NREL Advances in Technology at the National Renewable Energy Laboratory

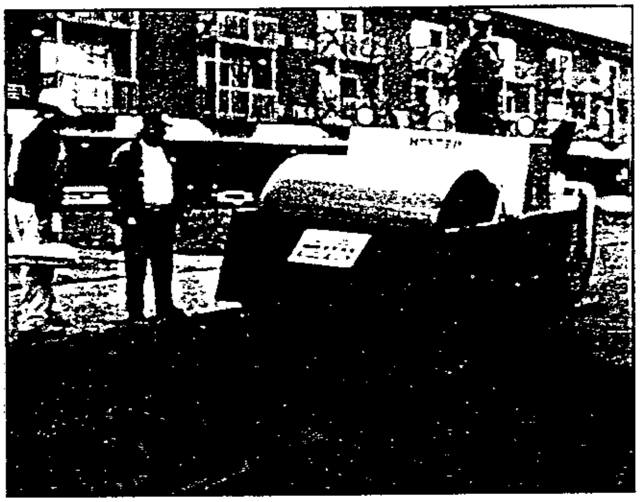
Technology Brief

Why Bury It When You Can Use It?

Ash from Waste-to-Energy Plants Makes an Excellent Road-Base Material

The expense of road building and the demand for landfill space are prominent concerns on many local government agendas. Taking advantage of ash from waste-to-energy plants may offer substantial help for both. Waste-to-energy plants burn trash to generate electricity or steam heat—dramatically reducing landfill use. Waste-to-energy plants provide a key element of an integrated waste management program and you may well already have one in your community or nearby. The ash from waste-to-energy plants is an excellent resource material that can be used in building roads and in several types of construction material. Such beneficial use of the ash saves other resources, further saves on landfill space, and may provide significant cost savings.

The United States and Canada lag far behind several European countries in using waste-to-energy plants as a way to beneficially manage municipal solid waste. Even more striking, however, is the lack of use of the ash from U.S. and Canadian waste-to-energy plants. Waste-to-energy plants produce "bottom ash" from the furnace itself and "fly ash" from air pollution control equipment. In Germany, 60% of waste-to-energy bottom ash is used as material for road base or in highway sound barriers. The Netherlands currently uses 40% of its fly ash to make asphaltic paving material and uses more than 90% of the bottom ash as road base and embankments or to make concrete or asphalt products. In Denmark, as much as 90% (depending on current demand) of bottom ash is used as a base for parking lots, bicycle paths, and paved and unpaved roads. France uses about 64% of the bottom ash produced by its waste-to-energy plants. Of the more than 7 million tons per year of ash generated by waste-to-energy plants in the United States, nearly all is landfilled, with less than 7% being put to use.



Courtesy of CMA Engineers, Inc./PIX 04360

Ash from waste-to-energy plants makes an excellent road-base material. Study of this road construction in Laconia, New Hampshire, found it to perform very well and cause no environmental problems.

Management of Municipal Solid Waste in Selected Countries

Country	% Recycling	% Waste-to-Energy	% Landfill	Current Beneficial Use of Waste-to-Energy Ash (%)
Germany	18	36	46	60 (bottom)
France	13	42	45	64 (bottom)
Sweden	19	47	34	Under consideration
Denmark	23	48	29	60 to 90 (bottom)
Netherlands	20	35	45	40 (fly), 90+ (bottom)
Japan	5	72	23	10 (bottom)
Canada	21	5	74	Very small
United States	23	15	62	6.4 (combined)

Well-Demonstrated Ways to Use Substantial Resource

Waste-to-energy plants burn municipal solid waste to produce steam for heating or for generating electricity (see "What is a Waste-to-Energy Plant?" sidebar next page). As of 1995, 114 waste-to-energy plants in 34 states processed 15% of the more than 200 million tons

What is a Waste-to-Energy Plant?

Waste-to-energy plants are facilities that burn trash to boil water to produce steam in much the same way power plants burn coal, oil, natural gas, or wood. The steam can drive an electrical turbine or be used directly for industrial processes or community heating. The most common technology—mass burn—accepts trash after minimal preprocessing. The trash is carried through the combustion chamber on a slowly moving grate with air injected both above and below the grate to burn at 1100°C to 1375°C (2012°F to 2507°F). Noncombustible material and ash pass through for collection. Other waste-to-energy technologies include rotary kiln and fluidized-bed combustion processes.

An alternative approach processes the trash by removing noncombustible material, reducing the size of the combustible material, and sometimes forming it into pellets. The resulting refuse-derived fuel or process-engineered fuel can then be burned on site, at a separate waste-to-energy facility, or as an additive to a coal-fired plant with resulting reduction of toxic air emissions.

As of March 1995, there were 114 waste-to-energy facilities in the United States serving more than 1600 communities. They process more than 28 million metric tons (31 million short tons, about 15%) of the trash generated in the country. Each hour, these plants generate about 2650 megawatts of electricity plus 640,000 kilograms (1.4 million pounds) of direct-use steam—enough energy to replace approximately 30 million barrels of oil per year. Most waste-to-energy plants separate out noncombustible and recyclable materials—106,000 metric tons (117,000 short tons) per year—prior to combustion in the plant. High-grade ferrous metal—670,000 metric tons (739,000 short tons) per year—is then recovered from the waste-to-energy ash (see other sidebar). This yields additional recycled material and in no way interferes with the amount of recycling done prior to energy generation. Communities with waste-to-energy plants have a recycling rate of about 26%, slightly higher than the national average of 23%.

Modern waste-to-energy plants have quite sophisticated air pollution control equipment and are far cleaner than coal-fired electric plants and comparable to natural-gas power plants in terms of acid gas, particulate, and hydrocarbon emissions. And because waste-to-energy plants burn material generated by "recent" plant growth with its associated carbon dioxide uptake, they contribute very little to global warming gas emissions compared to fossil fuel combustion that emits carbon dioxide that had been "locked up" for centuries.

of trash generated annually in the United States. Waste-to-energy combustion reduces waste volume by 90% for sizable landfill capacity savings—even if the ash is landfilled. On a weight basis, however, the ash produced still weighs about one-fourth to one-third as much as the trash processed, leaving a sizable resource of aggregate material for road building and other construction.

Although certain uses may require additional processing, waste-to-energy ash can be directly used as aggregate with little more processing than screening out of large items that might interfere with use. However, most waste-to-energy facilities will also process the ash to recover metals for recycling. As described below, there are also several systems that process the ash more extensively as a general practice. Project economics are generally more favorable in localities that do not have a local aggregate source, and for waste-to-energy plants that must pay off-site landfill costs because they do not have on-site disposal capability. As landfill management criteria become more and more restrictive, beneficial use of ash grows even more appealing.

