorating components, use of bypass doors, burn rates, and chimney/stove draft considerations are among the issues which should be addressed in a new consumer publication. The NRBP will approach EPA and others to assure that such a brochure is written and published.

Wood Pellets

The concept of the pellet stove began to catch on with wood stove manufacturers in the 1980s, and has since come in to widespread residential use in the western United States. The advantages of pellets over cord wood are threefold. First, because pellets are dryer and more uniform in their combustion characteristics and moisture content than cord wood, pellets can be relied upon to burn more efficiently. Second, because of their small size, pellets are more convenient to use and transport. (The smaller size also contributes to their combustion efficiency.) Third, pellets burn cleanly – so much so that they can be vented directly to the outdoors, much like a clothes dryer.

In the Northeast, the potential for this efficient and cleaner-burning wood fuel technology is great – but as yet largely unrealized. As with many new technologies, the development of a residential pellet market is impeded by a lack of information: the public is not yet sufficiently familiar with the



Woodfuel comes in several forms, including cordwood, wood chips, and pellets.

technology to generate a strong demand, and stove and pellet manufacturers need some assurance that demand will be there before they invest in meeting it. The NRBP will seek to pinpoint and to address both specific barriers to and opportunities for developing a strong residential and small commercial wood pellet market in the Northeast.

Commercial/Industrial Wood Usage

The absence of performance data evaluating the operating efficiency and operations and maintenance (O&M) costs for wood-chip combustion and gasification systems inhibits the adoption of these technologies in commercial and institutional buildings. The large variability in combustion efficiency and overall efficiency estimates by the biomass engineering community creates uncertainty and skepticism among potential wood system owners about the cost-effectiveness of wood systems. By conducting performance measurement studies of installations in schools and public buildings, NRBP intends to document efficiencies, cost-effectiveness and start-up problems associated with small and medium combustion and gasification systems.

Industrial/Utility Biomass Usage

Public service commissions in more than 20 states are considering, or have adopted, environmental externality indexes to attach costs to environmental damages associated with fossil fuel, nuclear, and renewable technologies which generate electricity. Renewables and energy efficiency, considered environmentally benign in comparison to most conventional technologies, would benefit in least-cost planning evaluations of new power sources. Yet the environmental impacts of biomass generating stations are not well known to many in the utility and utility regulation fields. The potentially benign contributions of woody biomass to global climate change, for example, are not well understood.

Some early valuations of biomass facilities have rated them poorly on environmental criteria, despite their known advantages over most fossil fuel technologies in SO2, NOx, and hydrocarbon emissions. As a result NRBP will ask specialists in this field to take another look at biomass in the environmental externalities calculation, including the consideration of public health criteria which enhance its advantages over other fuels. The objective is to insure that biomass enjoys a level playing field in its utility applications against other technologies. Although less attractive environmentally, municipal solid waste technologies also deserve another look in this context.

Prospective biomass facility operators and utility planners might improve their evaluation of wood and waste wood energy systems with the assistance of a computer-based decision-making model. A software package which permitted an integrated economic analysis of all phases in the decision-making process and provided tools for management of the project development phase would be most helpful. A proposal under review would improve upon the currently existing cost-effectiveness review packages by adding fuel supply issues, environmental permitting constraints and energy use analysis. Decisions made in one module would be tied to the requirements of another. By inputting air quality regulations, for example, one could set limits on the emissions from the conversion system.

Global Warming Mitigation Strategies

The NRBP's secondary literature review and policy analysis of potential biomass strategies to mitigate the Northeast region's net contribution to carbon dioxide and methane emissions will result in a series of policy recommendations and suggested topics for further research. Pending the completion of this study, the NRBP will seek to disseminate its findings to policy-makers and, broadly, to the general public. Other follow-up may include: further developing and refining the most promising strategies and promoting their implementation at the appropriate levels of jurisdiction (regional, state, local) within the Northeast region; and supporting further research, e.g., expanding the analysis to encompass other greenhouse gases (and other pollutants) and examining potential environmental and economic trade-offs among different biomass energy strategies.

