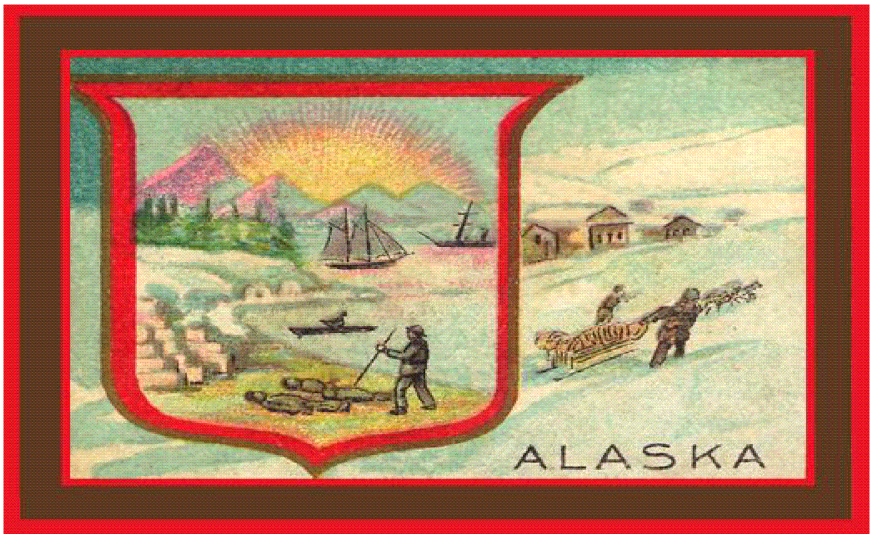
TECHNICAL FEASIBILITY STUDY FOR DEVELOPING A WASTE REDUCTION AND ENERGY RECOVERY FACILITY IN SOUTHEAST ALASKA



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ABSTRACT

Waste management is a serious concern in SE Alaska due to the increased cost of landfilling and the loss of capability to effectively manage wood waste from the timber industry due to shutdown of local pulp and paper mills. Economic development is difficult to achieve because of limited power and focus on failing natural resource related markets such as fisheries, timber and mining. This study identifies options and feasibility for co-management of solid waste and wood waste utilizing new gasification technologies that could enhance local economies.

SE Alaska is composed of 44 communities with a population of 61,956 growing at a rate of 5.8% per year (rate is decreasing annually at ½%). 15 communities contain 95% of the population – 58,714. The trend relative to waste management is to ship out of state to avoid expense, which is increasing at a rate of 5% per year. The following waste generation rates and costs have been determined:

Municipal Solid Waste – 147 TPD
- Off-site shipping is $90-$130/t – 4 communities
- Landfilling is $35-$50/ton – 9 communities
- Incinerating is $50-$70/ton – 2 communities
- Infrastrucutre and compliance costs are $93M/yr

Construction and Demolition Debris – 73 TPD
- Landfilling is $20-$30/t – 15 communities
- Infrastrucuture and compliance costs are $2M/yr

Industrial Waste – 500 TPD
- Off-site shipment exceeds $250/ton – 15 communities
  - 58,714 tires/yr + 100,000 stored
  - 500,000 gal used oil/yr
  - 3,000 cars/yr

Hazardous Waste – 1,500 TPY
- Off-site shipment exceeds $1,150/ton – 15 communities
- No State disposal facility
- $750 k/yr to manage household hazardous waste

Woodwaste – 516 TPD
- Projected harvest of 189 MMBF – 20% waste
- Breakeven costs to manage waste are $30-$60/ton

Use of biomass to produce power utilizing the waste streams noted is expanding in the US at a rate of 3% per year. Biomass-to-energy systems are common in Scandanavia, Europe and Asia where landfilling is banned and conditions are similar to those in Alaska.

A variety of technologies to manage wastes were investigated and evaluated including source reduction, recycling, landfilling, incineration and gasification. Technologies to manage wood waste and solid waste together were evaluated including direct combustion, co-firing, thermal conversion, anaerobic fermentation, composting and thermal gasification. Since gasification appeared to have advantages, gasification technologies were evaluated including fixed bed, fluidized bed, rotary kiln, catalytic chemical oxidation, molten salt oxidation, low pressure gasification, DC electric arc and plasma torch. Plasma torch systems were noted to have significant advantages.

US Plasma providers with capability to manage solid waste were investigated including Startech Environmental, IET, Retech, US Plasma, Meltran and Westinghouse. Westinghouse was selected as the company with the most mature commercialized technology and operating plants similar to those desired in Alaska.

The environmental impact of plasma gasification was investigated including potential emissions to air, water and soil. Gasification technology was determined to be the most environmentally acceptable even over current landfilling practices. Plasma systems can be used to gasify SE Alaska waste. Gasification results in the production of synthetic gas for producing power or ethanol, production of distilled waster and inert glassified slag. Many companion industries can be attached to plasma systems including multiple density fiberboard, fiberglass, tiles and hydroponics.

Power in SE Alaska costs $0.06 to $0.08/Kwhr. Power is restricted because of no connection to the North American grid. The local Tyee intertie has 15MW of capability. A grid connection is possible 65 miles into BC from the Bradfield Canal. The intertie is expected to bring economic benefit to SE Alaska. Sales on the North American grid are from $0.06 to $0.12 Kwhr with a $0.008 wheeling fee out of BC.

Recycling is not deemed profitable in SE Alaska with the exception of aluminum. Shipping costs are the limiting factor in recycling success. In summary, SE Alaska has sufficient biomass to consider co-generation as an alternative. The best technical option to be considered is plasma gasification. The advantages to such a system are:

- Controls increasing solid waste costs
- Reduces compliance costs
- Eliminates landfilling
- Addresses future fish processing waste issues
- Promotes a regional waste authority
- Stimulates regional timber economy by providing a wood waste solution
- Provides a transmission line corridor to the Cassier Highway in BC
- Opens up hydro power sales in SE Alaska
- Creates jobs
- Returns revenue to the community
- Environmentally superior to existing methods of waste management
- Establishes a business development base with possible new industries.

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont.)

BACKGROUND

The initial concept of this study was first presented in draft form to the Department of Energy – National Renewable Energy Laboratory (NREL) and United States Forest Service - Woods Product Laboratory as an unsolicited proposal on November 27, 2001 titled, “Cogeneration of Woodwaste and Municipal Solid Waste for Power and Steam”. A concurrent unsolicited submittal was also made to the Denali Commission and the EPA. The proposal was well received, but rejected for lack of detail. Organizations were positive about pursuing the study as a grant opportunity and recommended that the study be formally developed and submitted for funding.

Extensive effort was undertaken to develop sufficient detail to support a formal grant submittal. On April 17, 2002; a new unsolicited proposal was prepared titled, “Proposal for Cogeneration of Biomass with New Thermal Reactor Technology in Wrangell, Alaska”. This proposal focused on deployment of a commercial technology developed and successfully utilized in Scandinavia.

The Alaska Forest Association agreed to promote the proposal and prepared a letter soliciting $98,790 in funding from the City of Wrangell to complete the study defined in the proposal. DMC Technologies made a formal presentation of the unsolicited proposal to the City Council on May 13, 2002. The presentation was well received, but the request from AFA was denied for lack of a clear and acceptable funding mechanism.

DMC Technologies and Silver Bay Logging agreed to provide an incentive to complete the $98,790 study. DMC Technologies agreed to provide $30,000 in labor at no cost towards completion of the study. Silver Bay Logging agreed to fund $32,790 of the study if the City of Wrangell could obtain a grant for the remaining $36,000. The grant was obtained in the winter of 2002 and the study was initiated. The study has now been completed and is submitted herewith.

GRANT INFORMATION

The following grant information is provided relative to the this study. This information was extracted from Appendix A of the grant application.

The Department's Mini-Grant Assistance Program is funded by federal grants from the US Forest Service (USFS) and the Denali Commission. The amount of USFS and Denali Commission funding for this particular grant is identified on the grant agreement cover sheet under funding sources.

The purpose of this grant is to conduct a technical feasibility study for developing a biomass waste reduction and energy recovery facility. The goals are to eliminate the negative impacts of wood by-products created by timber processing activities, reduce costs and environmental issues associated with municipal solid waste disposal, and recover energy (steam) to power future manufacturing activities. The immediate objectives of the study is to determine whether the volumes of solid waste (municipal and industrial) and wood by-products exist locally and within the region to economically construct a waste reduction facility and if the revenue or benefits from the energy (steam) recovery as well as potential diversified investments can sustain its long term operation. The City of Wrangell and Sliver Bay Logging, Inc. will work cooperatively to identify alternatives, funding, permitting assistance and the public review process in order to achieve the goals and objectives. Grant funds are to be used for the consultant contract.

The scope of work will include the following:

1. ***Solid Waste and Woodwaste Survey**: analyzing the volume and composition of the region's solid waste stream (municipal and industrial) and volume of wood by-product generated by SBL and other wood processing firms;*

2. ***Technology Validation**: identifying and analyzing the various cogeneration technology available to manage solid waste and woodwaste together, identifying plants in operation, their advantages and disadvantages, and industry leaders in constructing and operating such facilities;*

3. ***Environmental Impacts**: identifying potential environmental impacts from discharge to the air, soil and water, identifying the nature of hazardous materials and wastes that might be used/produced at such facilities, defining the state and federal regulatory requirement for such facilities, and determining the best available pollution control technologies;*

4. ***Power Survey**: identifying applicable power generation and transmission requirements that are subject to state review, investigating the current power contracting scenario with the Tyee Transmission, and identifying industries and technology benefiting from inexpensive steam heat;*

5. ***Recyclable Materials**: investigating the recycling markets for Southeast Alaska, evaluating the technical feasibility of recycling identified waste streams.*

6. ***Advantages/Disadvantages Evaluation**: performing an evaluation of the advantages and disadvantages of the various technologies identified and using that determination in selecting the best technology.*

Silver Bay Logging, Inc. (SBL) is a diversified company in wood products and related services. SBL's primary location for the wood products division is located in Wrangell at the Silver Bat Logging Sawmill. The sawmill currently mills approximately 20 million board feet of timber annually from the Tongass National Forest, State, Municipal, and private lands. The company employs 275 – 300 persons company wide, with 65-100 employees located or stationed in Wrangell.

Silver Bay Logging, Inc. has been leading in the investigation of these technologies, the environmental and regulatory issues and the cost/benefit analysis in developing a waste reduction and energy recovery facility. SBL has initially identified cogeneration as a promising technology for their needs, but requires further analysis before making a full decision. The benefits to them as a business are efficiency, cost reduction, full utilization of the resource and future economic development opportunity. The City of Wrangell is interested because of the potential for reducing municipal solid waste disposal costs, and the future economic benefits that can result from additional manufacturing opportunities and jobs.

The expected outcome of the feasibility study is to provide data necessary to determine a method of waste reduction that will benefit not only SBL and the City of Wrangell, but also serve as a regional alternative disposal solution. Upon completion of the study, SBL will complete a financial analysis to determine their level and other investors participation in the construction of the facility.

The City's interest in this effort is to reduce the cost associated with waste steam, provide economic benefits from the reduced costs, new job growth, and regional benefits as an alternative economic solid waste disposal solution.

The City of Wrangell and Silver Bay Logging, Inc. have entered into a cooperative agreement that details specifically the participation and responsibility of each entity. This agreement has been reviewed and approved by the Department.

Upon Completion, the grantee will submit to the Department a disk with an electronic copy and two hard copies of the finalized study upon completion. In addition, the following language will be included in the study, "This study was produced in part with Mini-Grant Assistance funds made available through the Department of Community and Economic Development and the Denali Commission".

STATEMENT OF PROBLEM

Regional Issues

The combined cities and boroughs comprising the Southeast Alaska coalition produce significant quantities of municipal solid waste each year. The cost of municipal solid waste disposal is increasing. Landfill regulations are becoming more stringent and the cost to upgrade or develop a new landfill is prohibitive. Rather than incur these expenses, local landfills are closing or are operating outside the regulations. Choices to manage solid waste are limited. A significant quantity of municipal solid waste is shipped to Washington State for landfill disposal at a cost 2-3 times the national average. Other locations are incinerating wastes and accepting the adverse consequences of air pollution. The increased cost to manage municipal solid waste is a concern to municipalities already suffering from worsening economic conditions.

Industrial wastes produced in Southeast Alaska are also shipped to Washington for processing. Larger waste streams include metal scrap, used oil and tires. Other similar industrial waste streams managed, either locally or out-of-state, include oil contaminated debris, batteries, old cars, fish processing waste and sewage sludge. New regulations continually complicate the cost effective management of these wastes. Disposal costs for industrial wastes are significant and exceed the cost of municipal solid waste management. Management of industrial wastes is a significant issue since no disposal options exist inside Alaska.

Sawmill operations within the defined region produce large quantities of wood waste annually including yard scrapings, hog fuel and chips from low grade lumber. Wood waste is currently stockpiled on-site with no real disposal option since pulp mills formerly consuming wood waste are now closed. Wood waste piles create environmental concerns due to leachate containing low pH and wood derived organic chemicals. The cost of managing wood waste is significant. With the downturn in timber, companies are concerned about making a profit. Diverting dollars to manage wood waste is not acceptable.

The total cost of managing and disposing of Southeast Alaska municipal solid waste, industrial waste and wood waste is significant. An option must be explored to reduce these costs and stabilize waste management practices.

Local Issues

Wrangell is a small community in Southeast Alaska suffering from depressed economic conditions. Wrangell has municipal solid waste manage concerns. Historically, municipal solid waste was buried in a local landfill. This landfill has been filling rapidly and the cost of developing a new landfill under new landfill regulations is considered prohibitive. The landfill will soon be capped. Wrangell now disposes of only construction and demolition debris in the landfill to slow the rate of fill. Municipal solid waste is now shipped out-of-state for disposal at significant cost.

Recycling is not generally practiced in Wrangell and scrap metal, tires, batteries and used oil are shipped out-of-state for disposal. The volume and cost of this disposal is unknown but considered significant. The current landfill will soon be filled to capacity Another location will be needed to manage construction and demolition debris.

Silver Bay Logging owns and operates the Zimovia Sawmill, one of the largest in Southeast Alaska, located 7.5 miles from Wrangell. In spite of downturns in the timber industry and closure of pulp mills in Sitka and Ketchikan, the sawmill continues operating. The sawmill may have a long term sustained life and may even expand in consideration of recent judicial opinions support continued timber sales in the region. At full operation, the sawmill produces large quantities of wood waste. There is no current market for wood waste in the region. Very little wood waste is used as hog fuel for boilers and pulp mills are closed. Wood waste fills have been historically created in Wrangell. The Army Corp of Engineers and the Department of Environmental Quality, due to leachate generation concerns, now strictly control fills. Wood waste fills are a diminishing and expensive disposal option. Woodwaste is stored on the ground pending an acceptable management option.

The sawmill currently purchases power from the City of Wrangell at a nominal cost. The cost of power is under negotiation with fear that it could potentially increase. This action would damage economic conditions at the mill by decreasing output to offset profit loss and by inhibiting expansion. Continued operation of the mill would be questionable. Further, the increased power cost would deteriorate already depressed economic conditions in the City with potential job and revenue losses.

Potential Solution

Commercial thermal reactor technologies are currently available to cogenerate municipal solid waste and wood waste (biomass), even when wet to produce energy. Southeast Alaska (particularly Wrangell) appears to be an excellent candidate for such a technology/facility.

A regional solid waste authority could be developed by the State to promote the establishment of a regional solution, reduce costs and improve compliance with environmental regulations (i.e. improper disposal). Such an authority working in conjunction with an effective technology would resolve most of the identified regional and local problems.

GOALS AND OBJECTIVES

Main Goal

The main goal of the study is to determine the technical feasibility for developing a biomass waste reduction and energy recovery facility. To be technically successful in Alaska, such a technology/facility must:

1) Eliminate the negative impacts of wood by-products created by timber processing activities

2) Reduce costs and environmental issues associated with municipal solid waste disposal

3) Recover energy to power future manufacturing activities

Objectives

The immediate objectives of the technical feasibility study are:

1) Determine whether the volumes of solid waste (municipal and industrial) and wood by-products exist locally and within the region to economically construct a waste reduction facility.

2) Identify the commercially available technologies that can achieve the stated goals in an environmentally prudent manner.

3) Determine if the revenue or benefits from the energy recovery as well as potential diversified investments can sustain long term operation of a facility.

4) Determine if a regional waste authority would improve waste management issues.

The expected outcome of the technical feasibility study is to provide data necessary to determine a method of waste reduction that will benefit not only SBL and the City of Wrangell, but also serve as a regional alternative disposal solution. Upon completion of the study, SBL will complete a financial analysis to determine their level and other investor's participation in the construction of the facility.

SOLID WASTE SURVEY BACKGROUND INFORMATION

Municipal Solid Waste (MSW)

MSW—more commonly known as trash or garbage—consists of everyday items such as product packaging, grass clippings, furniture, clothing, bottles, food scraps, newspapers, appliances, paint, and batteries. In 1999, U.S. residents, businesses, and institutions produced more than 230 million tons of MSW, which is approximately 4.6 pounds of waste per person per day, up from 2.7 pounds per person per day in 1960.

Several MSW management practices, such as source reduction, recycling, and composting, prevent or divert materials from the waste stream. Source reduction involves altering the design, manufacture, or use of products and materials to reduce the amount and toxicity of what gets thrown away. Recycling diverts items, such as paper, glass, plastic, and metals, from the waste stream. These materials are sorted, collected, and processed and then manufactured, sold, and bought as new products. Composting decomposes organic waste, such as food scraps and yard trimmings, with microorganisms (mainly bacteria and fungi), producing a humus-like substance. Other practices address those materials that require disposal. Landfills are engineered areas where waste is placed into the land. Landfills usually have liner systems and other safeguards to prevent groundwater contamination. Combustion is another MSW practice that has helped reduce the amount of landfill space needed. Combustion facilities burn MSW at a high temperature, reducing waste volume and generating electricity.

Total waste generation (in million tons) has increased from 1960 to 2000. In 1960, the per capita generation of waste was 2.7 pounds per person per day, and total waste generation was 88.1 million tons. In 1970, the per capita generation of waste was 3.3 pounds per person per day, and total waste generation was 121.1 million tons. In 1980, the per capita generation of waste was 3.7 pounds per person per day, and total waste generation was 151.6 million tons. In 1990, the per capita generation of waste was 4.5 pounds per person per day, and total waste generation was 205.2 million tons. In 2000, the per capita generation of waste was 4.5 pounds per person per day, and total waste generation was 231.9 million tons.

Construction and Demolition Debris (CDD) Waste

C&D debris waste is produced when new structures are built and when existing structures are renovated or demolished. Structures include all residential and nonresidential buildings as well as public works projects, such as streets and highways, bridges, piers, and dams. Many state definitions of C&D debris also include trees, stumps, earth, and rock from the clearing of construction sites. The following C&D facts are noted:

- An estimated 136 million tons of building-related C&D debris were generated in 1996 (Table ES-1)

- The estimated per capita generation rate in 1996 was 2.8 pounds per person per day.

- Forty-three percent of the waste (58 million tons per year) is generated from residential sources and 57 percent (78 million tons per year) is from nonresidential sources.

- Building demolitions account for 48 percent of the waste stream, or 65 million tons per year; renovations account for 44 percent, or 60 million tons per year; and 8 percent, or 11 million tons per year, is generated at construction sites.

The composition of C&D debris is highly variable and depends critically on the type of activity where sampling is done. Whereas wood is typically the largest component of waste material generated at construction and renovation sites, concrete is commonly the largest component of building demolition debris. Road, bridge, and land clearing wastes represent a major portion of total C&D debris, and the same processors and landfills that manage building-related wastes manage some of the materials produced. A methodology was not developed in the scope of this project to estimate these wastes. Point source waste assessment data were not available for these projects.

The most common management practice for C&D debris is landfilling, including C&D landfills, MSW landfills, and unpermitted sites. An estimated 35 to 45 percent was discarded in C&D landfills in 1996. An estimated 30 to 40 percent of C&D debris is managed on-site, at MSW landfills, or at unpermitted landfills. A 1994 survey done for the EPA identified about 1,900 active C&D landfills in the United States.

An estimated 20 - 30 percent of building-related C&D debris was recovered for processing and recycling in 1996. The materials most frequently recovered and recycled are concrete, asphalt, metals, and wood. There is an trend toward increasing recovery of C&D debris in the United States. ***C&D Recycling*** estimates there are about 3,500 operating facilities that process C&D debris materials in the United States. Recent deconstruction demonstration projects show that high diversion rates may be achieved. Deconstruction minimizes contamination of demolition debris; however, it is labor intensive, and generally requires more time than traditional demolition.

Metals have the highest recycling rates among the materials recovered from C&D sites. The Steel Recycling Institute estimates that the recycling rate for C&D steel is about 85 percent (18.2 million tons out of 21.4 million tons generated). These numbers include not only scrap steel from buildings but also from roads and bridges. We estimate there are about 500 wood processing facilities in the United States that derive wood from C&D debris. The leading states for these wood-processing plants are North Carolina, Oregon, and California.

Industrial Waste

American industrial facilities generate and dispose of approximately 7.6 billion tons of industrial solid waste each year. EPA, in partnership with state and tribal representatives, and a focus group of industry and public interest stakeholders have initiated development of recommendations and tools to assist facility managers, state and tribal regulators, and the interested public in better addressing the management of land-disposed, nonhazardous industrial wastes. However, many of these wastes remain unregulated. The following categories of industrial wastes are discussed:

Waste Tires

Waste tires present a major environmental problem across the globe today. Estimates of the number of waste tires in stockpiles in the United States vary. The EPA report "Markets for Scrap Tires" estimated that two to three billion waste tires were in stockpiles in 1991. More recently the International Tire and Rubber Association estimated the number of waste tires in stockpiles in the U.S. for 1996 to be approximately 700 to 850 million. More than 270 million more used tires are generated each year.

Cleaning up these piles and reassessing the continual generation of waste tires is essential to prevent health risks and degradation of the environment. Waste tires, particularly in piles, pose serious health risks to humans and the environment. When improperly stockpiled or illegally dumped in large quantities, toxic materials from tires leach into the ground, and the piles create an ideal breeding ground for disease-carrying rodents and mosquitoes. They also pose a threat for massive fires. The unique challenges inherent to tire fires have become all too clear over the past few years. When ignited, large tire piles are difficult to extinguish and may burn for months, releasing enormous amounts of heat, toxins, and oil into the air and surrounding environment, costing millions of dollars to mitigate.

It is a commonly held belief among those in the tire industry that the number of waste tires discarded each year corresponds with the nation's population. The number of waste tires discarded each year is based on a 1:1 ratio with the nation's population. The Rubber Manufacturers Association (RMA) tracks the number of new tires shipped each year in the United States. Data compiled by the RMA confirms this commonly held belief.

When viewed as a re-usable material, waste tires offer a wealth of important resources. On the average, it takes 22 gallons of crude oil, steel, natural rubber, a large amount of energy, and other resources to produce one single tire. These valuable resources can, and should, be recaptured and reused in utile products and processes, rather than left in wasteful and dangerous stockpiles.

Used Oil

Used oil is exactly what its name implies, any petroleum-based or synthetic that has been used. During normal use, impurities such as dirt, metal scrapings , water or chemicals, can get mixed in with the oil, so that in time, the oil no longer performs well. Eventually, this used oil must be replaced with virgin or re-refined oil to do the job correctly.

In the United States alone it is estimated that 200 million gallons a year of used oil is improperly disposed by being poured onto he ground, dumped in the trash (ends up in landfills) or poured down the storm sewer. Used oil from one oil change can contaminate 1 million gallons of groundwater if dumped down a storm drain.

Automobiles

The automobile is one of the most recycled products in the world today, but the sheer number of end-of-life vehicles makes the remaining waste stream, which is primarily disposed of in landfills, a high priority for recycling efforts. The automotive industry and its suppliers in the U.S. have responded to market pressures at home and regulatory pressures abroad by beginning to create Extended Product Responsibility programs to reduce the portion of the car sent to landfill.

Approximately 12.2 million passenger and commercial vehicles were produced in the U.S. in 1994, and about 10 - 11 million vehicles are taken out of service each year. The predominant method of dealing with end-of-life vehicles in the U.S. involves dismantling, shredding, and recycling of steel and aluminum. Dismantlers remove high-value parts for reuse and reconditioning. Shredders shred the auto hulks to recover ferrous and non-ferrous metals, which are sent to recycling mills. It has been estimated that 94 percent of the cars and trucks at the end of their useful lives is currently returned to dismantling and shredding facilities for recycling where approximately 75 percent of the vehicle, by weight, is recycled. With the number of automobiles, however, the 25 percent of the vehicle that is not recycled represents a major solid waste stream. This waste stream, which is composed primarily of plastics and fibers, is called auto shredder residue (ASR) or “fluff.” About 2.5 to 3.0 million tons of this waste is disposed of in solid waste landfills each year in the U.S.

While there are no general restrictions on the land disposal of ASR in the U.S., and ASR is generally classified as non-hazardous waste, increasingly stringent regulations for municipal solid waste landfills have increased ASR disposal costs while reducing landfill capacity. Furthermore, ASR has, on occasion, failed the toxicity characteristic test for hazardous waste due to heavy metal contamination, and at least one state, California, has classified ASR as hazardous waste. Hazardous waste designation dramatically increases ASR disposal costs by requiring management in licensed hazardous waste facilities. At the same time that ASR disposal has become more expensive and disposal capacity has declined, automotive manufacturers have turned more to plastics to reduce vehicle weight for fuel efficiency gains. This, in turn, has increased the percentage of ASR from shredders. Plastics content in an average vehicle in the U.S. increased nearly 50 percent between 1976 and 1992.

Household Hazardous Waste (HHW)

Leftover household products that contain corrosive, toxic, ignitable, or reactive ingredients are considered to be "household hazardous waste" or "HHW." Products, such as paints, cleaners, oils, batteries, and pesticides, which contain potentially hazardous ingredients, require special care when you dispose of them. One way to help determine if your household waste has hazardous components is to read the labels on products. Labels that read danger, warning, caution, toxic, corrosive, flammable, or poison identify products that might contain hazardous materials. Leftover portions of these products are called household hazardous waste (HHW). These products, if mishandled, can be dangerous to your health and the environment.

- Americans generate 1.6 million tons of HHW per year.
- The average home can accumulate as much as 100 pounds of HHW in the basement and garage and in storage closets.
- During the 1980s, many communities started special collection days or permanent collection sites for handling HHW. In 1997, there were more than 3,000 HHW permanent programs and collection events throughout the United States.

Although we cannot completely stop using hazardous products, we can make sure that leftovers are managed properly. The best way to handle HHW is to reduce the amount initially generated by giving leftover products to someone else to use. To deal with household hazardous waste, many communities have set up collection programs to prevent HHW from being disposed of in MSW landfills and combustors. These programs ensure the safe disposal of HHW in facilities designed to treat or dispose of hazardous waste. More than 3,000 HHW collection programs exist in the United States.

Improper disposal of household hazardous wastes can include pouring them down the drain, on the ground, into storm sewers, or in some cases putting them out with the trash. The dangers of such disposal methods might not be immediately obvious, but improper disposal of these wastes can pollute the environment and pose a threat to human health. Many communities in the United States offer a variety of options for conveniently and safely managing HHW.

Certain types of HHW have the potential to cause physical injury to sanitation workers, contaminate septic tanks or wastewater treatment systems if poured down drains or toilets, and present hazards to children and pets if left around the house. Some communities do allow disposal of HHW in trash, particularly those areas that do not yet have collection programs. Call your local environmental, health, or solid waste agency for instructions on proper disposal. Follow their instructions and also read product labels for disposal directions to reduce the risk of products exploding, igniting, leaking, mixing with other chemicals, or posing other hazards on the way to a disposal facility. Even empty containers of HHW can pose hazards because of the residual chemicals that might remain.

Hazardous Waste

Industrial and manufacturing processes create solid and hazardous waste. The EPA Office of Solid Waste (OSW) regulates all this waste under the Resource Conservation and Recovery Act (RCRA). RCRA's goals are to:

1. Protect us from the hazards of waste disposal
2. Conserve energy and natural resources by recycling and recovery
3. Reduce or eliminate waste, and
4. Clean up waste, which may have spilled, leaked, or been improperly disposed of.

Hazardous waste comes in many shapes and forms. Hazardous wastes are either identified because of “inherent hazardous characteristics” (toxic, flammable, corrosive, or reactive) or because the wastes are known hazards and are “listed” (EPA F, K, P, or U lists).

Many industries deploy processes that create hazardous waste. RCRA tightly regulates all hazardous waste from "cradle to grave." The EPA has identified three categories of hazardous waste generators:

Conditionally Exempt Hazardous Waste

Conditionally Exempt Small Quantity Waste Generators (CESQGs). CESQGs are those that generate no more than 100 kilograms of hazardous waste or no more than one kilogram of acutely hazardous waste in a month and who accumulate no more than 1,000 kilograms of hazardous waste or no more than one kilogram of acutely hazardous waste at one time.

The EPA has issued regulations that require any existing nonmunicipal, nonhazardous waste disposal unit that receives CESQG waste to comply with new technical standards for landfills. Units that receive CESQG hazardous waste will be subject to location restrictions, ground-water monitoring requirements, and corrective action standards. CESQG hazardous waste disposal in MSWLFs can occur so long as such landfills meet CFR 40 Part 258 Criteria. Reuse or recycling facilities continue to be an acceptable option for managing CESQG hazardous waste.

Small Quantity Generators

Small Quantity Waste Generators (SQGs) are those that generate more than 100 kilograms of hazardous waste and more than 1 kilogram of acutely hazardous waste in a month but less than 1,000 kg of hazardous waste and less than 10 kg of acutely hazardous waste in a month.

SQGs cannot accumulate no more than 5,000 kilograms of hazardous waste or more than 10 kilogram of acutely hazardous waste at one time.

Large Quantity Generators

Large Quantity Waste Generators (LQGs) are those that generate more than 1,000 kilograms of hazardous waste and more than 10 kilograms of acutely hazardous waste in a month.