In addition to the extensive European experience in beneficial use of waste-to-energy ash, several projects in the United States demonstrate effective ways to put waste-to-energy ash to good use and keep it out of landfills. Waste-to-energy ash has been effectively used in this country as a substitute for aggregate in road-base material, building construction, artificial reefs, and landfill cover.

A Few Examples

Following successful testing for the Sumner County, Tennessee, waste-to-energy plant, the American Ash Recycling Corporation (AAR) of Jacksonville, Florida, built a 110-ton-per-hour ash recycling facility for the Metropolitan Government of Nashville and Davidson County, Tennessee, waste-to-energy plant. The AAR facility recovers nonferrous as well as ferrous metals from the ash and is selling those materials in addition to the aggregate itself. The AAR facility is not only processing current ash production from the Nashville waste-to-energy plant, but is also processing previously generated ash—reclaiming space from the landfill. The state of Maine recently approved the use of AAR's processed ash for beneficial use. AAR will build a plant in Scarborough, Maine.

In 1988, the SEMASS Resource Recovery Facility in Rochester, Massachusetts, began to manufacture Boiler Aggregate™, an engineered, granular product made from the facility's bottom ash. In 1994, the SEMASS ash processing plant produced 29,000 metric tons of Boiler Aggregate™. In the process, 3600 metric tons of nonferrous and 20,400 metric tons of ferrous metals were recovered from the ash, in addition to 13,200 metric tons of ferrous metals recovered from the trash prior to combustion. An asphalt access road constructed at the site using 30% Boiler Aggregate™ substitution has performed well. The state of Massachusetts recently approved the use of Boiler Aggregate™ in asphaltic paving.

The city of Commerce, California, has been using the ash from its waste-to-energy plant for 5 years. So far more than 100,000 tons of ash has been used for road base at the landfill—and more than 8000 tons of ferrous metal has been recovered. For the last 2 years the city has not had to dispose of any ash.

Some processes treat waste-to-energy ash prior to beneficial use. Wheelabrator Environmental Systems, for example, has developed and patented an ash stabilization process— WES-PHix®—which it has marketed since 1987 and advertises as the most widely used in the United States.

Rolite, Inc., of Wayne, Pennsylvania, has been processing combustion ash since 1988. Rolite's cement-based stabilization process produces small, ash-cement balls with good physical properties as a lightweight aggregate in concrete. The product has been evaluated for use in landfills as daily cover, gas venting, and drainage layers, and for structural fill.

Beneficial Ash Management of Morrisdale, Pennsylvania, has been using fly ash and fluidized-bed-combustor ash from coal-fired power plants to create a cement-like material or grout which it has in turn used to successfully "cap" strip mine reclamation sites with impermeable barriers to prevent acid mine drainage. Because of the large amounts of grout needed for such mine reclamation, use of conventional portland cement would be prohibitively expensive. The alkali-activated, ash-based grouts, similar to the cement used by the Romans—much of which is still intact today—are far less expensive. Now the company has established a sister company, Municipal Ash Management, to make similar grouts from waste-to-energy ash.

The state of Florida has certified that bottom ash from Tampa's McKay

What is Waste-to-Energy Ash?

Two main types of residue are generated by waste-to-energy plants. Bottom ash—about 90% by weight—is the noncombustible material that passes out the end of the combustion chamber plus the "siftings" that fall through the grate. Air pollution control (APC) residues—about 10%—contain captured particulate fly ash and treatment chemicals added by the pollution control equipment. In Europe the two types of residue are usually kept separate, but in the United States they are generally mixed together as "combined ash" or more properly, residue.

Bottom ash contains glass, ferrous and nonferrous metals, slag from glass and melted metals, and other material. The ash is generally screened to remove large objects and magnetically separated to recover ferrous metals. Some processes also recover nonferrous metals. The recovered metals are of high quality and are easily recycled. They include a lot of metal that could not have been recovered without combustion. The screened bottom ash looks like a grey sand or gravel of relatively uniform size. Its characteristics (porous, lightweight, high specific surface area, and 15%–25% moisture) make it a good aggregate material for road and other construction. Because combined ash is predominately bottom ash, it has largely the same general characteristics.

Beneficial use of waste-to-energy ash has environmental advantages of saving landfill space, avoiding mining and crushing of virgin aggregates, and in some cases reducing transport distances for aggregate. Waste-to-energy ash has been extensively tested for leaching of hazardous materials and passes pertinent regulatory tests. In practice, leachate from ash landfills is usually far cleaner than laboratory tests would predict. This was confirmed by a pair of U.S. Environmental Protection Agency studies of the actual leachate from waste-to-energy ash landfills. These studies also found that the leachate met standards determining it to be nonhazardous, and that levels of several heavy metals met drinking water standards.

A 1994 Supreme Court decision that waste-to-energy ash is not exempt from hazardous waste regulation means that, before it can be beneficially used or disposed of in nonhazardous landfills, all waste-to-energy ash must be determined to be nonhazardous. A standard Toxic Characteristic Leaching Procedure test of the ash is generally used to make this regulatory determination. The court decision may, however, turn out to make it easier to make beneficial use of waste-to-energy ash by ending uncertainty and some of the variation among state regulation.

Courtesy of Chesner Engineering/PIX 04359

As part of a road construction project in New Jersey, this pile of waste-to-energy ash was left exposed for several months and carefully monitored. There was no hazardous leachate or other environmental problem.

Bay Refuse to Energy Facility is a suitable material for road construction and therefore considered a recovered product not subject to regulations for waste materials. The state has also approved Permabase®, a soil cement substitute made from ash from the Hillsborough County, Florida, waste-to-energy facility.

The State University of New York at Stony Brook built a boathouse of hollow masonry blocks made from a mixture of waste-to-energy ash and portland cement. Thorough testing found that the blocks did not release environmental contaminants and performed well structurally. The university and others have also demonstrated the suitability of beneficial use of waste-to-energy ash products in the ocean by building artificial reefs and erosion control structures.

NREL Studies

NREL is cosponsoring a series of five studies on the use of waste-to-energy ash. A completed study in Laconia, New Hampshire, examined substitution of bottom ash for rock in an asphalt mixture. Used for resurfacing a federal highway, the asphalt performed well and produced no adverse environmental consequences. A study of using waste-to-energy ash for road-base aggregate in New Jersey found that there were no adverse environmental consequences of storing the ash in exposed piles prior to use. This ash was mixed with asphalt for paving the entrance to an industrial park in Elizabeth, New Jersey. The city of Honolulu, Hawaii, is testing the use of their waste-to-energy ash in place of soil in landfill maintenance.

