FINAL REPORT OF THE STUDY GROUP ON ENERGY AND THE ENVIRONMENT

Research and Recommendations of the
Study Group on Energy and the Environment
Established Pursuant to P&S Law 1993, Chapter 80

Prepared and Submitted by the
Maine Public Utilities Commission
With Contributions From The
Maine State Planning Office
And The
Maine Department of Environmental Protection
January 1, 1996

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INTRODUCTION

The Commissioner of the Department of Environmental Protection, the Director of the State Planning Office, and the Chairman of the Public Utilities Commission are pleased to submit the Final Report of the Study Group on Energy and the Environment.

The major portion of the report describes, to the extent data are available, the environmental impacts and regulations relating to the major sources of energy in Maine. This introduction sets forth our conclusions and recommendations based on the report.

CONCLUSIONS

Despite, or perhaps because of, the enormous amount of information we have assembled in this report, we are not prepared to recommend specific ways of dealing with environmental externalities. We have, however, identified a number of additional steps that we plan to undertake that will, in our view, contribute materially to our effort to harmonize economic and environmental regulation in Maine, at least where such regulation implicates our electric utilities.

Specifically, we intend to:

1. continue to refine the report to facilitate comparisons among fuels and to highlight areas where additional data may be necessary to make meaningful comparisons;

2. collect information from other jurisdictions on how they have dealt with the issues of externalities, and what the results have been of those efforts; and

3. have DEP and SPO submit to the PUC, by the end of May, 1996, their recommendation concerning if and how the issue raised by environmental impacts and/or externalities should be incorporated into the PUC's inquiry into the restructuring of the electric industry.

While we have not reached a conclusion on the particular policy approaches to environmental externalities, we have identified a number of policy options that should be considered as the investigation and debate continue. It may be the case that, in order to achieve our common goal of enhancing Maine's environment in the most economically efficient way, in a way that is as fair and balanced as possible to all market segments (utility and non-utility alike), a combination of policy tools will be required.

BACKGROUND AND SUMMARY

Energy development and use in Maine is tightly interwoven with several major environmental issues. Fossil fuel combustion for power and heat releases a variety of air pollutants. Burning carbon based fuels contributes to the concentration of carbon dioxide in the atmosphere, leading to concerns for global warming. Burning fuels containing sulfur compounds contributes to the creation of acid rain and subsequent deposition into terrestrial ecosystems. The combustion process itself generates nitric oxides, which contribute to the formation of ground level ozone. The development and use of non-fossil energy sources have environmental consequences as well. Hydropower development impacts rivers and riparian areas. Biomass energy development increases the demand on Maine's forests. Nuclear power generation results in very long term waste management and disposal problems.

Despite over 20 years of increasingly tightening environmental regulations, some feel that all of the environmental consequences of energy use are not completely accounted for or reflected in energy prices. Consequently, energy users do not fully appreciate or pay for the impacts of their energy choices. These choices can often carry additional costs to society that are not reflected in energy price signals influencing energy decisions.

This report describes the array of fuel types used in Maine, and their widely varied and particular impacts. This degree of variability suggests that it is impossible to create a non-site-specific method for estimating externalities which can be applicable to all of the fuel choices. As a result, externalities or unaccounted for impacts associated with a specific project or energy application likely must be evaluated on a case by cases basis. Although existing methodologies can provide a degree of uniformity to the process of identifying and evaluating the impacts of secondary impacts, a variety of unaccounted influences are likely to be present.

While the current study provides what we believe to be useful information on methods and values for rating and valuing environmental externalities associated with energy use, the lack of a complete data base, incomplete understanding of scientifically valid causes and effects, and the difficulty of putting bounds on induced effects to be included in an analysis limits the implementation of a current externalities methodology.

MENU OF POLICY OPTIONS

1. Add "environmental impacts" to MEPA's list of "factors" to be considered in least-cost planning (without specifying how this should be done). (Section 3191, MRSA 35-A)

2. Use the EXMOD software developed as part of the New York State study to develop externality valuations for air emissions during the combustion stage of all combustion energy resources.

3. Use externalities values to:

   a. do benefit/cost analyses of proposals for controlling air emissions;

   b. enhance planning activities (for example, DOT's congestion mitigation programs) by taking resulting estimates of externality costs and benefits into account explicitly;

   c. develop energy taxes that would be optimal across all resources and economic sectors (this would increase overall economic efficiency in resource use - revenues could be used to replace taxes that decrease economic efficiency);

d. enhance utility planning; and

e. estimate the externality costs and benefits of electric industry restructuring.