Universal Waste

Federal Universal Wastes are:

- **Batteries** such as nickel-cadmium (Ni-Cd) and small sealed lead-acid batteries, which are found in many common items in the business and home setting, including electronic equipment, mobile telephones, portable computers, and emergency backup lighting.
- **Agricultural Pesticides** that are recalled under certain conditions and unused pesticides that are collected and managed as part of a waste pesticide collection program. Pesticides may be unwanted for a number of reasons, such as being banned, obsolete, damaged or no longer needed due to changes in cropping patterns or other factors.
- **Thermostats** which can contain as much as 3 grams of liquid mercury and are located in almost any building, including commercial, industrial, agricultural, community, and household buildings.
- **Lamps**, which are the bulb or tube portion of electric lighting devices that have a hazardous component. Examples of common universal waste electric lamps include, but are not limited to, fluorescent lights, high intensity discharge, neon, mercury vapor, high pressure sodium, and metal halide lamps. Many used lamps are considered hazardous wastes under RCRA because of the presence of mercury or occasionally lead.

- **Mercury-Containing Equipment** used in several types of instruments that are common to electric utilities, municipalities, and households. Some of these devices include switches, barometers, meters, temperature gauges, pressure gauges, and sprinkler system contacts.

Streamlined hazardous waste management standards for the federal universal wastes have been developed governing the collection and management of these widely generated wastes. This facilitates the environmentally-sound collection and increases the proper recycling or treatment of the universal wastes mentioned above. These regulations also ease the regulatory burden on retail stores and others that wish to collect or generate these wastes. In addition, they also facilitate programs developed to reduce the quantity of these wastes going to municipal solid waste landfills or combustors. It also assures that the wastes subject to this system will go to appropriate treatment or recycling facilities pursuant to the full hazardous waste regulatory controls.

Small and large businesses that generate hazardous wastes that are in the universal waste categories listed above, can use the more streamlined requirements under the universal waste rule. The Universal Waste Rule eases the regulatory burden on businesses that generate these wastes.

Specifically, it has streamlined requirements for notification, labeling, marking, prohibitions, accumulation time limits, employee training, response to releases, offsite shipments, tracking, exports, and transportation. For example, the rule extends the amount of time that businesses can accumulate these materials on site. It also allows companies to transport them with a common carrier, instead of a hazardous waste transporter, and no longer requires companies to obtain a manifest.

Many industries strongly support these regulations because they have identified easy collection of universal wastes as a priority to ensure sound environmental management. These regulations make it easier for companies to establish collection programs and participate in manufacturer take-back programs required by a number of states. Many large manufacturers and trade associations plan national and regional collection programs for their products.

Businesses that produce less than 100 kilograms (220 lbs) of universal wastes per month have the option of handling their universal wastes under the universal waste regulations or as a Conditionally Exempt Small Quantity Generator (CESQG)

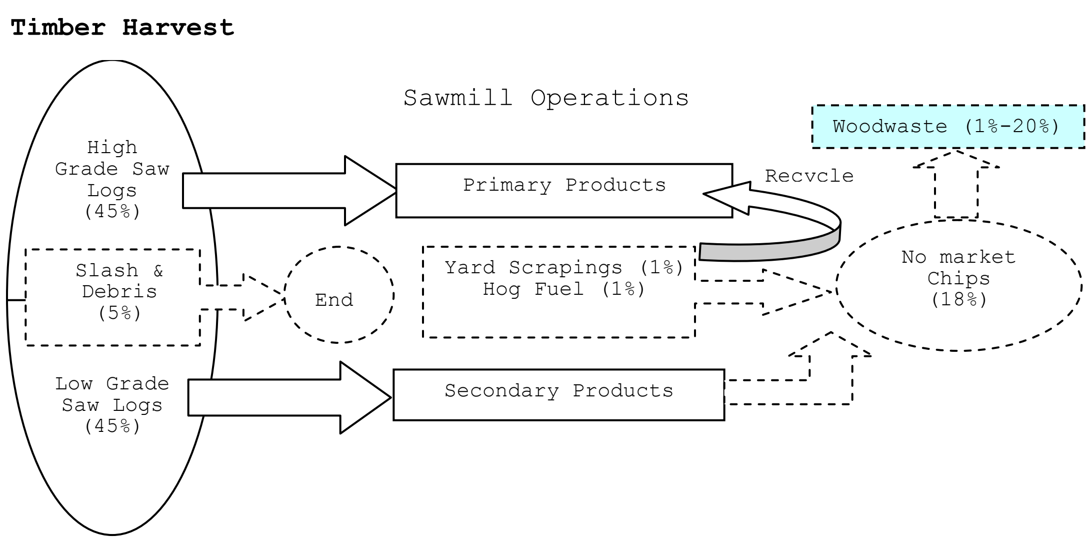
Woodwaste

Forest Management and Woodwaste Origin

Today, forest growth in the United States exceeds harvest by 37%. More than 730 million acres of forest cover the U.S. - that equals two-thirds of the forested area present when Columbus landed in America. There is now 28% more standing timber volume in the U.S. than in 1952. Wood is ***renewable, biodegradable*** and ***recyclable.*** There is no other resource that can replace wood in an environmentally sound or economically feasible way. Every year, each American consumes 630 pounds of paper and lumber, equal to a 100 foot tall tree. Hundreds of everyday items have their roots in forests.

Some people think trees shouldn't be cut at all, that they will last forever. But forests are living systems - trees grow up, grow old and die, whether they are harvested or not. Benefits accrue to the local communities from active management by professional foresters. Forestry is a scientific discipline, which prepares professional foresters to manage forests. Management includes leaving wildlife habitat areas along streams and shorelines. Logging is planned with care to protect sensitive areas. Helicopters are used in more sensitive areas to minimize road construction, slash and snags are left for wildlife habitat, and so on. Different species of trees need different methods of harvest for optimum regrowth and economic return. In northern climates, species like western hemlock and Sitka spruce desire openings for optimum regeneration and regrowth. Clearcut logging takes advantage of this tendency and allows young trees the opportunity to thrive. Also, relatively thin bark on these species makes them more susceptible to harm from selective harvesting. Cedars are more shade tolerant and could benefit from multiple age management in a mixed forest.

The logging process results in the production of woodwaste. The volume of timber harvested is directly correlated to the amount of woodwaste produced as illustrated in the following simple model:



Timber Harvest and Woodwaste Production

Nationally, timber harvest increased by about 40% from 1952 to 1996. There was slow, steady growth through 1976, followed by a sharp increase from 1976 to 1986, and a subsequent decline. After 1986, harvest continued to rise in the East, but this increase was more than offset by decreases in harvest in the West.

Pulpwood production tripled from 1952 to 1996, increasing to 25% of total harvest (pulpwood is used for paper and similar products). One-third of the total harvest is used to produce saw logs; this fraction is down slightly from 1952, despite a 20% increase in harvest for this purpose. Harvest for all uses other than pulpwood and saw logs declined in 1996 compared to 1986. Based on 2000 data, about 42 billion cubic feet of timber was harvested and 3 billion cubic feet of logging residue (woodwaste) is produced (7%). This falls within the woodwaste range of 1% - 20% expressed in the model.

Woodwaste Management

In the past, woodwaste was burned in beehive burners. (A beehive burner is a large conical steel shell with an opening in the top in which woodwaste is burned.) This had severe environmental impacts, such as the emission of fine particulates and air pollution. The first attempt to phase out beehive burners in the 1970s met with little success because there were few viable alternatives to the burners other than landfilling. The complete banning of beehive burners led to landfilling management practices and tons of woodwaste was then co-landfilled with municipal solid waste or placed in engineered monofills. Landfilling was not performed without environmental concerns associated with leachate production and pollution of surface and groundwater resources. Strict controls are now applied to any woodwaste fill.

The focus on woodwaste management has shifted to recycling for energy production. In fact, pulp and paper mills already produce over 600 MW of the power they need by burning woodwaste. Wood residue can be converted into energy in several different ways. It can be burned directly to produce steam and electricity. In cogeneration facilities, the steam is then used to create usable heat. New technologies have now been developed, which will be explored later in the report that involves gasification of biomass fuels. In this process, wood residue is converted to gas. The gas is then used to heat air, which passes through a turbine to create electricity. Pyrolysis is another new technology that can be used to create electricity from biomass. It is a closed-system heating process that produces bio-oil, which can then be used to fuel generators to produce electricity.

One major advantage of gasification systems is that electricity generation is very efficient – up to 30% to 50 % more efficient that conventional steam generation. These efficiencies are realized by using a gas engine or gas turbine in a combined cycle with a steam turbine. Another advantage is that the gases produced contain less particulate matter and can be used directly in existing boiler facilities to reduce fossil fuel usage and reduce overall emissions. This also reduces the costs associated with emission control technologies.

The main disadvantage of advanced gasification systems is that the initial capital costs can be significantly higher than for conventional systems. However, in US there are numerous potential sites that would be suitable for small (1MW to 5MW) or large gasification systems (>5MW).

SOUTHEAST ALASKA WASTE SURVEY INFORMATION

Municipal Solid Waste

The 61,956 residents of SE Alaska produce approximately 147 TPD of municipal solid waste (MSW). Historically, MSW has been inexpensively disposed in landfills. New landfill regulations have recently been promulgated that require liners, leachate collection systems, and engineered covers. Landfill construction activities to meet these new requirements are expensive. To reduce costs, communities are exploring MSW management alternatives. The current trend is recycling, incineration or off-site shipment via barge to landfills in Washington State. In spite of these efforts, the cost of MSW management continues to increase. This is a concern to municipalities already suffering from worsening economic conditions.

The following 2000 Census information was used to drive the waste survey. Data was collected from 44 communities. 15 communities comprise 95% of the population – 58,714. The population is still increasing at a rate exceeding 5%. However the rate is decreasing by ½% per year.

Census Area	Town	Population #		
		Tot. 1995	Tot. 2000	Prd. 2005
Prince of Wales - Outer Ketchikan	Hyder	89	97	105
	Metlakatla	1,281	1,375	1,469
	Hollis	137	139	141
	Kasaan	44	39	34
	Thorne Bay	543	557	571
	Hydaburg	368	382	396
	Craig	1,313	1,397	1,481
	Klawock	788	854	920
	Meyers Chuck	13	21	29
	Naukati Bay	123	135	147
	Coffman Cove	189	199	209
	Edna Bay	47	49	51
	Whale Pass	46	58	70
	Port Protection	71	63	55
	Point Baker	41	35	29
	Tot.	***5,093***	***5,400***	***5,707***
	Avg.	*340*	*360*	*380*
Ketchikan Gateway Borough	Ketchikan	7,371	7,922	8,473
	Saxman	457	431	405
	Tot.	***7,828***	***8,353***	***8,878***
	Avg.	*3,914*	*4,177*	*4,439*
Petersburg	Thoms Place	29	22	15

Census Area	Town	Population #		
		Tot. 1995	Tot. 2000	Prd. 2005
	Wrangell	2,161	2,308	2,455
	Petersburg	3,038	3,224	3,410
	Kupreanof	32	23	14
	Kake	655	710	765
	Port Alexander	68	81	94
	Tot.	***5,983***	***6,368***	***6,753***
	Avg.	*997*	*1,061*	*1,126*
Sitka Borough	Sitka	8,317	8,835	9,353
	Tot.	***8,317***	***8,835***	***9,353***
	Avg.	*8,317*	*8,835*	*9,353*
Juneau Borough	Juneau	28,711	30,711	32,711
	Tot.	***28,711***	***30,711***	***32,711***
	Avg.	*28,711*	*30,711*	*32,711*
Skagway-Hoonah-Angoon	Hobart Bay	4	3	2
	Angoon	531	572	613
	Cube Cove	74	72	70
	Tenakee Springs	80	104	128
	Hoonah	842	860	878
	Whitestone Logging Camp	105	116	127
	Game Creek	28	35	42
	Pelican	148	163	178
	Elfin Cove	36	32	28
	Gustavus	404	429	454
	Klukwan	120	139	158
	Skagway	829	862	895
	Tot.	***3,201***	***3,387***	***3,573***
	Avg.	*267*	*282*	*298*
Haines Borough	Excursion Inlet	16	10	4
	Mud Bay	117	137	157
	Haines	1,690	1,811	1,932
	Lutak	33	39	45
	Covenant Life	101	102	103
	Mosquito Lake	222	221	220
	Tot.	***2,179***	***2,320***	***2,461***
	Avg.	*363*	*387*	*410*
Yakutat Borough	Yakutat	644	680	716
	Tot.	***644***	***680***	***716***
	Avg.	*644*	*680*	*716*
SE Alaska				
	Tot.	***61,956***	***66,054***	***70,152***

Census Area	Town	Population #		
		Tot. 1995	Tot. 2000	Prd. 2005
	Avg.	*1,408*	*1,501*	*1,594*

Over 500	**58,714**		
	95%		
Growth	Rate	6.2%	5.8%
	Year	95-00	00-05

The focus of the survey is on the larger 15 communities comprising 95% of the population. These locations are estimated to produce 147 TPD of MSW. Actual data collected indicates a generation rate of 123 TPD.

The following municipal solid waste practices are noted for the 15 larger communities:

Community	**Waste Management Practice**	**Calc. Generation (TPD)**
Metlakatla	Landfill	3
Thorne Bay	Landfill	1
Craig	Landfill	3
Klawock	Landfill	2
Ketchikan	Barge and Ship to Landfill	20
Wrangell	Barge and Ship to Landfill	6
Petersburg	Barge and Ship to Landfill	8
Kake	Landfill	2
Sitka	Barge and Ship to Landfill	22
Juneau	Incinerator	77
Angoon	Landfill	1
Hoonah	Landfill	2
Skagway	Incinerator	2
Haines	Landfill	5
Yakutat	Landfill	2

Actual waste generation rates based on community records may be 30% - 40% lower than calculated rates indicating poor records collection practices and or residential disposal (burn barrels or toss outs). Three communities produce 90% of the waste.

The following tabulation of methods is presented:

Landfilling – 9 (2 planning to ship off-site)
Barge and Ship to Landfill – 4
Incinerator – 2

The trend is to ship off-site to a regional landfill. Shipments are managed by Rubanco (Allied Inc.) with 5-year contracts. Several of these are coming due in the next few years. Costs of off-site shipment vary between $90 and $130/ton. Landfilling costs range from $35 - $50 per ton. Incinerations costs costs are $50 to $70 per ton. Statewide costs of infrastructure and compliance for solid waste may exceed $93M annually (landfilling - $70M, Incineration - $23M). Costs are rising at a ate of 5% per year in step with population rate increases.

Census data provided by the State indicates that communities are saving significant funds associated with solid waste management – typically either to close or develop new landfills. Approximately $25M is being held in SE community reserves for solid waste management. ADEC is interested in developing a regional SE solid waste authority to manage costs.

Construction and Demolition Debris Waste

It is estimated that Alaskans produce 73 TPD of C&D wastes. All this waste is managed in landfills. The actual generation rates may be lower due to illicit disposal. C&D landfilling costs are $20-$30 per ton with related management and infrastrucuture costs of $1 - $2M per year.

Industrial Solid Waste

The residents of Alaska produce approximately 500 TPD of Industrial solid wastes (ISW) including 500,000 gal/yr of use oil, 60,000 tires per year and 3,000 autos per year. Due to limited landfill space and rising costs, these wastes are also shipped to Washington for recycling or disposal. Other similar industrial waste streams managed, either locally or out-of-state, include oil contaminated debris, batteries, fish processing waste and sewage sludge. Management of ISW is a significant issue since no disposal options exist inside Alaska. Out-of-state disposal costs are approaching $250/ton. No alternatives are apparent to reduce these costs. Costs associated with remediating spills of these waste materials are also significant.

Hazardous Waste

Alaska posts 72 large quantity genratos and 189 small quantity generators of hazardous waste. These generators produce approximately 1,500 tons per year of waste and spend approximately $1,150 per ton for disposal. All wastes are shipped out of State. Alaska has no RCRA disposal facilities.

Residents in SE Alaska spend approximately $750k/yr managing household hazardous wastes.

Woodwaste

General

Approximately 60% of the timber harvested from the forest is sold as "saw logs" for producing dimensional lumber. The remaining 40% of the timber harvested from the forest does not qualify for dimensional lumber production and is processed into wood chips. Chips are loaded in barges and transported to off-site locations for sale. Historically, chips were sent to local pulp and paper mills in Sitka or Ketchikan as a fiber source. These Alaska mills are now closed and chips are barged to pulp and paper mills in Canada – a marginally profitable operation. Without a good market for chips, logging is not profitable, the timber industry suffers, and chips become industrial wood waste (IWW). During peak production, approximately 850 TPD of chips are shipped from Alaska to Canada. Breakeven management costs for hog fuel alone is $30/ton. Breakeven costs for managing chips is approximately $60/ton.

Other classes of IWW are also produced during logging and related sawmill operations including yard scrapings (wood, soil and rock debris) and hog fuel (bark and wood debris). Sawmill operations in SE Alaska produce approximately 300 TPD of these types of IWW. Historically, this waste was burned in boilers or used to create engineered fills such as road bases, berms and pads. However, in the 1980s, environmental regulations controlling air emissions and allowing IWW fills were tightened due to environmental concerns. The cost associated with compliance with new standards is significant. With no viable disposal options, IWW is simply stockpiled on-site. Stockpiles continue to grow. It is estimated that approximately 1,000,000 tons of IWW are currently stored in the region.

Wood waste stockpiles permeated with precipitation produce low pH leachate containing wood derived organic chemicals. The low pH also results in leaching of metals from surrounding natural environments. Together, the metal ions and wood derived organics pollute nearby surface water and ground water systems. Remediation of such problems is expensive.

Silver Bay Logging

Silver Bay Logging owns and operates the Zimovia Sawmill, one of the largest in Southeast Alaska, located 7.5 miles from Wrangell. In spite of downturns in the timber industry and closure of pulp mills in Sitka and Ketchikan, the sawmill continues operating. Recent judicial opinions support continued timber sales in the region. From this perspective, the sawmill may have a long-term sustained life and may even expand. At full operation, the sawmill produces approximately 60,000 tons per year of wood waste. Approximately 20,000 tons of wood waste is currently stored on the ground. There is no current market for wood waste in the region. Very little wood waste is used as hog fuel for boilers and pulp mills are closed. Wood waste fills have been historically created in Wrangell. The Army Corp of Engineers and the Department of Environmental Quality, due to leachate generation concerns, now strictly control fills. Wood waste fills are a diminishing and expensive disposal option.

The sawmill currently purchases power from the City of Wrangell at a cost of $0.0375 per kilowatt-hour. From 1999 to 2001 the sawmill consumed an average of 4.31 megawatts. The cost of power is under negotiation with fear that it could potentially increase to $0.0675 per kilowatt-hour (doubling the cost). This action would damage economic conditions at the mill by decreasing output to offset profit loss and by inhibiting expansion. Continued operation of the mill would be questionable. Further, the increased power cost would deteriorate already depressed economic conditions in the City with potential job and revenue losses.

Alaska Forests

In Alaska, there are 129 million forested acres across the state comprising two distinct forest types – the coastal rainforest and the boreal interior forest. Four landholders - the federal government, 51%; state, university and local governments, 25%; Native corporations, 24%; and other private landowners, 0.4%, manage the timber regions. Most of the commercial timber harvest is in the coastal zone, primarily on federal and Native corporation land. Today, Alaska's forest products industry provides hundreds of jobs and contributes millions of dollars to Alaska's economy. Furthermore, each direct timber job creates at least three indirect jobs for doctors, retailers, teachers, and more.

The coastal rainforests begin in southern southeast Alaska, and extends through Prince William Sound, and down the Kenai Peninsula to Afognak and Kodiak Islands. The two largest national forests in the United States are in this region. Sitka spruce, hemlock and cedar are the dominant species in these forests. Unassisted regeneration takes place rapidly in Alaska's coastal forests, seedlings growing as much as 4 feet per year for the first 20 years. These forests are the product of extreme climatic factors. Temperatures can vary as much as 160F from summer to winter. Summer days are long and daylight hours in the winter months are few. Slow, short growing periods cause the trees to have tight growth rings, making the wood prized for strength and delicate beauty. The boreal forests extend from the Kenai Peninsula to the Tanana Valley near Fairbanks, and as far north as the foothills of the Brooks Range. They stretch from the Porcupine River near the Canadian border and west down the Kuskokwim River valley. Species with commercial value include white spruce, quaking aspen, and paper birch. Other species include black spruce, balsam poplar, and larch. Within the boreal forest, conditions vary considerably. North of the Alaska Range, precipitation rarely exceeds 20 inches per year, so moisture from snow melt nurtures the forests. Heavier snowfall and more rain in South-central causes different growth and maturity rates in the trees of that region. The forest industry in the Interior has been limited to small mills and cottage industries. There is increased interest in these resources, however, the state legislature recently enacted laws that may encourage industry growth over the next decade.

Tongass National Forest

With 16.8 million acres, The Tongass National Forest is the largest national forest in the United States. Although established in 1907, only 400,000 acres have been harvested to date. That's only 4% of the 9.5 million forested acres on the Tongass in almost 90 years. The 1997 Tongass Land Management Plan schedules 176,000 acres for timber harvest over the next 100 years. The primary species of trees in the Tongass are Sitka spruce, western hemlock, western red cedar, and Alaska (yellow) cedar. These trees are prized for their durability, usefulness and beauty.

Natural regeneration is so abundant in this area, that many new trees quickly replace the harvested forests. Many areas require thinning for healthy regrowth after the first 15 years and after about 50 years, the second growth area will have more timber volume than the original old growth acreage.

- The Tongass National Forest spans 16.8 million acres.
- There are 6.6 million acres within the Tongass National Forest that are congressionally designated Wilderness Areas, National Monuments, and roadless areas. That accounts for 39% of the Tongass. No logging is allowed in these areas.
- For each acre of the Tongass that are scheduled for timber harvest in the future, there are 10 acres of land designated by Congress as Wilderness that will never be logged and another 14 acres that are managed for recreation, wildlife habitat and uses other than logging.
- There are 9,933,000 (9.9 million) forested acres in the Tongass and 6,949,000 (6.9) acres of the Tongass are not forested. That means trees cover 58% of the Tongass and 41% is covered by rock, meadows, water, etc.
- Of the 9.9 million acres of trees on the Tongass there are 4,233,455 (4.2 million) acres that have been deemed by the land manager, the Forest Service, "non productive" timberlands. So 43% of the forested acres on the Tongass are "non-productive" which means they are either lands not capable of growing commercial wood, or land physically unsuitable for reasons such as steep slopes.

- The remaining forested acres comprise the area where timber harvest may be planned. There is 3.6 million acres in the available "commercial forest" of the Tongass. That accounts for 37% of the forested acres of the Tongass, or 22% of the entire Tongass.
- The Tongass Land Management Plan revised in 1997 plans to harvest timber from 676,000 acres of the commercial forest of the Tongass over a 100-year rotation. That means that less than 10% the forested in the Tongass will be cut in the next 100 years - a mere 4% of the entire Tongass is available for timber management, which means there's 96% left for many other uses!
- The Tongass is roughly the size of the entire state of West Virginia.
- The new Tongass Land Management Plan provides for maintaining deer habitat capability sufficient to sustain wolf populations and current levels of human deer use.
- The importance of the beach and estuary buffers to a variety of ecological functions is well established. The current TLMP establishes 1,000 foot no harvest zones along beaches and estuaries to protect important habitat for deer, goshawks, marten, brown bear and bald eagles. The 1,000 foot no harvest zone along the coastline is in addition to the millions of acres of forested lands in Wilderness and Habitat Conservation Areas, where no logging is allowed.
- When President Theodore Roosevelt created the Tongass National Forest in 1907 he did so with the utmost wisdom. Roosevelt was way ahead of his time, recognizing as early as 1903 the importance of multiple uses. "...First and foremost," President Roosevelt explained, "You can never afford to forget for a moment what is the object of our forest policy. That is not to preserve the forests because they are beautiful, though that is good in itself, nor because they are refuges for the wild creatures of the wilderness, though that too is good in itself; but the primary object of our forest policy, as the land policy of the United States, is the making of prosperous homes."

Chugach National Forest

The Chugach National Forest (pronounced Chew'gatch) is 5.9 million acres in south central Alaska, south and east of Anchorage, encompassing the Prince William

Sound area and much of the Kenai Peninsula. Roughly the size of Massachusetts and Rhode Island combined, the Chugach is the second largest national forest in the United States, next to the Tongass in Southeast Alaska.

Shaped by glacial ice, earthquakes and volcanoes, most of the Chugach is managed as fish and wildlife habitat. Only about 6% of the land base is considered productive forestland, so harvests are relatively small compared to other national forests. The primary tree species are Sitka and white spruce. Cottonwood, hemlock, black spruce and Lutz spruce also occur.

Established in 1907, the timber resources are only just beginning to be developed for commercial use. Unfortunately, spruce bark beetle infestations have killed much of the trees on the Chugach in recent years. This pest has affected the entire Chugach, and much of the Kenai region.

SE Alaska Timber Industry History

Established in 1917, the Tongass is the largest National Forest in the United States. Roughly, 85 percent of the land in Southeast Alaska—an area 500 miles long and 100 miles wide—is included within its borders. At the time the National Forest was established, logging activity was primarily directed toward meeting the needs of the resident population and to support expansion of the fishing and mining industries. Local timber supplies were used for fish traps, piling, packing cases, mine timbers, dock piling and timbers, and housing materials. World War I generated an increase in the demand for Sitka spruce from Alaska for airplane manufacture. By 1920, approximately 20 million board feet (MMBF) of timber was harvested from the Tongass each year, including a large volume of free-use wood for the Alaska Railroad and other entities. Even at this time, mills in the Puget Sound area posed a threat to local processors, as large volumes of Douglas fir lumber were being shipped to Alaska at a competitive price.

Eventually, despite relatively high operating costs, the Alaska timber industry was able to increase its stronghold in the State. During the 1930's, local manufacturers supplied 84 percent of Alaska's total wood consumption, a significantly larger percentage than in prior years (estimated at 32 percent). Logging activity in Southeast Alaska intensified in the 1940's, once again in response to the demand for aircraft parts made from Sitka spruce. After World War II, the collapse of the mining and fishing industries prompted a vigorous effort by the Forest Service to increase the scale and manufacturing capabilities of the region's wood products industry. Wood pulping facilities were targeted to meet the dual objectives of utilizing a vast timber supply and providing stable, year-round employment. In 1951, after several years of intensive effort to recruit wood-based industry to Southeast Alaska, an agreement was reached with Louisiana Pacific to build and operate the region's first large-scale pulp mill in Ketchikan. As part of the agreement, the company received a fifty-year contract for some 8.5 billion board feet (BBF) of timber from the Tongass National Forest. At the time it was built, the mill cost nearly $52.5 million and represented the single largest industrial investment made in the Territory of Alaska.

A second fifty-year contract for Tongass timber was awarded to Alaska Lumber and Pulp Company, Inc. (ALP) in 1957. As part of this agreement, ALP constructed and operated a pulp mill in Sitka, Alaska. The mill was completed in November 1959 at an approximate cost of $66 million to a Japanese parent firm, Alaska Pulp Company, Ltd. The Sitka pulp mill was the first major foreign investment made by Japan after World War II. The fifty-year timber contracts represented a commitment by the Forest Service to make a substantial and consistent supply of timber available to the industry. Years later, Congress bolstered this timber supply commitment with Section 705(a) of the Alaska National Interest Lands Conservation Act (ANILCA; P.L. 96-487, Dec. 2, 1980) which read as follows:

> *Sec. 705. (a) The Congress authorizes and directs that the Secretary of the Treasury shall make available to the Secretary of Agriculture the sum of at least $40,000,000 annually or as much as the Secretary of Agriculture finds is necessary to maintain the timber supply from the Tongass National Forest to dependent industry at a rate of four billion five hundred million board feet measure per decade.*

Under ANILCA, Congress attempted to set aside large areas of the Tongass for wilderness while ensuring that employment in the timber industry employment would be maintained. To offset the reduction in timber supply caused by more restrictive land use designations and State and Native land selections, Congress included the Tongass Timber Supply Fund. The purpose of this $40 million annual earmark was to fund pre-roading, cultural treatments, and innovative logging systems to achieve an offer level of 4.5 BBF (billion board feet) per decade. However, the subsequent decline in timber industry employment was testimony to the fact that an ample supply of national forest timber alone could not guarantee prosperity in the region’s timber industry. Market conditions and the demand for wood products were equally important.

In the years following the passage of ANILCA, several significant changes took place in Alaska’s stumpage markets and international wood product markets. Alaska began losing market share in the Pacific Rim during the 1980’s and its foothold in the Japanese market steadily eroded. From 1972 to 1985, Alaska’s share of North American softwood lumber exports to Japan dropped from 42 percent to six percent. The volume of lumber exported declined from a high of 340 MMBF to 87 MMBF. The diminished role of Alaska’s producers in lumber export markets has been attributed to a coincident drop in Japanese housing starts (along with a decline in the share of wood-based houses) and increasing competition from lumber producers in the Pacific Northwest and British Columbia.

While lumber production steadily decreased in Alaska, the Forest Service continued to offer timber sales consistent with the direction set forth in ANILCA Section 705(a). From 1980- 1987, the Forest Service prepared and offered an annual of 467

MMBF of timber each year while the volume sold and harvested averaged 280 MMBF. Witnessing the apparent disparity between supply and demand, an intense debate broke out among interest groups as to whether the 4.5 BBF referenced in ANILCA was intended to be a cut level, an offer level, a ceiling, or a floor. Although the market rebounded in later years, the stage had already been set for Congress to revisit the controversial timber provisions of ANILCA.

In 1990, Congress passed the Tongass Timber Reform Act "to make management of the Tongass consistent with the management of the other 155 forests in the National Forest System." In doing so, the unique timber supply provisions and fixed appropriations included in Section 705(a) of ANILCA were repealed and replaced with the following more general direction in Section 101:

> *Sec. 705. (a) Subject to appropriations, other applicable law, and the requirements of the National Forest Management Act (P.L. 94-588); except as provided in subsection 9d) of this section, the Secretary shall, to the extent consistent with providing for the multiple use and sustained yield of all renewable forest resources, seek to provide a supply of timber from the Tongass National Forest, which (1) meets the annual market demand for timber from such forest and (2) meets the market demand from such forest for each planning cycle.*

The judicial interpretation of Section 101 of the Tongass Timber Reform Act (TTRA) is documented in two court decisions. The Ninth Circuit found in *Alaska Wilderness Recreation and Tourism Ass'n v. Morrison* that "TTRA envisions not an inflexible harvest level, but a balancing of the market, the law, and other uses, including preservation. It thus gives the Forest Service leeway to choose among various site-specific plans, provided it follows the procedural requirements of the applicable statutes." The District Court of Alaska likewise found in *Alaska Forest Association v. United States of America* that "allocating timber for sale is simply one of many factors which the Forest Service is to consider within its discretion in determining whether to make timber in the Tongass available for sale." The court also held that "TTRA's reference to seek to meet market demand was not a mandate. Instead, it was an admonition to be considered together with other goals in establishing a timber plan for the Tongass."