Two other studies are under way in Virginia. One will test the use of ash mixed with portland cement to build containers for "pop-up" railroad-crossing barriers. The other will examine the environmental consequences of using blocks made from waste-to-energy ash and phosphate cement for revetment walls for beach erosion protection. In addition to the NREL studies, a Federal Highway Administration evaluation of use of ash products for road construction projects in six states found that they worked well.

Opportunities for Mutual Benefit

Perhaps you represent a public agency or private firm that builds roads or does other construction work. Or maybe you operate a waste-to-energy plant that now pays to landfill waste-to-energy ash. Consider the ways that beneficial use of waste-to-energy ash could help your program. You may find that it could pay off well in saved landfill space, less expensive road construction material, reduced trucking of waste-to-energy ash or construction aggregate, or enhanced recycling. If waste-to-energy ash utilization appears to be a promising opportunity and you would like more detailed information, the waste management program at NREL (303-275-2915) would be happy to help. The Integrated Waste Services Association trade association (202-467-6240) may be another valuable source of information. Waste-to-energy ash is a significant resource that can be put to good use instead of taking up landfill space.

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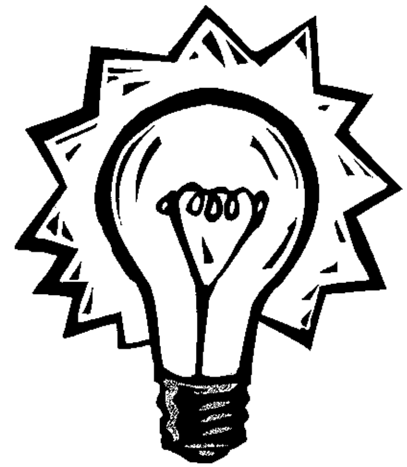

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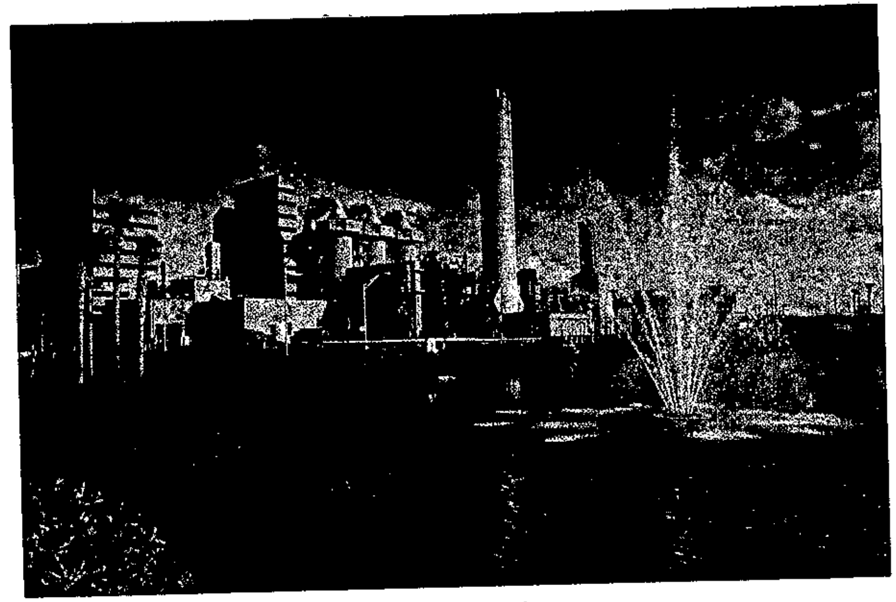
Integrated Waste Services Association

Integrated Waste Services Association (IWSA) was formed in 1991 to promote integrated solutions to municipal solid waste management problems. Within this capacity, the association strives to encourage the use of waste-to-energy technology as a key component of community programs. IWSA's members include American Ref-Fuel Company, Foster Wheeler Power Systems, Inc., Montenay Power Corporation, Ogden Projects, Westinghouse Electric Corporation, and Wheelabrator Technologies Inc. Together, the members represent 58 waste-to-energy facilities, disposing of approximately 77,000 tons of trash each day while generating enough clean energy to supply electricity to more than a million homes. IWSA member facilities meet the disposal needs of about 30 million people in 19 states. The technology of today's modern waste-to-energy plants is based on sound science and testing, and makes waste-to-energy a viable method for the disposal and recycling of municipal solid waste.



Wheelabrator's waste-to-energy plant operating in North Broward, Fla.

Waste-to-energy turns trash into steam or electricity to heat, cool, light and otherwise power homes and industry through the process of combustion. Modern waste-to-energy plants are clean-burning facilities that benefit the environment and the economy in hundreds of cities across America.

By the year 2000, Americans will generate more than 218 million tons of trash annually. The Environmental Protection Agency (EPA) expects about one-third to be recycled or composted, leaving 150 million tons of trash to be managed. This remaining trash will be handled using other elements of EPA's integrated waste management approach, including source reduction, waste-to-energy and landfilling.

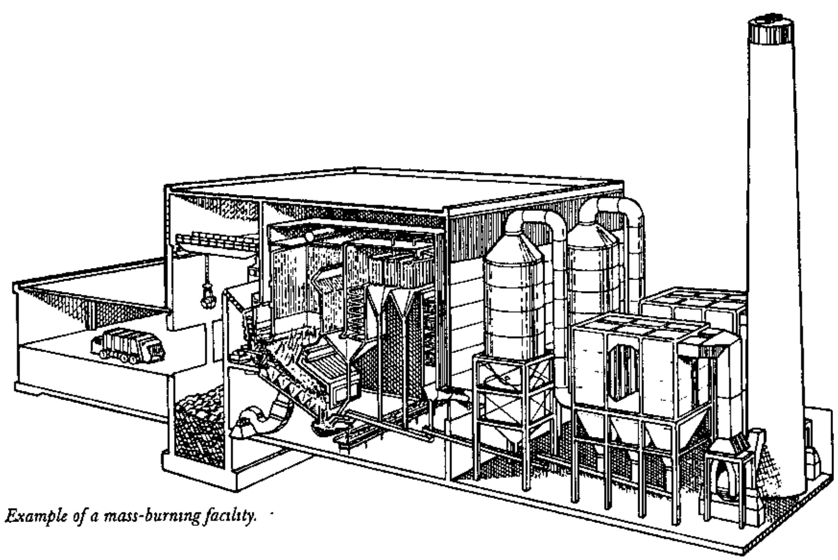
Waste-to-energy effectively reduces trash using safe, environmentally friendly and economical technologies. Waste-to-energy destroys disease-causing bacteria, pathogens and other harmful elements commonly found in trash. Trash processed through waste-to-energy plants is reduced in volume by about *90%.*

What Is Waste-to-Energy?

