STRATEGIC PLAN

for the

**NORTHEAST WASTE MANAGEMENT
ENTERPRISE**

NOVEMBER 1994

MASTER

**Long Island Research Institute
110 Lake Ave. South - Suite 35
Nesconset, NY 11767**

**Brookhaven National Laboratory
Associated Universities, Inc.
Upton, NY 11973**

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The Northeast Waste Management Enterprise

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TABLE OF CONTENTS

1. EXECUTIVE SUMMARY	1
2. CONTEXT	1
2.1 Waste Management Problem	1
2.2 Opportunity	3
3. HISTORIC BACKGROUND	3
4. MISSION AND STRATEGY	4
5. ORGANIZATION	5
5.1 Participants	5
5.2 Responsibilities	5
5.3 NEWME Organization	8
6. FINANCIAL STRUCTURE	11
6.1 Program and Project Finance in NEWME	13
6.2 Leveraging of DOE's Investment	15
6.3 Overall Cost-Benefit	17
6.4 Towards Self-Sufficiency	17
7. NEWME WORK PLAN	17
7.1 Program Focus	18
7.2 Project Identification	18
7.3 Technology Evaluation and Commercialization Plan	21
Appendix A	23

FIGURES and TABLES

FIGURE 1:

INITIAL NEWME STRUCTURE	10
--------------------------------------	-----------

FIGURE 2:

PROJECT STRUCTURE EVOLUTION	12
--	-----------

TABLE 1:

NEWME NOTIONAL FINANCIAL PARTICIPATION	16
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1. EXECUTIVE SUMMARY

The Northeast Waste Management Enterprise (NEWME) is a new form of partnership whose goal is to increase the economic, commercial, and environmental effectiveness of solid waste management (SWM) through implementation of new technologies. This goal will be achieved by bringing together expertise and technologies in the federally-supported research community and the private sector to trigger the emergence of a high-tech, highly competitive waste management industry, first locally on Long Island, then nationally as well as internationally. Of particular interest to NEWME are technologies that are applicable to the Northeast's waste management problems and technologies applicable to the Department of Energy's waste management and environmental clean-up programs.

NEWME, which is being managed by the non-profit Long Island Research Institute (LIRI) in collaboration with Brookhaven National Laboratory, has already identified potential technology candidates. These include land reclamation using bioremediation, pyrolysis, waste stabilization/ash utilization, and landfill containment. The next step, which has already begun, is to evaluate specific technologies within these focus areas. This validation and verification process will take place with appropriate academic and commercial partners. We anticipate the need, in some instances, for a demonstration project. A concurrent economic analysis will take place along with each program, which, together with technical evaluations, will form the basis for decisions relating to the ultimate commercialization of the technology.

The financial plan for NEWME anticipates an evolution over time in which the Federal Government provides most of the funding in the early design phase, with some industrial participation. As the program progresses through demonstration and early commercialization, the program becomes more expensive, and a larger fraction of the costs is borne by the private sector. NEWME itself will participate financially in each commercialization vehicle in order to form the basis for the eventual self-sufficiency of the program.

2. CONTEXT

2.1 Waste Management Problem

Perhaps the most important, long-term environmental problem facing the Northeast during the next decades is what to do with the massive amounts of municipal and industrial waste generated daily. With the highest population density in the country, this region consumes more energy and produces more waste than any other, yet it possesses the fewest sites for waste disposal. Approximately 180 million tons of municipal solid waste were produced in the U.S. in 1988. Long Island has the dubious honor of leading the world in per capita solid waste production at 7 1/2

pounds per day. For a variety of economic, environmental, and political reasons, as the amounts of solid waste increase, the number of acceptable disposal options decreases. This has resulted in a large and growing interstate traffic in solid wastes. New York and New Jersey are the most aggressive solid waste exporting states, accounting for more than 50% of the total interstate traffic in solid wastes in 1989. Local flow control laws have recently been invalidated by the Supreme Court, thus increasing the incentives for interstate transport of waste. Trucking waste long distances, however, has high societal costs: it is wasteful of energy and burdensome on the transportation infrastructure. It also fails as a long-term solution, since fewer and fewer sites are available to accept wastes.

Fully integrated resource recovery systems are becoming more attractive as a solution to regional solid waste management, as are environmentally benign manufacturing processes. However, as discussed in a recent seminal monograph, "The options for ultimate disposal -- for that fraction of the municipal [and industrial] solid waste stream that cannot be eliminated through source reduction, reuse, and recycling -- are limited to two: landfilling and incineration."¹

While the Northeast may be the best region for addressing this problem, the problem of municipal and industrial waste is a rapidly-growing concern in the rest of the country and throughout the world. Thus, competitive, effective solutions arrived at in the Northeast can form the basis of world-wide commercial activities.