4. Study tools for dealing with risks in environmental policy that are caused by scientific uncertainty.

5. Policies that reduce the use of fossil fuels may yield numerous environmental benefits. The Legislature could reaffirm Maine's traditional emphasis on conservation, energy efficiency, DSM, and renewables. (Some programs of this nature could be negative cost, or win/win.)

6. Focus on voluntary and low or no cost strategies to deal with global climate destabilization risks caused by the emission of carbon dioxide and other greenhouse gasses. State government could increase contribution to the development of and support the Action Plan of the Maine Climate Change Task Force.

7. Encourage the development of natural gas infrastructure (for example, extend gas service to more areas of the state and provide filling stations for natural gas vehicles). Encourage the substitution of natural gas for dirtier heating and industrial fuels.

8. Exploit the benefits of regulatory coordination and regional approaches to pollution control by:

a. supporting the efforts of the New England PUCs' Staff Committee on Regional Coordination to find ways of reducing the costs of environmental compliance by developing interstate regulatory coordination, and to analyze the environmental impacts of various electric industry restructuring scenarios;

b. developing uniform regional energy taxes;

c. urging the Federal government to impose stronger pollution controls on sources in the midwest and, to the extent it is available, seeking to invoke Federal law dealing with upwind generators of air pollution;

d. developing regional alternative vehicle infrastructure; and

e. supporting efforts to develop regional tradeable allowance programs for NOx.

9. Emphasize controlling sources now, rather than cleaning up later.

10. Try to improve economic incentives influencing environmental quality by:

a. giving a sales tax credit to encourage the use of environmentally beneficial products;

b. using fuel taxes to create a level playing field regarding combustion emissions between utility electric generation and diesel self-generation;

c. using environmental targets in utility performance based ratemaking (for example, a credit for increasing the percentage of benign resources in a utility's resource portfolio); and

d. eliminate any tax disincentives that reduce the attractiveness of alternative vehicles.

11. Focus on reducing emissions from especially dirty mobile sources (for example, clunkers and certain trucks). Recognize, generally, the role of mobile sources in diminished air quality and enact policies that reduce the need for long-range, noncommercial travel.

12. Make effective use of state government resources by:

a. establishing an alternative fuel vehicle fleet;

b. adopting appliance and construction efficiency standards for state buildings; and

c. allowing a longer pay-back period for BPI decisions involving energy efficiency.

13. Seek building market transformations by:

a. promoting energy efficiency through revised building codes; and

b. encouraging the use of more efficient alternative lighting and heating technologies, especially in new buildings.

PART I - STUDY GROUP PROJECT

A. Work of the Study Group on Energy and the Environment.

P&S Law 1993, Chapter 80, *An Act to Establish a Study Group on Energy and the Environment*, created a study group consisting of the Chairman of the Public Utilities Commission (PUC), the Director of the State Planning Office (SPO), and the Commissioner of Environmental Protection (DEP). (P&S Law 1993, Chapter 80, is provided as Attachment A.) It charges the Study Group with four duties, as well as an interim progress report which was submitted January 1, 1995, and a final report to be submitted January 1, 1996.

The first task is to create at the PUC a comprehensive library of environmental externalities literature, including a file containing available summaries of this literature. The Library is also to contain information about the locations in the literature where methods are provided for evaluating the relative magnitude of different externalities.

This first task has been undertaken by the PUC. The Group has substantially completed the first task, as will be detailed in section II of this report, although we still await publication of certain important acquisitions.

The second task is to identify and summarize the state and federal environmental regulations and policies that affect the price of energy resources in Maine, and to quantify, as far as possible, the price effects of environmental compliance. The Law provides a list of energy resources (see below).

The third task is to identify environmental impacts that are not reflected in current pricing (i.e., externalities).

The second and third tasks have been accomplished by members of a staff working group from the three agencies.

The fourth task is to recommend preferred methods for taking externalities into account in energy decision-making.