After the Tongass Timber Reform Act was passed, the long-term contracts between the Forest Service and the pulp companies continued to offer some assurance of stability in the supply of timber made available each year. However, a guaranteed timber supply was not enough to ensure the viability of these operations in the face of increasingly competitive markets. In a letter to the Forest Service dated June 30, 1993, the Alaska Pulp Corporation announced its intent to suspend the operation of its Sitka, Alaska pulp mill effective September 30, 1994. The company cited adverse world market pulp conditions, increasing production costs, and a shortfall in the amount of timber available at an affordable price as reasons for the suspension. The pulp mill closure prompted the Regional Forester's decision to terminate APC's long-term timber contract on April 14, 1994. Almost three years later, the Forest Service terminated the remaining long-term timber contract. In the fall of 1996, the Ketchikan Pulp Company (KPC) announced its intent to close its Ketchikan, Alaska pulp mill on March 24, 1997. The announcement prompted discussions between the company and the federal government as to the fate of the company's long-term contract and the resolution of pending claims against the United States government. On February 21, 1997, an agreement was reached between the two parties to cancel KPC's long-term timber contract and to release all legal claims between the company and the federal government. As part of the agreement, KPC would receive 300 MMBF of timber over a three-year period to be used for the continued operation of the company's sawmills. The U.S. also agreed to pay KPC $140 million to resolve all past and future legal claims against the federal government.

Absent the long-term contracts and the timber supply mandate of ANILCA, the Tongass timber program is, for the first time, comparable to that of other National Forests. While the Forest Service still plans to put forth a regular and stable timber program, the agency will do so without the force of statutory or contractual obligation. Among industry members, there is now a higher level of uncertainty with regard to future timber supplies. However, it is also true that without the processing requirements in the long-term contracts, the industry has greater latitude in determining the rate at which timber is purchased and processed. In any case, movement away from maintenance of an industry structure planned in the 1950's to an industry structure linked to the competitive market will be a lengthy and difficult process.

Many of the obstacles the industry faced in the 1950's remain and others have emerged. Given Alaska's small population base, distance from markets, and relatively high operating costs, success in the wood products industry remains a challenge for even the most talented of entrepreneurs. Within the last decade Japan--historically Alaska's largest trading partner--has more than doubled its imports of softwood lumber. Accounting for 14.9 million cubic meters in softwood logs and 10.9 million cubic meters of softwood lumber in 1996, Japan's demand for imported wood far exceeds the supply currently available from Alaska's forests. However, the primary issue for Alaska is not the size or growth of wood product markets, but achieving a competitive position in those markets.

Traditional lumber producers in Southeast Alaska face intense competition from regions with lower costs and/or higher productivity, such as the Pacific Northwest, Canada, New Zealand, Chile, and Europe (primarily Scandinavia). A host of engineered wood products are also capturing a share of the market traditionally filled by solid-wood building products. Alaska's wood product manufacturers will need to move swiftly and aggressively to counter these broader market trends if they are to remain viable over the long run.

The Tongass Land Management Plan (TLMP) Revision was completed May 23, 1997. As stated in the Record of Decision for the Plan:

> *"A primary goal of the Forest Plan is to provide for the sustainability of the resources of the Tongass National Forest, while directing the coordination of multiple uses, such as outdoor recreation, timber, wildlife, fish, watershed and wilderness."*

Thus, the Forest Plan established the framework needed to develop a timber program that was consistent with the multiple use provisions in Section 101 of the Tongass Timber Reform Act. The Forest Plan classifies lands suitable for timber production and determines where timber harvesting should be allowed, in accordance with the regulations of the National Forest Management Act (NFMA), 36 CFR 291.14(a), and Section 102 of the Tongass Timber Reform Act. Tentatively suitable lands have the biological capability, and availability, to produce commercial wood products. The tentatively suitable land base on the Tongass is currently 2.4 million acres.

Land Use Designations (LUDs) in the Forest Plan further define where specific management activities may occur and ensure the biological integrity of the forest ecosystem. To provide for a full spectrum of forest ecosystem conditions and resource uses, some of the LUDs restrict timber harvest activity on lands otherwise suitable for commercial timber production. Finally, even within LUDs where timber harvest is permitted, there may be unanticipated factors that effectively reduce the suitable land base on a case-by-case basis. Based on past experiences with this project-level "fall down", the Forest Service was able to estimate the cumulative effect on the suitable land base in the Forest Plan. After complying with all legal mandates, providing for the sustainability of forest ecosystems and ecosystem processes, and allowing for unforeseen events in Plan implementation, roughly 676,000 acres are considered suitable and available for commercial timber production.

Current Timber Industry Status

Since 1990, the volume of timber harvested from the Tongass National Forest has dropped from 470 million board feet to 120 million board feet annually, a 75 percent decline. Timber industry employment is at its lowest point in over 30 years, now directly accounting for only about 670 jobs. At its peak, in the 1970s, the Tongass generated 4,000 timber industry jobs in Southeast Alaska. The loss of 1,700 timber industry jobs during the 1990 to 1998 period has rippled through the regional local economies. The total job loss (including direct and indirect jobs) is estimated at approximately 2,900 jobs and over $100 million in annual payroll in Southeast Alaska. Further, a 75 percent reduction in Tongass stumpage receipts has affected nearly every local government in Southeast and has been especially harmful to the region' s smaller communities. The economic effects of the declining Tongass timber harvest are still unfolding. Additional direct employment losses include the recent closure of the Annette Island sawmill in Metlakatla. Additional lay-offs will occur as KPC completes the harvest associated with its contract extension. Further, the long-term, indirect economic consequences of timber industry declines will continue to unfold in communities that have lost key employers, especially in Ketchikan, and in communities dependent on Tongass stumpage receipts.

Prior to the 1990s, the timber industry was able to accelerate timber harvests in response to strong market conditions. During the 1985 to 1990 period, for example, market prices increased 90 percent. The industry responded with a 100 percent increase in the harvest. In 1995, however, market prices increased to all-time record highs, but the industry was unable to respond due to inadequate volume.

Finally, it is important to recognize that the economic impacts of declining timber harvest have been mitigated to some degree by the $110 million in Tongass disaster relief funds distributed to Southeast' s timber dependent communities. If these funds had not been made available the economic out-fall in Wrangell, Sitka and Ketchikan, among others, would undoubtedly be more severe than recorded in this report.

Timber Availability and Supply

The allowable sale quantity (ASQ) is the maximum amount of timber that may be scheduled for sale from the suitable lands on the Forest over the next ten years (36 CFR 219.3). It is usually expressed as an annual average. The Tongass Land Management Plan provides for an ASQ of 2.67 BBF per decade, the equivalent of 267 MMBF per year. Although sale volumes may exceed 267 MMBF in any given year, the total program must remain within the ASQ for the decade.

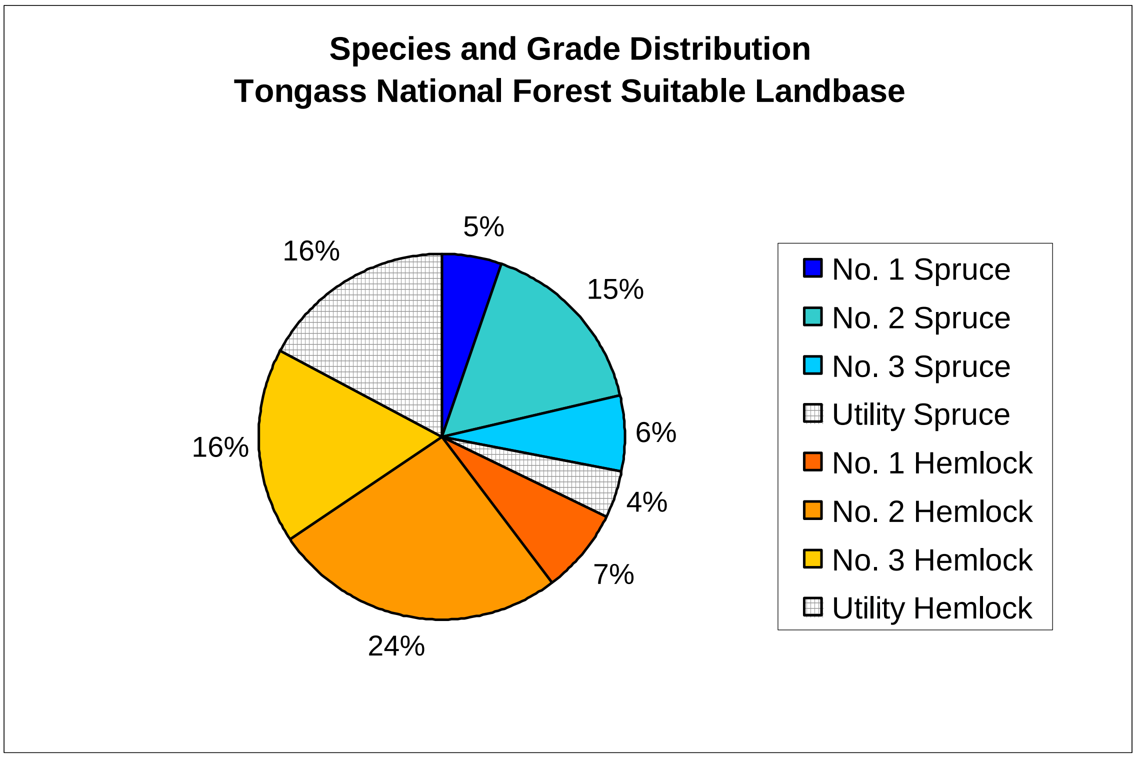
The ASQ consists of two separate "Non-Interchangeable Components" (NICs) referred to as NIC I (2.2 BBF) and NIC II (.47 BBF). The term "non-interchangeable" refers to the fact that lower sale levels in one component in the course of the decade may not be compensated for by higher sale levels in the other. As with the ASQ, the NIC limitations are binding on a decadal basis. The NIC I component includes timberlands that can be harvested with normal logging systems. The NIC II component includes timberlands with especially high logging costs due to isolation or special equipment requirements. Relative to historic sale patterns, a larger proportion of the ASQ (about 20 percent) will be supplied from areas of the Tongass with the highest logging costs.

The ASQ is an upper limit on sale volume. It is not a future sale projection or a target and does not reflect all of the factors that may influence future sale levels. With regard to the timber provisions of the Tongass Timber Reform Act, the ASQ represents the maximum timber supply the Forest Service can make available to meet market demand over the next decade. Just as timber demand is more accurately represented by a curve, timber supply is also more accurately represented as a set of price/volume relationships. Because the available timber supply is limited by the ASQ and by the Federal budget process, timber supply curves from the Tongass tend to be relatively inelastic with respect to price. Although higher stumpage prices may initially bring the timber from the NIC II component into the market, continued price increases cannot be expected to bring forth additional supplies.

The species and grade distribution for the commercial timberlands of the Tongass is shown below. The composition of a specific timber sale may vary considerably from this forest wide average, however, it is important to note that roughly 42 percent of the timber inventory is comprised of the lower grade #3 and utility logs.

A Forest Service timber sale is essentially a bundle of different species and grades of timber, each of which will be valued and processed according to the expected product yield. The rate at which timber sales will be purchased and processed depends upon the raw material requirements of local manufacturers and the extent to which an average sale meets those requirements.

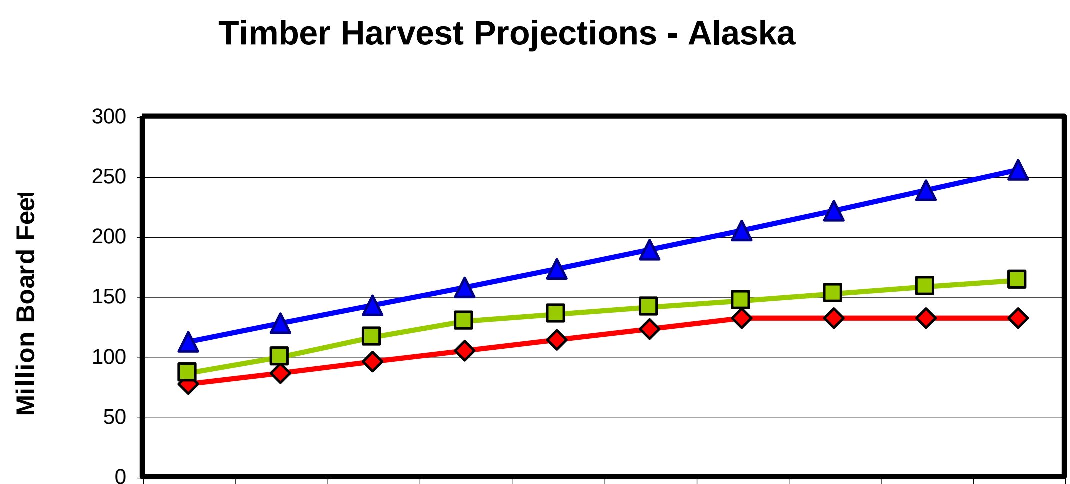
Until recently, the region's pulp industry provided an outlet for this material. **Ultimately, the future of the industry rests on developing the ability to economically process or otherwise dispose of this component of the wood supply.**



Over the ten- to fifteen-year planning cycle, the number of firms in an industry may increase or decrease in response to trends in industry performance and profitability. Therefore, when projecting market demand over this time period, it must be assumed that all inputs to the manufacturing process--including the number and type of processing facilities in the region are subject to change.

Other changes in the industry over a longer period of time may include technological improvements, productivity gains, increased utilization of raw materials, and the addition of new processing capacity and capability to older facilities. As the Tongass Land Management Plan was being revised, research economists at the Pacific Northwest Research Station (PNW) were asked to update their earlier projections of Alaska timber products output and timber harvest by ownership.

The most recent projections of timber harvest over the planning cycle account for several dramatic changes in the region's manufacturing capabilities, increased competition from a number of sources, and the steady erosion of North America's share of Japanese timber markets. Three scenarios--labeled "Low", "Medium", and "High"--were developed to display alternative futures for Alaska's forest sector and the resulting demand for National Forest timber (Table 1). The values of key parameters for each forecast scenario are compared in Table 2. In the "Low" scenario, increasing stumpage costs and higher logging and manufacturing costs limit Alaska's market share. Moreover, the North American share of the Japanese market is not expected to increase appreciably. In contrast, under the "High" scenario, Alaska is expected to develop a more efficient, competitive lumber industry, and to participate in a somewhat broader array of markets. Gains in efficiency are assumed to increase overrun ratios and reduce raw material input per unit of lumber output. The overall effect is a modest increase in timber harvest relative to the "Low" scenario.



	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Low	77.3	86.4	95.5	104.6	113.7	122.8	131.9	131.9	131.9	132
Medium	86	99.3	115.9	129	134.9	140.8	146.5	152.2	157.8	163.4
High	112.2	127.9	142.7	157.7	173.1	188.9	205	221.4	238.2	255.3

Year

In a recent report, timber researchers emphasized the uncertainty inherent in predicting the future demand for National Forest Timber:

"We characterize the future for demand for National Forest timber as having a high degree of uncertainty because of the magnitude of recent changes in the Alaska forest sector, and because many of the factors that will determine the size and type of industry in the future cannot be predicted. The level and reliability of timber supplies from Alaska National Forests are only two among a number of sources of uncertainty; rates of economic growth in key markets, changing technology and tastes and preferences of consumers, and the strength of competition are among other sources of uncertainty."

Sawmills Survey

In 1998, the Forest Service, University of Alaska Cooperative Extension Service, and the Alaska Department of Commerce jointly funded a survey of Alaska sawmills, which was conducted by the Institute of Social and Economic Research (ISER) at the University of Alaska Anchorage.

The 1998 survey covered mill capacity, employment, total production, production by type of product and export or domestic sale, log consumption by species and original timber ownership, chip and residue production, information on suppliers and customers, and several questions about the timber industry in general. It focused on data for calendar year 1997. Some principal findings were:

- Respondents reported a design capacity of about 240 MMBF annually, almost 200 MMBF of that capacity in Southeast Alaska. They reported that the practical capacity of their mills was somewhat lower – about 205 MMBF statewide, with 174 MMBF in Southeast.

- In 1997, production ranged from 20 MBF to 20,000 MBF. Most firms produced less than 1,000 MBF, and aggregate production was about 67,000 MBF.

- About 55 percent of products were exported and 45 percent sold domestically. About55 percent of exports were dimensional lumber and 40 percent cants. Domestic sales were 70 percent dimensional lumber and 20 percent cants.

- Of the 27 mills that answered the down time questions, 13 reported no down time due to supply problems. Five firms reported that they lost one day per week or more – up to over half of their total possible time - to lack of supply; the remaining 9 reported just a few days each year.

- Tongass timber accounted for about 90 percent of all the log consumption reported statewide, and over 98 percent of Southeast firms' logs. Elsewhere, privately owned timber provides almost half of Southcentral sawmills' supply, and over 10 percent of Interior sawmills' logs, with the remainder of wood in those regions coming primarily from state land.

- Most mill residue (about 85 percent) is sold (for landscaping and bedding) or used for energy rather than landfilled or burned.

- About half the mills responding in Southeast and Interior reported supply problems, and 4 out of 5 Southcentral mills did. The most common suggestion for government help was more state and local timber sales. Almost half the respondents believed government could help the industry most by providing a dependable timber supply and providing more sales

By referring to various industry and government publications, one can get a general sense of mill capacity in Southeast Alaska, however, it is not always clear what the available data represent. Some mills report end product output vs. log throughput; others report design capacity vs. effective capacity. Consequently, there is a need for the systematic collection of information on the effective capacity of the wood product manufacturers in the region. For purposes of this analysis, the best available information was used to arrive at a current installed processing of 281 million board feet annually (log scale).

Over the last fifteen years, the installed sawmilling capacity in Southeast Alaska has reportedly ranged from a high of 401 MMBF in 1983 to a low of 164 MMBF in 1996. Sawmills providing information for the 1998 survey are noted below:

- KPC Annette Sawmill
- KPC Ketchikan Sawmill
- Silver Bay Logging Wrangell Sawmill
- Viking Lumber Company
- Seley Corporation
- Herring Bay Lumber
- Icy Straits Lumber
- Metlakatla Forest Products
- W.R.Tonsgard Lumber
- Star Cedar Products
- Black Bear Cedar
- Miscellaneous Sawmills (5)

Total – 281 MMBF

Estimates of lumber output in Southeast Alaska were compiled by the PNW Research Station to determine the historical rate of capacity utilization in Alaska’s lumber industry. As shown here, the rate of capacity utilization varies considerably and is closely linked to market conditions. For example, the data indicates that from 1983-1985,roughly 33- 36 percent of the installed capacity was utilized. This is in sharp contrast to the capacity utilization rate of 76-88 percent observed during the peak of the market cycle (1991-1993).

Data from the Pacific Northwest, Alaska's competitor region, suggests an average capacity utilization rate of 71 percent from 1985-1995. In contrast, Alaska mills averaged 51 percent utilization for the same time period. There are a number of possible explanations for the relatively low rate of capacity utilization in Alaska's sawmills. As noted previously, most of the sawmills in Southeast Alaska have been in place for many years (most of the installed capacity dates back to the early 1970's). Because the initial investment has been amortized, decision about production levels for these mills may be disproportionately influenced by short-term profitability. It seems likely that, given the minimal investment costs, Alaska's mills will be more likely to close during periods of poor markets. Coupled with Alaska's relatively high operating costs, this heightened sensitivity to market cycles serves to amplify the effect on lumber output in the region. Poor markets trigger temporary mill closures only to be followed by a resurgence in production after the market rebounds.

The extent to which the raw material in a sale can be fully utilized depends upon the technology installed in the region, the degree of processing infrastructure and integration, log export policies, and market conditions. Both Western Red Cedar and Alaska Yellow Cedar have traditionally been considered surplus to local manufacturing needs, although industry members have recently shown more interest in manufacturing Western Red Cedar. However, in fiscal year 1997, the Forest Service began implementing procedures to phase out the export of Western Red Cedar from the Tongass.

Special consideration must also be given to "utility-grade" logs. This material (estimated at 18 percent of average timber sale volume) is not currently used in lumber manufacture. It is assumed that utility-grade logs will be chipped in the region before shipping to other destinations. Finally, depending on market conditions and log grade, varying percentages of the saw log component of the harvest volume have been processed in the region's sawmills. The percentage sawn in Alaska can be expected to increase over time as the industry acquires the equipment needed to utilize smaller diameter logs and as fewer log export permits are granted.

Although the Tongass National Forest has historically provided the bulk of the timber processed in Southeast Alaska, other entities have occasionally participated in this market as well. The Alaska Native Corporations have supplied Alaska's pulp mills with pulp logs and the State of Alaska maintains a small timber program in the region. Most saw logs from these non-federal sources have been exported from the state without processing. However, recent changes in overseas timber markets are forcing a new look at potential domestic uses for some of this timber supply. For instance, the Ketchikan Pulp Company and Sealaska (the Regional Native Corporation) have been studying the feasibility of manufacturing veneer in Southeast Alaska. At the present time, there appears to be no compelling reason to expect private timber supplies to offset industry dependence on less expensive federal timber. The steady erosion of the hemlock log market in Asia suggests that private timber owners will be exploring every opportunity to diversify their products and markets. However, it is still not clear whether efforts to find markets for hemlock logs will lead to wood products manufacturing in Southeast Alaska as a viable outlet for private timber supplies. In contrast, the State of Alaska has directed considerable effort toward negotiated sales and other provisions designed to encourage local processing of State timber resources.

In addition to the timber processed in a given year, the annual demand for timber includes the volume needed to build, rebuild, or maintain an adequate "buffer stock" of uncut timber. This backlog of uncut timber is, in essence, the industry's "dependable timber supply." A sufficient supply of volume under contract allows the industry to adjust output in response to market conditions. It also appears to play a significant role in the stabilization of regional timber prices. Finally, basic operational considerations underscore the importance of maintaining sufficient timber inventories. For example, after a sale is awarded, it can take an operator one or more years to complete the road construction necessary to gain access to the timber. While this work is underway, the purchaser is harvesting and processing timber purchased in prior years. Consequently, timber processors generally maintain some volume under contract that is carried over from one year to the next.

What is an adequate level of uncut timber inventory? During the late 1960s and early 1970s, the ratio of uncut volume inventory to sales (roughly equivalent to harvest at that time) ran at approximately 2:1 for the Forest Service Region 6 (PNW), 3:1 in Region 5 (PSW), and 2.75:1 in the northern Rockies (Region 1). During the 1980-82 recession, the uncut/sold volume ratio increased to roughly 4.5:1. By 1987, the bulk of the timber surplus had been reconveyed to the Forest Service under special contract relief legislation and the uncut/sold volume ratio returned to the level observed in the 1970's.

Data for the Tongass independent sale program shows substantial fluctuation in this ratio. This may reflect the dominance of the two long-term timber contracts during this time period and/or periodic shortfalls in timber sale offerings. Planning for and managing an adequate raw materials inventory is an important business function. Precise formulas have been developed to help firms determine the appropriate level of inventory to carry given inventory carrying costs, the anticipated demand for finished products, the speed at which additional raw materials can be obtained (the lead time), and the variability in lead times. The firm will generally wish to carry a raw material inventory equal to the expected demand during lead time plus an extra buffer (or safety stock) to cover excess product demand or variation in lead time.

Timber Industry Capacity

The Alaska Forest Association has calculated the capacity of Southeast Alaska timber manufacturing facilities. Remaining sawmill capacity in Southeast Alaska currently stands at 355.5 million board feet (mmbf). This is an increase above 322 mmbf, which is the number calculated by the Forest Service as a part of the revised Tongass Land Management Plan. The government has stated its intention to sell about 200 million per year, which clearly does not meet capacity.

The primary manufacturing capability calculation is based on 10 small and medium size sawmills, one large sawmill and a group of tiny mills, mostly on Prince of Wales Island. These sawmills represent the backbone of Alaska's present and future forest products manufacturing industry. Currently, they are all operating below capacity.

Over the long haul there is tremendous potential for selling Alaska wood, especially sawn products and manufactured wood products, in Asia. These opportunities are likely to extend well into the next century. To take advantage of these prospects, a stable and sufficient supply of logs to our sawmills must be provided. Because it is the principal forest land owner, the federal government holds the key to the future success of Alaska's sawmill industry.

This was recently confirmed by the McDowell group in a study titled, " The Global Market for Timber from the Tongass National Forest". The McDowell study shows that global demand for the types of wood products we are capable of producing in Southeast Alaska is virtually unlimited. The only real restraints on ability to produce are timely supply and higher operating costs. The cost issues can and are being addressed through industry efficiencies and by developing niche markets with a higher return per board foot. But those who own the timber – that means the federal government can make or break our economy by selling or not selling timber in a timely manner and on a cost-effective basis, can only address the supply problem.

BIOMASS BACKGROUND INFORMATION

It is becoming obvious that we must decrease our reliance on fossil fuels and nuclear energy. The cost of continuing to use fossil and nuclear fuel is significant. Numerous hidden costs are included such as damage to the environment, illness from pollution, radioactive waste disposal, economic and employment effects, damage from acid rain, long-term effect of greenhouse build-up, interest on money for imported oil, and the military cost of defending foreign oil supplies. Recent attempts to quantify these costs show that every US citizen is paying $1,000 a year in subsidies to fossil fuel and nuclear power plants. This equates to a gasoline cost of over $4 per gallon.

A recent US Department of Energy study concluded that 88% of the economically accessible energy of the future will come from solar and biomass. The world now derives less than 15% of its energy from 1% of the solar energy that is continually being captured in the chemical bonds of growing plants around the world.

We waste far more energy than we use efficiently. If we ended our addiction to fossil/nuclear fuel, used less energy more efficiently, and restored the 40% of mother nature’s bounty we have destroyed; we would be rewarded with far more stored solar energy in the form of renewable biomass than we would ever need. Several studies indicate that biomass can contribute 40% to 90% of our future energy needs. Unlike fossil fuels, biomass does not contribute to the greenhouse gas build-up when replanted on a sustained yield basis, nor is it explosive, dangerous or contaminating to the environment like gas, oil, coal, and uranium. Ash from wood is also an excellent fertilizer.

Energy from biomass is the wave of the future and Alaska is the best location for its application Total biomass energy in the US is 3.34 quads (quadrillion BTUs) or 3% of total US energy consumption. This value increased 25% between 1990 and 2001. About 81% of the supply is from the industrial sector, primarily wood and woodwaste. The US forest product industry obtains 56% of its own energy from woods products. The last 10-year trend is a 40% increase in wood for commercial and industrial and a 133% increase in alcohol.

US energy demand to increase by 1.4% between 2000 and 2020. (115 to 130 quads). Biomass is predicted to increase from 3.3 Q to 4.7 Q in 2020 annual rate of 1.8% per year

Our US goal is for biomass consumption in industrial sector to increase by an annual rate of 2% through 2030 at 4.8 Q. The goal for biomass consumption in electrical utilities is to double every 10 years through 2030. It is expected that biopower will be 5% of industrial and electric generator demand in 2020.

Biofuels are liquid fuels, produced from biomass, that are used in stationary and mobile applications. The Biomass Research and Development Act of 2000 defines biomass as:

"any organic matter that is available on a renewable or recurring basis, including agricultural crops and trees, wood and wood wastes and residues, plants (including aquatic plants), grasses, residues, fibers, and animal wastes, municipal wastes, and other waste materials."

The Advisory Committee has identified three primary goals for biofuels. They are to:

- Triple production of fuel from biomass sources, from 2000 levels, by removing technology and policy barriers
- Provide benefits to farmers and forest landowners by increasing the value of agricultural and forestry products and assisting rural communities with economic development.
- Encourage investment by mitigating the financial risk involved in biofuels.

The Advisory Committee has identified the following areas in which biopower research and development, demonstration, and technology transfer are necessary:

Thermochemical Conversion

Necessary research into thermo chemical conversion of biomass feedstock's including direct use of gaseous products includes: basic and applied research and feasibility studies, research on the integration of conversion systems with power generation equipment, and overcoming technical barriers such as tar removal prior to firing biogas in a turbine system. In addition, analytical studies on costs, performance, and life-cycle emissions are necessary.

Co-Firing

Co-firing of biomass with coal, oil, or gas has the greatest potential for increasing biomass power generation by 2010. To increase the application of both existing and emerging technologies, there is a need for increased technology demonstration and technology transfer activities. Initial priorities include cyclone boilers and co-fired fluidized bed boilers. Co-fired pulverized coal boilers and related feed systems are nearly ready for commercial demonstration. One area with unrealized potential is gasification-based co-firing, which will integrate this advanced boiler technology with oil and natural gas-fired boilers and combined cycle combustion turbines (CCCT's) through the use of duct burner technology or other appropriate co-firing technology. Continued R&D is needed in each of these systems to broaden the range of usable feedstocks to include all available, environmentally appropriate feedstocks. There is also a need to develop design standards and permitting standards in electronic form, as well as to enhance technology transfer to feedstock producers and electric power developers.

Direct Combustion

Another method for increasing biomass power generation is direct combustion of 100 percent biomass in units of 75 megawatts or less. A commercial demonstration program for this technology is required along with development of units that operate at higher main steam temperature and pressure (>1500 psi) for increased efficiency. Development of a reheat boiler based on biomass firing merits additional research. Particular attention should be paid to technology transfer for existing use of multiple fuel boilers in the forest products industry. Other factors that will improve this process include improved burner design, a better understanding of the combustion characteristics of feedstocks, and design and permitting standards in electronic form.

Thermal Gasification

Thermal gasification has great potential for increasing biomass power generation beyond 2010. Waste sources from the forest products industry represent 30 GW of potential output. The forest products industry and relevant federal biomass research programs should remain informed of advances in DOE Fossil Energy research in gasification technology and hot and cold gas clean up, and coordinate with the Fossil Energy program as appropriate. Key developments should include small modular biopower systems that use small gasifiers. As noted previously, gasification can also be applied to co-firing with particular application to CCCT installations.