Cross-Cutting Information and Training Issues

The state air quality offices in the region treat permit applications for wood-fired facilities very differently from one another. Applications for wood waste-fired boilers in particular face a bewildering variety of regulations, enforcement and monitoring requirements. In recent years, facility operators and

equipment vendors have claimed that permits are inappropriately classified as hazardous waste plants or incinerators and that the available body of research concerning field emissions from woody and waste wood boilers is not widely shared among air quality offices. A dialogue among industry representatives, NRBP officials and air quality regulators should improve the information flow and facilitate more uniform treatment of these proposed facilities. Discussions between NRBP and the Northeast Coordinated Air Use Management (NESCAUM) organizations are underway to formalize these discussions.

Utilization foresters in every state report that their knowledge of markets for recycled wood wastes is less than optimal. Special training opportunities for these foresters would also help secondary forest products industries understand their options – including energy production – for using these wastes. Waste haulers, transfer stations, landfills and rural industries requiring substantial steam loads are additional audiences who may benefit from the advice of knowledgeable market utilization foresters employed by the United States Forest Service.

A 1990 study of residual stand damage to forests harvested for wood fuel markets revealed less than 10% collateral damage to affected plots. Where damage was noted, poor forestry management planning and/or inadequate equipment operator practices were identified as the chief contributing factors. To improve the practice of equipment operators, the Maine NRBP representative is working with several private organizations to establish a certification program which features appropriate training in equipment operations to minimize residual stand damage. If this certification program takes shape in Maine, NRBP has an opportunity to facilitate its adaptation throughout the region.

Technology Transfer and Capacity-Building

The NRBP also seeks to promote technology transfer for R&D developments undertaken by the U.S. Department of Energy and other agencies and research institutions which address biomass feedstocks and development.

Regional Issues/Regional Responses

The issues surrounding increased biomass energy use in the Northeast tend to be regional in nature. While the NRBP will continue to maintain and build the capacity of state energy, forestry, and environmental quality offices to promote biomass technologies effectively and responsibly, the Program will emphasize regional responses to regional issues.

Not all sections of the region will respond to all issues equally. State programs and technical projects in the southern tier will stress utilization of wood wastes, forestry residues and co-firing wood with coal. In the northern New England states, forestry management and harvesting practices, whole tree chip markets, and opportunities for siting wood-fired power plants will receive emphasis. Throughout the region, addressing the siting, handling, and combustion issues associated with municipal solid waste and recycled wood wastes will be a priority.

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* *Managing Municipal Solid Waste: A Comparative Risk Analysis of Landfill and Resource Recovery Facilities.* Energy Systems Research Group, Inc., November 1988.

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* *Air Emission Regulations for Small to Moderate Sized Wood-Fired Boilers.* Northeast States for Coordinated Air Use Management, January 1985.
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* *Stack Emission Standards for Industrial Wood-Fired Boilers.* Roy F. Weston Company, April 1985.
* *Wood Ash Disposal and Recycling Sourcebook.* By Omni Environmental Services, April 1988.

Regional Impacts

* *Economic Impacts of Wood Energy in the Northeast*: Three Volumes: *Summary Report, State Reports, Technical Appendix.* Resource Policy Center, Thayer School of Engineering, Dartmouth College, April 1986.

* Note: Copies of starred publications can be obtained from:

CONEG Policy Research Center, Inc.
400 N. Capitol Street, Suite 382
Washington, D.C. 20001
(202) 783-6674