Modern waste-to-energy facilities differ significantly from old fashioned municipal incinerators. The waste-to-energy process recovers the heat value of trash to generate steam and electricity to power homes and industry. Modern pollution control systems ensure a cleaner-burning power plant. Combustion reduces the volume of trash by about 90% and the remaining ash may be recycled in landfills as daily cover or used in road building materials.

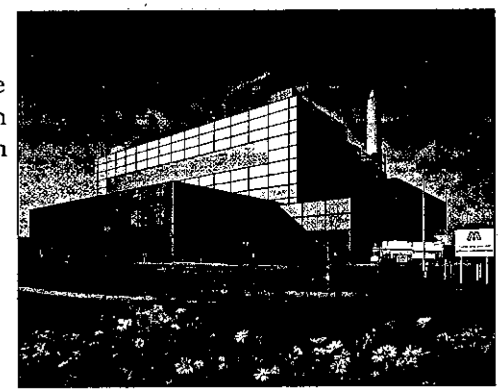
Waste-to-energy technology is divided into three basic types:

1. ***Mass burn facilities*** generate energy by feeding mixed municipal waste into large furnaces dedicated solely to burning trash. The resulting energy produces steam or electricity. Many mass burn facilities have nearby material recovery facilities, or MRFs, that separate and recycle trash prior to waste-to-energy and processing.
2. ***Refuse-derived fuel*** or ***RDF plants*** remove recyclable or unburnable materials and shred or process the rest of the trash into a uniform fuel. Sometimes, the RDF powers a generating plant on site, and sometimes the fuel is burned off site for energy.
3. ***Modular facilities*** are similar to mass burn plants, but these smaller plants are prefabricated and can be quickly assembled where they are needed.



Example of a mass-burning facility.

Waste-to-Energy Plants Offer One Essential Element of the Solution for an Ever-Growing Waste Stream



Montenay's SERRF project in Long Beach, Calif.

Recycling rates across the United States have risen steadily over the last decade, and continue to move upward. Over the last ten years, the average amount of trash disposed of by individuals has fallen from previous levels.

Without further study, statistics such as this could lead to the conclusion that the amount of waste sent for disposal must be going down. Wrong. While it is true that individuals are disposing of less, due to increases in population there are more disposers. This means that waste sent for disposal is actually *rising* at a rate of 4% annually. The good news is that, without recycling, this rate would be climbing at a much higher rate.

This ever-increasing waste stream provides a virtually limitless source of *clean* fuel to generate energy. Consider:

- There are 121 waste-to-energy plants, operating in 32 states, in all regions of the U.S.
  - these plants burn about 15% of the trash generated nationwide or, on average, about 97,000 tons each day,
  - they generate enough energy to power more than 1.2 million homes,
  - they serve the disposal needs of more than 37 million people,
  - they generate enough energy to replace more than 30 million barrels of oil.
- These plants represent a national capital investment of more than $10 billion.
- A recent survey published in *Solid Waste and Power Industry Sourcebook* and conducted in 70 cities nationwide shows that almost three-quarters of U.S. residents polled believe waste-to-energy plants are vital components of the nation's environmental and economic future. Respondents also believe that waste-to-energy programs mean cleaner disposal of wastes, less need for landfill space and are a cost-effective method of safe power generation.

Waste-to-Energy Plants Enhance Local Economies

- Waste-to-energy plant employees receive total annual wages in excess of $150 million. This translates into local economic benefits of more than $300 million. The waste-to-energy industry directly and indirectly provides tens of thousands of jobs for American workers.
- The value of energy produced annually at waste-to-energy plants in this country exceeds $850 million. Waste-to-energy provides a reliable form of power because even after source reduction and recycling, the supply of fuel (trash) is dependable. Waste-to-energy is mainly comprised of biomass, a renewable fuel.

The Facts about Waste-to-Energy and the Environment

- The waste-to-energy industry is one of the most tightly regulated industries in the U.S. As such, modern waste-to-energy plants use the most advanced emissions control and monitoring technology yet developed to meet federal, state and local requirements.
- Repeated testing of waste-to-energy emissions by federal, state and local governments has shown that, in many instances, these plants generate power cleaner than oil and coal.
- The National Centers for Disease Control, the EPA and a long list of state agencies have conducted a battery of environmental tests at modern waste-to-energy facilities. The results of the risk assessments and environmental tests show that modern waste-to-energy plants are safe.
- Waste-to-energy facilities are among the most *environmentally friendly* energy generators in the world today. Energy can be produced from trash about as cleanly as from natural gas, according to a recent booklet jointly released by the U.S. Conference of Mayors and the American Society of Mechanical Engineers. Since modern waste-to-energy plants usually replace older oil or coal burning facilities, they can actually *improve* the air quality in the communities where they operate.
- By replacing fossil fuels, waste-to-energy reduces the buildup of carbon dioxide in the atmosphere. Trash burned in waste-to-energy facilities is mostly biomass; materials such as paper, natural rubber, wood, cloth and food waste. Biomass is a renewable energy source that *does not add* to the buildup of greenhouse gases.
- How clean are modern waste-to-energy facilities? Consider: In 1993, John Eppich and Don Avilla of The Los Angeles District Sanitation Department, and Joe Smisko, plant manager of the Commerce, California waste-to-energy plant, concluded that their local facility created less pollution than the trucks used to haul trash to a nearby landfill.
- The U.S. Department of Energy has labeled waste-to-energy technology as a major part of a plan to reduce greenhouse gases in the U.S.
- A recent air sampling at a waste-to-energy facility in Indianapolis showed that sulfur dioxide emissions were reduced by 52% over the levels produced by the city's old coal-powered generating plant.
- According to EPA calculations; if half of the trash produced annually in the U.S. was used to generate electricity, ***1.4 billion*** fewer pounds of pollutants would be discharged into the atmosphere compared to energy generation through coal or oil burning.
- Recognizing the effectiveness of modern waste-to-energy facilities, the Clean Air Act can provide pollution reduction credits to utility companies and municipalities that use waste-to-energy in lieu of older power plants.