Anaerobic Fermentation Gases

Power from anaerobically generated gases has great potential for increasing biomass power generation beyond 2010. The sources for these gases include 500 Btu/cu ft gases from landfills, anaerobic digestion of animal manure and food/feed/grain products and by-products, use of wastewater treatment digestion gas, sludge and sewage treatment gases, and other sources. Over 600 million tons of carbon equivalent methane is produced annually in the U.S.[3] Low intensity methane should be viewed as a resource instead of a waste product. Systems for the use of methane from 10 – 300 Btu/cu ft are technically feasible and should be developed. Research on integrating thermal gasification with anaerobic digestion provides another opportunity for synergies between technologies.

Modular Systems

Advances also need to occur in the development of modular systems and distributed small-scale generation of less than 200 kW. Systems should be developed that can consume small caches of waste or dedicated resources for distributed generation of power and heat locally for use on-farm, on-site, and in small industrial systems. The alternatives developed could include integration of modular biomass systems with fuel cells. Resources include food/feed/grain processing plant waste: nutshells, corncobs, tomatoes, carrots, fruit, rice hulls, as well as urban and wood waste, and other sources. There is potential for limited development before 2010 and widespread use after 2010. The primary R&D opportunities in this area are the development of scaled-down, skid-mounted or mobile installations and fuel concentrators to increase energy density. Significant opportunities for modular systems exist in low value by-products from grain, soy, wood and other processing systems, and in farm and forest residues where the high cost of transporting biomass to larger facilities can be avoided.

Feedstock Research

The above systems must be complemented by research into feedstock issues including improvements in: energy and tree crop growth (GMO/ rate/ quality/ hardiness) and management, feedstock collection, transportation, crop and tree cycle integration, residue recovery and fuel preparation. R&D opportunities include overcoming the seasonal nature of generation, improving storage methods, developing open and closed systems, expanding the growth of energy crops, and assuring the quality of feedstocks. At the same time, research into the agronomic, economic and environmental impacts of harvesting lignocellulosic material must be established to ensure that these materials are used for beneficial lifecycle impacts.

Biomass in Alaska

Alaska has an estimated total installed biomass capacity of 10 MW. The Alaska Pacific Regional Biomass Energy Program is working to increase this. With an expected doubling of landfill size over the next 15 years, the Energy Program wants to develop a biomass facility that will turn the excess waste into usable energy. The Municipality of Anchorage is generating > 500 mmcf/year of landfill gas with this amount expected to double in 2015.

Residues from two of the state's major industries are suitable for conversion into liquid biofuels. UniSea Inc.'s, along with Alaska Energy Authority and the Biomass Program, is testing the use of fish oil in diesel generators at its Dutch Harbor plant. About 1.4 million gallons of B50 were used for power production in 2002 with an expected increase of use to about 2.6 million gallons of B50 in 2003. Alaska Energy Authority is also working with Sealaska Corporation to explore the production of ethanol from wood residues. The last phase of the project is to erect a commercial facility to help meet Alaska's fuel-ethanol demand. Finally, Alaska Energy Authority is working with rural Alaskan communities on a wood fuel substitution project for offsetting fuel oil usage. The purpose of the project is to identify site-specific cost-effective measures that will reduce the amount of oil used for space heating major buildings in select rural Alaskan communities and for power production. Alaska Statues specify a tax exemption for gasohol, which translates to 6-cent/gal tax credit for gasohol with a minimum of 10% ethanol, or 8 cents/gal if it is biomass-based. The tax credit is only for ethanol used in CO non-attainment areas (Anchorage, and possibly Fairbanks). Alaska also has a sales tax exemption for renewable fuels, which reduces the tax on gas by 24 cents per gallon in designated areas.

TECHNOLOGY VALIDATION

MSW Management Technologies

EPA has ranked the most environmentally sound strategies for MSW. Source reduction (including reuse) is the most preferred method, followed by recycling and composting, and, lastly, disposal in combustion facilities and landfills. Currently, in the United States, 28 percent is recovered and recycled or composted, 15 percent is burned at combustion facilities, and the remaining 57 percent is disposed of in landfills.

Source Reduction

Source reduction can be a successful method of reducing waste generation. Practices such as grass cycling, backyard composting, two-sided copying of paper, and transport packaging reduction by industry have yielded substantial benefits through source reduction. Source reduction has many environmental benefits. It prevents emissions of many greenhouse gases, reduces pollutants, saves energy, conserves resources, and reduces the need for new landfills and combustors.

Source reduction, often-called waste prevention, means consuming and throwing away less. Source reduction includes purchasing durable, long-lasting goods and seeking products and packaging that are as free of toxics as possible. It can be as complex as redesigning a product to use fewer raw materials in production, have a longer life, or be used again after its original use is completed. Because source reduction actually prevents the generation of waste in the first place, it is the most preferable method of waste management and goes a long way toward protecting the environment.

Reusing items by repairing them, donating them to charity and community groups, or selling them also reduces waste. Use a product more than once, either for the same purpose or for a different purpose. Reusing, when possible, is preferable to recycling because the item does not need to be reprocessed before it can be used again.

Ways to Reuse

- Using durable coffee mugs.
- Using cloth napkins or towels.
- Refilling bottles.
- Donating old magazines or surplus equipment.
- Reusing boxes.
- Turning empty jars into containers for leftover food.

- Purchasing refillable pens and pencils.
- Participating in a paint collection and reuse program.

Recycling

Recycling turns materials that would otherwise become waste into valuable resources and generates a host of environmental, financial, and social benefits. After collection, materials (e.g., glass, metal, plastics, and paper) are separated and sent to facilities that can process them into new materials or products.

Recycling is one of the best environmental success stories of the late 20th century. Recycling, including composting, diverted 64 million tons of material away from landfills and incinerators in 1999, up from 34 million tons in 1990. By 1999, more than 9,000 curbside collection programs served roughly half of the American population. Curbside programs, along with drop-off and buy-back centers, resulted in a diversion of 28 percent of the nation's solid waste.

Benefits of Recycling

- Conserves resources for our children's future.
- Prevents emissions of many greenhouse gases and water pollutants.
- Saves energy.
- Supplies valuable raw materials to industry.
- Creates jobs.
- Stimulates the development of greener technologies.
- Reduces the need for new landfills and incinerators.

In order to make recycling more economically feasible, we must "buy recycled" products and packaging. When we buy recycled products we create an economic incentive for recyclable materials to be collected, manufactured, and marketed as new products. Buying recycled has both economic and environmental benefits. Purchasing products made from or packaged in recycled materials saves resources for future generations.

Creating a strong market for recycled products is key to completing the recycling process or "closing the loop." Consumers close the loop when they purchase products made from recycled materials. Governments can promote buying recycled products through their own purchasing programs and guidelines. Manufacturers can participate as well by using recycled materials in their products.

Product labels can be confusing to consumers interested in buying recycled because of the different recycling terminology used. The following definitions might help clarify any uncertainty regarding manufacturers' claims:

- ***Recycled-content products*** are made from materials that would otherwise have been discarded. Items in this category are made totally or partially from material destined for disposal or recovered from industrial activities—like aluminum soda cans or newspaper. Recycled-content products also can be items that are rebuilt or remanufactured from used products such as toner cartridges or computers.
- *Postconsumer content* refers to material from products that were used by consumers or businesses and would otherwise be discarded as waste. If a product is labeled "recycled content," the rest of the product material might have come from excess or damaged items generated during normal manufacturing processes—not collected through a local recycling program.
- *Recyclable products* can be collected and remanufactured into new products after they've been used. These products do not necessarily contain recycled materials and only benefit the environment if people recycle them after use. Check with your local recycling program to determine which items are recyclable in your community.

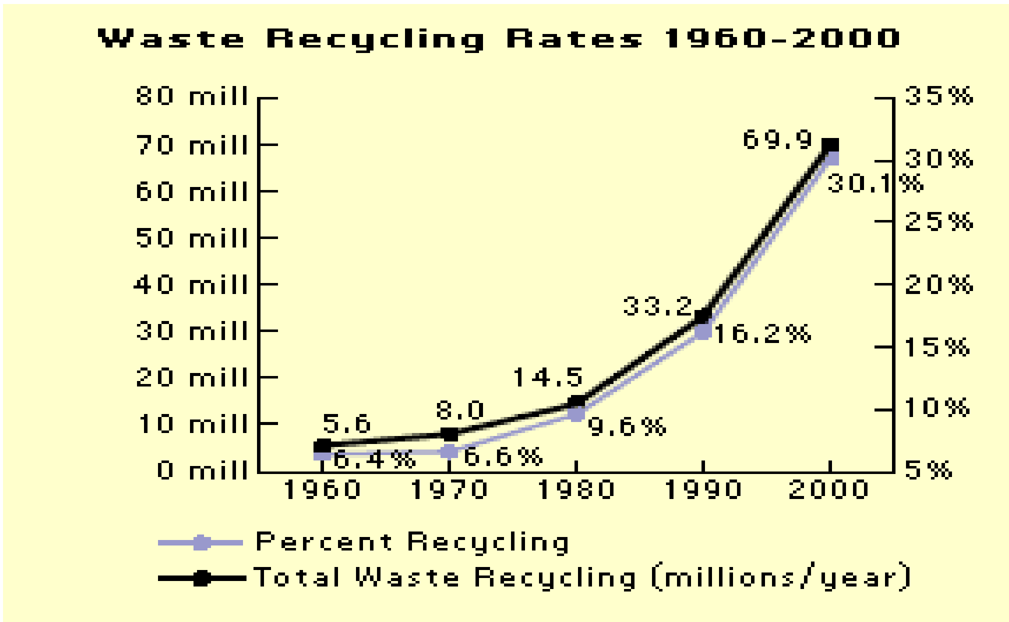
There are more than 4,500 recycled-content products available, and this number continues to grow. In fact, many of the products people regularly purchase contain recycled-content

Another form of recycling is composting. Composting is the controlled biological decomposition of organic matter, such as food and yard wastes, into humus, a soil-like material. Composting is nature's way of recycling organic wastes into new soil used in vegetable and flower gardens, landscaping, and many other applications.

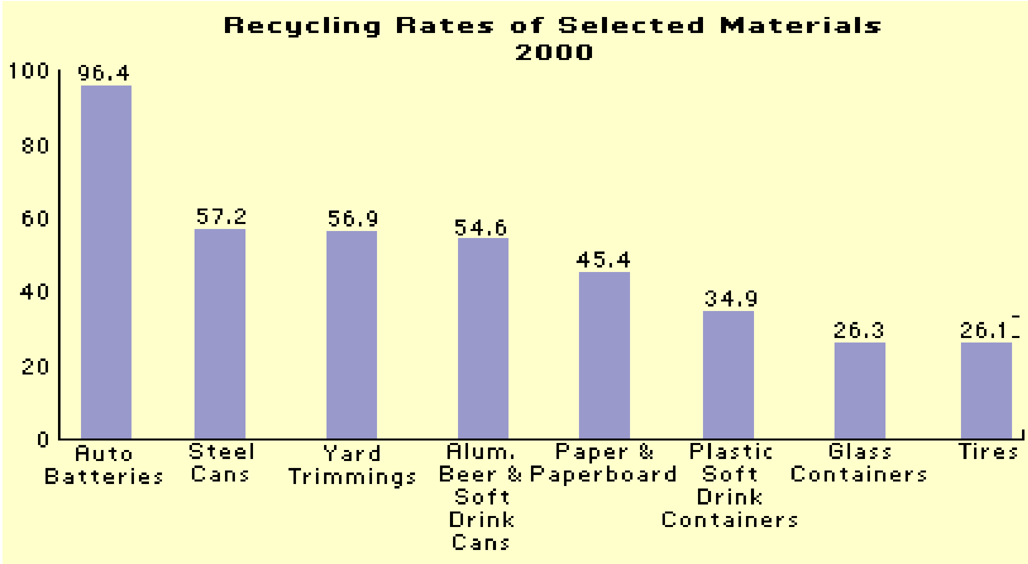
Benefits of Composting

- Keeps organic wastes out of landfills.
- Provides nutrients to the soil.
- Increases beneficial soil organisms (e.g., worms amd centipedes).
- Suppresses certain plant diseases.
- Reduces the need for fertilizers and pesticides.
- Protects soils from erosion.
- Assists pollution remediation.

Recycling, including composting diverted 64 million tons of material away from landfills and incinerators in 1999, up from 34 million tons in 1990. Typical materials that are recycled include batteries, recycled at a rate of 96.9%, paper and paperboard at 41.9%, and yard trimmings at 45.3%. These materials and others may be recycled through curbside programs, drop-off centers, buy-back programs, and deposit systems.



This line graph depicts waste recycling rates in the U.S. from 1960 to 2000, in both percentage and tons. In 1960, the recycling rate was 6.4%, and 5.6 million tons of materials were recycled. In 1970, the recycling rate was 6.6%, and 8 million tons of materials were recycled. In 1980, the recycling rate was 9.6%, and 14.5 million tons of materials were recycled. In 1990, the recycling rate was 16.2%, and 33.2 million tons of materials were recycled. In 2000, the recycling rate was 30.1%, and 69.9 million tons of materials were recycled. Recycling rates of selected materials are noted below:



Recycling prevents the emission of many greenhouse gases and water pollutants, saves energy, supplies valuable raw materials to industry, creates jobs, stimulates the development of greener technologies, conserves resources for our children's future, and reduces the need for new landfills and combustors. Recycling also helps reduce greenhouse gas emissions that affect global climate. In 1996, recycling of solid waste in the United States prevented the release of 33 million tons of carbon into the air—roughly the amount emitted annually by 25 million cars.

Combustion/Incineration

To reduce waste volume, local governments or private operators can implement a controlled burning process called combustion or incineration. In addition to minimizing volume, combustors, when properly equipped, can convert water into steam to fuel heating systems or generate electricity. In 1999, in the United States, there were 102 combustors with energy recovery with the capacity to burn up to 96,000 tons of MSW per day. Burning MSW can generate energy while reducing the amount of waste by up to 90 percent in volume and 75 percent in weight.

A variety of pollution control technologies reduce the toxic materials emitted in combustion smoke. Among these are scrubbers—a device that uses a liquid spray to neutralize acid gases in smoke—and filters, which remove tiny ash particles from the smoke. Burning waste at extremely high temperatures also destroys harmful chemical compounds and disease-causing bacteria. Regular testing ensures that residual ash is nonhazardous before being landfilled. EPA's Office of Air and Radiation is primarily responsible for regulating combustors because air emissions from combustion pose the greatest environmental concern.

Landfilling

Under the Resource Conservation and Recovery Act (RCRA); state, tribal, and local governments primarily regulate landfills that accept MSW. EPA, however, has established national standards these landfills must meet in order to stay open. Municipal landfills can, however, accept household hazardous waste. Households often discard many common items such as paint, cleaners, oils, batteries, and pesticides, which contain hazardous components. Leftover portions of these products are called household hazardous waste (HHW). These products, if mishandled, can be dangerous to your health and the environment.

The number of landfills in the United States is steadily decreasing—from 8,000 in 1988 to 2,300 in 1999. The capacity, however, has remained relatively constant. New landfills are much larger than in the past.

Although source reduction, reuse, recycling, and composting can divert large portions of municipal solid waste (MSW) from disposal, some waste still must be placed in landfills. Modern landfills are well-engineered facilities that are located, designed, operated, monitored, closed, cared for after closure, cleaned up when necessary, and financed to insure compliance with federal regulations. The federal regulations were established to protect human health and the environment. In addition, these new landfills can collect potentially harmful landfill gas emissions and convert the gas into energy. A summary of concerns managed by the standards is noted below:

Federal Landfill Standards

- **Location restrictions** ensure that landfills are built in suitable geological areas away from faults, wetlands, flood plains, or other restricted areas.
- **Liners** are geomembrane or plastic sheets reinforced with two feet of clay on the bottom and sides of landfills.
- **Operating practices** such as compacting and covering waste frequently with several inches of soil help reduce odor; control litter, insects, and rodents; and protect public health.
- **Groundwater monitoring** requires testing groundwater wells to determine whether waste materials have escaped from the landfill.
- **Closure and postclosure care** include covering landfills and providing long-term care of closed landfills.

- **Corrective action** controls and cleans up landfill releases and achieves groundwater protection standards.
- **Financial assurance** provides funding for environmental protection during and after landfill closure (i.e., closure and postclosure care).

Household Hazardous Waste

The options of reduction reuse, recycling, and disposal—listed in order of EPA's preferred waste management hierarchy—are all-important tools to safely manage HHW. The following information can help you determine the best ways to reduce, reuse, or dispose of common household products that may contain hazardous ingredients.

Consider reducing your purchase of products that contain hazardous ingredients. Learn about the use of alternative methods or products—without hazardous ingredients—for some common household needs.

- **Permanent collection or exchange.** See if your community has a facility that collects HHW year-round. Some of these facilities have exchange areas for unused or leftover paints, solvents, pesticides, cleaning and automotive products, and other materials. By taking advantage of these facilities, materials can be used by someone else, rather than being thrown away.
- **Special collection days.** If your community doesn't have a year-round collection system for HHW, see if there are any designated days in your area for collecting solid waste at a central location to ensure safe management and disposal.
- **Local business collection sites.** If your community has neither a permanent collection site nor a special collection day, you might be able to drop off certain products at local businesses for recycling or proper disposal. Some local garages, for example, may accept used motor oil for recycling.

BIOPOWER TECHNOLOGIES

Direct Fired Combustion

With more than 7,000 MW of installed capacity, biomass is the second-most utilized renewable power generation resource in the U.S. Most of today's Bio-power plants are direct-fired systems that are similar in concept to most existing fossil fuel fired power plants. Combustion research mostly takes place at DOE's experimental facilities at its national laboratories. Information on several ongoing projects that fit into DOE's long-term R&D plans is available from the laboratories. On line technical reports describing previous work are also available.

DOE's Experimental Facilities are located at the National Renewable Energy Laboratory (NREL) in Golden, Colorado; Sandia National Laboratories in Livermore, California; and the National Energy Technology Laboratory (NETL) in Pittsburgh,

Co-Firing

Cofiring involves replacing a portion of the coal with biomass at an existing power plant boiler. For utilities and power generating companies with coal-fired power plants, cofiring with biomass may represent one of the least-cost renewable energy options. For utilities and power generating companies with coal-fired capacity, cofiring with biomass may represent one of the least-cost renewable energy options. Cofiring involves replacing a portion of the coal with biomass at an existing power plant boiler. This can be done by either mixing biomass with coal before fuel is introduced into the boiler, or by using separate fuel feeds for coal and biomass. Depending on the boiler design and fuel feed system employed, biomass can replace up to 15% of coal in a cofiring operation.

Currently, six power plants in the U.S. are cofiring coal and wood residue products on a regular basis, and a seventh plant recently ceased cofiring after more than 10 years of continuous operation. Another ten plants have successfully tested cofiring over the last decade, and at least six more plants are now conducting or planning tests. According to a recent report prepared for the Department of Energy by five National Laboratories, domestic biomass generation capacity could reach 20-30 GW by the year 2020 by cofiring at existing U.S. coal-fired power plants.

Gasification

Gasification is a major and unique element in the development of improved Bio-power systems. It is a thermo chemical process that converts solid biomass raw materials to a clean fuel gas form. The fuel gas form allows biomass to use a wide range of energy conversion devices to produce power: gas turbines, fuel cells, and reciprocating engines. This process gives biomass tremendous flexibility in the way it can be used to produce power.

Gasification Process Description

Gasification is a two-step, endothermic (heat absorbing) process in which a solid fuel (biomass or coal) is thermo chemically converted into a low- or medium-Btu gas. In the first reaction, pyrolysis, the volatile components of the fuel are vaporized at temperatures below 600°C (1100°F) by a set of complex reactions. Included in the volatile vapors are hydrocarbon gases, hydrogen, carbon monoxide, carbon dioxide, tar, and water vapor. Because biomass fuels tend to have more volatile components (70-86% on a dry basis) than coal (30%), pyrolysis plays a larger role in biomass gasification than in coal gasification. Char (fixed carbon) and ash are the pyrolysis by-products which are not vaporized. In the second step, the char is gasified through reactions with oxygen, steam, and hydrogen. Some of the unburned char is combusted to release the heat needed for the endothermic gasification reactions.

Advantages:

- Gasification is an additional process step that not only produces a more easily used fuel form for power generation equipment, but provides the means to remove fuel components that are problems for downstream power generation systems.
- Gasification gives biomass the flexibility to fuel a wide range of power systems: gas turbines, fuel cells, and reciprocating engines.
- A wide variety of biomass materials can be gasified, many of which would be difficult or impossible to burn otherwise.
- Gasification offers one means of processing waste fuels, many of which can be problematic. Gasification and conversion to energy is an outstanding alternative to expensive and environmentally unfavorable disposal in landfills.
- It is easier to distribute and control a gaseous fuel.
- Gasification coupled with advanced conversion cycles reduces air emissions per kWh of electricity produced.
- A gaseous fuel allows biomass to leverage the high efficiency power generation capabilities of combined gas and steam cycle plants and fuel cells.

Gasification Technology

Air-blown fixed-bed and fluidized-bed gasifiers appear to have several advantages for biomass power systems. The oxidant for the gasification process can be either atmospheric air or pure oxygen. Oxygen-blown gasifiers offer a higher-Btu gas and faster reaction rates than air-blown systems, but have the disadvantage of additional capital costs associated with the oxygen plant. Currently, the preferred equipment for biomass integrated gasifier power systems is the air-blown gasifier, which produces a gas diluted with nitrogen from the atmosphere.

A second consideration for gasifiers is the choice between dry-ash and slagging gasifier designs. The slagging gasifier requires substantially less blast steam injection for the gasification process and, because it operates at higher temperatures, the gasifier has the potential for greater throughput capacity.

There are also alternative methods for transferring the heat from char combustion to the gasifier feedstock. In direct combustion gasifiers, the char is burned in the vessel where thermo chemical reactions occur. Indirect gasifier systems, on the other hand, utilize a separate reactor for char combustion from which heat is transferred to the gasifier reactor. With the latter system, nitrogen from the atmosphere and the combustion process is kept from combining with, and subsequently diluting, the product gas.

Options on Gasification Technology

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Fixed Bed Gasifiers

The most successful of the fixed-bed designs is the updraft gasifier, in which the biomass is fed from the top of the gasifier and successively undergoes drying, pyrolysis, char gasification, and char combustion as it settles to the bottom of the gasifier. The product gas is removed from the top of the gasifier and the ash from the bottom. Blast air and steam are injected into the gasifier to keep the ash below melting temperatures (in a dry-ash gasifier) and to facilitate char conversion. The product gas from this process has a low velocity and low temperature. The low operating temperature creates a considerable amount of condensable oils and tars in the product gas. However, the filtering effect of the bed and low stream velocities create a product gas with low particulate concentrations.

Because of the volatility of biomass, the excellent heat transfer design, and high peak temperatures found in the fixed-bed design, carbon conversion efficiency is typically 99%; the hot gas efficiency is in the range of 90-95%. Furthermore, the design and operation of the fixed-bed is relatively simple and is the most widely used commercially. The fixed-bed gasifier, however, requires large, dense, uniformly sized fuels. Thus, agricultural residues would generally require densification, thereby increasing fuel-handling costs.

Low Pressure Gasification

The Vermont Gasifier operates at low pressure, has a high throughput, and produces a medium-Btu gas that can directly fuel a standard, unmodified gas turbine. DOE is currently co-sponsoring a scale-up demonstration of a low-pressure gasifier in Burlington, Vermont.

This process uses two reactors where two separate chemical reactions take place. In the first reactor, biomass is surrounded by hot sand where pyrolysis takes place and the volatile chemical components of biomass separate from the remaining solids consisting of char, ash, and the sand. The gases are separated from the solids in a cyclone separator, and the sand and char move on to the second reactor. There the char is burned to provide heat for the pyrolysis and gasification in the first reactor.

The gas passes through a scrubber to remove particulate matter to meet the particulate specifications of a gas turbine. The resulting gas has a medium-Btu content of about 500 Btu per cubic feet and is suitable for fueling a standard gas turbine.

Fluidized-Bed Gasifiers

In a fluidized-bed gasifier, a continuous feed of biomass and inert heat-distributing material (i.e. sand) is "fluidized" by an oxidant and/or steam. There are two options for the way in which heat is supplied to the gasifier. In a directly heated fluidized-bed gasifier, heat required for gasification comes from char combustion in the gasifier reactor.

In an indirectly heated fluidized bed gasifier, char is removed from the gasifier and burned in a separate vessel. The resulting heat is transferred to the gasifier by either in-bed heat exchangers or by recirculating the inert bed material heated in the char combustor. The advantage of indirect heating is that gasification product is not diluted with the char combustion by-products.

In either design, pyrolysis takes place throughout the bed and is not localized. Because the injected air prevents the ash from melting, steam injection is not always required. As in the fixed-bed design, the product gas is drawn from the top of the gasifier. The superior mixing, which occurs in the fluidized-bed, generates excellent heat and mass transfer which subsequently yield uniform temperatures, better fuel-moisture utilization (fuel moisture to keep bed temperatures below the ash melting temperatures), and faster reactions. These benefits allow higher throughput capabilities, which, in turn, can reduce the size and capital cost of the gasifier. Also, although the peak temperatures are lower, the average temperature in a fluidized-bed is greater than in a fixed-bed. A significant amount of tars and oils are converted into permanent gases.

Product gas composition, carbon efficiency, and hot gas efficiency for the fluidized-bed process are comparable to those found in the fixed-bed designs. Fluidized-bed designs, however, are capable of handling much smaller, less dense, and less uniform feedstocks. In fact, the fuel and fuel handling systems are more likely to set the lower limits for the acceptable bulk density. A shortcoming of the fluidized-bed design is the high particulate level in the raw gas.

Small Modular Biopower

Working with industry, the U.S. Department of Energy's Small, Modular Systems Project is developing small, efficient, and clean Bio-power systems. Modular Bio-power systems have the potential to help supply electric power to the more than 2.5 billion people in the world who currently live without it. Small, modular Bio-power systems have the potential to help supply electric power to the more than 2.5 billion people in the world who currently live without it. The potential exists because most of these people live in areas where large amounts of biomass are available for fuel. Small systems, with rated capacities less than 5MW, could potentially provide power at the village level to serve many of these people and their industrial enterprises.

Small biomass systems also have a great potential market in industrialized regions of the world in distributed applications. These applications consist of power generation attached to the transmission and distribution grid close to where the consumer uses electricity; some might be owned by the consumers and would be connected to the power grid on the customer side of the electric meter. Both of these applications have large potential markets both inside the United States and abroad.

Compared to fossil fuel-based small, modular power systems predominating today's markets, biomass provides a more environmentally acceptable alternative. Furthermore, successful commercialization of small Bio-power systems completes the development of a Bio-power industry covering a range of power applications, including small systems for village power or distributed applications; combined heat and power systems for industrial applications; and cofiring, gasification, and advanced combustion for utility-scale power generation.

Working with industry, the U.S. Department of Energy's Small, Modular Systems Project is developing small, efficient, and clean Bio-power systems. The project consists of feasibility studies, prototype demonstrations, and proceeding to full system integration based on a business strategy for commercialization.

Thermal Decomposition

Thermal destruction technologies that are applicable to waste include the following:

Plasma Torch

A plasma torch system uses energy from a thermal plasma arc, generated by Joule or inductive heating of a gaseous electrical conductor, to destroy organics and melt inert waste components. The plasma arc is generated within the furnace primary chamber by a cylindrical, hollow electrode that is moveable within the furnace to direct the plasma torch onto the waste. Several configurations of plasma torches are available. The most common type is the arc plasma torch (APT) with electrodes made of copper or refractory metals. A plasma torch without electrodes, called an induction plasma torch (IPT), is also available. Plasma heating is accomplished by initiating and maintaining an electrical conducting path through a gas injected into the center of the torch (the plasma arc column), and using the resistance of the arc to convert electricity into heat. The initiation and maintenance of the plasma arc is the function of the plasma torch.

The most common design is the vortex-stabilized torch. A plasma gas is injected tangentially between the rear electrode and the front of the torch. The rotating gas or vortex forms a low-pressure central core on the common axis of the electrodes within which the plasma arc is stabilized. Efficient mixing of the plasma column and the surrounding gas generates a volume of high-temperature gas that is used as a heat source. The range of gas velocities is about 650 to 2000 ft/sec at the front of the torch causing rapid mixing and heating of the ambient gas. The plasma arc column is generated at about 12,000°C (21,500°F) and heats the surrounding gas to an average bulk temperature of about 4,000°C (7,200°F). Heating with the APT and IPT is by high-temperature gas convection, radiation from the plasma arc, and reradiation from the furnace walls. About 60 to 65% of the thermal energy that reaches the work piece or feed material is absorbed, the remainder is lost to the walls of the furnace or as enthalpy of the effluent gas.

Arc plasma torches incorporate two basic electrode types, the transferred and non-transferred. Both the transferred and non-transferred arc require positive and negative attachment points between the plasma arc and a solid electrode. The non-transferred type of torch uses internal metallic rear and front electrodes as arc attachment points. The transferred type of torch uses the rear electrode for the internal attachment point and a conductive hearth, or melted pool of waste, as the external attachment point to complete the electrical circuit. Thus, the transferred arc torch also generates heat in the workpiece by Joule heating.

The induction plasma is generated and maintained without electrodes or attachment points by a high frequency alternating current. However, a non-transferred arc must be struck within the electrode to form a current carrying path for the induction plasma to be initiated. The inductive coupling between the flowing gas and the induction coil heats a portion of the gas to plasma temperatures. For some applications, the IPT is capable of slightly higher plasma temperatures because of the absence of arc attachment points. However, the need for high-frequency power to provide adequate electromagnetic coupling between the induction coil and gas volume limits the available power levels. The containment vessel must be transparent to the magnetic field and non-metallic so that high currents and heat are generated in the gas volume and not in the containment vessel.