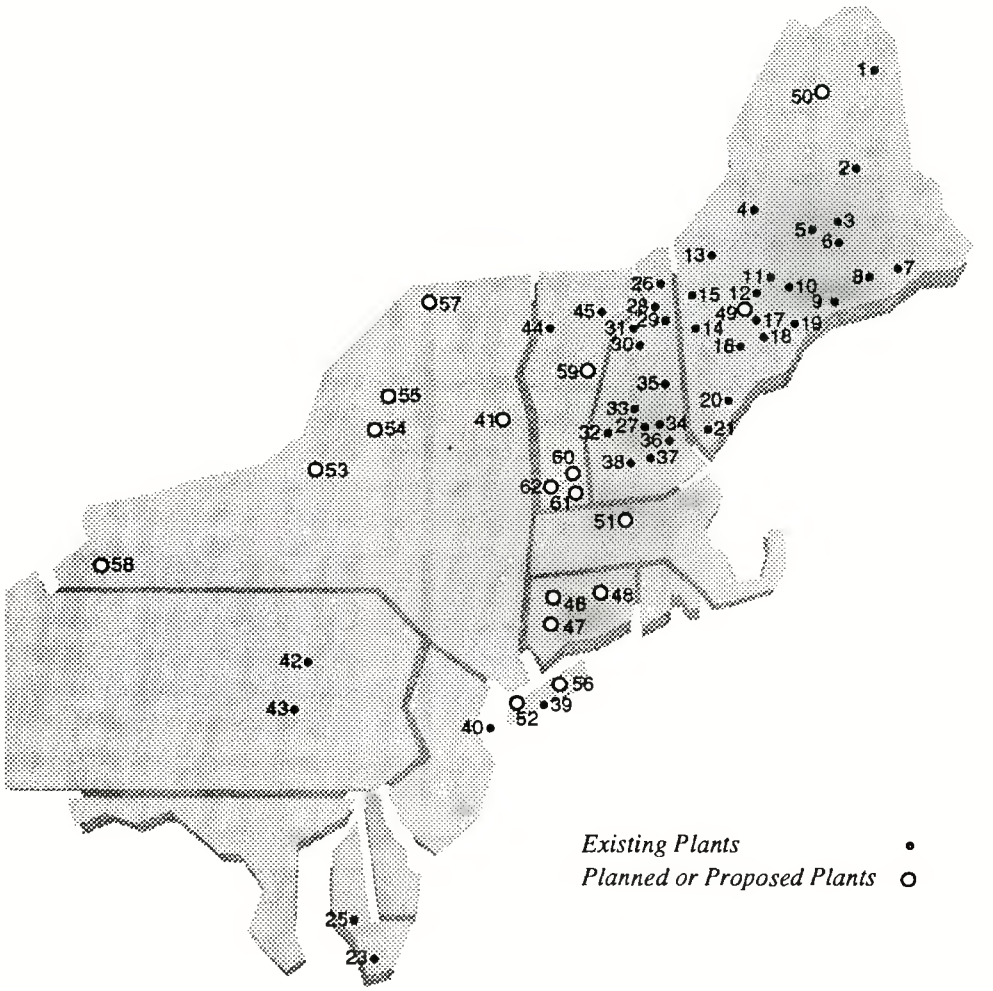
Copies of all other publications can be obtained from the Biomass Energy Contact person for the state publishing the report, or from the author.

Wood-Fired Power Plants in the Northeast

The map (page 61) and accompanying table show all existing, planned, and proposed wood-fired electric plants in the region, grouped by state.

There are currently no plants located or proposed in Delaware, New Jersey, or Rhode Island.

map index	*city/town*	*state*	*owner/operator/plant name*	*capacity (megawatts)*	*status*
46	Torrington	Connecticut	Kenetech Energy Systems (BioGen)	13.00	Planned
47	Naugatuck	Connecticut	Kenetech Energy Systems (Uniroyal)	24.00	Planned
48	Killingly	Connecticut	Killingly Energy Ltd. Partnership	35.00	Planned
1	Ft. Fairfield	Maine	Fairfield Energy Ventures	32.00	Existing
2	Sherman Stn.	Maine	Wheelabrator Sherman Energy	16.50	Existing
3	Chester	Maine	Beaverwood	15.39	Existing
4	Greenville	Maine	Greenville Steam	13.80	Existing
5	Mattawamkeag	Maine	Forster Manufacturing	1.00	Existing
6	West Enfield	Maine	Ultrapower	24.50	Existing
7	Jonesboro	Maine	Ultrapower	24.50	Existing
8	Cherryfield	Maine	Down East Peat	23.00	Existing
9	Bucksport	Maine	Champion	32.70	Existing
10	Athens	Maine	Gorbell, Inc.	13.65	Existing
11	N.New Portland	Maine	Dirigo Dowell	0.30	Existing
12	Strong	Maine	Forster Manufacturing	1.25	Existing
13	Stratton	Maine	Stratton Energy Association	36.80	Existing
14	Bethel	Maine	Chadbourne Cogen.	1.60	Existing
15	Rumford	Maine	Boise Cascade	75.00	Existing