One of the most substantial undertakings of the Federal Government is to restore the environmental quality at hundreds of sites involved in its activities and those of its predecessor agencies. Of particular concern are sites historically involved with the production of materials for nuclear weapons. The price tag associated with this vast clean-up effort has been estimated at some \$100 billion. Thus technologies that can reduce that cost would be of significant benefit to the nation.

After assessing the prevalence and risks of its various kinds of environmental problems, and the comparative need for technology to address them, DOE has identified five initial remediation and waste management focus areas within its weapons complex: contaminant plume containment and remediation; mixed waste characterization, treatment and disposal; high level waste tank remediation; landfill stabilization; and facility transitioning, decommissioning and final disposition. As we consider technologies to be developed in the NEWME program, an important consideration is their relevance to these DOE focus areas.

¹ Schubel, J.R., and H.A. Neal, Garbage and Trash, Can we Convert Mountains into Molehills?, Monograph Series of the New Liberal Arts Program, Research Foundation of the State University of New York at Stony Brook (1992).

2.2 Opportunity

The Department of Energy and other federal agencies have invested significant sums over the last three decades in understanding the scientific and technical aspects of environmental contamination. As a result of these programs, there reside in the federal laboratories and academic research institutions a number of promising technologies that, for the most part, have been developed only up to bench-scale demonstration. Bringing those technologies to the point at which they can contribute to the solution of real life environmental problems can only be accomplished through partnerships with industry. The creation of such partnerships is one central objective of NEWME.

In January of 1994, DOE defined a new approach to environmental research and technology development. This plan calls for more industry and academic involvement in developing and implementing solutions to DOE's remediation needs; enhancing regulator and stakeholder involvement; and accelerating DOE - private sector technology transfer in both directions.² NEWME constitutes a regional vehicle for implementing this new approach, drawing on relationships and mechanisms already put into place by Long Island Research Institute.

3. HISTORICAL BACKGROUND

In October 1992, in response to a request from the Department of Energy, the National Laboratories formed the Strategic Laboratory Council (SLC) to carry out integrated planning to guide future investments in technological solutions to environmental restoration and waste management problems facing DOE and the Nation. An important SLC recommendation was the establishment of "The Alliance", a new organization to facilitate interaction among DOE Laboratories, industry, and universities. The objective was to create an environment for cooperative development in key technology thrusts and cross-cutting technologies.

During March 8-9, 1993, the Deputy Assistant Secretary of the DOE's Environmental, Restoration and Waste Management Program attended a workshop at Brookhaven National Laboratory (BNL) to discuss the Alliance concept as it pertained to the Northeast. With the previously cited environmental and waste management problems as background, it was decided to bring together the diverse talents now existing in the Northeast to trigger the emergence of a highly competitive waste management industry, first locally, then on a regional basis, and finally nationally and internationally.

² "A New Approach to Environmental Research and Technology Development at the U.S. Dept. of Energy" - Action Plan, Jan. 25, 1994. USDOE, Washington DC.

NEWME was able to achieve a rapid start-up by exploiting existing regional organizational structures. The Long Island Research Institute (LIRI), a non-profit organization created by Long Island's major research institutions to facilitate technology commercialization and cooperative research, was the ideal vehicle to manage the undertaking. LIRI had already established effective working relationships with Brookhaven National Laboratory, the University at Stony Brook, Cold Spring Harbor Laboratory and North Shore University Hospital, its founders, and with industry and the financial community in the region.

NEWME held its first formal meeting on May 7, 1993 at the University at Stony Brook Campus under the sponsorship of LIRI. Attendees included representatives of the solid waste management (SWM) industry, including a firm which is perhaps the preeminent source of information to the SWM industry, as well as the Commissioner of SWM for the Town of Brookhaven (the largest political entity on Long Island, with a population in excess of 400,000). Several key needs of the industry were defined, spanning the gamut of waste stream separation, recycling and reuse, incineration, and landfilling. Several applicable technologies were identified which could serve as initial examples for technical and economic evaluation by NEWME.

The Stony Brook meeting contributed to the development of an initial business plan for NEWME. The draft plan was circulated during the summer of 1993, and Brookhaven received start-up funding for NEWME from DOE in July. Numerous meetings with industry, academic and government representatives were held during the summer and fall. Of particular note were meetings between Brookhaven and RPI to establish a partnership for environmental education and research. In September, Brookhaven, with LIRI co-sponsorship, organized a symposium on problems and commercial opportunities in waste recycling.³ LIRI and Northeast industry and regional governmental agencies contributed a significant amount of effort to the design of NEWME during the second half of 1993. In April 1994, Brookhaven awarded LIRI a contract.