The electrode of the arc plasma torch is the only consumable part of the torch. It is water cooled to retard the rate of metal loss through vaporization at the attachment points and subsequent electrode failure. However, water-cooling of torch components results in energy loss due to absorption of heat from the plasma arc and the furnace environment. These losses range from 8% for the transferred torch to a high of 30% for the non-transferred torch. The useful life of the electrode is determined by the materials used to fabricate it and by the arc current density at the attachment point. Copper is the preferred electrode material because of its high thermal conductivity and diffusivity. The copper may be alloyed with zirconium or chromium to improve its strength and oxidation resistance at high temperature. High current densities significantly shorten the life of the electrode due to erosion by the high-current arc.

Input Stream

Waste is introduced into the furnace into a molten bath of material, which could be inert waste or other material. The high temperature plasma zone and the molten bath (in excess of 1650°C) pyrolyze (or combust) the organics and melt all other inert materials into the bath. Volatile organics are further treated in a secondary combustion chamber. Very small gas volumes are required for the plasma arc, resulting in low off gas volumes.

This technology has minimal application to wastes containing water. Small amounts of moisture may lead to steam explosions unless provisions are made for adequate venting of the drums containing wet solids or liquids. The plasma arc may also have minimal application to organic liquids unless, again, the drums are adequately vented or the liquids are metered and sprayed into the plasma zone; however, this technique could cool the plasma and would require testing and demonstration of its viability and determination of the off gas constituents. Applicability to contained liquids and associated hazards needs to be determined.

The plasma arc is highly applicable to dry homogeneous and heterogeneous solids. Drums and heterogeneous solids can be slowly inserted into the furnace at their melt rate and dripped into the molten bath. Material from the drum will also melt and/or flow into the molten bath and be further melted. However, care must be taken to prevent excessive amounts of volatile or energetic material from entering the furnace at too rapid a rate to prevent pressure excursions.

Output Streams

Molten solid material can be removed continuously by overflow or poured by batch. The solid byproduct is a vitrified slag that stabilizes entrapped toxic metals and radionuclides. An off gas system is required to treat the off gas for particulates and volatilized organics, heavy metals and radionuclides.

Advantages

The technology is generally well known and has been used on an industrial scale for metal production. It is applicable to a wide range of waste streams and matrices, both homogeneous and heterogeneous, including high melting-point materials, metals, non-metallic inorganics, and organic/combustible material. It is thought to be a robust technology that may minimize the need for characterization. The technology operates at very high temperature to provide destruction & stabilization in one unit. The carrier gas can be varied to achieve an oxidizing or reducing environment.

Disadvantages

Waste composition will affect the melt and waste form characteristics as well as the off gas composition. High temperatures may lead to high NOx levels and increased volatilization of heavy metals and radionuclides. Thus, waste segregation may be required. A secondary combustion chamber is required to achieve the 99.99% destruction and removal efficiency required for toxic organic wastes. Highly combustible organics can result in pressure surges that overload the APC system, and high turbulence of the carrier gas may cause excessive particulate carryover.

The metal electrode requires water-cooling thereby decreasing the energy available to the material being processed, and introducing the possibility of injecting high-pressure water into the furnace in the event of an electrode failure. Torch life is severely limited so that provisions are required for frequent electrode maintenance and replacement.

Technology Status

There are several companies that have plasma systems of various designs available for waste treatment. The DOE for application to mixed waste has tested two of these plasma systems extensively. Commercial application of many of these plasma systems has been limited to hazardous waste, although at least one system is being used in Europe for mixed waste. Companies that have plasma torch systems include Startech Environmental, Westinghouse Plasma, IET, ReTech, PEAT, MeltTran, Resorption Canada Ltd, and Thermal Conversion Corp.

DC Electric Arc Furnace

Electric arc melters are high temperature melters that were first developed in the metal processing industry. Arc melters function by using DC current to maintain an arc between a carbon (graphite) electrode(s) and the processed material. The high voltage between the electrode and the molten waste (or conducting hearth) creates a high temperature plasma arc that is capable of melting contaminated soils and other wastes producing a durable, glassy, final waste forms similar to long-life natural analogues (e.g., basalt). Arc melters differ from plasma melters in that no plasma torch or torch gas is used. With this technology, a submerged arc mode of operation is possible taking advantage of a cold cap to reduce the evolution of volatile metals.

In the electric arc process, the carbon electrodes are consumed. As the tip is consumed, the electrode is lowered to maintain the desired arc length or to maintain the electrode submerged in the melt. In order to reduce electrode consumption, the gas space above the melt is maintained under reducing conditions. Therefore, arc melters are operated as pyrolyzers to drive off organic materials. The high temperatures of the molten bath quickly destroy the organic components while melting the inert material into a glassy slag. Material feed for a closed furnace can be provided through feed handling chutes, hollow electrodes, or a series of air-lock doors. Molten metal and glass waste products are periodically transferred to their respective waste receipt canisters through a heated bottom drain and/or heated overflow section.

Heat is transferred to the melt by convection from the plasma gas, radiation from the arc, reradiation from the surrounding refractory walls, and Joule heating from the current flow through the melt. Because of the direct radiation from the arc, higher melt temperatures can be sustained with an arc furnace relative to a Joule heated melter. Successful operation of an arc furnace requires maintenance of a stable arc.

Input Stream

The DC Arc is applicable to the same wastes as the Plasma Arc. It is applicable to soils, sludges and debris, containers of buried and stored wastes, and weapons components stored at DOE sites.

Waste materials fed into the system are melted into the bath. Organics are pyrolyzed at the high operating temperatures and may be destroyed in the plenum or in a suitable afterburner. Oxide materials, including many hazardous and radioactive species, are immobilized in the durable glass/slag phase. Metals are converted to a denser molten-metal phase.

Output Streams

Organic material vaporizes and decomposes, and inorganic material is melted producing a slag. Molten metal and glass waste products are periodically transferred to their respective waste receipt canisters through a heated bottom drain and/or heated overflow section. The solid byproduct is a vitrified slag that stabilizes entrapped toxic metals and radionuclides. An offgas system is required to treat the offgas for particulates and volatilized organics, heavy metals and radionuclides.

Advantages

This technology is generally well understood having been adapted from well-established industrial processes. It has essentially the same advantages as the plasma arc; however, it is somewhat simpler and safer to use (no cooling water) and requires less down time because there is no torch that requires replacement. Graphite electrodes do not require water-cooling and they permit higher levels of dc arc current, providing the capability to transfer large amounts of heat to the material to be processed. The ability of the graphite electrode to operate in the submerged mode decreases the emissions from the furnace, including emission of volatile metals. It is a single, high-temperature thermal process that has the potential to treat a wide range of wastes, thereby minimizing the need for multiple treatment systems. The DC Arc minimizes the need for extensive sorting and segregating large volumes of waste, reduces the final waste volumes, produces a leach resistant waste form, and destroys organic contaminants.

Disadvantages

High temperatures may lead to high NOx levels and increased volatilization of heavy metals. The Graphite Electrode DC Arc has a high rate of electrode consumption, and use of an oxidizing atmosphere to combust organics increases electrode consumption.

Technology Status

Nonradioactive and radioactive bench-scale tests have been completed on waste surrogates at Idaho National Engineering and Environmental Laboratory in FY96, and at Savannah River Site on simulated Plutonium-238 contaminated job control waste in FY97.

Nonradioactive bench-scale tests and engineering-scale real waste demonstrations were completed on Pantex classified waste in FY98 that allowed disposal as a nonclassified, low-level waste in FY98.

Knowledge gained from the DC Arc and other high-temperature melter programs was used by the commercial sector to develop a second-generation plasma-assisted joule-heated melter. Two of the second-generation melter systems commercialized by Integrated Environmental Technologies have been sold to Allied Technology Group for use at Hanford's Environmental Technology Center in Richland, Washington. Electro-Pyrolysis, Inc. is also building and commercializing DC arc systems.

Molten Salt Oxidation

The molten salt oxidation process uses a bath of molten salts maintained at 900 to 1000^{o}C to oxidize organic wastes (primarily organic liquids) and retain radionuclides and metals in a salt residue. In the process, air and wastes are fed into a ceramic-lined vessel containing the molten salt. For most waste materials appropriate for treatment by MSO, the heat of oxidation may keep the salt molten, but for some wastes, such as those with large water content, supplemental heat such as natural gas or fuel oil may be required. The salt, which typically contains sodium carbonate, in theory may be reprocessed for reuse, reducing the volume of contaminated salt residue requiring disposal. Since acids formed in the oxidation process are scrubbed by the alkaline carbonate bed, the only off gas control systems needed are particulate removal devices (e.g., prefilters and HEPA filters).

The salt typically used in the MSO process is sodium carbonate, or sodium carbonate mixed with other salts such as potassium carbonate. The molten salt bath acts as a dispersing medium for both the waste being processed and the air or oxygen used in the process. It enhances completeness of chemical reactions by providing better physical contact and a stable heat transfer medium that resists thermal surges. In addition, it acts as a catalyst for the oxidation reactions and accelerates the destruction of organic material. Under steady state conditions, a melt overflow stream would leave the bed continuously to purge ash and sodium chloride. An equal amount of sodium carbonate is added. Reportedly, the salt melt will retain most of the metals and radionuclides, although there is insufficient information available on the fate of currently regulated metals.

The molten salt is typically discharged when its accumulated ash content reaches approximately 20 percent or a dissolved impurities content is high enough to have a negative effect on acid gas retention or other operating parameters. Undissolved impurities include various metal oxides and silicates. Dissolved impurities are primarily salts such as sodium chloride, sulfate, or phosphate. If sodium carbonate recycle is utilized, the partitioning of impurities and recycling operation must be designed for the specific impurities involved.

Input Stream

MSO treatment is considered applicable to waste streams with high organic content and ash residuals less than 10%. Other limiting factors for waste streams that can be fed to the MSO include chlorine content, as chlorides also accumulate in the melt, and volatile metal content. Ash accumulations within the bath itself must be limited to about 20 percent; sodium carbonate must be added to keep the melt concentration at an operable level.

According to an OTD Technical Review Panel, wastes potentially suitable for treatment by MSO include contaminated paper products, cloth, graphite, halogenated organic liquids, leaded rubber, oil, organic sludge, PE/PP and some other plastics, rubber and wood.

Certain organic waste streams will require pretreatment. Thick sludges may have to be diluted to facilitate pumping into the molten bed. Since large amounts of water cannot be used due to excess steam release and energy requirements, an alternative would need to be investigated. Solids will have to be sorted to remove most metals and the size must be reduced to approximately 0.125 inches.

Output Streams

The discharged carbonate salt contaminated with excess ash or chloride is a waste that must be disposed unless steps are taken to separate the unspent sodium carbonate for recycle. Without recycle, the volumes of waste may be up to five times that which would be generated by incineration. According to DOE studies, the MSO process residue (on a mass basis) without recycle, with stabilization for disposal was 60% of the incoming waste mass. With recycle, the final waste mass was 38% of the incoming waste mass (still higher than what would be generated by incineration). However, depending on the incoming waste stream's ash and chloride content, the final volume can vary from less than the initial volume to more than the initial volume. Development of an acceptable waste form for LDR disposal or delisting of materials in the waste is needed.

The absence or presence of dioxins/furans in the MSO offgas needs to be determined, as no measurements have been made of these species in tests to date. Bench scale data generated indicate that carbon monoxide levels higher than those allowed for incinerators are emitted at moderate chlorine levels in the molten salt bed.

Advantages

- This technology may be able to successfully process difficult-to-treat wastes such as nuclear grade graphite and tributyl phosphate and may be suitable for other problem waste streams such as sodium metal.
- MSO operating systems may be constructed in relatively small units for small quantity generators.
- The process has shown excellent destruction and removal efficiencies (DREs), notably HCl destruction.

Disadvantages

Technical issues that may hinder development of MSO for treatment of mixed wastes include:

- Potential for increase in viscosity of the molten salt with high chloride or ash contents.
- Potential for build up of metals in the reactor vessel with extended operation. It is known that lead and aluminum may form a separate phase in the salt melt, but it is not known how this may affect operation.
- Bench-scale tests have shown generation of products of incomplete combustion, some at levels as high or higher than typically found in hazardous waste incinerator off gas (it has been suggested that higher melt residence times will be required to obtain lower PIC levels).
- Potential for corrosion of materials and formation of foreign salts, tars, and carbon residue under reducing conditions.
- Potential for entrainment of salt in the off gas and subsequent plugging of the off gas ductwork.
- Either pre-characterization of input to monitor parameters including chemical reactivity, and chloride and ash content, or extensive monitoring of salt reactivity (by remote monitoring of ash content and breakthrough point monitoring of effluent gases) is required. Insufficient characterization will increase the probability of process failures.

Technology Status

Rockwell International has conducted bench scale tests of the process on several organics, including chlordane and polychlorinated biphenyls. Demonstration scale tests from 150 to 2,000 lbs/hr were run on gas streams, combustible solids and various organic forms. This work was sidelined in the late 1970s as incineration became a common, relatively inexpensive form of waste treatment. However, interest has been revived recently, as alternatives to incineration have been sought.

Rockwell has used a MSO unit to destroy and oil/TCE mixture at the rate of 0.25 lbs/hour using a bench-scale, one-stage reactor made of ceramic material. The Rockwell team claims to have controlled the problems of salt melt viscosity (by use of appropriate additives) and salt-aerosol entrainment in the off-gas stream. In addition, Rockwell has been able to reprocess the salt for reuse.

LLNL has developed a two-stage molten salt unit that uses a low-temperature (750° C) reducing stage followed by a higher temperature (> 900° C) oxidizing stage and has conducted numerous test runs of several hours each. Currently, MSO systems are not available commercially for the treatment of MLLW; however, they are under consideration for limited applications at a few DOE sites.

Rotary Kiln Incinerator

Typical incinerator facilities include structures and systems for receiving, sorting, storing, and preparing the waste; burning the waste in the rotary kiln and the secondary combustion chamber; air pollution control and residue and ash handling.

The rotary kiln is a horizontal cylindrical refractory lined shell that is mounted on a slight slope. Rotation of the shell transports the waste through the shell as well as mixing the burning waste. The waste may move either concurrent or countercurrent to the gas flow. The residence time of waste solids in the kiln is generally o.5 to 1.5 hours. This is controlled by the kiln rotational speed (typically 0.5 to 1.0 revolution per minute), the waste feed rate, and whether or not internal dams are used to retard the rate of movement through the kiln. The feed rate is also adjusted to limit the amount of waste being processed in the kiln to at most 20% of the kiln volume.

The primary function of the kiln is to convert solid waste and organic contaminants to gases, which occurs through a series of volatilization, destructive distillation and partial combustion reactions. An afterburner is necessary to complete the gas-phase combustion reactions. The afterburner is connected directly to the discharge of the kiln where the gases exiting the kiln are directed into the afterburner chamber. A "hot cyclone" may be installed between the kiln and afterburner to remove solid particles that might otherwise create slagging problems in the afterburner. To insure adequate mixing and sufficient oxygen, the kiln is normally operated with 50 to 250% excess air and the afterburner with 120 to 200% excess air.

The afterburner is usually a simple refractory lined cylinder (either horizontally or vertically aligned) equipped with one or two waste burners. Liquid hazardous waste may be fired through separate burners in many afterburners. In some cases, aqueous waste streams may be fired into the afterburner as a temperature control measure. Both the afterburner and kiln are usually equipped with an auxiliary fuel firing system to bring the units up to temperature and to maintain the desired operating temperatures. Typical operating temperatures in the kiln are 1200 to 2300° F, and in the afterburner 2000 to 2500° F.

Following the incineration process, combustion gases typically need to be treated in a air pollution control (APC) system to remove particulates, vaporized metals, organic products of incomplete combustion, SOx and NOx. The presence of chlorine or other halogens in the waste will require a scrubbing or absorption step to remove HCl or other halogen acids. A typical APC system includes a water-spray quench column (gas cooling and conditioning) followed by a venturi scrubber (particulate removal), packed bed (acid gas removal), and a demister to reduce the visible vapor plume. The off gas may then be heated (reheater) to remove liquids as the offgas is passed through HEPA filters, which remove most of the remaining particulate matter, both chemical and radioactive.

The inorganic components of the waste are not destroyed by incineration. These materials exit the incinerator either as bottom ash from the combustion chamber, as contaminated scrubber waters and other APC residues, and in and in small amount in air emissions from the stack.

Ash is commonly air-cooled or water quenched after discharge from the combustion chamber. From this point it is frequently stabilized to meet LDR regulations, placed in containers and sent to a MLLW disposal facility. In the TSCA incinerator, the ash is discharged from the kiln into a mix chamber that deposits the ash into a water sump. A drag flight conveyor removes the ash from the sump and discharges it into 55-gal drums. In the CIF, ash drops from the discharge end of the kiln into a water-filled ash collection tank.

Input Stream

Rotary kilns are versatile in that they are applicable to the destruction of a wide variety of wastes including solid wastes, soils with organic contamination, slurries, containerized waste and liquids. Because of the rotary motion of the kiln, excellent mixing of the waste and contact with the combustion gases is achieved. Thus, inert solids such as soils contaminated with organics can be treated.

The TSCSA incinerator is capable of treating a wide variety of solid, semisolid, and liquid waste, including various organic liquids, organic and inorganic process residues, organic chemicals, contaminated soils, and combustible and inorganic debris. Solid waste treated at TSCAI includes concrete, wood, plastic, graphite, filters, trash, rags, spent carbon, and personal protective clothing materials. The process has feed limits on such waste as fluorine, beryllium, chromium, mercury, and radionuclides. Incoming waste is blended to maintain parameters at the allowable limits. Waste feed-rates are based on the characteristics of the waste, including the waste heat content (Btu/lb). Control of the feed rates allows a maximum combustion rate of 30 million Btu/hour. The maximum annual capacity for incinerating liquid or solid waste is about 6 million lbs each, based on 300 days per year operation.

Three categories of waste are treated at CIF: organic liquids, aqueous liquids, and solids. All solids processed in the CIF are in approximately 21 **x** 21 **x** 21-in. boxes. A conveyor transports the boxes through several stations, where the boxes are checked for radiation dose rate, weight, and presence of containerized liquids and metal objects by x-ray.

Output Streams

Combustion conditions are typically adequate to meet regulatory requirements (e.g., destroy over 99.9999% of the PCB TSCA waste and over 99.99% of the RCRA hazardous organics). Further, the offgas system must be designed such that the effluent gas released from the stack to the atmosphere meets emission requirements for other air pollutants.

The incineration process generates gaseous, liquid, and solid waste. Ash that fails the treatment criterion may be recycled for incineration or stabilized for disposal. Ash that meets the treatment criterion for TSCA waste (less than 2 ppm for PCBs) may be disposed offsite in 55-gal drums. Ash from waste that contained RCRA material must pass TCLP or be stabilized such that it passes TCLP prior to disposal.

Air pollution control residues are generated from the combustion gas quenching, particulate removal, and acid-gas absorption steps. Process residues include wastewater, adsorbents, organic and inorganic sludges, activate carbon, resins and HEPA filters. The aqueous streams arise from quench and scrubber blowdown, ash handling sump overflow, firewater and rainwater. These aqueous wastes contain entrained particulates, absorbed acid gases (usually as HCl), salts, and trace amounts of organic contaminants. Waters must be treated to remove the contaminants. Depending on the nature of the dissolved contaminants and their concentration after treatment, waters may be returned to the process, discharged to sewers or stabilized for disposal. Sludge from wastewater treatment is removed from sumps, dewatered and stabilized if necessary prior to disposal.

Advantages

Rotary kilns can process large volumes of waste and are applicable to a variety of compounds in various matrices. Because of the mixing process, they can treat non-combustible wastes such as soils contaminated with hazardous organics. As with other incinerators, rotary kilns, when properly designed, can achieve required destruction efficiencies.

Disadvantages

The excess air required for adequate mixing and exposure of the waste to oxygen produces large volumes of exhaust gas. As with other types of incinerators, heavy metals such as mercury are volatilized and dioxins/furans may be produced. These contaminants must be removed from the offgas prior to emission. Because of the mixing process, rotary kilns have high particulate carryover and, because of the rotary action, the kiln seal is difficult to maintain.

Technology Status

EPA currently designates incineration as BDAT for destruction of RCRA wastes. The rotary kiln is the most universal of thermal waste-treatment systems. These are many commercial vendors and operators of rotary kiln systems

Gas Phase Reduction

This process requires a preliminary thermal desorption process to convert organic contaminates to the gas phase. Vaporized organic wastes are mixed with hydrogen rich (>50% dry basis) gas at high temperature (850° C to 950° C) in an electrically heated reactor to accomplish nearly complete hydrogenolysis of the waste components. Hydrogenolysis reaction products are comprised primarily of light hydrocarbons (primarily methane and ethylene), plus some H_2O, CO, CO_2, and acid halogens formed depending on the oxygen, moisture, and halogen content of the waste stream.

"Seed" hydrogen is required for process startup. During steady-state operation, a fired steam reformer is used to generate hydrogen from a portion of the hydrogenolysis product stream. Moisture in the waste stream or added steam may also form some hydrogen via the water shift reaction.

Product gas from the hydrogenolysis reactor is quenched and cleaned in a multistage wet scrubber which employs:

- Packed bed caustic scrubbing to remove acid gas,
- Neutral oil scrubbing to remove residual higher molecular weight hydrocarbons (primarily benzene and naphthalene), and
- Scrubbing with monoethanolamine (MEA) to remove carbon dioxide.

Hydrocarbons are stripped from the neutral oil and routed to the steam reformer for destruction. Carbon dioxide is stripped from the MEA and discharged to the atmosphere. Removal of the carbon dioxide is necessary to help drive the reforming and water shift reactions, and to produce a high BTU product gas suitable for firing the process boiler, steam reformer, and gas heaters.

Gases exiting the scrubber are primarily hydrogen (60%), light hydrocarbons (30%), carbon dioxide (8%), carbon monoxide (2%) and traces of higher molecular weight or aromatic hydrocarbons, e.g., benzene and naphthalene. Gas in excess of that necessary for recirculation to the process is compressed, stored, and analyzed in preparation for use in firing process equipment. A co-fired (propane/process gas) boiler generates process steam for the steam reformer and liquid waste evaporator and also serves as an incinerator for excess process gas.

Since the hydrogenolysis reactions must be completed in the gas phase, a number of techniques and systems must be employed to desorb or vaporize waste principle organic contaminants (POCs) and transport them to the high temperature reactor:

- Aqueous wastes may be vaporized in a steam-heated evaporator and fed directly to the hydrogenolysis reactor.
- Concentrated organic liquids and evaporator bottoms may be injected via atomizing nozzles to the hydrogenolysis reactor.
- Organic constituents in a homogeneous solid waste matrix may be desorbed or vaporized in a thermal reduction mill (hot ball mill) or thermal desorption unit.
- Larger or monolithic solids may be treated in an insulated autoclave-like chamber called a sequencing batch vaporizer (SBV) to vaporize organic contaminants.

Recirculated product gas is used to purge these "head-end" systems and transport the desorbed, vaporized, or partially reacted contaminants to the high-temperature hydrogenolysis reactor. Purge gas is heated in gas fired or electric heaters for feed to the head-end systems.

Input Stream

Organic contaminated aqueous wastes and concentrated or pure organic liquid wastes are vaporized or atomized and injected directly into the hydrogenolysis reactor. Some filterable slurries, granular solids, and tractable caked and friable sludges containing organic wastes having relatively high vapor pressures may also be suitable for direct treatment by the process.

Significant hydrogenolysis does not occur at the relatively low temperatures existing in Eco Logic’s head-end thermal desorption systems. Typical combustible debris wastes will be degraded too slowly for practical application. Only debris wastes exhibiting easily desorbed surface contamination will be good candidates for processing with this technology.

Output Streams

POCs are completely destroyed by the process. Data from large-scale (several tons/day) demonstration tests have shown overall process DREs for PAHs and PCBs to exceed 99.9999% based on total organic feed and constituents measured in the stack emissions. Tests on wastewater containing about 3,700-ppm perchloroethane yielded a DRE of 99.99%. Aqueous and organic liquid wastes are completely destroyed in the hydrogenolysis reactor.

Volume reduction of solid or debris wastes will be limited by the extent to which head-end processes can separate hazardous components from matrix materials. This process will not particularly attack the combustible debris fraction. There should be no regulated secondary waste produced. The process features a high degree of internal waste recycle and has no waste generating side streams.

Advantages

- The Eco Logic process offers the possibility of closed loop operation with no uncontrolled emissions.
- The process provides complete destruction of POCs without formation of undesirable PICs such as dioxins and dibenzofuran.

Disadvantages

- The process uses and produces large quantities of reactive and combustible gasses.
- The process can only treat organics in the gas phase or particulate solids that can be entrained in a gas.

Technology Status

Eli Eco Logic has commercialized the technology and has built systems having a design capacity of 150 tons/day for contaminated soils and other solids, 60 tons/day for watery wastes, and 30 tons/day for concentrated (100%) PCB liquids.

The process is offered commercially as an integrated transportable (7-10 trailers) system for on-site hazardous waste treatment. Although all of the components have been demonstrated in an integrated hazardous waste treatment system, the process has not been demonstrated or implemented in radioactive service.

Catalytic Chemical Oxidation (CCO)

The CCO technology, which was developed by Lawrence Berkeley National Laboratory (LBNL), is an extension of catalytic conversion technology used in the automotive industry. It is a high-temperature, non-flame process that decomposes organic chemicals in the presence of alumina pellets and platinum-coated alumina pellets as catalysts. The primary focus at LBNL is treatment of tritiated mixed waste. Research institutions conducting life science and biomedical studies and the pharmaceutical industry invariably produce mixed waste containing tritium and other radioisotopes. Currently, there is no satisfactory disposal route for tritiated mixed waste of high specific activity. Therefore, the objective of CCO treatment is efficient conversion of hazardous organics contained in the tritiated wastes and subsequent disposal of the remaining radioactive wastes. Before this application, the technology had been applied successfully to destruction of hazardous organic chemicals for remediation projects. The LBNL process can accommodate and treat both organic and aqueous mixtures to a 99.999% DRE.

The CCO process consists of a preheater, an oxidation chamber, a heated packed-bed reactor filled with catalyst pellets, and an emission reduction device. The entire assembly is contained in a glove box enclosure. The operating temperature of the catalytic oxidation unit is in the 450–750° C range. During treatability studies, LBNL is constrained to process no more than 10 kg of liquid tritiated waste per year. At the maximum proposed flow rate, processing rates of approximately one L/day are feasible. DREs in excess of 99.999% have been demonstrated successfully with surrogate and actual mixed waste samples. The recovered tritium will be recycled; final disposition of the oxidation products will be determined by the outcome of a Delisting Petition.

Input Streams

Liquid organic or aqueous waste contaminated with hazardous organics and tritium.

Output Streams

The off gas contains carbon dioxide, tritiated water, and products of incomplete oxidation. The packed bed material may be a secondary waste stream depending on the content of the waste.

Advantages

Ability to treat tritiated wastes and recover chemicals.

Disadvantages

- Feasibility depends on the EPA delisting process to allow disposal of the remaining tritiated waste material as low-level, non-RCRA waste.
- Oxidation of hydrocarbons may be inhibited in the presence of nitrogen containing compounds.
- A continuous process has not been demonstrated at a scale larger than one L/day

Technology Status

The process at LBNL is fully operational for tritiated waste treatment at a capacity of one L/d. Other DOE sites and private industry have indicated an interest but no commercial system currently exists.

Plasma Gasification (Thermal Decomposition)

Plasma arc technology was developed and employed in the metal industry during the late 1800s to provide extremely high temperature. During the early 1900s, plasma heaters were used in the chemical industry to manufacture acetylene fuel from natural gas. This application remains the largest (150 megawatt) plasma heater industrial plant in the world, located in he Chemische Were Huls plant, Marl, Germany.

Plasma Arc heaters received renewed attention when the United States NASA Space program, during the early 1960s, evaluated and selected Plasma Arc Heating technology for simulating and recreating the extreme high heat of reentry into the earth's dense atmosphere encountered by spacecraft from orbit. Using a water-cooled copper electrode, a 50 megawatt arc heater was used to convert electricity into heat in order to test the reentry heat shield material from NASA.

Subsequently, small scale prototype plasma heater processes were built and tested during the decade of 1970s. Large-scale industrial plants were built and commissioned during the decade of the 1980s. Today, plasma technology is being used successfully in industrial plants worldwide for different applications ranging from chemical industry and metallurgical industry to the waste/environment industry.

General Plasma System

Leading companies in the field of plasma technology have tested, treated and analyzed hundreds of waste streams at industrial capacity (from several hundred kilos to over two metric tons per hour) over many years. These tests and/or treatment periods are at times performed on behalf of certain clients (public or private) and at other times as part of our R & D efforts, which have resulted in hundreds of patents.

The waste streams, which were successfully treated and disposed of by plasma arc technologies, include (but are not limited to):

1. Municipal solid waste
2. Automobile tires
3. Waste coal
4. Coal
5. Sludges
6. Hazardous fly ash
7. Incinerator ash
8. Steel scrap
9. Car fluff
10. Hospital medical waste
11. Pyrolysis of PCB oil
12. Ferrous chromium containing waste
13. Portland cement manufacture waste
14. Pathological wastes
15. Ferro-manganese reduction
16. Electric arc furnace dust
17. Titanium scrap melt
18. Asbestos containing material
19. Asbestos fibers
20. Niobium recovery
21. Glass waste
22. Ceramic waste
23. Harbor Sludges
24. Natural gas for acetylene production
25. Solvents

26. Paints

27. Low level radioactive waste

28. Contaminated landfill material

29. Mixed source waste (combination of different waste source with MSW, ash, coal, tires, etc.)

30. Contaminated soils and fines

Based on the experience resulting from applications the following specific information on the treatment and disposal of each and every waste stream is available; these data include

a) The SER (Specific Energy Requirement} for each waste stream, i.e. the amount of energy required within the plasma system to completely gasify and vitrify a ton of the specific waste stream.

b) The cost of operation per ton of waste,

c) The behavior of each waste stream within a plasma reactor

d) The optimum capacity of the plant for each waste stream,

e) The heat and material balance for each waste stream,

f) The characteristics and composition of the synthesis gas generated by the waste stream under plasma PPV conditions

g) The energy content of the fuel gas and the energy recovered from the gas either in the form of electricity or liquid methanol fuel, etc..

h) The characteristics and safety of the vitrified slag, its TCLp limits, etc..

i) The environment impact of our system

j) The air pollution control/gas scrubbing system required for each waste stream

k) The optimum waste condition/composition to generate the maximum energy/material recovery.