Waste-to-Energy Complements Recycling


Many recyclable materials do not make good fuel.

Communities with waste-to-energy plants recycle an average 25% of total waste as compared to the national average of nearly 22%. Many recyclable materials, such as bottles and cans, do not make good fuel. Separating them from the waste stream makes good sense. Much of the paper and plastic that make good waste-to-energy fuels are commingled with food and other bacterial wastes. Such commingled products are difficult to recycle, but because of waste-to-energy's high temperature combustion and superior emissions control systems, the materials can be excellent energy sources.

Waste-to-energy enables communities to recover materials that otherwise might not be recycled. Ferrous metals remaining in the ash are extracted by powerful magnets and sent to recycling centers. Approximately 640,000 tons of metals are recovered by U.S. waste-to-energy plants each year that otherwise would not be recycled.

Plastics: Fuel for Thought

Source reduction plays an important part in reducing our trash. Consumers are calling for less packaging. Existing packaging weighs less than ever before and packaging is getting smaller. The National Science Foundation reports that a long-term trend to less packaging can be traced to increased use of plastics. For example, to deliver 1,000 gallons of a beverage, it takes 143 pounds of plastic packaging versus 3,122 pounds of glass packaging. Proper packaging also prevents food spoilage, resulting in less solid waste.

Source reduction, however, doesn't mean the total elimination of waste. What do we do with the new, lighter weight plastic? Recycling is one answer, but sometimes it is not economically or environmentally responsible. In cases such as these, plastics can be a vitally important part of a waste-to-energy feed stream.

Waste-to-energy recovers the energy or heat value of plastics. Today's waste-to-energy plants use high-temperature (greater than 1800° F) furnaces and the most modern emission control systems to ensure clean air. The power plants can capture the heat value of plastic that, pound for pound, rivals the energy value of conventional fuels such as coal and oil.

Some people voice concern over the chlorine in plastics and its fate once burned. Will it create pollution, like dioxin? In recent tests at a modern waste-to-energy plant, scientists added excessive amounts of plastics to the waste stream to see if the added packaging would affect the emissions. There was no increase in emissions – particularly the dioxin emissions – which some claim to be a serious health concern. In fact, a slight improvement was recorded.

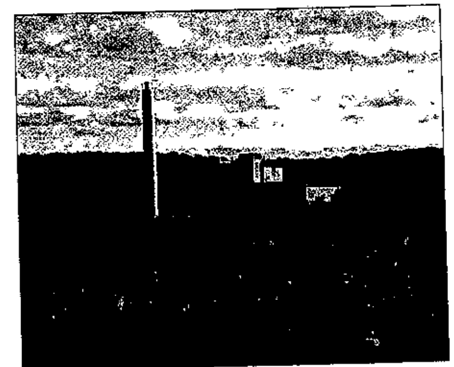
Chlorine, it seems, is everywhere in the environment. The salt we eat or spread on a wintry road or the wood we burn or use to build our homes. So, even though uncontrolled burning of a chlorine product may result in more of certain emissions like dioxin, controlled high temperature technology employed at waste-to-energy facilities doesn't result in any greater amount of dioxin than burning waste without any plastic in it at all.

Controlling Air Emissions

Trash is heterogeneous fuel that varies day-to-day, season-to-season. Modern waste-to-energy plants control air emissions by a combination of controlled, high temperature combustion and the best available control technologies. First, trash spends sufficient time at temperatures exceeding 1800° F to destroy organic compounds. Next, sophisticated devices clean the flue gases of acids, metals and trace organics. Acid gas scrubbers neutralize gases. Baghouses or electrostatic precipitators trap particles that may contain trace organics and metals.

Waste-to-energy plants are equipped with intricate monitoring systems that continuously sample and analyze flue gases for the slightest irregularity. Should something unusual be detected, computer sensors automatically adjust combustion parameters and operators are notified by an alarm. In this manner, waste-to-energy facilities meet the strictest power plant environmental standards.

Two substances in trash – mercury and dioxin – attract special attention. Dioxin is a byproduct of all combustion. Modern waste-to-energy plants control dioxin better than many other combustion processes. High temperature combustion coupled with high efficiency control technology is the answer. More than 99% of the small amount of dioxin coming from the boilers is removed by control technology. The Clean Air Act of 1990 calls for new air standards that mandate all facilities meet the strict standards now achieved at the newer waste-to-energy plants. Older facilities are being equipped with scrubbers and advanced particulate control equipment. Once in place, waste-to-energy combustion nationwide will account for less than 1% of all known dioxin emissions.


American Ref-Fuel waste-to-energy plant operating in Preston, Conn.

Modern waste-to-energy plants attack mercury emissions with similar zeal. Environmental health risk assessments on new and existing plants show mercury emissions result in human exposures 10-to-100 times less than the threshold amount of concern. The amount of mercury in alkaline batteries has been virtually eliminated by manufacturers. EPA banned mercury for use in latex paints, also leading to less mercury in the waste stream. Mercury control using activated charcoal is required on all new plants. Old plants will be retrofitted with the new technology.

Decades of practical application have proven waste-to-energy plants are clean and effective and that emissions are well below the strict, safe limits defined by scientific research.

To illustrate the importance placed on controlling emissions, consider: approximately 30% to 40% of the construction cost of a modern waste-to-energy facility is used for emissions measuring and control equipment.

Ash: Safe and Useful

Waste-to-energy technology reduces trash to about 10% of its original volume. When trash is burned, residue from the incinerator falls off the boiler grates as bottom ash. Fly ash is the residue trapped in pollution control equipment that cleans the flue gases. About 90% of all ash is bottom ash; 10% is fly ash. Fly ash contains a greater concentration of heavy metals that are of concern. Bottom ash and fly ash are commonly mixed at the facility to create one residue with properties similar to concrete and appropriate for landfilling. Once the ash is placed in a landfill it is compacted and hardens like cement. The result: studies conducted over the past decade show that leachate from ash landfills is like salty ocean water, with metals content at about the same level as the standards set for safe drinking water.

Waste-to-energy ash is tested for its toxic characteristics. One of the best potentials for commercial reuse of ash is in landfills where it is effectively used as daily cover in place of soil. Ash provides an additional barrier for modern landfills and further reduces the potential for rainwater to leach contaminants from raw garbage into the ground.

Additionally, ash can be used as a substitute for aggregate in road base materials, building construction and artificial reefs. Ash reuse is underway in projects from Florida to Maryland, Minnesota, Pennsylvania, Massachusetts, Tennessee and New York.