4. MISSION AND STRATEGY

The mission of NEWME is to contribute to the creation of a technically sophisticated, internationally competitive waste management industry for the United States. The initial foci are the solid waste management problems associated with densely populated areas such as the Northeast U.S., and the waste cleanup problems of the U.S. Department of Energy. To realize that vision, a new form of partnership will

³ Goland A. N. and Leon Petrakis, "Recycling Technologies and Market Opportunities," Proceedings of a Conference held at Brookhaven National Laboratory, BNL Report BNL-52421, September 1993.

be formed to combine the expertise and resources of government, the scientific and technical capabilities of the research community, and the technical, financial and entrepreneurial resources of the private sector.

The overall strategy is to identify key environmental problems that can be attacked through the application of technology resident in the research community paired with private industrial capabilities. In some instances, we expect that it will be a matter of upgrading technology already resident in the private sector. In other instances, technology will have to be transferred from federal research institutions into the private sector. The *ab initio* participation of local, state and federal regulatory agencies will facilitate the demonstration and commercialization process and ensure that technologies conform with existing regulations. While the process will be catalyzed by the Federal Government, with DOE taking the lead, private industry and private capital will drive the commercialization process. The central criteria that are being used to evaluate technologies for NEWME are commercial, such as the size of the market and economic competitiveness.

5. ORGANIZATION

5.1 Participants

Each of the participants in NEWME will perform a well defined set of functions. As the coordinating organization, LIRI will provide management and guidance from the pre-competitive stages of a project through its early commercial development. Brookhaven National Laboratory will be responsible for technical aspects of NEWME and for coordination with other federal laboratories. Various participants will work together at different times in this process. Some participants will be involved at the continuing, programmatic, level; others will participate in technology-specific projects. At both levels, there will be participants from the research community and from private industry. Other participants will come from waste management professional organizations, and environmental groups.

5.2 Responsibilities

The role of NEWME Manager is a natural one for the Long Island Research Institute. LIRI was created by Brookhaven National Laboratory, the State University of New York at Stony Brook and Cold Spring Harbor Laboratory (later joined by North Shore University Hospital) as a non-profit entity specifically to commercialize technologies from research laboratories and to foster productive interactions between research institutions and industry. LIRI's Board of Directors and its Scientific and Business Advisory Council already include senior representatives of the region's technical, industrial, and financial communities. Furthermore, LIRI's senior staff have extensive experience in managing large scale multi-disciplinary technical projects.

Brookhaven National Laboratory plays a number of key roles in NEWME: as a source of technologies and technical support, a point of coordination with other federal laboratories, and an evaluator of technologies. Brookhaven is one of the nation's strongest and most diversified R & D laboratories. The Environmental and Waste Management Center in BNL's Department of Advanced Technology has recognized expertise in areas related to mixed wastes, including materials development for containment, encapsulation, and in-situ establishment of barriers. These researchers have also developed new technologies for monitoring groundwater and air pollution. Researchers in BNL's Department of Applied Science have developed ultra-low concentration perfluorocarbon tracers, and are investigating the role of naturally occurring microbes in waste degradation and transformation, and advanced materials development for landfill containment and corrosion resistance.

Brookhaven's major facilities are invaluable tools in support of industry. Its National Synchrotron Light Source, one of the world's most intense x-ray source, currently supports more than 70 industrial users. BNL encourages Cooperative Research and Development Agreements (CRADAs) with industry, as do other federal laboratories. Each CRADA represents a cooperative program between personnel at the laboratory and those from the private sector. It is anticipated that some field demonstrations of NEWME technologies will be funded through the CRADA mechanism.

As part of its role in NEWME, Brookhaven will access technologies under development at other federal laboratories through existing databases, through DOE channels, and through established direct relationships.

Involvement of various academic institutions will provide additional technical and analytical expertise to NEWME. The University at Stony Brook's Waste Management Institute has a variety of research and educational programs aimed at reducing the impact of waste generation and disposal on society. An ongoing research program studies the use of incinerator ash for construction materials. Its staff have collaborated with BNL scientists in areas related to bioremediation and materials development. For NEWME, they recently completed an evaluation of pyrolysis technologies.

Among the northeastern universities that are expected to play roles in NEWME are Rensselaer Polytechnic Institute (RPI), with which BNL has a cooperative program to address waste technology research and education; Polytechnic University (Department of Civil and Environmental Engineering), with which BNL has designed cooperative educational programs; MIT (Center for Nuclear Chemical Technology in the Department of Nuclear Engineering); and the Waste Management Institute at Cornell University's Center for the Environment.