Commercial Viability of Plasma Technology

The majority of plants utilizing the different plasma torches and plasma heating systems have been in use typically 24 hrs a day year round (except for routine maintenance) at industrial capacity and have a life expectancy/guarantee for over 15 years (depending on size and applications, of course).

For example, the GM plant in Defiance, Ohio, employs six (6) Marc II 2.5 megawatt torches simultaneously, handling over forty tons per hour of scrap metals, while the Geneva plant in Utah utilizes nine (9) Marc II 2.5 megawatt torches simultaneously to treat over 60 tons per hour. The Alcan plant treats Aluminum waste 24 hrs a day with an exceptional equipment longevity (the longest torch electrode life ever demonstrated in plasma industrial plants) despite the caustic nature of the waste material.

Currently implemented projects clearly demonstrate that the plasma arc technology is a well-proven, well-demonstrated commercially viable technology, which is currently utilized in industrial plants worldwide.

Plasma Technical Details

Plasma is the fourth state of matter and is an ionized gas resulting e.g. from electric discharge. Plasma causes the gasification and molecular dissociation of organic matter at a temperature of approximately 2000 deg C. Adding some steam to the process causes the gasification to occur in a few milliseconds; there are no any intermediate reactions. Since there is no oxygen available there is no burning in any form, no furans, dioxins, fumes and ashes are formed. Simplifying the processes can be set as follows:

Molecular dissociation

□ Thermal cracking (pyrolysis)
□ Partial oxydation in the presence of steam vapour:
$C + H_2O \rightarrow CO(g) + H_2(g)$
$C + 2\ H_2O \rightarrow CO_2(g) + 2\ H_2(g)$
$C + CO_2 \leftrightarrow 2\ CO(g)$

The result of plasma gasification is a highly energetic synthesis gas, which is composed in 80% of hydrogen and carbon monoxide.

Plasma thermal reactors are clean burning enough to pass strict new emission regulations and are also affordable, fully automated, reliable and able to burn the great variety of waste and biomass fuels continually produced. Plasma technology harnesses biomass energy and is the cleanest biomass energy technology available. Plasma technology has been in development over the past 25 years. Extensive testing of 11 patented prototypes of various sizes and configurations has been completed. numerous prototypes are still in operation, in service for as long as 10 years. The U.S. Department of Energy has also extensively tested the system. Numerous commercial units have been constructed and are currently operating. Units have been designed to treat as little as 1

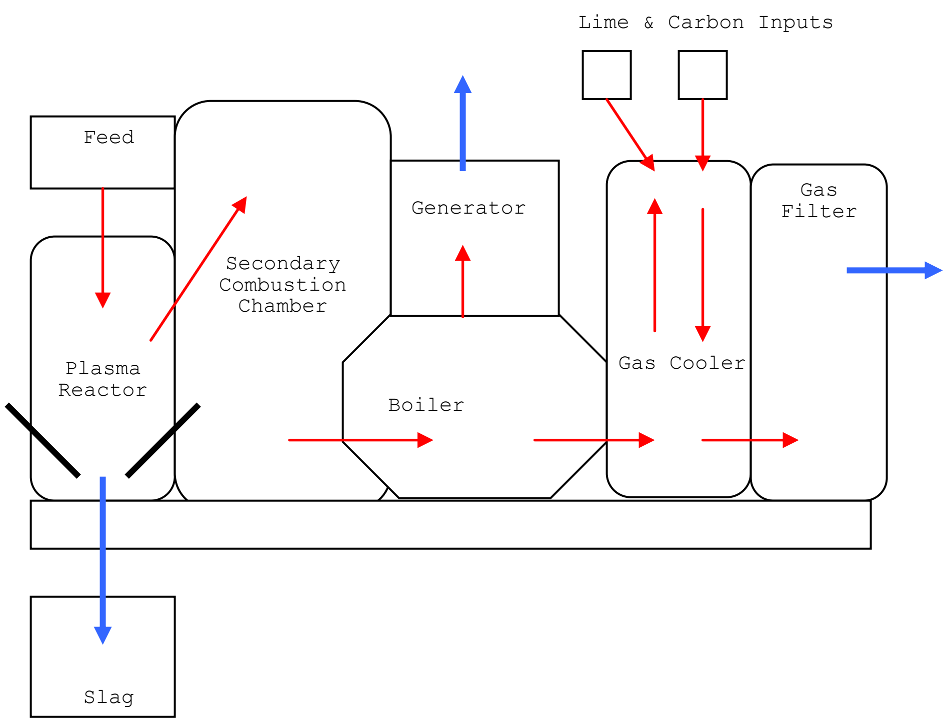
TPD and as much as 3,000 TPD of solid waste. Because plasma technology is so clean and simple and capable of handling such a diversity of fuels, it should be ideally suited for applications where biomass waste disposal is a priority need and presently available solutions are extremely costly and complex. This means SE Alaska!

Seven companies in the United States have developed commercial units including Westinghouse-Plasma, Startech Environmental, Integrated Environmental Technologies, Meltran, ReTech, PEAT and Thermal Conversion. Detailed information was obtained and reviewed from all seven companies. Four facilities were visited and observed in operation. Westinghouse was selected as the company with the most mature and reliable plasma technology. The company has been in business the longest and operates the largest plasma facilities used to burn solid waste and produce energy.

The location selected to carry out the proposal is in Wrangell, Alaska. Wrangell is a small-decentralized community with both woodwaste and municipal solid waste concerns. The City is seeking economic development opportunities and has land available for use. The City has need for the power and steam heat. Wrangell presents a centralized location in SE Alaska ideal for deploying the technology.

Plasma Facility

The following layout illustrates a typical plasma facility for managing solid waste:



Solid waste is recycles to remove whatever component is profitable to collect and sale. The remaining waste is shredded to large size and placed by grapple or conveyor into a preheated plasma reactor. Electrodes heat the core of the reactor to apx. 15,000 C. The ambient temperature in the reactor is apx. 5,000C. These temperatures are 100 to 300 times hotter than convention incinerators. At these high temperatures, organic waste is molecularly dissociated into synthetic gas (CO and H_2). Metal and glass fall to the bottom of the reactor and are removed as molten slag or vitrified glass. This material is completely inert and valuable. Options for its use include fritting to produce aggregate, spinning to produce rock wool insulation, or molding to produce tiles and blocks. Synthetic gas is passed to a secondary combustion chamber where traces of residual organics are combusted to purify the synthetic gas, which is actually cleaner than LPG but has less BTU value. The synthetic gas is then burned in a boiler to produce stream and drive an electric generator. Power is produced from the energy one lock-up in the waste. A facility that burns apx. 200 TPD solid waste will generate 20MW of power. During the power production process, low pressure steam and heat are also produced. Combusted gas from the boiler is cooled, scrubbed and filtered before release to the environment. Lime and activated carbon are added to purify boiler gas. Fly ash removed from the boiler is recycled to the plasma reactor for vitrification. Pure condensed water (distilled water) is removed from the boiler and can be used.

Plasma thermal decomposition of biomass is as clean a process to manage solid wastes as is currently known to man. This technology is growing rapidly in Scandinavia, Europe and Asia. The rapid deployment of the technology is tied to landfill bans. Landfilling in these countries is expensive due to rainfall, rugged terrain and crowded conditions. These are similar circumstances tot those noted in Alaska. The most attractive option to the facilities is their ability to burn any solid or industrial waste in a clean manner and produce power.

A typical installation of a capacity 150 000 t/year of municipal and industrial wastes will produce 12 MW of electric power, 4 MW of heat and about 45 tons/year of liquid ethanol that can be used as an ecological component of gasoline.

Plasma Arc Heaters use electricity as a source of energy and convert it into a clean, low mass heat. Low mass heat means that very little gas is used to generate the "plasma. Plasma conducts electricity like a metal wire and, like a metal wire, Plasma resists the flow of electrical current. The resistance to the flow of electrical current is the mechanism for converting electricity into heat. This heat is used to generate electricity, which is usually more than the electricity supplied to it.

However, unlike metal wires and other standard heating techniques that have melting temperature limitations, the Plasma conductor has no temperature liitation. This unique ability of the Plasma Arc column (i.e., to continue to exist at high temperatures and not melt) makes it possible to generate sustained heat at temperatures much higher than is possible by combustion heaters or metallic resistance heaters. The sustained high temperatures that are achievable only by Plasma heaters qualify this novel heat source for the specific and stringent heating demands of our waste management systems.

Plasma arcs are generated by the electrical discharge in the gas, usually between high voltage electrodes. The pressure of the gas involved determines the temperature and transport properties of each Plasma, allowing us to tailor its destructive capacity to meet the demands of various waste materials. With core temperatures of up to 14,000 degrees Centigrade, Plasma can break down toxic compounds within MILLISECONDS in a very safe way.

Plasma Gasification Basic Process Description

Plasma gasification is a non-incineration thermal process which uses extremely high temperatures in an oxygen-starved environment to completely decompose input material into very simple molecules. The extreme heat and lack of oxygen results in pyrolysis of the input waste material. Pyrolysis is the decomposition of matter in the absence of oxygen. Incineration is merely the burning of waste material in the presence of oxygen, and incinerators have significant air emission control problems.

The byproducts of pyrolysis are: (1) combustible gas, which can be used to generate electricity, and (2) inert slag, which is a vitrified glassy rock, primarily composed of silicon, which can be directly drawn off, and make wool insulation. The heat source is a plasma arc torch, a device that produces a very high temperature plasma gas. Plasma gas is the hottest sustainable heat source available. The plasma arc centerline temperature can be as high as 50,000 degrees Centigrade, and the resulting plasma gas has a temperature profile between 3,000 and 8,000 degrees Centigrade.

A plasma gasification system is designed specifically for the type, size and quantity of waste material, which must be processed. The refractory-lined reactor vessel is preheated to a minimum of approximately 1,100 degrees Centigrade before any processing commences. The very high temperature profile of the plasma gas then provides an optimal processing zone with the reactor vessel through which all input waste material is forced to pass. The reactor vessel operates at atmospheric pressure.

Pyrolysis provides for virtually complete gasification of all volatiles in the source material, while non-combustible material, including glass and metal, is reduced to an inert slag. With municipal solid waste as the input waste material, the product gas and slag have very distinct characteristics. The product gas is high in hydrogen and carbon monoxide with traces of methane, acetylene and ethylene; therefore, it can be combusted very efficiently resulting in carbon dioxide, nitrogen and water vapor as the only gaseous exhaust to the atmosphere. The carbon dioxide can be recovered through use of special membrane filters. The slag is a homogeneous, silicometallic monolith with leachate toxicity several orders of magnitude lower than those specified in current landfill regulations. This slag could also be converted into brick and very high quality tiles or into wool insulation.

The product gas and slag from the plasma gasification of municipal solid waste both have commercial value. The product gas has a heating value approximately 1/4 to 1/3 the heating value of natural gas; therefore, it can be used as an efficient fuel source for industrial processes, including the generation of electricity, and the production of methanol and ethanol. The slag can be used in the construction industry, wool insulation or for road paving. All other byproducts, such as scrubber water and cyclone catch material; can be recycled into the process for reprocessing to alleviate disposal requirements. Plasma gasification has no byproducts, which must be disposed of, as waste; therefore, it can be viewed as a totally closed treatment system and the ultimate recycling process. This is a viable process for using low-grade coal as fuel stock to generate electricity.

Other types of waste will generate different product gas and slag characteristics. The chemical composition of different input waste materials will result in differing gas and slag characteristics. Input waste materials with a high carbon content and a high percentage of non-volatile material will produce results very similar to those with municipal solid waste. Other waste materials, such as biomass, liquid wastes and organic wastes will not produce hardly any slag since virtually all of the waste is gasifiable.

Limitations

Plasma gasification is a generic type process, which can accommodate virtually any input waste material in as-received condition, including liquids, gases and solids in any form, combination or packaging. Moisture content is not a problem. Liquids, gases and small particle size waste materials are very easily and efficiently processed. Bulky items, such as household appliances, tires and bedsprings, can also be readily accommodated without loss of destruction efficiency. The reactor vessel and waste feed mechanism are designed for the physical characteristics of the input waste stream.

Handling Capabilities and Versatility

Plasma gasification systems can be implemented in virtually any size capacity. They are modular which provides operability and maintainability advantages. Modularity also provides for future growth at minimal incremental cost.

The standard module size for normal municipal solid waste is 300 tons per day. Such a module is comprised of one or two individual plasma heating sources per vessel, which would permit efficient operation through a wide range of waste throughput.

Maintenance Requirements

Plasma systems are very reliable since no moving parts are involved. An annual inspection of the refractory can easily achieve a very high availability, with an up-time of 340 days plus per year.

Configuration Variability

Plasma technology allows the formation of a Fuel To Energy facility of different configuration depending on the end user requirements. Plasma gasification systems are highly modular, which provides tremendous versatility and configuration flexibility to handle wide variations in the type and quantity of input waste loads. Since the heat source is completely independent of the existing infrastructure, full flexibility is realized to implement any configuration to best meet the needs of the waste type and quantity.

Plasma gasification systems can be implemented as an adjunct to existing processes, such as incinerators or coal-fired power plants. The plasma system can process the bottom and fly ashes, as well as flue gases directly from the incinerator or coal-fired power plants.

Mobile/transportable plasma systems are under development to provide waste disposal services to locations, which do not have sufficient waste quantities to justify a permanent installation.

If needed, plasma gasification systems can be installed largely underground for aesthetic purposes. Such installations require only a single floor above ground to house administrative offices and provide an area for waste haulers.

Technology Advantages

Plasma gasification is not a new technology but its application for waste treatment, electricity generation and processing is new. The technology addresses those concerns, which other technologies could not address. It provides specific size, cost, operability and operational advantages over other state-of-the-art technologies. In addition, to the cleaner environmental mission characteristics, plasma gasification offers many unique advantages.

Plasma Gasification is a new generation technology that has been, developed and introduced to minimize the known shortcomings experienced by other technologies. As a result it provides for specific size, cost, operability and operational characteristics giving advantages over other less than state-of-the-art-technologies. In addition to its cleaner environmental emission characteristics it possesses the following inherent unique features:

1. Can handle any waste material in any form without loss of destruction efficiency; therefore, there is no need for additional treatment or disposal of the solid constituents of many waste materials, such as contaminated steel drums.

2. Requires an extremely small space compared to other disposal technologies. Install within an existing superstructure, underground for a pleasing aesthetic appearance increasing public acceptance.

3. The unit is modular and thus provides much operational flexibility. Initial capacity can be geared to the initial requirement and the modularity feature can provide the desired growth when required, at a minimal cost.

4. Produces a combustible gas as a discrete byproduct. This gas can be used immediately, stored for future use or piped to a remote location for use. On the other hand an incinerator automatically produces steam regardless of steam demand.

5. The plasma torch is an independent heat source providing temperature controllability, heat transfer rate and process variability benefits. Optimal operating characteristics can be set and maintained.

6. Process is independent of input moisture content; therefore, there is no loss of destruction efficiency if the moisture content varies.

7. Provides for the complete removal of all carbon from the input material. This destruction efficiency is in marked contrast to incineration which can leave as much as 30 percent unprocessed material in the ash ! Process provides an immense volume reduction ratio of input material to slag. This figure is in excess of 250:1 for as-received municipal waste (99.6 percent reduction) and 400:1 reduction for boxed biomedical waste (99.7 percent reduction). Other technologies such as incineration offer only 5:1 (80 percent reduction).

8. A Plasma Gasification Processing system can handle any waste in any form without loss of destruction efficiency. This feature negates the requirement for additional treatment or disposal of the solid constituents of many waste materials, such as the contaminated steel drums, which store PCB oils prior to disposal.

9. A plasma gasification system requires an extremely small space compared to other disposal technologies. In addressing specific industrial waste problems a plasma system can very often be installed within existing superstructure, or it can be installed largely underground for a more pleasing, aesthetic appearance, thereby enhancing public acceptance.

10. A plasma gasification system is modular and provides additional operability, maintainability and dependability advantages. Initial capacity can be geared directly to the specific requirement and the modularity feature can provide the desired growth as and when required at minimal cost.

11. Plasma gasification produces a combustible gas as a discrete byproduct. This gas can be used as and when required; it can be used immediately, it can be stored for future use or it can be piped to a

remote location for use. This is in marked contrast to incinerator installations that automatically produce steam regardless if the steam needed.

12. The plasma torch is an independent heat source providing temperature controllability, heat transfer rate, and process variability benefits. The optimum characteristics can be set and readily maintained. This is not affected by the condition of the waste material.

13. The Plasma Gasification Process is independent of the input moisture content; therefore, there is no loss of destruction efficiency if the moisture content varies

14. The Plasma Gasification Process provides for the virtual complete removal of all carbon from the input material in marked contrast to incineration which can leave upwards of 30% unprocessed material in the ashes

15. The Plasma Gasification Process provides an immense volume reduction ratio of slag to input material. This is in excess of 250:1 for as-received municipal waste (99.6% reduction), and 400:1 for boxed biomedical waste (>99.7% reduction). Other technologies offer approximately 5:1 (80% reduction).

The Plasma Gasification Process offers many benefits that other waste technologies cannot offer and therefore a plasma system costs less to operate and/or less to purchase;

- The Plasma Gasification Process requires no presorting of waste, negating the need for saving on labor and machinery.

- No post process treatment of the waste is required. Profits will not be diminished through secondary hauling and/or disposal fees.

- The amount of land required for USP's Plasma Gasification system is significantly less than for landfill or incineration disposal methods.

- The Plasma Gasification Process creates two revenue-generating byproducts.
    - An energy rich gas that can be used to create electricity, and
    - a slag that has many and varied commercial uses.

- A Plasma Gasification Operator can offer its clients freedom from downstream liability because the processed waste is chemically non-recognizable.

The unique features and benefits of a Plasma facility will ensure the Plasma Gasification Process remains at the forefront of the environmental and waste industry well into the millennium.

Increased Efficiency

Current coal fired power plant technology is only 35-40% efficient. The waste gasses and fly ash can fed into a plasma plant and reclaim what would normally be waste and converted into electricity. This results in a about a 90% efficiency for the coal fired plant. These coal-fired power stations can be closed down once there useful life has expired and totally use this plasma process.

Commercialized System

The plasma gasification process is in full commercialization. The following companies were identified as suppliers of plasma technologies:

- Active Light Corp., Poulsbo, WA; Products: gas plasma displays from Fujitsu, Pioneer,
- Advanced Display Technology, Beaumont, Texas; Products: gas plasma monitors & other types
- Advanced Energy, Fort Collins, Colorado; Products: power conversion and control systems for plasma-based thin film plasma processing, subsidiaries: Fourth State Tech. Inc., Austin, TX, sensor-based manufacturing solutions, RF Power Products
- Advanced Heat Treat Corp., Waterloo, Iowa; Products: "Ultra Glow" ion nitriding surface treatment using glow discharge plasma
- Advanced Plasma Systems Inc., St. Petersburg, Florida; Products: gas plasma technology for surface modification, applications in products list
- Anatech Ltd., Springfield, Virginia; Products: batch style box, barrel and planar electrode systems designed primarily for cleaning and surface modification
- Applied Materials; Products: plasma etch processing chambers and etch processing platforms, decoupled plasma source (DPS), high-density plasma chemical vapor deposition (CVD) system, (largest producer of wafer fabrication systems)
- Bekaert Advanced Coating Technologies; Development and production of diamond-like coatings by plasma enhanced chemical vapor deposition products: coatings for electronics, CD and DVD molds, and metal framing applications

- Centricut, Lebanon, New Hampshire; Products: plasma cutting consumables and replacement torches
- Control Vision Inc., Idaho Falls, Idaho: Products: digital camera imaging of extremes in brightness, temperature, and high-speed processes
- Daytona MIG, Daytona Beach, Florida; Products: portable welders and plasma cutters; pocket plasma system
- Diamonex, Allentown, Pennsylvania, Products: ion beam and RF plasma deposition of diamond coatings
- Eastlund Scientific Enterprises, Corp., Texas; Products: plasma processor applications to environmental systems, wafers and thin films, packaging, electromagnetic systems, energy [Bernard Eastlund was co-inventor of fusion torch about 1970, and co-founded Fusion UV Systems], experiments: large volume plasma processor LVPP
- ENI (division of Astec America Inc.), Products: RF power delivery systems, physical vapor deposition (PVD) tools esp. for plasma etch, IC manufacture, storage media, flat panel and enhancement coating, DC high power conversion
- FM Technologoes, Inc., Fairfax, Virginia; Products: object-oriented PIC simulation code, various codes and plasma experimental units, experiments: DPX, PHLUX
- Fujitsu General America, Products: Plasma vision, plasma display technology, explanation
- GaSonics International, San Jose, California; Products: semiconductor processing equipment, including plasma source for 200mm and 300mm photoresist
- General Atomics Fusion Group, General Atomics, San Diego, California; Products: tokamak research - all aspects, diagnostics ICF research, ICF target support software: transport code ONETWO, equilibrium EFIT, data analysis 4D, equilibriu TOQ, experiments: National Fusion Facility DIII-D ICF, target support for five ICF laboratories
- Global Plasma Systems Corporation, Washington, D.C.; Products: waste management services utilizing plasma heating technology; waste-to-energy and waste disposal and treatment; mixed waste sources including low-level radioactive, industrial and medical waste, contaminated soil, compact inert slag output
- Hypertherm, Hanover, New Hampshire; Products: plasma cutting technology (up to 2" steel), history of plasma cutting technology and plasma arc process, plasma cutting animation
- Integrated Environmental Technologies, LLC; Richland, Washington; Products:

plasma enhanced melter (PEM) for wide variety of wastes; process demo since 3/97, waste streams - radioactive, hazardous, medical, industrial, municipal, tire waste, economic and environmental benefits

- Kinema Research and Software, Monument, Colorado; Products: software 2-D plasma modeling system PLASMATOR, non-equilibrium, time-dependent plasma chemistry code KINEMA, Boltzmann equation solver ELENDF, plasma chemistry modeling and surface modeling
- Komatsu Cutting Tech., Wilmington, Massachusetts; Products: 'RASOR" fine plasma cutting systems; 5'x10' cutting up to 1.5" thick
- LAM Research Corporation, Fremont, California; Products: dry etch processing systems, both conductive etch and dielectric etch
- Lincoln Electric, Cleveland, Ohio; Products: 1/4 to 3/4" plasma cutting
- Litmas, Matthews, North Carolina; Products: high density plasma tools; atmospheric plasma systems at 8 mTorr to 1 Torr; switch mode RF power supply and high density plasma source technologies; abatement of perfluorinated compounds such as CF4 and other PFC emissions
- Litton Electron Devices, Woodland Hills, California; Products: microwave power devices
- March Instruments, Concord, California; Products: plasma technology for electronics and medical device industry, fluxless soldering, plasma treatment; atmosphere plasma and "Roth" reactor, free plasma cleaning guides; advances in plasma treatment file
- GE Mathis Co., Chicago, Illinois; Products: 40 ton indexable punching capability and true-cut air plasma cutting up to 60" wide, 1000# plates
- Modern Machine Tool Co., Jackson, Mississippi; Products: laser and plasma cutoff lathes; cut stock automatically up to 5 tons, 20 ft
- Novellus, San Jose, CA; Products: chemical vapor deposition (CVD), physical vapor deposition (PVD) automated wafer fabrication systems for deposition of thin films; dielectric plasma enhanced CVD (PECVD), dielectric high-density plasma (HDP-CVD) systems
- PEAT Inc., Huntsville, Alabama; Products: thermal destruction and recovery (TDR) process; plasma process and vitrification of waste streams - medical, pyrotechnics and explosives, thermal batteries, ammunition, redwater, labpacks
- Phoenix Solutions Co., Minneapolis, Minnesota; Products: plasma heating systems for waste treatment, plasma arc torches, melting metals and hazardous waste, converting organics such as municipal solid waste to fuel gas and useable chemicals, enhance recycling

- Plasma Automation, Inc., Hicksville, New York; Products: vicon plasma cutting machines; thin metal cutting, control software
- Plasma Coatings Inc., Waterbury, Connecticut; Products: custom application of specialty surface materials; release/non-stick, traction, traction & release, helps with low friction, wear & corrosion conductivity (thermal and electrical)
- Plasma Etch Inc., Carson City, Nevada; Products: high-capacity plasma etch systems applications list under 'markets for plasma tech'
- Plasma Systems Inc., San Jose, California; Products: etchback and conformal coating and potting; nickel and gold plating
- Plasma Technics Inc., Products: high voltage transformers
- Plasma Technology Inc., Torrence, California; Products: thermal coating industry; about 300 different coatings with five different coating techniques; about 32 significant variables in coating process
- Plasmacam, Inc., Products: plasma-cutting systems for artistic and geometric metal parts.
- Plasma Co., Highland, New York; Products: 60-inch HDTV plasma display panel
- PlasmaSol, Hoboken, New Jersey; Products: capillary discharge non-thermal plasma reactor provides for volatile organic contaminant remediation, surface cleaning and combustion control.
- Plex, LLC, Cambridge, Massachusetts; Products: compact EUV photon source (20-300A) for lithography using plasma pinch source
- Precision Products, Canaan, New Hampshire; Products: precision cut plasma torches
- Pro-Fusion Technologies Inc., Newbury Park, California; Products: plasma welding torches
- Pulsed Plasma Energy, Lombard, Illinois; Products: Thermal ionization of coal and petroleum into syngas/methane; cogeneration and disposal of hazardous waste; medical waste PCB processing
- Retech, Inc., Ukiah, California; Products: manufacturer of fully integrated metallurgical processing equipment; precision pouring, plasma arc melting, consumable casting and metal powder production; plasma melting furnace for stainless steel, titanium and nickel ingots; plasma arc vitrification
- RF Services Inc., Sunnyvale, California; Products: RF generators and matching networks for 13.56 MHz RF impedance, 300 W to 15 kW, used in semiconductor industry to generate RF plasma

- Stainless States Products, Inc., Coatesville, Pennsylvania; Products: CNC plasma cutting, from 4" square to 136"x333" and to 5" thick stainless
- Stainless Processing Inc., Products: CNC plasma system - from 11 gauge sheet to 5" plate; supplier of rings, discs, flanges, custom shapes
- Startech Environmental Corp., Products: Plasma Waste Converter; economical processing of all solid, liquid and gaseous wastes; organic and inorganic; hazardous and non-hazardous.
- Osram Sylvania, Danvers, Massachusetts; Products: lighting systems, fluorescent lamps, lighting research, services, products
- Talison Research, Products: coating services and products for deposition of plasma polymerized organic thin films, for surface engineering and scratch resistance, enhanced biocompatibility
- Thermal Dynamics, Thermadyne Industries Group, West Lebanon, New Hampshire; Products: plasma arc cutting systems and supplies design and manufacture of plasma arc cutting and welding torches and systems since 1957; precision cutting of any material from light gauge to 4" (9.6 cm) thick
- Thermal Conversion Corp., Kent, Washington; Products: high-temperature thermal technologies; key system is induction-coupled plasma (ICP) torch; 1MW input power, 5000 degrees C to over 15K degrees; no consumable electrodes as in conventional DC arc plasma technology; handles up to 110 kg/hour of feed material with temperature in reactor of 700 to 1500 degrees C.
- TRION Technology, Tempe, Arizona; Products: maker of plasma etch and deposition systems note: plasma cookbook
- Vanguard Research Inc., Lorton, Virginia; Products: Plasma Energy Pyrolysis System; converts waste streams into clean fuel gas and construction aggregate; fixed site and mobile systems.
- Vapor Technologies Inc., Boulder, Colorado; Products: deposition of metallic and ceramic coatings by low-temperature arc vapor deposition (LTAVD), or cathodic arc plasma vapor deposition process (PVD); metalization of plastics, metalization of dielectric substrate for capacitors, medical device applications
- VARIAN, Palo Alto, California; Products: ion implant systems
- Wavemat, Inc., Plymouth, Michigan; Products: microwave technology for materials processing; microwave plasma disk reactor (MPDR) for microwave and ECR-enhanced plasma processing applications; CVD diamond deposition, anisotropic semiconductor etching, power metal preheating, ceramic sintering and polymer curing

- Westinghouse Plasma Inc., Pennsylvannia; Products: plasma torch systems for waste processing
- Weldlogic, Inc., Newbury Park, California; Products: micro-arc plasma; 50 amp plasma welding torch (PT-10)
- Yield Engineering Systems, San Jose, California; Products: plasma strippers, plasma cleaning systems, acquired Glen Tech

All the facilities managing solid wastes were visited by the author and reviewed in detail. The Westinghouse facility had the most advanced commercialized technology with numerous designs in operation. The Westinghouse facility is considered by the author to be the best technology available.

ENVIRONMENTAL IMPACTS

Bio-power resources are renewable. When biomass is used to produce power, the carbon dioxide released at the power plant is recycled back into the regrowth of new biomass. This renewable and recycling process makes it possible to generate power without adding to air emissions. Biomass can be grown as bio-energy crops or gathered from forests, mills and landfills as a byproduct. Growing bio-energy crops has important land, habitat and soil conservation benefits. Producing energy from residues in forests, mills and landfills avoids the release of methane into the atmosphere from decomposition of unused wood and agricultural wastes.

The key to successful biomass power development is to use the resource efficiently in modern conversion systems that maximize the energy produced and minimize the byproducts of conversion processes. Until the 20^{th} century, in most parts of the world including the U.S., using biomass to generate heat or to drive steam engines was the most common way to produce energy. However, historical methods of burning wood, field residues, or wood wastes and byproducts have tended to be less efficient than modern conversion systems currently available and in development. In modern times, the combination of improved technological efficiencies, scientific advances, increased environmental awareness, and environmental protection regulations have turned biomass conversion into a cleaner, more efficient process.

Landfilling Impacts

Landfilling impacts are significant in environments receiving significant quantities of rain and in rocky terrain. Leachate is a major concern and the landfills leave a contaminated footprint currently not recoverable.

Off-site waste shipment is at risk of spills into the pristine waters of Alaska or Canada. Off site shipment also requires multiple handling scenarios and increased risk of accident:

- Collection and transfer to barge
- Barge shipment
- Transfer to truck
- Transport and delivery to landfill

Incinerator Impacts

Current incinerators utilized in Alaska are air pollution hazards due to the presence of dioxins, furans and heavy metals. Incinerator ash is also hazardous and can deteriorate environmental conditions at landfills.