Saving Landfill Space

The recipe is simple. The less we put in, the longer a landfill will last. In the 1980s, New York's wandering garbage barge named *Mobro* dramatized the lack of landfill space in some areas of the country as it meandered up and down the east coast seeking a place to unload its cargo.

Some areas of the country, such as the Northeast, are running out of places to put their trash and are having to transport it to increasingly distant points for disposal. Similar landfill space shortages might not be seen in other sections of the country for decades, but such space is clearly not infinite.

Converting waste into energy is a sensible form of recycling that helps deal with our nation's mountain of trash, augments traditional recycling programs, and feeds America's voracious appetite for energy.

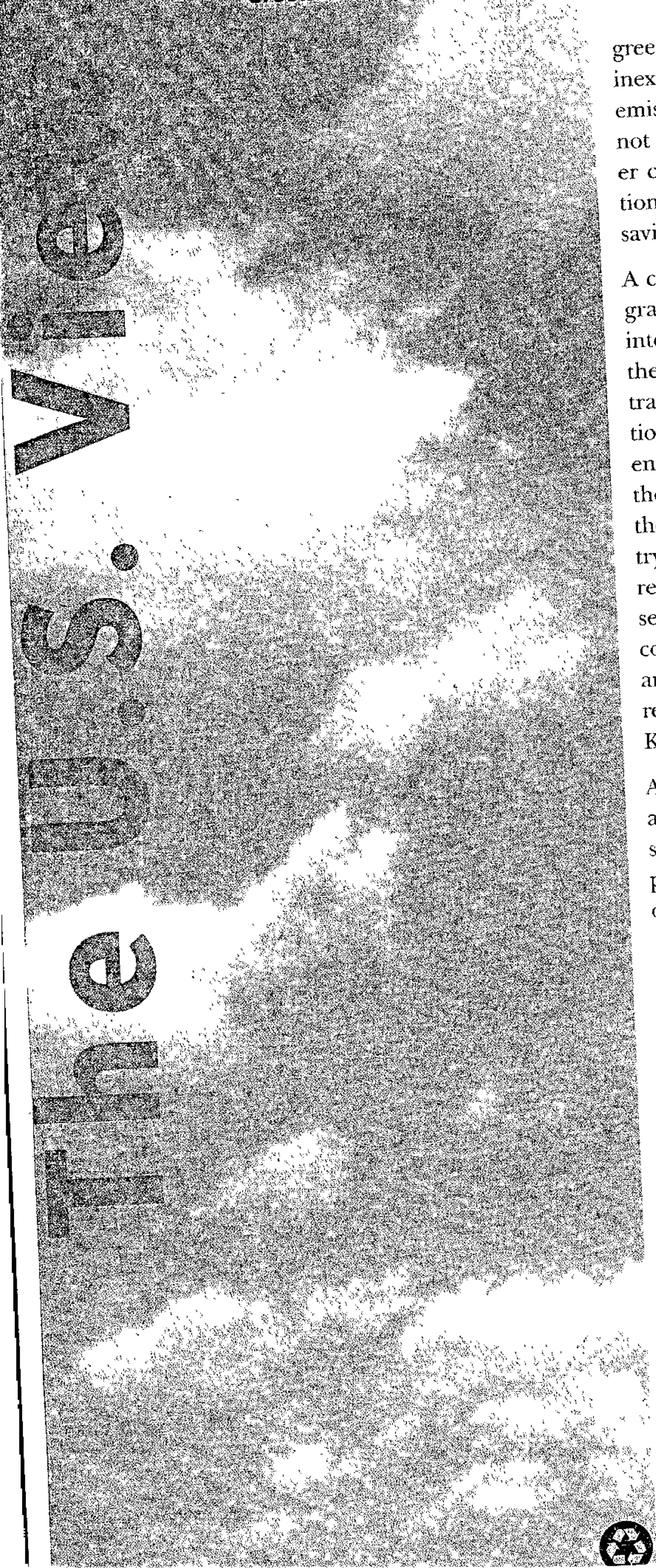
Conclusion

Waste-to-energy is safe, clean, economical and effective. The technology of today's modern waste-to-energy facilities is based on sound research, testing and more than 20 years of operation that makes waste-to-energy a viable method for disposal and recycling for generations to come.

Ogden Projects' waste-to-energy facility operating in Pasco County, Fla.

"We've had as good an experience as anyone in the country. We located the plant downtown rather than sending the trash somewhere else. The plant preserves environmental quality and fits into the community. I feel this is a major form of recycling...turning unusable trash into energy. Most of the things we burn have no other use."

– Robert Ganley, city manager,
Portland, Maine.



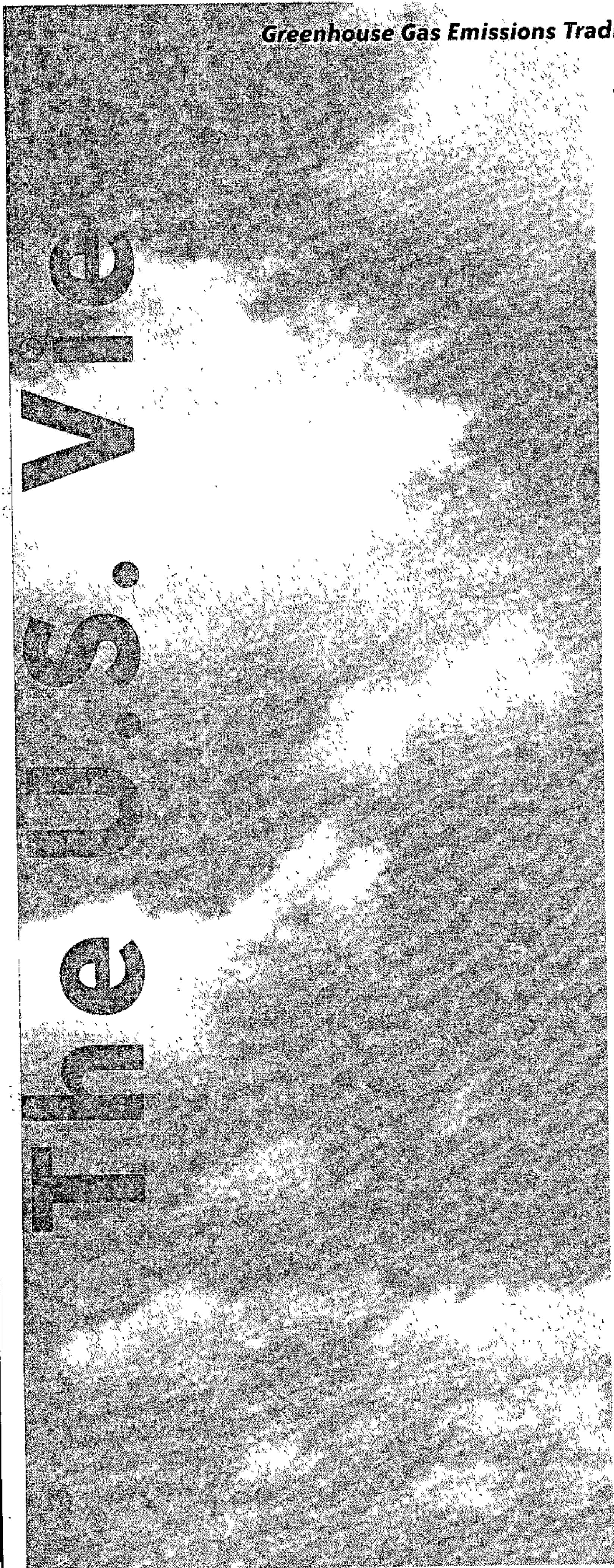
greenhouse gas emissions. Those who found inexpensive opportunities to reduce their emissions could sell the allowances they do not need to other companies who face higher costs. These tangible rewards for innovation should result in a steady stream of cost-saving breakthroughs and new technologies.