As discussed below, the structure of NEWME is expected to evolve over time. However, the initial functions of the major participants are as follows:

NEWME Advisory Board

- Advise on NEWME policies and priorities
- Advise on industrial participants
- Advise on financial and intellectual property issues
- Facilitate high level industry and government participation
- Facilitate interaction between NEWME participants

Long Island Research Institute - NEWME Coordinator

- Overall management and coordination
- Designate and supervise Project Managers of individual NEWME projects
- Evaluate business/financial aspects of projects
- Structure cost sharing and private sector involvement in projects and commercial undertakings
- Encourage participation by state and regional agencies

Brookhaven National Laboratory

- Manage DOE financial participation
- Coordinate participation of other federal laboratories
- Evaluate potential technologies for NEWME projects
- Develop data bases for NEWME and related DOE projects
- Conduct research in support of NEWME projects, in coordination with other federal laboratories and universities
- Supply facilities for project demonstration
- Conduct environmental technology training programs with academic collaborators
- Conduct risk assessments

U.S. Department of Energy

- Provide funding for NEWME start-up
- Provide near-term co-funding of individual NEWME projects
- Facilitate interaction with DOE programs
- Create favorable climate for NEWME in other federal agencies
- Coordinate participation of other federal agencies in NEWME projects
- Provide information on technologies and research programs
- Provide information on DOE environmental restoration and waste management needs

Additional organizations will serve as resources that can provide important support services as follows:

U.S. EPA

- Provide guidance on critical environmental issues and regulations
- Provide co-funding of research activities related to impact of technologies
- Advise on regulatory barriers to acceptance of technologies
- Work with state and local agencies to resolve regulatory anomalies

Other Federal Agencies

- Provide guidance on agency programs and needs
- Provide co-funding of agency-relevant projects

N.Y. State Department of Environmental Conservation

- Advise on regulatory requirements for development and demonstration projects
- Advise on issues related to acceptance of commercial technologies
- Advise on potential sites for demonstrations
- Facilitate permitting of demonstrations, etc.

Other State Agencies

- Identify high priority SWM issues
- Represent economic development interests of states
- Provide co-funding of projects

Private Industry

- Propose new ideas/technologies to NEWME
- Participate in project design and demonstration, with in-kind services
- Commercialize technologies

Academia

- Provide research and general academic expertise
- Coordinate education and retraining within NEWME objectives
- Participate in technology evaluations
- Provide general peer review

In performing technology, siting, and risk assessments, NEWME will seek input from environmental organizations and appropriate municipal agencies; several of these are identified in Appendix A. Solid waste management organizations will assist in identifying consultants, review technology evaluation, and provide guidance for needed research.

5.3 NEWME Organization

NEWME brings both new technical resources and a new organizational approach to the solid waste management problem. The organizational structure designed for NEWME is intended to bring together effectively all of the elements required to meet the program's objectives and to overcome critical institutional and

technical barriers. Figure 1 shows the initial NEWME structure. In the first phase of NEWME's development, the principal activity is a centralized one: the identification of critical technologies and the structuring of projects to advance each technology to the point preceding commercialization.

FIGURE 1
INITIAL NEWME STRUCTURE

The NEWME structure will evolve over time with the individual projects taking on greater and greater significance. Figure 2 shows, in simplified form, how that structure is expected to evolve. In the second phase, each project will have an appropriate set of working relations. A typical project may take the form of a technology demonstration involving several participants, for example, one or more companies, a research institution, DOE and NEWME itself. At this stage, it may or may not be appropriate to create a separate corporation to carry out the demonstration and commercialize the technology.

In Phase III, initial commercialization, a private entity, referred to in Figure 2 as Company A, will lead the commercialization effort. In most instances we would expect that entity to be selected in Phase II and to be a pre-existing company. Conceivably, a new company or joint venture could be formed in Phase II or III to implement the technology. As shown in the figure, private (venture) capital may be required in some instances to finance the implementing company. Even at this stage, it is quite possible that a relationship with a federal laboratory or a research university will still be useful. Under appropriate cooperative agreements, those institutions could serve as the R&D "department" of the implementing company. The meaning of "NEWME Inc" in Phase III will be made clear in the following discussion of financing.

6. FINANCIAL STRUCTURE

From its inception, a central tenet of NEWME has been that federal monies would be leveraged by the use of other funds. This is not simply a means of maximizing the return on federal investment. Rather, it reflects the basic concept of the activity as being a partnership between government and industry. If that kind of partnership is to succeed, the industrial partner must be sufficiently interested to commit resources to the effort. The ultimate objective is for the technology to be commercially viable on its own merits. In this situation, excessive federal funding can mask the commercial realities.