map index	*city/town*	*state*	*owner/operator/plant name*	*capacity (megawatts)*	*status*
16	Lewiston	Maine	Lewiston Steam & Power	11.80	Existing
17	Hinkley	Maine	Scott	45.49	Existing
18	Winslow	Maine	Scott	18.80	Existing
19	Searsmont	Maine	Robbins Lumber Co.	1.20	Existing
20	Westbrook	Maine	Scott	62.50	Existing
21	Sanford	Maine	AR Lavalley Lumber	1.25	Existing
49	Livermore Falls	Maine	Alternative Energy Inc.	30.00	Planned
50	Ashland	Maine	Alternative Energy Inc.	30.00	Planned
23	Westover	Maryland	Eastern Shore Correctional Inst.	2.20	Existing
25	Linkwood	Maryland	Dorchester Lumber Co.	.75	Existing
51	Westminster	Massachusetts	Kenetech Energy Systems, Inc.	16.00	Proposed

map index	*city/town*	*state*	*owner/operator/plant name*	*capacity (megawatts)*	*status*
26	Dixville Notch	New Hampshire	Tillotson	0.60	Existing
27	Alexandria	New Hampshire	Alexandria Power Station	14.70	Existing
28	Groveton	New Hampshire	James River	5.00	Existing
29	Berlin	New Hampshire	James River	17.50	Existing
30	Bethlehem	New Hampshire	Pinetree Power	15.00	Existing
31	Whitefield	New Hampshire	Whitefield Power & Light	15.00	Existing
32	Springfield	New Hampshire	Durgen & Crowell	16.00	Existing
33	Bridgewater	New Hampshire	Bridgewater Steam & Power	17.00	Existing
34	Barnstead	New Hampshire	Timco	4.00	Existing
35	Tamworth	New Hampshire	Pinetree Power	25.00	Existing
36	Rochester	New Hampshire	Spaulding Fiber	12.00	Existing
37	Concord	New Hampshire	New Hampshire Hospital	2.00	Existing
38	W. Hopkinton	New Hampshire	Bio Energy	12.00	Existing
39	Bay Shore	New York	Hubbard Sand & Gravel	3.00	Existing
40	Staten Island	New York	Proctor & Gamble	8.00	Existing [1]
52	Long Island	New York	Weiss Florists	2.00	Planned
53	Geddes	New York	Atlantic Energy Systems, Inc.	5.00	Planned
54	Rome	New York	Atlantic Energy Systems, Inc.	7.50	Planned
55	Lyonsdale	New York	Diamond Energy	19.00	Planned
56	Long Island	New York	Atlas Rolloff	13.00	Proposed
57	Chateaugay	New York	Pacific Generation Company	17.00	Proposed
58	Ellicottville	New York	Ellicottville	4.00	Proposed
41	Whitehall	New York	Meridien Group (developers)	20.00	Proposed
42	Montgomery	Pennsylvania	Koppers Industries, Inc.	7.50	Existing [2]
43	Northumberland	Pennsylvania	Viking Energy	18.00	Existing
44	Burlington	Vermont	Burlington Electric Department	50.00	Existing
45	Gillman	Vermont	Simpson Paper	3.00	Existing
59	East Ryegate	Vermont	Bonneville Pacific Corporation	18.00	Planned
44	Burlington	Vermont	Burlington Electric Dept.	40.00	Planned [3]
60	Springfield	Vermont	To Be Announced	25.00	Proposed
61	Rockingham	Vermont	To Be Announced	35.00	Proposed
62	Bennington	Vermont	To Be Announced	20.0	Proposed

[1] Expected to close in 1991.

[2] Pulp and paper mills and a variety of other facilities in Pennsylvania use primarily biomass fuels to cogenerate thermal and electric power, most of which they use on site, and a small fraction of which is sold to the power grid. These cogenerators account for approximately another 50 megawatts.

[3] BED plans to increase the output of its Burlington wood-fired plant to 90 MW in the summer of 1991.

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