A country's domestic emissions trading program would also connect seamlessly with the international emissions trading system, using the same system of national registries to keep track of every allowance traded. An international trade between legal entities of different countries would be carried out by moving the traded allowances from the account of the selling entity in the registry of one country, to the account of the buying entity in the registry of the other country. By buying and selling allowances not only within the same country, but also across borders, companies and other legal entities would dramatically reduce the overall cost of meeting the agreed Kyoto targets.

And that is the key to success in meeting the ambitious commitments made in Kyoto, and sustaining and strengthening our efforts to protect the global climate over the coming decades.

1 Allowances would be identified by serial number and country of origin. Those that have been used to cover emissions would be marked in the user country's registry as permanently retired. Those not yet used could be kept for use later in the five-year period, traded to other countries, or "banked" for the country's use in the next commitment period.

2 A country can distribute allowances in several ways: They can be auctioned to the highest bidders, or they can be allocated (given out) by a variety of formulas to the companies that the country makes responsible for emissions, to consumers, or to others



The greatest savings can come if private sector companies with the ability to reduce emissions are allowed to buy and sell allowances with other companies in the same country and with companies in other countries.

How Would a Country Engage in Emissions Trading?

Trading rules should require a country that wants to trade to have the necessary capacity and infrastructure to measure and report on its emissions of greenhouse gases, according to the requirements of Articles 5 and 7 of the Protocol. In addition, the rules should require the country to establish a national registry—a computerized system to record who holds tradable allowances; to keep track of changes in allowance holdings due to emissions trading; and to show which allowances have already been used to cover past emissions (these would be permanently retired) and which remain available to be used against future emissions.[1]

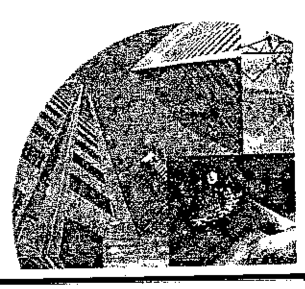
A country that wants to increase the number of tons of greenhouse gases that it is allowed to emit could seek out other countries that are willing to sell some of their tradable allowances. Buying and selling countries could arrange their transactions directly or use brokers or exchanges. Trades would be accomplished by removing allowances from the national registry of the selling country and adding them to the national registry of the buying country.

Trading rules should require each country to report to the Secretariat for the Framework Convention on Climate Change in Bonn at least once each year on the trades it has conducted and the appropriate increases or decreases in its assigned amount. These reports would be in addition to the annual reports that countries must make to the Secretariat on their greenhouse gas emissions. Together, this information would serve as the starting point for determining

independent verification of surface warming over the last 500 years. These data reveal that the Earth's average surface temperature has increased by about 1 degree C over the last 500 years, with 80 percent of the warming occurring since 1800 and 50 percent since 1900. The data set also is consistent with the temperature history derived from proxy climate data. (*Huang* et al., Temperature trends over the past five centuries reconstructed from borehole temperatures, Nature, Vol. 403, 756-758, 2000)

- **Measurements of freshwater spring ice melt and fall freeze-up changes show increases in the ice-free season, concentrated in the past century.** The development and analysis of a freeze and thaw data base reveals that thaw dates advanced 6.5 days/century, and freeze-up dates, 5.8 days/century between 1846 and 1996, corresponding to an air temperature increase of about 1.2° C/century. (*Magnuson*, et al., Historical trends in lake and river ice cover in the Northern Hemisphere, Science, Vol. 289,1743-1746, 2000)

- **Snow accumulation in the Himalayas for the last 1,000 years reveals increased warming in the 20th century.** Cores from glaciers on the Tibetan Plateau describe the imposition of a common warming trend at all sites during the 20th century, whereas the sites demonstrated more independent climate records during the previous 900 years. Temperature increases were greatest at the highest elevations. (*Thompson*, et al., A high-resolution millennial record of the South Asian Monsoon from Himalayan Ice Cores, Science, Vol. 289, 1916-1919, 2000)



Since the last period of government service in 1981, Mr. Loy has served or chaired numerous board of directors of non-profit organizations, particularly in environment and fostering democracy in Eastern and Central Europe. These include: the Environmental Defense Fund, on whose board he has served since 1981—he was chair from 1983-1990; the Budapest-based Regional Environmental Center for Central and Eastern Europe, where he served from the time of his appointment in 1990 by the Bush administration until 1997; the League of Conservation Voters, the bi-partisan political arm of the environmental community; the Institute for International Economics, which he helped found in 1981; and the Foundation for a Civil Society—where he currently serves as chair, which for the past seven years has conducted programs promoting democratic institutions in Central and Eastern Europe, particularly the Czech and Slovak republics.

Educated in Germany, Italy, and Switzerland in his early years, Mr. Loy went to public schools in Los Angeles from the age of 10. He earned a B.A. degree at the University of California at Los Angeles and an LL.B. at Harvard Law School. He lives in Washington with his wife, Dale Haven Loy, a painter, and is the father of two children, Lisel and Eric.

David B. Sandalow

David B. Sandalow serves as Assistant Secretary of State for Oceans, Environment and Science (OES). In his capacity as Assistant Secretary, Mr. Sandalow helps manage U.S. diplomacy on a broad range of environment, science, and technology issues, including climate change, ozone depletion, biodiversity, oceans, forests, chemicals, cooperation in outer space, finance and environment, and regional environment issues.