Nonetheless, federal involvement is critically important. A central thrust of the DOE's program is to maximize the benefits to the U.S. economy from the Department's investment in environmental restoration and waste management. Federal participation is required to overcome the significant barriers to commercialization of technologies and skills resident in the National Laboratory system. For example, many technologies of interest have been proven only on a small scale within the laboratories, and the risks of larger scale demonstration are too high to attract private capital.

FIGURE 2
PROJECT STRUCTURE EVOLUTION

Thus a central design problem in NEWME was to craft an appropriately shifting balance of funding between federal and private sources over the commercialization process. Beyond individual projects, it would be desirable for the overall process eventually to become self-sufficient.

6.1 Program and Project Finance in NEWME

We should emphasize that the amounts and the balance between various sources of funds in the NEWME project will depend greatly on the nature of the specific technologies with which we are dealing, and the specific steps required to make them commercial. In this discussion we use an individual technology as the basis for discussion, realizing, however, that there will be a sequence of technologies in the program. As the program matures (and assuming the demonstrated success of the process), at any one time there may be several technologies in each project phase.

Earlier, we identified several categories of participants and their roles in the process. For this discussion we group them into the following categories:

1. **Federal Government.** This is primarily DOE, but funding may also come, for example, from EPA or DOD. The participation of the National Laboratories and universities is central, and their participation will be funded in the early stages by the government. While the most evident financing by the government will be in cash, the expertise provided by government agencies, as well as the risk-reduction inherent in government involvement will be important contributions.

2. **Industry.** Industry will carry an increasing fraction of an increasing financial burden over time.

3. **Private Capital.** In some circumstances, private venture capital, as distinct from the pre-existing resources of the industrial participants, may be important. If the industrial participant is a relatively small company, but otherwise uniquely qualified to commercialize a technology, venture capital may be required to fund a demonstration or technology transfer. If the industrial partner is large and well capitalized, there may be no need for additional private capital.

4. **Other.** Depending on the technology, an important "other" could be state government. In fact, New York State, through LIRI, has already been a significant contributor to the development of the NEWME plan. As described below, we view NEWME itself as another source of financing over the long term.

Let us now look at the role of the various sources of financing during the various phases of a NEWME project.

Planning and Development

The planning and development phase, in which the overall program is designed, technologies are evaluated, and participating companies are selected, involves the largest element of risk and uncertainty. Furthermore, the value created during this phase of the program can not be captured by specific companies (indeed it would be inconsistent with DOE policy and the public interest for that "capture " to occur). Thus, this phase must be primarily supported by federal funds. At the same time, the involvement of industry is also necessary. It is also very important for the future success of the overall effort for other federal agencies (e.g. EPA) and state and local agencies to be involved and to "sign on" to the program objectives and to the process. These involvements will constitute significant contributions in kind.

NEWME is now part way through this planning and development phase, and there has already been significant participation of parties other than the Federal Government. New York State has provided significant funding for the early NEWME planning process. LIRI's work in FY 1993, for example, was entirely supported by the State Science and Technology Foundation. State and local government personnel have also participated generously in the planning process to date.

The planning and development phase of NEWME relates both to the overall program, and to specific technologies or projects. Although of obvious fundamental importance, this phase is the least expensive, on the order of \$1 million per year.

Demonstration

In the demonstration phase, federal and/or university technology is allied to private industrial capability and critical technical, regulatory and economic issues are resolved. While success in identifying a promising technology now reduces uncertainty, this phase still carries considerable risk. Depending on the particular technology, and the particular issues to be addressed, it can be an expensive phase. However, since the industrial participant is gaining access to technology and possibly other benefits such as a facilitated demonstration process, it will be expected to cover a significant fraction of the cost. One model for designing this phase is the Cooperative Research and Development Agreement (CRADA), described above (p.6).

Depending on the technology and the needs of the industrial partner, private venture capital can start to play a role in this phase. We would anticipate that this phase would involve a roughly equal level of effort between the federal participants on the one hand, and the non-federal on the other. The total cost of this phase might be as much as an order of magnitude greater than the first phase (\$5-\$10 million).

Early Commercialization

The first commercial installation of a technology may not be financially optimal, and significant technical improvements may still be possible. Construction and operation of the first full scale plant will be the responsibility of the private sector. Private venture capital may play a role, particularly for smaller companies. Sources of loan financing may also begin to be tapped in this phase. Depending on the financial strength of the companies involved, there may be some funding by industry of the national laboratory or university participants, perhaps on a joint basis. It may also be justified for DOE to provide funds for technical support, or to address specific (e.g. environmental) issues or to contract for the initial plants or services. For some technologies the scale of this phase may be another order of magnitude higher than the previous one, conceivably in the \$100 million range.