Plasma Impacts

Regulatory

With the advent of new, more stringent EPA and World Bank regulations for particulate matter and ozone, industrial sources and infrastructure, projects will be required to meet more stringent emission limitations by 2004. Investment in the plasma gasification technology will ensure that an infrastructure facility is in compliance with current and future air emission limitations.

Environmental standards invariably become more stringent and improved standards are achieved when new technologies demonstrate they can reliably meet more stringent limits. The plasma gasification process effectively produces no associated air, soil, and groundwater or surface water contamination.

Environmental Emissions Superiority

The consistently low environmental emission characteristics exhibited by plasma gasification indicate that it can be used as a waste treatment and coal-fired power station alternative to other technologies with significantly lower air emissions than competing technologies. The extremely tight physical and chemical bonds within the slag results in consistently low leachate characteristics.

Emissions Profiles

Emissions from a typical plasma facility are noted below:

<u>Exhaust Gas</u>

Component	Composition
Dioxin	<0.01ng-TEQ/m^{3}N
Particulate	<0.01g/^{m3N}
Sulfuric Oxide	<20ppm
Hydrogen Chloride	<30 ppm
Nitrogen Oxide	<50 ppm

<u>Slag/Vitrified Glass</u>

Component	TCLP Composition
Lead	<0.001mg/l
Cadmium	<0.001mg/l
Mercury	<0.00005mg/l
Hexavalent Chromium	<0.002mg/l
Arsenic	<0.001mg/l

Plasma systems operate at 1/10 to 1/100 the maximum contamination limits expressed in Title V air discharge requirements. The State of Alaska has a complete regulatory program developed to manage a plasma facility.

POWER SURVEY

North American Grid System

You go home, unlock the front door and flip a switch, and your hallway lights up. It may seem like a simple thing, turning on that 60-watt bulb. But that bulb is actually part of a web of generators, power lines and other people's bulbs that are interconnected in a complex electrical network known as the North American power grid. It stretches from one end of the United States to the other and includes parts of Canada and Mexico, with more than 700,000 miles of high-tension lines.

Within the grid are three interconnected divisions; within each one, the amount of electricity used must equal the amount of electricity produced at every given instant. Because the alternating current in your electrical lines travels at virtually the speed of light and cannot be stored, every time you turn on a reading lamp, a generator somewhere in the grid has to provide a tiny bit more power to the entire system.

The electricity travels long distances over circuitous routes, following paths of least resistance. It's like the flow of traffic into a city: if one freeway is jammed, cars will use alternate routes.

Take power shipped from Portland, Ore., to Los Angeles, for example: some 30 percent of that shipment will probably flow through Utah en route. Meanwhile in the East, if a Canadian hydropower plant is fueling someone's midnight repast in New York, the electricity could flow as far west as Ohio and as far south as Virginia — nearly instantly — before reaching the house where it is needed. If a lightning storm knocks out one line in the grid, or a generator stops working unexpectedly, the rest of the grid is affected. Other lines handle more power to make up for the downed line, or other generators work harder. Every part of the system is sensitive to changes in any other part of the system.

While the system uses alternating current, or AC, the three divisions are connected by direct current, or DC, lines, which are easier to control. So in an emergency, power can be transferred from one connection to another, but power failures will not spread.

The power grid has evolved over the last hundred years or more. Gene Gorzelnik, director of communications at the North American Electric Reliability Council, said that 138 "control areas" monitored the modern grid, using computer systems to predict energy flow and anticipate reactions to power failures.

John Casazza, author of "The Development of Electric Power Transmission" (Institute of Electrical and Electronics Engineers, 1993), remembers a simpler time. Mr. Casazza recalls working with an early analog computer, built in 1927, that used electric components to reproduce an electric system in miniature. Such early devices, each big enough to fill a large living room, were used until the 60's to simulate the impact of various events on the grid. In the 60's, electric companies switched to digital computers.

The first commercial power plant opened in San Francisco in 1879. That was followed in 1882 by Thomas Edison's better-known Pearl Street station in New York, which delivered electric power using DC lines. In 1893, AC lines were displayed at the Chicago World's Fair, and in 1896, AC lines delivered energy harnessed at Niagara Falls some 20 miles to Buffalo, setting today's AC-line standard.

The latest change in the power system is deregulation, which has occurred in California and went into effect in the New York area this month. Instead of having a utility that owns the generator, transmission lines, substations and distribution lines, deregulation will result in separate ownership for various segments of the grid. Electric utilities bid for electricity from various generators in two auctions, one that happens the day before the power is scheduled to be used and another that happens an hour before.

That requires very detailed monitoring, which in turn requires an advanced, complex system. Critics of deregulation, like Mr. Casazza, say that the complexity of the grid, compounded by a proliferation of auction data, will lead to an increase in the number of blackouts, like the infamous 1965 New York City blackout that left 30 million people in the Northeast and Canada without power and led to a Federal push for more reliable power.

Professor Carl Blumstein, a research associate at the University of California's Energy Institute, said he doubted that the number of blackouts would increase with deregulation, but he added, "We'll just have to wait and see if there's a difference."

The complex network that puts electricity where it needs to be — and does it in less than a wink — is a model of cooperation. Transformers are used throughout the grid to increase voltage for transmission over long distances or reduce it for local distribution.

Power Components

Generator

The most common types of electrical generators use coal, natural gas, oil, falling water or nuclear energy to produce electricity. But garbage and other waste products can also be burned to produce electrical energy, and generators can harness wind or solar power. Total generator output has to rise and fall to meet the total demands on the electric system, and a combination of types of generating units is used to match the demand. Economic considerations, environmental constraints and availability determine which units supply power at a given time. Different combinations of these power sources are most economical under different conditions, like the time of year. In the fall, for example, hydroelectric reservoirs tend to be depleted, so hydroelectric power is less readily available. Generators usually produce electricity at 7 kilovolts (a kilovolt is a thousand volts) to 25 kilovolts; transformers at the generators step up the voltage, to 60 kilovolts to 500 kilovolts, before sending the power into the grid.

Transmission Substation

Transmission substations act as way stations that link various lines for increased reliability. They can also step up the voltage again, depending on how far the electricity needs to travel.

Transmission Lines

High-tension lines are more efficient for transmitting power. Raising the voltage lowers the current, and since wires waste power in proportion to the square of the current, that results in less power loss. Even so, substantial amounts of power are lost over long-distance lines. (Those orange balls occasionally seen on high-tension lines, by the way, are to warn off aircraft.)

Distribution Substation

At distribution substations, the electricity is stepped back down for customers, usually to between 12 kilovolts and 35 kilovolts, depending on how the individual system was designed.

Distribution Lines

When the electricity is sent from a distribution line to a house, field transformers step down the power to 120-240 volts (the voltage that comes out of the plug in your wall). In commercial areas, the power may be stepped down to voltages higher than those for houses.

Transformer

A final step-down transformer, often located on a utility pole or in a vault under a city street, decreases the voltage to the 120-240 volts used in most homes. A transformer consists of two wires wound around a metal core. Power enters the first, or primary, coil and induces a magnetic field in the core, like an electromagnet. As the current alternates, the magnetic field reverses, creating an electric field that induces a current in the secondary coil. The ratio of the number of turns in the two coils determines the voltage change. If the secondary coil has half the turns of the primary, half steps down the voltage; if it has twice the turns, the voltage is doubled.

Regulation/Deregulation

In the 1980’s, regulation was abolished in several industries. While maintaining some governmenta control over safety and trying to prevent business abuses, price regulation was lifted in the banking sector, airline, trucking, natural gas, and telecommunication industries. In most cases, new services and lower prices were introduced to gain market share. Obviously, many people wondered why the electric utility industry should remain regulated and looked for ways to open up its market by using lessons from deregulated industries, specifically, telecommunication, airline, and natural gas industries. Restructuring of the electricity market started in Canada and the U.S. in early 1990`s and has been continuing ever since. This brief report provides an assessment of the North American electricity market in the context of deregulation/restructuring.

Definition of Restructuring

Restructuring refers to reorganizing electric utilities from vertically-integrated monopolies into separate generation, transmission and distribution entities. This separation or *unbundling* is intended to promote competition between generators and to provide an open access to the transmission and distribution systems, eventually increasing competition in the supply and marketing of electricity, thus lowering the price. Only generation is being deregulated; *transmission and distribution will remain regulated and noncompetitiv*e. It should be noted that vertically-integrated utilities in Canada are mainly provincially-owned as opposed to the U.S. where ownership is in private hands (i.e. Investor Owned Utilities or “IOU”).

Wholesale Access vs. Retail Access

Two essential aspects of restructuring are wholesale access and retail access. ***Wholesale acces***s refers to generators (utilities or independent power producers) having the ability to obtain access to transmission systems to compete for wholesale markets, which include distribution utilities and independent marketers (retailers) that buy and sell electricity. Approximately half of all electricity generated in the United States is purchased and traded between utilities and marketers in the wholesale market before being sold to ultimate consumers in the retail market. In North America, the wholesale power system (also known as bulk power) has evolved into four major networks (the interconnected Eastern, Western, Texas, and Quebec power grids) consisting of extra-high voltage connections between individual utilities designed for the transfer of electrical energy from one part of the network to another.

Wholesale transactions allow utilities to reduce power costs, increase power supply options, and face emergency situations. In regions where retail access is implemented (see definition below), wholesale transactions will usually go through a centralized electricity marketplace, often called *"Power Pool*", (e.g. Alberta Power Pool, NEPOOL in New England). Operating much like a commodity exchange or a stock market, the Power Pool establishes a market price for electricity by matching aggregate supply and demand and working ahead of physical delivery (usually one day ahead). The pricing mechanism and bidding process normally differ from one pool to another. The operation of the Power Pool must be regulated and the system operator must be independent in that it will not exercise market power or discriminate among market players. Power Pools are now in operation in the U.S., Canada (Alberta), England, Norway, Australia, Spain, Chile and Argentina, among others. Electricity pools can be mandatory (e.g. England, Alberta Power Pool) or non-mandatory (e.g. Norway) in which case bilateral trade outside of the pool (i.e. utility-to-utility, marketer-to-marketer, or utility-to-marketer) is permitted. By nature, it is impossible to track the physical movement of electricity produced (i.e. the electron) from the generation site to the end-user. In fact, it can be exchanged many times between utilitiesand marketers in the wholesale market, before the user consumes it.

Retail access refers to marketers and retailing businesses of utilities having the ability to obtain access to distribution systems to sell to end-use consumers (i.e. industrial, commercial, and residential), thus allowing ultimate customers a choice among electricity suppliers. Usually, retail access is put in place on a *phase-in* basis, commencing with industrial customers to be followed by commercial and residential. Thus, full retail access will occur when all end-use consumers have this choice.

Wholesale Markets – Open Access

Open access to transmission grids is a key element to wholesale trading in that it prevents intra-utility favoritism (i.e. a vertically integrated utility that would be keeping a certain amount of transmission capacity for the exclusive use of its generation arm or would be charging higher transmission fees to other generators, thus lowering their competitiveness). Successful open access had to lead to unbundling of utilities' generation, transmission and distribution functions into separate entities and the formation of independent transmission operators (e.g. the Independent Transmission Administrator-ITA in Alberta and the Independent Electricity Market Operator–IMO in Ontario). In short, their main function is to operate transmission grids on a non-discriminatory basis while utilities still remain owners through their transmission arm. The Federal Energy first implemented open access to transmission systems in the U.S.

Regulatory Commission (FERC) through the *Energy Policy Act of 1992.* This act eventually resulted in *FERC Order 888* in 1996, which requires that any utility using other transmission systems to sell power in the bulk market must open its own transmission line to other utilities and charge a non-discriminatory open access tariff based on the cost of service method (since transmission remains regulated).

Under FERC Order 888, a Canadian electricity exporter who wants to market electricity in the wholesale U.S. markets, must obtain an export license from FERC by providing U.S. marketers access to its transmission facilities. This is referred as the *reciprocity requirement* of Order 888. Note that Hydro-Quebec has obtained such a license in 1997 and can therefore export electricity to the U.S. through its subsidiary H.Q. Energy Services (U.S.) Inc., which is a participant in the New England Power Pool (NEPOOL) and the New York Independent System Operator (NYISO), formerly known as the New York Power Pool (NYPP) before 1998. Most recently in the U.S., to increase competition in the wholesale markets, *FERCOrder 2000* required transmission companies under FERC jurisdiction to form *Regional Transmission Organizations (RTO's)* by Dec. 2001. The purpose of these organizations is to consolidate the operations of a number of transmission systems into one independent entity aiming at establishing a unique tariff.

The formation of RTO's is expected to lead to increased north-south trade and increased integration of the U.S. and Canadian electricity markets. As such, FERC encourages Canadian participation. Alberta is currently considering joining RTO West, which comprises transmission facilities of Northwest U.S. and B.C. Note that FERC is the U.S. counterpart of Canada's National Energy Board (NEB), since it regulates U.S.interstate and export energy transmission, as does the NEB in Canada. In the U.S. and Canada, intra-provincial or intra-state matters are regulated under the umbrella of provincial bodies or state commissions (e.g. "Régie de l'Énergie"in Québec and "CaliforniaPublic Utilities Commission"-CPUC -in California).

Electricity Restructuring Background

In the traditional market structure, the electricity supply industry was regarded as a natural monopoly. Vertically integrated utilities in North America achieved the lowest cost by building large-scale power plants along with extensive transmission and distribution networks. It was not (and is still not) economically feasible to build competing transmission and distribution lines to serve the same market. In the 1970's and later, utility construction became increasingly costly, with some long-delayed power plants. In Canada and the U.S., a number of trends began to emerge in the 1980's and early 1990's that caused several jurisdictions to question this traditional market structure:

(i) Many jurisdictions experiencing high electricity prices (e.g. US Northeast and California) realized that access to a utility's transmission lines should be made available to other utilities (on a non-discriminatory basis) to provide access to cheaper supplies from other regions. Technological advances in generation made the construction of smaller gas-fired generation plants feasible, particularly combined-cycle natural gas turbines. These power plants can be built more quickly and at a much lower capital costs than traditional large scale projects such as hydro-electric and nuclear or coal-fired power plants. Moreover, these smaller facilities allow industrial consumers to produce process steam and required electricity on-site (cogeneration) from natural gas and sell any surplus of electricity to the grid

(ii) Experience with electricity deregulation in other countries (such as England, Australia, New-Zealand, Germany, Argentina), and restructuring in other industries in North America (e.g. airlines, natural gas, and telecommunications) suggested that fair market competition between service providers would lower prices and provide a broader range of services to customers.

Electricity Prices

Unlike oil (a world market influenced by world supply/demand balance driven by OPEC/NON OPEC member's actions) and gas (a continental market influenced by North American supply/demand balance, gas storage and pipeline capacity), the North American electricity market is *regional in natur*e, because of the differences in fuels used for power generation, market structure, and regulation and pricing. Oil & gas production is concentrated mainly at three major sites in North America: WCSB (Western Canadian Sedimentary Basin), Gulf of Mexico Bssin, and the Grand Bancs located offshore Newfoundland/NovaScotia, whereas diversified electricity production (i.e. different generation bases) takes place in every single U.S. States and Canadian provinces. That explains in most parts why electricity should be viewed as a province-by-province or state-by-state market instead of a continental or world market. Canadian and US electricity prices are low by international standards. In recent years, Canadian residential prices have been the bottom range of the US$0.06-0.18/kwh reported for the industrialized countries (Can: 0.06, US: 0.083, UK: 0.12, Germany: 0.16, Japan: 0.185). However, a great disparity in prices exists between different areas in North America. For instance, the electricity cost to a Canadian residential customer in 2000 was in the range of C$0.065-0.11/kwh. Electricity rates tend to be lower in the hydro-rich provinces (B.C., Manitoba, Quebec) and higher in Atlantic Canada (thermal-based generation). For the same year in the US, residential prices ranged from US$0.061 to 0.134/kwh (North West: 0.061, California: 0.111, New England: 0.114, New York: 0.134). Rates have been high in California and New England, mainly associated with nuclear power plants whose costs have escalated due to delays and construction problems. Elsewhere in the US utilities used cheaper fuel (e.g. hydroelectricity of Pacific Northwest) and owned older and largely depreciated power plants. *The above-noted price disparity is a key driver for electricity deregulation.*

Convergence

In recent years, a growing phenomenon of convergence between electricity and natural gas markets has occurred as a result of increasing use of gas in power generation. Consequently, electricity prices have become closely related to gas prices. As natural gas is a cleaner fuel than coal and oil, industrial electricity consumers are building more and more gas-fired generation plants in order to meet their electricity needs. Also, energy investors increasingly favor small, efficient power plants fired by natural gas or renewable energy.

These decentralized power plants (also called micro-power) are smaller, cleaner, and closer to the end-user than the former large-scale generation facilities built by public utilities (e.g. gigantic hydroelectric dams, nuclear or coal-fired power plants). Consequently, they are less dependent upon the transmission and distribution grid. Convergence can be demonstrated by the following: (i) electricity prices in the Alberta Power Pool influenced by the price of natural gas and (ii) non utilities' share of total electricity generating capacity which increased in the U.S. (from 7% in 1988 to 11% in 1998) and is still growing today. Note that *non-utilities* (or Independent Power Producers–IPP) generate power for their own use and/or for sale to utilities in the wholesale market.

Stranded Assets

An initial concern regarding electricity deregulation was that some utilities would not be competitive in a deregulated environment because they would not be able to sell electricity as cheaply as new entrants. For instance, a utility operating an expensive nuclear power plant would need to charge higher rates (to recover costs according to the "cost of service" pricing mechanism) than would an independent power producer using a gas turbine generator and cheap natural gas. Accordingly, these utilities were said to hold stranded assets due to the construction of high cost facilities during the formerly regulated environment when they had the obligation to serve all customers. In a competitive environment, that obligation would be waived, but utilities would still be responsible for paying off these expensive assets acquired earlier. Then, the issue arose as to how these costs would be recovered by utilities. In the U.S., stranded assets were associated with some nuclear facilities and older, less-efficient fossil fuel plants (particularly in the Northeast). Various ways have been designed to recover these stranded costs, such as *securitization* (i.e. issuing a long-term bond equivalent in the value to the stranded asset) and direct recovery through *"Competition Transition Charges"* on the Transmission and Distribution part of the electricity bill (which remains regulated). These Transition Charges can't be bypassed by changing electricity supplier. In Ontario, the outstanding debt from Ontario Hydro (also associated with expensive nuclear facilities) has been referred to as stranded costs. A successor company is managing the debt to Ontario Hydro (named Ontario Electricity Financial Corp.) and will be recovered from a *"Debt Reduction Charge"* of 0.7 cents/kwh until the debt has been repaid. Stranded costs have not prevented restructuring of the electricity market. Initially many utilities in North

America were concerned with stranded assets issues as they were expecting toface huge debt that they might not be able to recover. In fact, state and provincial regulatory bodies have allowed for full recovery.

Electricity Competitions – Supporters and Opponents

Numerous debates arose from the competitive environment brought by restructuring. Some people feel that the introduction of market forces could benefit customers because of the introduction of new services and better prices, while others do not necessarily agree.

Ultimate consumers that are paying higher electricity rates in their region compared to other area want to lower their costs. For instance, major industrial customers have been pushing for deregulation in California or New England where prices are high. A California industrial end-user would certainly like to be able to obtain power from a utility just across the border in Oregon where rates are half those of California. That explains why large industrial users are among the most eager to see regulatory restraints lifted so they can have access to cheaper electricity around North America. Residential and commercial consumers in high-rate areas, also tend to be in favor of restructuring the electricity industry. Consequently, liberalized markets may promote *price convergence* or *price equilibrium* between regions: high-priced areas could experience lower prices.

Also interested by the prospects of deregulation are the independent power producers, these non-utility businesses that usually sell electricity to utilities based on long term contracts at fixed rates. They feel they could get better prices for their electricity if they had the opportunity to sell to a larger number of customers, both near and far.

Some individual residential customers argue that they will experience rate increase over the long run because (i) since they use much less power than industrials, they would have to be contacted individually, thus raising the cost of doing business with them, and (ii) only the high-cost producers would remain to serve residential customers, as the low cost producers would sell their power to the large users. Moreover, they also fear price volatility and uncertainty due to changing market conditions.

As mentioned earlier, *price convergence* between regions could occur as a result of electricity deregulation, and this may have the consequence of raising rates in low-price areas. This could happen in hydro-rich regions such as Quebec, Manitoba, British Columbia, and the Pacific Northwest states. For the sake of arguments, let’s suppose that full retail access is implemented all over North America. An industrial company in New York would probably buy its electricity from Hydro-Québec, as another one located in California would obtain it from an Oregon utility, thus benefiting from much lower rates. Then, what would happen over a long-term period to electricity rates in these regions? It may lead to an increase in Quebec and Oregon, and a decrease in New-York and California.

Status of Restructuring

The pace of restructuring is uneven in U.S. and Canada. Each State/Province has its own view about electricity deregulation, being influenced to a large extent by its generation base and electricity prices, which in turn are reflected in specific legislation and regulation.

Deregulation in the U.S. - Full Retail Access

As of May 2002, all States located in the US North East (except Vermont) and the mid-Atlantic area (except West Virginia), and some located in the Great Lakes area (Illinois, Michigan and Ohio), and the US South (Texas and Arizona) provide (or will soon provide)full retail access to all customers. These States represent approximately one third of all States in the U.S. (i.e. 16 States plus District of Columbia). The local utility continues to provide transmission and distribution services (unbundled), while retail access allows customers to choose their own supplier of electricity. Note that full retail access will be available on July 1 of this year in Maryland and on Jan. 1, 2004 in Virginia (with phase-in started Jan. 1, 2002 for all classes of customers).

Future of Deregulation in the United States

A key feature of the North American electricity market is its regional diversity, as indicated by the differences in fuels used for power generation, market structure, regulation, and pricing. Because of this heterogeneous aspect, electricity restructuring in U.S. and Canada has proven to be more difficult to implement than in other industries previously deregulated, such as airline, railroad, trucking, oil & gas, and banking. According to many observers, coordination between the 64 PST's (Provincial and State/Territorial) regulatory bodies and the large number of utilities and electric coops (municipal, rural) is the biggest issue, unprecedented in North America. Moreover, since this industry encompasses multiple classes of consumers (industrial, commercial, residential, which are usually divided into many sub-categories), a proper deregulation phase-in system has to be designed, which tend to complicate matters.

In fully deregulated areas, since alternative suppliers have usually not been able to compete with traditional utilities, most customers remained with their distribution utilities. It appears that deregulation is more popular with industrial customers because they have changed supplier in a greater proportion than commercial and residential end-users. The electric power industry in North America has been undergoing substantial changes as many jurisdictions have introduced competition in wholesale markets and some retail markets. However, the pace of restructuring varies across regions and the extent to which it will occur is uncertain. A key concern is the impact on electricity prices. As more jurisdictions deregulate in North America, market price equilibrium should take place: suppliers in low price areas will be able to sell to higher cost areas, and buyers in those low cost areas may have to bid higher to obtain supply, contributing to increase prices. Customers in those areas (e.g. hydro-rich regions such as Quebec, Manitoba, British Columbia, and the Pacific Northwest states) tend to be reluctant to retail competition. Also, California's failure to properly deregulate its retail market has created uncertainty.

Many industry watchers estimate that problems encountered with California retail competition may arise again in any other deregulated market: for example, a combination of insufficient supply/high demand situations, transmission constraints, limited natural gas supplies, very cold winter/hot summer or prolonged drought, market power, and deregulation shortcomings such as retail price caps. In most deregulated States, such price caps exist similarly to those of the previous California deregulated market. Moreover, an important debate related to transmission limitations and pricing pitfalls is still continuing. There is currently no major transmission capacity addition planned in North America even in the context of increasing electricity demand, due to license plate pricing adopted by FERC. Under FERC order 888, utilities are required to provide open access to their own transmission system to other utilities or marketers. However, according to this rating mechanism, wholesalers can use any transmission grids needed to move power from one region to another without paying any transmission fees, except to the utility located in the area where the power is sold to the end-user. This means that all other utilities are not getting paid relating to their transmission services. Accordingly, utilities that own transmission infrastructures are not interested to install new capacity under these conditions. This pricing issue has been brought to the attention of FERC, which recognizes the problem, but apparently won't change regulation for now. Utilities argue that postage stamp pricing combined with the formation of RTO's (as previously discussed) would lead to reliable transmission grids throughout North America. Under the postage stamp method, an average transmission tariff could be charged to wholesalers based on distance, like in the natural gas industry (e.g. TransCanada Pipeline Limited-TCPL-Western Zone, Central Zone and Eastern Zone).

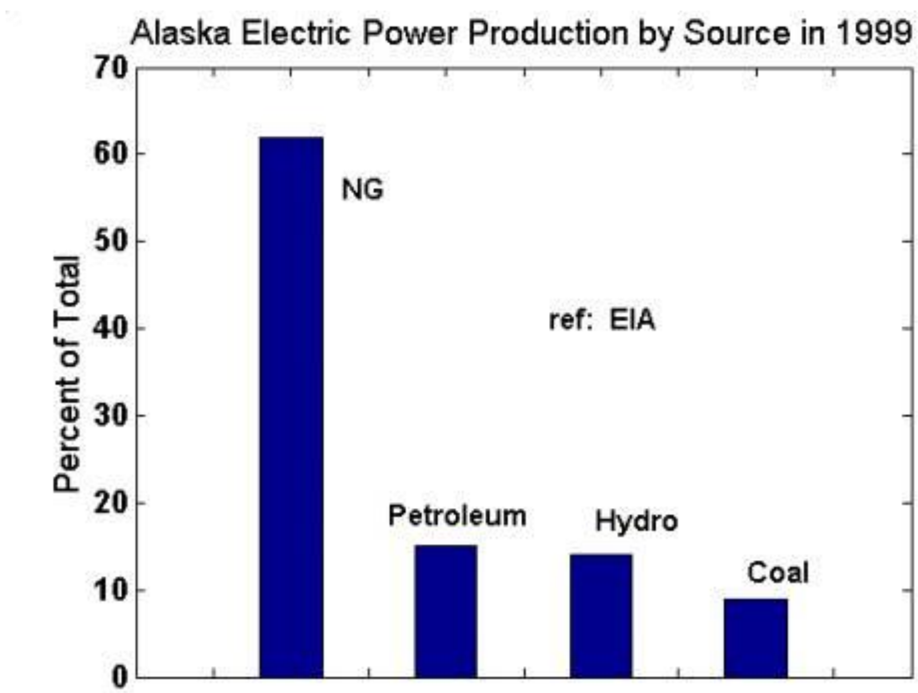
Power in Alaska

Alaska has more than 118 independent utilities serving a total population of fewer than 622,000 and covering an enormous range of geographic and economic diversity. The Alaska Energy Authority places emphasis on lowering the costs and increasing the safety and reliability of rural power systems. Emergency responses to utility systems and fuel storage failures are provided, as necessary, to protect the life, health, and safety of rural Alaskans.

Alaska's electrical energy infrastructure differs from that in the rest of the United States in that most consumers in the Lower 48 states are linked to a huge, transcontinental electrical energy grid through transmission and distribution lines. In Alaska, there are at least 175 rural communities in the state that are not interconnected and must rely on their own power sources. These communities rely almost exclusively on diesel electric generators. In the central part of the state, from Fairbanks to the Kenai Peninsula south of Anchorage, called the Rail belt, there is an interconnected grid. Natural gas is the primary fuel used in south central Alaska. Barrow, in far northern Alaska, also relies on natural gas. The largest hydroelectric plant is the state-owned 90 MW Bradley Lake Hydroelectric Project, near Homer, which provides approximately 10 percent of the electrical energy needs in the Rail belt. Four smaller state-owned hydroelectric projects, specifically Terror Lake, Solomon gulch, Swan Lake and Tyee, are grouped together as the Four Dam Pool and provide power to a number of communities, with the primary ones being Kodiak, Valdez, Wrangell, Petersburg and Ketchikan.

The Alaska Rural Electric Cooperative Association (ARECA) is the trade association for most electric utilities in Alaska. It provides advocacy and program services to help member utilities in their efforts to serve consumers with affordable, reliable electricity and improve the quality of life in Alaska's communities.

Power is distributed in Alaska as per the following diagram:



Utilities

A major electric utility in south central Alaska is Chugach Electric Association (CEA) with 513.1 megawatts of installed capacity including the Beluga natural gas-fired power plant across Cook Inlet from Anchorage. They also utilize two hydroelectric plants at Cooper Lake and Eklutna. CEA also takes its share of power from the state-owned Bradley Lake hydroelectric project near Homer. About 85 percent of the electricity sold by CEA each year comes from burning natural gas, with most of the balance coming from hydroelectric resources. Total sales were 2.4 B kWh bringing in $ 159 M in income during 2000.

CEA is actively pursuing alternative means of producing electricity including fuel cells, micro turbines, and wind power. Chugach installed and owns the nation's largest commercial fuel cell as one of the power plants on its system. This is a 1-megawatt installation was constructed behind the U.S. Postal Service's Anchorage Mail Handling Facility as a jointly funded project with the US DOE. The project is sited in the parking lot behind the Post Office near the Ted Stevens Anchorage International Airport. Chugach constructed the facility using five separate 200-kilowatt units, each fueled by natural gas.

While the USPS building takes most of the power from the project. Any power generated that is over and above the facilities needs flows back onto the CEA electric grid for other customers. CEA's fuel cell project also produces hot water that the Postal Service uses to help heat it's building.

CEA was also chosen some years back to install and continues to maintain two 200-kw fuel cells at the Alaska National Guard armory at Fort Richardson.

Together, CEA and the Alaska Village Electric Cooperative (AVEC) have been evaluating a 28-kw natural gas-fired and a 28 kW diesel-fired microturbine that were deployed at the AVEC headquarters in Anchorage. They plan to continue this work looking at their performances in a cogeneration mode.

In September, CEA and Cook Inlet Region, Inc.(CIRI) agreed to jointly fund a $50,000 project to study the feasibility of generating electricity from the wind on Fire Island. CIRI owns three-fourths of the 4,000-acre island. As part of the project, CEA erected a trio of temporary structures to collect wind and weather information around the clock for up to 18 months.