Previously, Mr. Sandalow was Associate Director for the Global Environment, White House Council on Environmental Quality, and Senior Director for Environmental Affairs, National Security Council. In these positions, he helped advise the President and the Vice President on global environment issues. Prior to his work at the White House, Mr. Sandalow was with the Office of the General Counsel at the Environmental Protection Agency and in the private practice of law. He also served as Special Assistant to the Director of the Michigan Department of Commerce.

Mr. Sandalow has served as a member of the American Bar Association Standing Committee on Environmental Law, co-chair of the American Bar Association's Annual Conference on Environmental law and member of the Steering Committee of the District of Columbia Bar's Committee on Environmental and Natural Resources Law. He has been a volunteer election observer in the Philippines and instructor on election observing in Nepal.

A Michigan native, Mr. Sandalow received his B.A. in Philosophy from Yale College in 1978 and his J.D. from the University of Michigan Law School in 1982.

Mark G. Hambley
U.S. Special Negotiator on Climate Change

Mark G. Hambley has headed the U.S. negotiating team at the numerous climate change conferences that have been held since the start of the Berlin Mandate talks in August1995 under the auspices of the UN Framework Convention on Climate Change.

This process culminated with the Kyoto Protocol, which was concluded at the Third Conference of the Parties in December 1997, where Ambassador Hambley served as Alternate Head of Delegation under Under Secretary of State Stuart Eizenstat, a position he also encumbered at the Fourth Conference at Buenos Aires in November 1998 and the Fifth Conference in Bonn in October 1999 and one that he will hold during the High Level Segment of the Sixth Conference in November 2000, where the U.S. Delegation will be led by Under Secretary of State Frank Loy.

In between these conferences, Ambassador Hambley heads the interagency working group on climate change and leads the U.S. delegations to the annual meetings of the subsidiary bodies of the climate change convention. His duties have entailed extensive travel throughout Europe, Africa, Asia, and Latin America where he has engaged governments and local business and environmental leaders on aspects of U.S. climate change policy. He has also been a frequent participant at numerous international and domestic workshops and panels on this topic.

Since joining the U.S. Department of State in 1971, Ambassador Hambley has had 15 postings in 11 countries, including appointments as U.S. Consul General in Alexandria, Egypt, and at Jeddah, Saudi Arabia. He served as the U.S. Ambassador in Qatar during the Gulf War and later as Ambassador to Lebanon. Since February 1995, he has been the U.S. Special Representative to the UN Commission on Sustainable Development. Ambassador Hambley has been a member of the Senior Foreign Service since 1989 and has received several governmental and civic awards, including the Director General's Reporting Award, Departmental superior and meritorious honor awards, and the U.S. Navy's Superior Public Service Medal. He is a Fellow of the Royal Geographical Society and a life-time member of the National Geographic Society.

A native of the State of Idaho, Ambassador Hambley was educated in Ontario and Illinois and at American University, the American University of Beirut, UCLA, and at Columbia. His languages are French and Arabic. He is very happily married and maintains residences in California and Massachusetts.

Roger S. Ballentine

On June 7, 1999, President Clinton named Roger Ballentine as Deputy Assistant to the President for Environmental Initiatives. In that capacity, he directs the Administration's efforts on climate change and, working closely with Chairman of the Council on Environmental Quality George Frampton, helps direct the President's Lands Legacy Initiative.

Mr. Ballentine was previously Special Assistant to the President for Legislative Affairs, where he focused on energy and environment issues. Prior to coming to the White House, he was a partner at the Washington law firm of Patton, Boggs L.L.P., and Adjunct Professor of Law at the Georgetown University Law Center. He has also served as Special Counsel to the Minority in the House of Representatives for the handling of election challenges.

Mr. Ballentine is a graduate of the University of Connecticut and Harvard Law School. He and his wife, journalist Jennifer Loven, live in Washington, D.C.

David Gardiner

David Gardiner is currently Executive Director of the White House Climate Change Task Force, where he directs the Administration's communications and policy development on global warming. Prior to becoming Executive Director, he served as Deputy Chairman of the Task Force and provided the Task Force with strategic and policy advice on domestic and international climate change issues. He oversaw the development of the Administration's FY2001 climate change budget and tax proposals and is actively engaged in shaping policy for the international climate negotiations.

In June 1993, President Clinton appointed Mr. Gardiner as Assistant Administrator for Policy at the U.S. Environmental Protection Agency (EPA), and he served in that position until July 1999. As Assistant Administrator, he led EPA's climate change efforts, as well as programs to reinvent EPA's approaches to key sectors, such as transportation, agriculture, metal finishing, and real estate development. He directed EPA's environmental economics and information policy efforts. Prior to joining EPA, he was the Sierra Club's Legislative Director in Washington, DC, overseeing their efforts on clean air, climate change, land protection, and international issues.

Mr. Gardiner has a Bachelor of Arts with honors from Harvard College. He lives in Arlington, VA, with his wife, Betsy, and their three daughters.

United States Department of State

Under Secretary of State
for Global Affairs

Washington, D.C. 20520-7250

November 13, 2000

Dear COP-6 Attendee,

As head of the U.S. delegation, I thank you for coming to The Hague and the sixth session of the Conference of the Parties to the UN Framework Convention on Climate Change.

The United States is fully committed to completing the work begun in 1997 at Kyoto and to arriving at a ratifiable Protocol with environmental integrity.

In this press kit, you will find materials describing the important progress the United States has made in curbing greenhouse gas emissions, as well as materials explaining U.S. positions on the most important outstanding issues to be addressed at the conference.

I am pleased to report that the United States has begun to win the battle against greenhouse gas emissions. For each of the past two years, U.S. economic growth has exceeded 4%, while greenhouse gas emissions have grown by about 1%. Of course, this is just a beginning. But we are proving that economic growth and emissions growth need not occur in tandem.

A lot has happened since we met for COP-5 a year ago in Bonn. The scientific evidence that climate change is real and that human activities are a factor has continued to grow. In the United States, the ranks of major corporations declaring that industry must do its part to ameliorate global warming have also continued to grow. And parties to the Protocol have made much progress toward shaping an agreement the international community can embrace.

During the next two weeks we will face many challenges as more than 150 nations pursue agreement on difficult and complex topics. But this is a challenge worthy of our efforts. I look forward to working in the weeks ahead to shape an agreement that will help protect our planet for our children and their children for years to come.

Sincerely,

Frank E. Loy