Late Commercialization

With full scale commercial implementation, industry is on its own. Indeed, in the NEWME model there will be a flow of funds back to the other participants. Again depending on the technology, there may be a continuing role of the research community (federal laboratory or university) in improving the technology or in addressing specific technical problems in implementation, funded by industry.

6.2 Leveraging of DOE'S Investment

Table 1 summarizes the trend of financing of the program over time. It should be emphasized that there will be wide variations among technologies and this table is only representative. The first phase includes activities relevant to the overall program, whereas later phases are technology-specific. As indicated in the table, the DOE share decreases from 80% in the relatively inexpensive first phase to 2% in the early commercialization phase, to zero in the final late commercialization phase. The column labeled "Level" gives estimates of the order-of-magnitude funding required for each phase.

The split indicated between private capital and industry in the table will depend on the financial strength of the industrial partner and the particular technology involved. The "Other" participants shown in the table are primarily state and regional government agencies.

The direct implication of the Table is that DOE funds will be leveraged in this program approximately 14:1. If the DOE is able to share its cost with other federal agencies, the leveraging of DOE funds (although not total federal funds) would, of course, be even greater.

TABLE 1

NEWME NOTIONAL FINANCIAL PARTICIPATION

PHASE	LEVEL \$ MILLION	Financial Participation, %		
		DOE, EPA	INDUSTRY	PRIVATE CAPITAL
I Planning & Development	1	80	20 ^a	
II Demonstration	10	50	40 ^b	10
III Early Commercialization	100	5 ^c	30	65 ^d

Notes:

^aIn-kind participation^bIn-kind and financial^cRelated research support^dDependent on industrial financial capability

6.3 Overall Cost-Benefit

The pattern of cooperative funding laid out in this section has been designed to accomplish the objectives of the program with the most economical and effective use of federal funds.

What is the anticipated return on this federal expenditure? One can distinguish two categories of benefit: benefit to DOE itself, and national benefit. At least some of the technologies commercialized in this program will have direct applicability to DOE's cleanup efforts. Even a very small percentage reduction in the cost of that effort will outweigh by orders of magnitude the cost to the government of this program. Some national benefit will also result from a reduction in the cost of remediation and waste management. The national economy will also benefit from the creation of a more globally competitive U.S waste management industry, which will increase jobs and tax revenues and improve the balance of payments.

6.4 Towards Self-Sufficiency

NEWME is designed to become self-sufficient over time, with federal funding replaced by internal resources. A corporate entity, possibly non-profit, will be created for this purpose. In the organization chart shown above in Figure 2, that entity is referred to as NEWME, Inc. As technologies are licensed to companies, or financing is arranged, NEWME, Inc. will participate in the royalty stream or in the equity of a newly financed company. As finances build up in NEWME, Inc., they will be used to replace the funding provided in early stages by DOE. Thus, from an overall perspective, the original DOE funding will be used to prime the pump of the program. The private sector will provide the lion's share of the funding, and the process will become self-supporting.

This is a very ambitious aim. Because it is unprecedented, and given the vagaries of commerce, it cannot be guaranteed. But NEWME is committed to it as an integral part of its design.

7. NEWME WORK PLAN

While this is not the appropriate context for a detailed work plan, we summarize here the major steps already taken and to be taken in that plan.

7.1 Program Focus

As discussed above, there are two domains of environmental problems that are addressed through NEWME projects: the solid waste management problems of the Northeast, and DOE's environmental cleanup problems. Ideally, we seek technologies that apply to both domains.

7.2 Project Identification

The first step in identifying the initial technologies for NEWME was to establish a set of relevant criteria. These criteria were:

- the problem to be addressed by the technology is significant, and perceived as such by major participants (public, government, scientific, community, etc);
- there is the potential for major impact by the application of new science or technology;
- a NEWME undertaking (e.g., a demonstration project) can make a difference and is practical;
- the application is economically and commercially attractive (i.e., there is a large market for the targeted product as revised);
- the technology has relevance to DOE's environmental management and clean-up problems.

After screening by these criteria, the following four technological areas have been selected for initial NEWME consideration:

Pyrolysis

Although the region's waste management strategy already includes a significant investment in incineration, the recent Supreme Court ruling on ash characterization is likely to hinder further use of this waste treatment technology, and adversely affect the economics of existing plants. Pyrolysis, which is a reductive heating process producing a high-carbon char and relatively clean gas stream, represents a desirable alternative to incineration for the treatment of municipal solid waste and hazardous waste streams. Conjoined with technologies that address radioactive contaminants, pyrolysis has wide applicability in treating mixed wastes.