Chugach Electric had accumulated over 90K hours of operation [since March 2000] on the 1 MW PAFC power plant at the Anchorage PO by June 2002 with an efficiency of 34.3% for electrical power production based on the higher heating value [HHV] of the natural gas fuel. If the cogenerated heat is included, the efficiency is 45.4%. Since commissioning on Nov. 1, 2000, the availability was 99.977% with 74 switching operations. Estimated costs for labor & parts and fuel were each ~ 4 cents/kWh. Significant knowledge gained included increased confidence in seamless switching and the adverse impact of thiophene in the NG supply on the reformer.

The NG fired microturbine had accumulated over 8,760 hrs run time by May 2002 and revealed an efficiency of 24.7% [LHV] and raw availability of 94% for the prior 3 months. Grid independent testing began April 2002.Of the 42 trips off line, 15 were fuel faults, 9 grid faults, 8 internal, and 6 fuel compressor failures. Noise attenuation has been successful. The oil fired unit had 30 hours of operation.

Chugach is investigated the wind resource in South Central Alaska and hopes to install a cluster of 3 wind turbines in the Anchorage bowl totaling ~ 2 MW by 2003-4. In the longer term, CEC hopes to use wind energy to produce hydrogen by electrolyzing water. The hydrogen can been used as a feedstock for IC engines or for fuel cells. The hydrogen could also have value as an exported item. CEC has been producing hydrogen via electrolysis for decades at its Beluga facility. It is used to help provide cooling for the generators.

Anchorage ML&P owns and operate two gas-fired power plants to provide electricty to the municipality. One of their plants utilizes waste heat from the power plant to pre-heat the City's municipal water system. AML&P also manages the Eklutna hydroelectric dam for CEA and Matanuska Electric Association (MEA). Homer Electric Association (HEA) manages the operation and maintenance of the Bradley Lake dam for the Rail belt utilities. It also recently installed a gas turbine at the Agrium petrochemical plant in Kenai that is generating power and providing process steam for the industrial facility.

The Golden Valley Electric Association (GVEA) serves 90,000 Interior residents in the Fairbanks, Delta, Nenana, Healy and Cantwell areas. It's generating capability of 228 MW is supplied by five generating facilities including a 25 MW coal-fired plants at Healy, a 120 MW oil-fired plant in North Pole, 65 MW at two oil-fired plants in Fairbanks, and 20 MW of the Bradley Lake hydropower facility located near Homer. GVEA's share of Bradley Lake is transmitted via the Rail belt Intertie system. GVEA is the northern control point for the Fairbanks/Anchorage Intertie, which serves most Rail belt communities. This transmission system allows exchange of existing and future generation reserves among Railbelt utilities and substantially increases system reliability for Railbelt communities. The Intertie allows GVEA to augment its 228 MW generation capacity with an additional 70 MW. Its peak demand was 182 MW in 1999.

In 1998, GVEA joined Alaska Wind & Solar (AKW&S) in a wind generation demonstration project in the Healy area involving a Bergey Excel 10-kilowatt (KW) wind turbine. It was installed on an existing microwave tower at GVEA's Healy Repeater site on the top of Garner Hill. The variable frequency three-phase power generated by the wind turbine is converted to single-phase 120-volt, 60-hertz power via electronics, and fed through an electric meter and 100-amp breaker. Then a distribution transformer steps the voltage up to 14kV and feeds it into GVEA's distribution system. The electronics package includes safety features that protect the system from electrical faults and prevent the wind turbine from energizing the distribution transformer during an outage.

Total energy production from the Bergey wind generator was 21,876 kWh as of 4/15/00. The system availability has been 76.8%. The total energy produced was 15.6% of rated capacity. For comparison, EPRI reported that the Central & South West Wind Power Project near Fort Davis, Texas had a system availability of 75.3% and produced energy amounting to 16.3% of capacity.

On October 10, 2001, Golden Valley Electric signed a $30 million contract with ABB Power Systems to construct the Battery Energy Storage System (BESS). When operational, BESS will provide 26 megawatts of backup power to GVEA's system for 15 minutes. The BESS will be composed of 13,760 high performance nickel-cadmium battery cells; and, when complete, will increase system reliability. The BESS is scheduled to be operational during the summer of 2003.

Alaska's third-largest community, Juneau, relies on hydropower from four plants, particularly the Snettisham Hydroelectric Project, which supplies most of the town's electricity. Juneau's hydro plants can produce up to 85 megawatts of power on demand, and the town's highest peak of 65 megawatts came in January 1996.

The Alaska Village Electric Cooperative, Inc. (AVEC) covers the largest area of any electric cooperative in the world and has operated since 1968. It is a non-profit electric utility serving residents in 51 locations throughout rural Alaska. The Cooperative's member villages span from as far north as Kivalina, to as far south as Old Harbor on Kodiak Island, and as far west as Gambell on St. Lawrence Island (within sight of Siberia), to as far east as Minto, located approximately 80 miles west of Fairbanks. Minto is the only AVEC community accessible by road. All other AVEC communities are only accessible by airplane or marine vessel.

AVEC has more power plants than all other RUS financed cooperatives in the State of Alaska combined. Over 144 diesel generators operate a cumulative total of more than 40,000 hours per year. The Cooperative stores fuel in 559 tanks with a combined usable capacity of 4,573,078 gallons of fuel.

The Kotzebue Electric Association (KEA) has now installed 10 AOC 50 kW wind turbines that are supplying at times up to 39% of that utilities electricity demand. Between 5-7% of the total electrical requirements are being supplied by the wind turbines. KEA has pioneered the deployment of wind power in rural Alaska.

Alaska Energy Authority

The Alaska Energy Authority (AEA) was created by the Alaska Legislature in 1976. Throughout the 1980s, AEA worked to develop the state's energy resources as a key element in diversifying Alaska's economy. A number of large-scale projects were constructed. Today, AEA's six hydroelectric projects have an installed capacity of 164 megawatts, and the Anchorage-Fairbanks Intertie's 170 miles of transmission line link Interior Alaska with less expensive energy available in the Southcentral portion of the state. As a result of legislation passed in 1993, AEA's primary role was to own these existing hydroelectric projects and the Intertie. The many AEA programs addressing the energy needs of rural communities were transferred to the newly created Division of Energy within the Department of Community and Regional Affairs. In 1999, the Alaska Legislature moved the rural energy programs back to AEA and the rural energy staff was hired by AIDEA to operate the rural energy programs. Oversight of AEA rests with the Alaska Industrial Development and

Export Authority (AIDEA), whose board of directors and executive director serve in the same capacity for AEA. AIDEA also provides staff to AEA.

Major projects owned by the AEA include:

- The Bradley Lake Project began commercial operation in 1991, providing improved power delivery to the Kenai Peninsula from Homer, along the Railbelt to Fairbanks and Delta Junction. A 610-foot long, 125-foot high concrete-faced and rock-filled gravity dam, Bradley Lake has a 3.5-mile power tunnel and steel-lined penstock. AEA has contracted with Homer Electric Association to operate this major power facility.

- The Four Dam Pool projects include Solomon Gulch, which serves Valdez and Glennallen. Ketchikan and the surrounding area derive power from the Swan Lake project, while Terror Lake services Kodiak. Tyee Lake provides power for Petersburg, Wrangell and associated transmission facilities. Collectively, these projects make up the Four Dam Pool. As of 2002, AIDEA has completed the transfer of the four dams to the local utilities. Funding for the Four Dam Pool projects originated from state grants totaling $295 million and a $181 million loan to AEA from the State of Alaska. The project gained its name from the fact that operation, maintenance, and debt costs are pooled, with the same rate charged for electricity drawn from any one of the four projects. Agreements are underway to transfer the Four Dam Pool projects to utility ownership.

- The Anchorage-Fairbanks Intertie is a 170-mile, 138kV transmission line that runs from Willow, north of Anchorage, to Healy, which is about 100 miles south of Fairbanks. This Intertie allows Golden Valley Electric Association in Fairbanks to purchase less expensive electricity from the Anchorage and Kenai Peninsula utilities. It is estimated that the Intertie has saved residents of Fairbanks $7 million a year. An added benefit has been a drastic reduction in the number of black/brownouts throughout the system. The Intertie enables multiple projects to be developed utilizing power where most needed and taking advantage of both hydro and natural gas electric generation sources.

- Established in 1991, the Larsen Bay Hydroelectric Project services this isolated Kodiak Island community. Like many other AEA ventures, this project provided additional benefit to the City of Larsen Bay's by replacing their old water supply system. They now have a more reliable source of water resulting in reduced maintenance and improved water quality.

Of particular note is the ongoing work AEA does in rural Alaska, where power costs are dramatically higher than in urban centers. Partnering with the Denali Commission, *AEA's Rural Energy Group is involved in a number of programs*:

- Rural Power Systems Upgrades (RPSU) projects can include the rebuilding or replacement of worn out diesel generator units, old and hazardous distribution systems and constructing new power generation systems. Currently Tuntutuliak and

Kotlik powerhouse projects were completed this year. Golovin, Kwigillingok, Newtok, Kongiginak, Atmautluak and Manokotak upgrades are in design stage with anticipated construction in 2002.

- Energy Efficiency and Alternative Fuels. AEA manages active programs in the area of biomass fuels, energy conservation, wind development, hydroelectric power, interties and diesel efficiency. The 20 projects in this area total $63 million in funding and generally focus on near-term technology deployment for energy cost reduction. A recent solicitation will authorize grants and loans totaling $7.6 million for 15 additional hydroelectric, heat recovery, electrical line extension, and diesel efficiency projects. Selection criteria include cost-effectiveness, economic need, and readiness for 2002 construction.

- Bulk Fuel Upgrades Rural Alaska communities require bulk fuel tank farms with sufficient storage capacity to meet their needs for an entire winter, and many of these storage facilities are in poor condition. By the close of 2001, new bulk fuel projects will be substantially complete and operational in nine communities: Kotlik, Chignik Lagoon, Old Harbor, Noorvik, Port Graham, Manokotak, Kiana, Allakaket, and Napaskiak. Current federal, state, and local funding for these projects totals around $22 million. An additional 21 Bulk Fuel Upgrade projects are planned for in the 2002 construction season and fourteen more in 2003.

- Power Cost Equalization. In May 2000, Governor Tony Knowles signed into law an innovative plan that addressed the long-term funding of the PCE program, which subsidizes rural energy costs, and authorized the sale of the Four Dam Pool to the communities they serve, with AIDEA financing the sale. Using the proceeds from the sale, the plan creates an endowment to provide long-term funding for PCE.

- Training**.** In 2001, the AEA training program for small rural utilities received funding for its sixth consecutive year. This funding provides training for rural utility clerks, bulk fuel operators, and an advanced powerhouse operator program.

- Loan Programs. The AEA's Power Project Loan Fund makes low interest loans available for small-scale energy project development, while the Bulk Fuel Revolving Loan Fund helps communities spread costs of large yearly diesel purchases over longer periods of time.

The AEA and the ASTF [AK Science and Technology Foundation] supported a study involving the use of fish oil to power a 2.3 MW DEG at UniSea Inc. in Unalaska. Test were conducted in October 2001in which fish oil was blended with no. 2 diesel fuel with concentrations varying from 0 to 100%. It was found that both CO and PM in the exhaust declined significantly as the oil content increased to 50 %. After that, the CO content continued to decrease while the PM went up somewhat. The fish oil has a sulfur content of only 0.004% compared with 0.5% for the diesel fuel. Hence, there will be substantial reductions in SO2 also. It is expected that the preferred use of fish oil from an energy perspective will be as boiler fuel. As of June, 2002 over 200,000 gallons of fish oil had been consumed. Additional testing in higher speed 4 cycle engines is planned for 2002-3.

Denali Commission

The Denali Commission is a federal-state partnership established by Congress in 1998 to provide critical utilities, infrastructure, and economic support throughout Alaska. Focusing on rural energy as its primary infrastructure theme in 1999, it initiated projects including bulk fuel storage repair and upgrades, power plant and utility distribution upgrades, hydroelectric power generation projects, and an inspection and needs-assessment project. By the end of the year 2000, bulk fuel storage tanks with a combined total capacity of 45,493,035 gallons had been inspected and assessed in 168 communities. The needed repairs identified add to a huge existing backlog of rural energy needs [approaching $300,000,000.

With these four projects and the twenty others completed since 1992, 8.5 percent (3,866,908 gallons of storage capacity) of the total fuel tank farms needing repairs or replacements identified in the assessment have been completed. The Commission's long-term goal is to complete scheduled work on the remaining bulk fuel infrastructure in the 168 communities by the year 2010. To accomplish this goal, the Commission is working with its partners to quadruple the pace of construction from 1.4 million gallons last year to at least 5 to 6 million gallons of storage capacity per year.

Energy projects comprise nearly $65 million of Denali Commission funding with $ 39.3 million committed to bulk fuel storage upgrades and $16.9 million for Rural Power Systems Upgrades. The bulk fuel storage upgrades cost about $ 10/gallon of fuel storage. Before project funding is awarded, the final design (including site control, documented community commitment, and an enforceable business plan) must be approved by the Commission.

Other Parties

The University of Alaska Fairbanks, (UAF) with support from the U.S. Department of Energy (USDOE), established an Energy Center (EC) in 1998 where new technologies relating to the production of heat and electric power can be evaluated in a northern setting. In its initial phase, the EC consists of a 74 m^2 test chamber plus an auxiliary structure in which hydrogen is produced. These structures in turn are located inside an unheated 520 m^2 warehouse. Initially, we focused on the evaluation of fuel cells (FCs) and reformers, looking at both performance and reliability issues. Fuel cells produce electricity electrochemically and require a fuel (normally hydrogen) and oxidant (air). Reformers are sometimes added to the front end to convert a conventional fuel such as diesel to hydrogen. Later, we will study the integration of the electric and other utilities and focus on Arctic engineering issues.

More recently, the Arctic Energy Technology Development Laboratory [AETDL] has been established at UAF with support from the USDOE. It's mission is to promote (1) research, development and deployment of oil recovery, gas-to-liquids and natural gas production & transportation and (2) research, development and deployment of electric power in arctic climates, including fossil, wind, geothermal, fuel cells, and small hydroelectric facilities.

The Institute of Social and Economic Research [ISER] at the University of Alaska Anchorage recently [2001] issued a draft report titled "Sustainable Utilities in Rural Alaska." Part of the findings were that " it costs between $80 million and $120 million per year to provide each of the major utilities -- electricity, water/sewer, and telecommunications -- to rural Alaska consumers. In the case of electricity, fuel and booked operation and maintenance together account for 59% of total cost. Capital costs carried on utility books account for 15%. The remaining 26% is "off-book" and consists of government-funded capital construction. Government funded O&M assistance accounts for less than 1% of the total true cost of electricity."

The true cost of bulk fuel storage is roughly $1.50 per delivered gallon from the tank with 60 cents of this being spill response capability. Bulk fuel is expensive because the the fixed capital cost is spread over relatively few gallons delivered [ie - long storage time].

The Southeast Conference proposed building a network of power transmission lines connecting most of the communities in the region over 10 years ago. The Conference commissioned a study in 1997 to explore its feasibility, costs and benefits. Through the Conference of Mayors and the financial support of key communities, the Southeast Conference obtained federal authorization for up to $384 million in federal funds to construct the intertie. The primary benefits of the intertie would be more reliable power at a reasonable rate to all communities served, and the elimination of up to two million gallons of diesel fuel burned in stand-alone power plants every year.

At its 2001 annual meeting in Prince Rupert, the Conference proposed organizing a Joint Action Agency (JAA) to build and operate the intertie, under Alaska Statute 42.45.300. Comments on this proposal were solicited. The Central Council of Tlingit and Haida Indian Tribes of Alaska (CCTH) responded by outlining their concerns regarding use of a JAA structure, and recommending formation of an electrical cooperative, under Alaska Statute 10.25.

The Southeast Conference sponsored a meeting of its electrical intertie committee in Juneau, Alaska, on March 22, 2002, to discuss options for organizing an entity to build and operate the intertie.1 Considerable legal research had been invested in analyzing two options for organizing the intertie entity. These options are formation of a Joint Action Agency (JAA) or an electrical cooperative.

Four Dam Pool

The four facilities comprising the four dam pool projects came on line in the 1980s. The project includes Solomon Gulch (12 megawatts) which serves Valdez and Glenallen, Swan lake (22MW) which serves Ketchikan, Terror Lake (20 MW) which serves Kodiak and the Tyee Lake (20 MW) which serves Petersburg and Wrangell, and associated transmission facilities. The facilities were financed with State grants totaling $295M and a $181M loan to AEA from the State.

Revenues received by AEA from the sale of power under a long term Power Sales Agreement are used to pay operating and maintenance costs for the projects and the debt service on the loan. The project gained its name from the fact that operation, maintenance and debt costs are pooled, with the same rate charged for electricity drawn from any one of the four projects. The local utilities are responsible for day-to-day operation of the projects.

The Four Dam Pool once belonged to the AEA and has now been sold to the municipalities that were serviced by it on February 1, 2002. The exclusive purchasers of power from the facilities operate under a 45-year power sales agreement with AEA that expires in 2030. The purchase includes $84 million; $74 million at closing and an additional $10 million to be paid to the State upon retirement of the acquisition debt if certain contingencies have been met.

Tyee Intertie

Once constructed (planned in 2003) the intertie will connect the Swan Lake leg (22MW) , which serves Ketchikan with the Tyee Lake leg (20 MW) which serves Petersburg and Wrangell. The $79 million transmission line is designed to limit the use of diesel-generated power and provide cost-effective energy to KPU's customers.

The work will involve clearing and logging to make room for construction of the intertie, as well as geotechnical work. It is expected to last through the summer and into fall. Clearing in a small, designated portion of the intertie's corridor could begin this summer. The U.S. Forest Service has agreed to allow city-owned Ketchikan Public Utilities to flag, survey and catalog the environment in areas within an 18-mile portion. Once the Forest Service approves clearing in that area, KPU then could begin work while cataloging is done in another area of the selected portion. As work takes place this summer, the remainder of the corridor that needs to be cleared could be put out for bid.

Wrangell to Cassier Highway

The economies associated with timber and fisheries are shifting to bases with lesser transportation costs than those experienced in SE Alaska. The collapse of these industries has had devastating effects on local economies.

A highway is desired from Wrangell at the Bradfield Canal area to British Columbia (Cassier Highway (BC37). The corridor will improve transportation efficiencies and link the SE Alaska power system to the North American grid. Much effort is being expended to make the highway a reality.

The road would bring benefit to the fishing industry by lowering costs. Energy transmission efficiencies would also be created. Misty Mountain Hydro is pursuing a low head run of the river project , which when constructed will put an interconnection to BC Hydro within 65 miles of the Tyee intertie. If connected, a transmission line in this area would alow the hydro power potential in SE Alaska to expand. The 80 MW of capacity at Thomas Bay could be explored. Wheeling fees out of BC are $0.008 per Kwh. Power sales on the grid could enhance industrialization.

RECYCLABLE MATERIALS

The Southeast Conference sponsored a comprehensive study of recycling in 1990. The results of the study indicated that recycling in SE Alaska was not profitable because of shipment costs and deflated markets. The only recyclable of value was aluminum at revenue of $785/ton.

This survey was repeated with the same general results. Aluminum remains the only recyclable material of value. Again the controlling factor in recycle success is transportation costs.

Recyclable material markets exist in Seattle only.

ADVANTAGES/DISADVANTAGES EVALUATION

Technological Alternatives

Current Practices

Many municipalities in SE Alaska, especially small ones, continue to landfill MSW. Several larger communities (Ketchikan, Wrangell, Petersburg, Sitka) ship MSW to Washington for disposal. Juneau and Skagway operate MSW incinerators. Sitka formerly utilized a MSW incinerator. Most ISW is shipped to Seattle. A small volume of tires and used oil are incinerated or landfilled. IWW is shipped off-site as chips or managed on-site in stockpiles.

Technological Options

1. Local or Regional SE Alaska Landfill

   Develop small landfills for individual communities; or, develop a large regional landfill and have all of the locations in SE Alaska ship to the landfill for disposal via a solid waste authority to reduce costs.

2. Regional Non-Alaska Landfill

   Continue shipping to a regional non-Alaska landfill for disposal. Have all communities ship to the facility via a solid waste authority to reduce costs.

3. Local or Regional Incineration

   Develop small incinerators for individual communities; or, develop a large regional incineration facility. Have all of the landfills ship to the facility for disposal via a solid waste authority to reduce costs.

4. Local or Regional Plasma Thermal Reactor

   Develop small reactors for individual communities; or, develop a large regional facility. Have all of the landfills ship to the facility for disposal via a solid waste authority to reduce costs.

5. Recycling and Composting Augmentations

   Develop recycling and composting options to reduce waste volume and continue to landfill or incinerate as needed.

Evaluation of Options

Each of the identified options has been evaluated against critical criteria noted below. A score of 1-5 has been assigned to each criteria: (1) Excellent, (2) Good, (3) Fair, (4) Poor, (5) Prohibitive

Criteria	Options				
	Alaska Landfill	Out-of-State Landfill	Incineration	Plasma Thermal Reactor	Recycling Compostin g
Capital Cost	5	3	4	3	3
Operating Cost	2	2	3	3	2
Revenue Generated	5	5	5	1	2
Jobs Created	3	5	3	2	3
Pollution Emitted	3	1	4	2	2
Environmental Liability	5	4	3	2	2
Economic Stimulus	4	5	4	1	4
Total	27	25	26	14	18

Plasma is the "best alternative" for SE Alaska. It is recommended that this option be considered in conjunction with establishment of a solid waste authority and some measure of recycling.

Technical Feasibility

Two technical options were identified to deploy a plasma thermal reactor in SE Alaska. The first option is a small facility deployment. The second a large facility deployment.

Option 1 – Small Facility

Construct a small modular reactor at Silver Bay Logging's Zimovia facility on a 5 acre footprint. The reactor will be used to decompose 50TPD of MSW and ISW. This waste flow will come from Wrangell, Petersburg, and surrounding communities. Waste will be delivered by barge to the complex where it will be recycled before processing. The unit will produce 5MW of power which will be used to drive the reactor at no cost or which can be used to provide back-up power to the mill. This facility is expected to cost $12,000,000 and will pay for itself in 10 years from the tipping fees received for managing solid waste. This facility is expected to create 10 to 50 jobs.

Option 2 – Large Facility

Construct a large facility in Wrangell on a 50 acre footprint likely located on the back-side of Wrangell. Develop new infrastructure at the site including power, water, sewer and deep-water port. This facility will be designed to decompose 500 TPD of solid waste including as much MSW and ISW as attainable from SE Alaska (200 TPD) and 300 TPD of IWW. Wastes would be shipped to the facility for processing. Woodwaste feedstock to the plant will be purchased at $30/t for hog fuel and $50/T for chips.

Construction of the facility will include the installation of power transmission line from British Columbia to the Swan Lake-Tyee interchange. This will allow power to produced and sold on the North American grid. The plant will be retrofitted with the necessary equipment to produce ethanol from woodwaste. Ethanol will be shipped to Washington for fuel blending. Excess steam and heat and power from the plant could be provided to a new attached MDF mill with complete emissions recapture. Distilled water from the plant will be provided to the City for blending or will be discharged. The plant will provide capability to directly unload wastes from cruise ships - dockside.

This plant represents an investment in Alaska of approximately $250,000,000. Option 2 is the recommended option.

Financial Feasibility

The total cost of managing and disposing of Southeast Alaska IWW could exceed $40,000,000 annually. An option must be explored to reduce these costs and stabilize IWW management practices.

Southeast Alaska Waste Concerns

Waste Type	Tons Produced/Day	Current Cost/Yr
Municipal Solid Waste (MSW)	250	$29,125,000
Industrial Solid Waste (ISW)	100	$10,070,000
Industrial Wood Waste (IWW)	300	$40,000,000
Total Solid Waste	650	$79,195,000

Two options have been identified to offset these costs. Both options have been determined to be financially feasible.

Option 1 – Small Facility

A private corporation invests $12,000,000 and pays for the plant over a 10 year period of time. The City provide inexpensive power as needed. Silver Bay Logging contributes land for the plant. Waste receipts will be negotiated. MSW can be disposed for $80/T. ISW can be disposed for $150/T. IWW will not be processed. This facility will grow by adding modules as needed and as new waste receipts are obtained. The plant is expected to grow from 50TPD capacity to 150TPD capacity in 10 years. All profit from the plant stays in the corporation. 10 – 50 jobs are expected to be created over a period of 10 years. This facility will gradually grow to become a regional solid waste facility.

Option 2 – Large Facility

A non-profit organization is established to own the large facility. The non-profit organization established two management companies to operate the business and facility. Any cash reserve produced from the facility is returned to the State or local communities. This effort requires an investment of $250,000,000 and is expected to return $20,000,000 per year to the local economy. The non-profit organization decides how the $20,000,000 is redistributed based on state and municipal recommendations. A larger facility will employ 200 – 250 persons. The larger facility immediately meets regional solid waste needs. It is anticipated that the State (ADEC) should establish a regional solid waste authority to support the facility. Three major actions must be completed to obtain the large amount of funding:

1) The fund reviews and approves a business plan for the facility. Initial meetings with financers indicated a high level of interest in the project.

2) Irrevocable letters of intent are collected and approved by the fund for the waste inputs and the product outputs. It is expected that these letters can immediately be obtained for 300 TPD of hog fuel. It is uncertain what could be obtained for chips, MSW or ISW. An ADEC sponsored regional solid waste authority is expected to assist in providing some guarantee.

3) A guarantee of the funding is provided as an irrevocable letter of credit or cash bond for 13 months during the design period. After the design period the construction performance bond provides the guarantee. The only entity known with capability to provide this guarantee is the State of Alaska.

When these three actions are met, the facility will be funded.

Advantages to Alaska

The following advantages to the State of Alaska are provided in return for the 13-month guarantee:

1. A power line is constructed from BC to the Swan Lake – Tyee interchange. The development of the power line creates three significant benefits:

   A. The transmission line opens a corridor for a road.
   B. The transmission line allows undeveloped hydropower in SE Alaska to prosper. The 80MW capability inherent at Thomas Bay could be developed and brought on line. This excess power could be sold for profit.
   C. The new line and roadway increase tourism in SE Alaska – particularly Ketchikan and Wrangell.

2. The new facility stimulates the sluggish timber industry. The plant can pay for woodwaste currently stockpiled with no viable market outlet. The plant can purchase both hog fuel and chips and use them to produce ethanol and/or power. Other benefits are also derived from this advantage:

   A. The timber industry re-emerges with viability and capability to utilize woodwaste. Logging becomes more profitable since all of the wood removed from the forest turns a profit and is driven locally.
   B. Support shipping industries flourish with new business delivering product to the new plant.

3. The regional solid waste concern is resolved. The money spent on landfills is put back into the economy. The local cost of managing solid waste is reduced thus saving money for each community. Collection of wastes improves thus reducing incidents of illegal disposal. In other words, the area starts getting cleaner.

4. A mechanism is proved to manage ISW and even hazardous waste on a local basis rather than shipping it at risk across the ocean. This acts to foster a cleaner Alaska. A local option reduces the prospect of illegal disposal.

5. The economic base of the regional economy is strengthened by production of new products including ethanol.

6. The local economy of Wrangell is salvaged with many new long term jobs.

7. New economic development opportunities are created with attached industries – MDF, Hydroponics, waste shipment, insulation, tile, aggregate, water, etc.

Does the value of the new large facility outweigh the risk of providing a 13 moth guarantee? It surely does. Here is a simple yet conservative balance sheet to consider:

New Hydropower Opportunities -	$50M/yr
Increased Tourism on Road -	$10M/yr
Reduction of Landfill Support -	$20M/yr
Savings in Solid Waste Fees -	$10M/yr
Stimulated Timber Industry -	$20M/yr
Cash Return to State from Facility -	$20M/yr
New Economic Developments -	$5M/yr
New Jobs -	$10M/Yr

Overall Benefit: $190M/yr (this is $1.9B in 10 years)

What is most significant is that the facility is not a giant corporate venture. This is a non-profit organization that returns benefit to the community. More than $189B is currently invested in the US in this manner annually. This type of investment provides significant tax benefit to large funds with little risk.

Technical Advantages

Advantages associated with deployment of this technology are significant an include:

- As many as 50 new jobs may be created to operate the facility. Another 30 indirect jobs may be created to manage fuel, etc.

- Using the woodwaste as fuel in the energy system can effectively reduce the SE Alaska stockpile of woodwaste. This eliminates the cost of landfilling the woodwaste or modifying boilers to meet new stringent air requirements for continued hog fuel use.

- Shipments of Southeast Alaska municipal solid waste to Washington State can be eliminate and cost savings obtained by managing the waste locally.

- The facility will produce heat, steam, and electricity for commercial sale. The cost of this energy will be less than is currently spent.

- Excess heat and steam can be used to develop other businesses. The heat could be supplied to new buildings or used in hydroponics, etc.

- Land is available on which to build a facility with nearby docking capability.

- The technology can use diverse fuels. Expansion is possible to include management of cruise ship waste. This is currently a critical need along the Inside Passageway.

- Emissions from the facility are very clean and operations can be safely conducted within regulatory requirements.

- The technology is simple to use and is low impact on neighbor

Attached Industries

Plasma facilities are very diverse and provide a strong economic expansion base. The following industry expansions can be achieved through use of a plasma reactor. These expansions are possible in addition to the waste reduction capability a plant posseses:

- Diverse waste destruction – plasma can be used to eliminate cruise ship waste, fish processing waste and even hazardous wastes.
- Power production – plants can produce large amounts of electricity especially if they are sourced with woodwaste. Power can be sold.
- Ethanol production – plants can produce ethanol directly from syngas or can provide heat and steam to drive a conventional ethanol plan. In these cases, ethanol emissions are captured and recycled to eliminate pollution.
- Hydrogen production – plants can produce hydrogen directly from syngas conversion or from aerosolizing molten metal.
- Steam and Heat – excess steam and heat can be used to heat buildings or to drive hydroponic operations.
- Power, Steam and Heat – plasma facilities can produce utilities for new industries such as a multiple density fiberboard mill or fish processing plant and can then be used to completely recycle emissions.
- Distilled Water – large volumes of pure water can be sold directly or can be blended into existing systems to improve quality and add capacity.
- Rockwool Insulation – insulation can be produced by spinning molten glass.
- Tile and Blocks – various tiles and blocks can be produced by casting molten glass.
- Aggregate – molten glass can be fritted and utilized as aggregate for many operations

POWER POINT PRESENTATION