Pyrolysis yields two product streams which have existing commercial markets. The char can be used as is to replace carbon black, or upgraded for use as activated

carbon for adsorption of VOCs and other contaminants. The hydrocarbon gas stream can be burned to power a steam power generation system, or condensed to liquids that can be used as plastics feedstocks or liquid fuels. Engineering difficulties that prevented full commercialization of this technology when it was studied in the 1970's appear to have been overcome, and its applicability to both MSW and DOE remediation needs make it an attractive candidate for commercialization via NEWME.

A thorough technology review, describing the relative strengths of four mature commercial pyrolysis technologies, was completed in March of 1994. This report includes recommendations for the next steps to be taken in development and commercialization of pyrolysis.

Bioremediation/Land Reclamation

Reclamation of contaminated land represents an attractive alternative to "greenfield" development because of public pressure to limit the development of wild land, and because previously used sites are served by an existing infrastructure. Bioremediation, especially when carried out in situ, represents an attractive alternative to excavation-based remediation strategies. Considerable progress has been made in isolating a variety of contaminant degrading organisms; NEWME's goal is to facilitate the engineering development needed to employ them in bioremediation-based application and treatment systems. Bioremediation has cross-cutting applicability to DOE's contaminant plume remediation, facility decommissioning, and mixed waste treatment needs.

NEWME has initiated efforts to explore the addition of PCB-degrading cultures isolated at BNL to the bulk solids handling capacity of existing MSW-composting technology. In this bioenhanced composting concept, the goal would be to reclaim a contaminated parcel of land and return it to public or commercial use. NEWME has begun a literature review to assess the extent of work in this area, and is identifying candidate sites for a demonstration of this technology.

A BNL-developed bioremediation process for the degradation of radionuclides and heavy metals is being explored as an option to treat uranium-contaminated soils at a DOE site in Ohio. This process has been successful in removing uranium contamination in bench-scale tests, but has not reached pilot scale. NEWME is working with Parsons Engineering to explore the feasibility of this process for the site in question, and to identify the development requirements for commercialization of this technology.

Waste Stabilization/Ash Utilization

Incinerator Ash Recycling: The use of incineration to dispose of MSW is limited by its production of hazardous substances in atmospheric emissions (e.g., dioxins)

and fly ash (e.g., heavy metals). It is generally agreed that constituents in bottom ash are of less concern. A recent Supreme Court ruling⁴ that MSW incinerator ash must be categorized and treated as hazardous waste if it does not pass EPA leachate (i.e., TCLP) tests has reinforced public objection to incineration. Nevertheless, a recent study comparing the full spectrum of environmental and health effects from incineration, landfills, pyrolysis, and waste-to-energy-facilities has found that well managed incinerators have the least negative impacts.⁵

Various process improvements (as well as new technologies such as afterburners) have mitigated concerns about atmospheric emissions from incinerators. Numerous attempts have been made to encapsulate incinerator ash, primarily bottom ash, in materials such as concrete and Portland cement. These materials are then used beneficially, such as in road aggregates and offshore reefs. Thus far fly ash as proven more recalcitrant, the few successful encapsulation technologies having failed EPA's leachate tests. Recently, however, Brookhaven researchers, employing materials and techniques developed to assist DOE in handling radioactive wastes, have encapsulated fly ash using sulfur and polyethylene cements.⁶

The Town of Brookhaven (ToB) has expressed interest in building a roadbed at its municipal landfill using aggregates from BNL's encapsulation technologies, if it can be demonstrated that such materials can be fashioned from bottom and fly ash produced from ToB MSW. NEWME has provided seed funds to BNL to demonstrate the feasibility of using sulfur and polyethylene cements to encapsulate ToB ash, and will move ahead with the ToB and academia (e.g., the Waste Management Institute at SUNY/Stony Brook) to establish a demonstration of BNL and other candidate technologies at the ToB landfill site.

Landfill Containment

Until recently the most common approaches to minimizing landfill leachate production and migration have been to cap the site (thereby preventing infiltration and subsequent leaching) and to construct systems to collect actual leachate. Capping

⁴ City of Chicago v. Environmental Defense Fund, No. 92-1639, Supreme Court of the United States, decided May 2, 1994.

⁵ Hahn, J. L. and K. H. Jones, "Waste-to-Energy: The Next Step in the Hierarchy After the 3-Rs," Ogden Martin Company, Proceeding of the 1994 Waste Processing Conference (16th Biennial National Conference) and the North American Waste-to-Energy Conference, The American Society of Mechanical Engineers, Boston, MA., 1994.

⁶ Kalb, P. D. and T. Lee, "Thermoplastic Polymer Treatment of Municipal Solid Waste Incinerator Ash: Preliminary Treatability Study Letter Report," BNL draft letter report, March 1994.

puts an end to any further useful operations of the landfill. Leachate collection systems are not very effective unless they are part of the original landfill design process, where they are engineered to work together with double or triple liners.

Recognizing the ubiquitous presence of leachate plumes at landfills, it is important to demonstrate other methods of managing these plumes. Examples of such techniques include pump-and-treat, pumping to effect massive hydrogeological changes in the vicinity of the site, the use of selected waste products to assist in reclaiming landfill sites,⁷ and emplacement of in-situ barriers.

NEWME has investigated several in-situ barrier technologies, including a system developed at BNL with funding from DOE's Office of Environmental Management (EM).⁸ An inexpensive, easily emplaced (i.e., injected) subsurface barrier would represent a major step toward containment of plumes at all sites of such contamination. As in the case of incinerator ash recycling, the Town of Brookhaven has expressed interest in the demonstration of in-situ barriers at its municipal landfill. Such a demonstration would also be possible at BNL.

7.3 Technology Evaluation and Commercialization Plan

The next step to be carried out in each technological focus area is to evaluate specific commercial embodiments of the technology or commercializable versions of the technology if there is no commercial embodiment. The main components of that technology evaluation are:

A. Issues and Objectives

Identification of the specific problem or problems to be addressed by the technology. To what extent is this a problem regionally, nationally, internationally and at DOE sites? What justifies the application of federal (or joint federal-commercial) funds to this problem? How does this address the needs of EM's focus areas?

B. Status of the Technology

What is the status of the technology, including competing versions of the technology? At what level has it been researched, demonstrated, or sold

⁷ Chesner, W. H. and J. P. Welsh, "The Use of Selected Waste Products for Reclamation of Existing MSW Landfill Sites," Proceedings of the National Waste Processing Conference, The American Society of Mechanical Engineers, Book No. 100328, 1992.

⁸ Heiser, J., "Polymer Containment Barriers of Underground Storage Tanks," presented at Waste Management '94, Tucson, AZ (Feb 27 - Mar 3, 1994).

commercially? Who are the major corporate actors? (Consideration will be given to overseas as well as U.S. R&D programs and commercialization efforts.)

What are the outstanding technical issues or problems associated with the technology? This discussion should, in particular, identify technical barriers that could be overcome through NEWME projects. Are there potential applications for the technology other than the one envisioned here?

C. Regulatory and Other Issues

This section will identify the non-technical issues that will affect the implementation of the technology. The relevant regulatory environment will be described regionally (e.g., by state) and nationally, both as it exists currently and as it is expected to evolve. There may be positive as well as negative regulatory implications. Other issues might include public perceptions or public opposition (e.g., to facility siting). There may also be liability or other legal issues.

D. The Market

What is the current and expected size of the market for this technology? In order to answer this question one should identify the competitors to the technology and, if relevant, competing versions of the technology. What are the pricing requirements or considerations? Overseas as well as U.S. markets should be assessed. Potential sales of the technology should be calculated on the basis of total market size and the estimated fraction of the market captured by the technology as a function of time.

The Technology Evaluation will form the basis for a decision whether or not to move ahead with a demonstration or other step towards commercial implementation. If it is decided to move ahead, an Action/Work Plan will be formulated to guide the next steps. A typical action plan will involve a specification of the participants, steps to be taken, time schedule, milestones and budget. The plan will state the rationale for the recommendation of the participating company or companies, recognizing that in some instances a competitive selection process will be required. The plan will also justify any recommendation of a specific demonstration site. A proposed budget will indicate suggested cost-sharing and financing arrangements.

APPENDIX A

Professional Organizations

The Air & Waste Management Association
The American Public Works Association
The American Society of Mechanical Engineers' Solid Waste Processing Division
The Association of State and Territorial Solid Waste Management Officials
The Solid Waste Association of North America

Industry Organizations

The American Paper Institute
The American Plastics Council
The Council on Plastics and Packaging in the Environment
The Glass Packaging Institute
The Institute of Clean Air Companies
The Institute of Scrap Recycling Industries
The Integrated Waste Services Association
The National Solid Wastes Management Association

Municipal and Government Organizations

The American Legislative Exchange Council
The Coalition of Northeastern Governors
The International City/County Management Association
The National League of Cities
The National Association of Counties
The U.S. Conference of Mayors (sponsors the Municipal Waste Management Association)
The National Conference of State Legislatures' Solid Waste Management Project
The National Governors' Association (sponsors the Committee on Natural Resources which focuses on SWM issues)

Environmental Organizations

The Sierra Club
The United States Public Interest Research Group
The Environmental Defense Fund
The Natural Resources Defense Council
The Audubon Society

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