B. Policy Background: Energy and Environmental Externalities Policy in Maine.

In 1991 the Legislature established a Commission on Comprehensive Energy Planning. This Commission issued a Final Report in May of 1992, which for the first time explicitly includes issues related to environmental impacts in the development of Maine's energy planning and policy. The Report recognizes that the use of energy resources is fundamentally important to the Maine environment, and provides a number of objectives and recommendations that aim at the achievement of a "sustainable energy future," which protects human health and the environment while promoting economic prosperity. The Report recommended in particular that Maine should establish a broad-based advisory group on energy and the environment to evaluate strategies for including externalities in energy decision-making.

Environmental externalities can be understood as resource costs in the form of damages to the environment and human health associated with various production and consumption activities - including the use of energy resources - where these costs are not reflected in the prices paid by consumers for these activities. For example, the burning of fossil fuels leads to air pollution, which in turn causes many forms of damage to ecosystems, crops, buildings, human health, and so on. In many instances the costs of such damages are not adequately included in the prices paid in connection with using fossil fuels. The result will be that prices understate the full costs to society of fossil fuel consumption. In particular, fuel prices do not provide incentives to avoid causing environmental damages, since the immediate out-of-pocket cost to consumers of externalities is (by definition) zero. Under such conditions resources are used wastefully. For that reason many economists hold that a method should be found to include externalities costs in prices and to consider them in public policy, as was recommended for energy decision-making by the Commission on Comprehensive Energy Planning. The expected result from the economist's perspective would be reduced environmental degradation, improved health, and increased overall economic efficiency. Another expected result would be changes in the relative prices and market shares of the various energy resources. For this reason, and a number of others including the complexity of the externality valuation process, externality policy is very controversial.

In recent years environmental externalities associated with the generation of electricity have attracted a great deal of attention (and have provoked much disagreement) among regulators and policy makers. Many studies have been conducted in an effort to develop appropriate methods for taking externalities into account in the planning and operation of electric utility systems. Quite a few state public utility commissions have adopted procedures for doing so.[1]

In Maine, externality consideration in electric resource planning has been an issue raised from time to time in the Legislature since 1988. In 1990, L.D. 2029 would have required the Maine Public Utilities Commission (MPUC) to consider the environmental impacts of utility services. An amended version of L.D. 2029 was passed directing the MPUC to "undertake analysis of the extent to which environmental and economic impacts of alternative energy resource plans should be included in the electric energy planning process subject to the Commission's jurisdiction."

On May 1, 1991, the MPUC submitted a majority report on "Environmental and Economic Impacts" to the Utilities Committee. The report concluded that additional study concerning methods for quantifying and valuing externalities and for taking them into account in planning was needed before externality consideration should be implemented in Maine. The need for externality consideration in the short term was judged not to be great, since few resources were expected to be acquired, and any such choices made would very likely be of environmentally beneficial resources. In the longer term, the Commission should continue to examine externality issues, since "externality value approaches may offer significant advantages over traditional techniques of environmental management."

The then current MPUC Chairman, Ken Gordon, was a member of the Commission on Comprehensive Energy Planning and contributed to its May 1992 Report

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1 Niemi, E., et al, Environmental Externalities and Electric Regulation. National Association of Regulatory Utility Commissioners (NARUC), 1993.

Rose, K., et al, Public Utility Commission Treatment of Environmental Externalities. National Regulatory Research Institute (NRRI), 1994.

(mentioned above). The Report expressed unanimous support for addressing the environmental effects of energy production as a fundamental policy objective. It also stated that it is "not so much a matter of whether, but of when and how" externalities consideration will become part of Maine's least-cost planning process. It also noted that some of the difficulties in addressing externalities result from differences in the degree to which environmental costs are reflected in the prices of various energy resources, particularly utility vs. non-utility. The fact that the Commission endorsed externality consideration in energy policy decisions, but was unable to recommend a method, led to its recommendation concerning the creation of an advisory group to study such issues further. The Report indicated that the study should "look at all types of energy use across all energy use sectors" in order to "avoid unwanted cross-over effects."

During 1993 a number of bills were introduced in the Legislature that address externality issues. Among these, L.D. 356 sought to establish the Advisory Council recommended by the Commission on Comprehensive Energy Planning. In 1994 an amended version of L.D. 356 passed - P&S Law 1993, Chapter 80 - establishing a body of this nature, the Study Group on Energy and The Environment, which is issuing this Final Report. The Group is made up of the Chairman of the PUC, the Commissioner of the DEP, and the Director of the SPO. A staff working group from these three agencies has been assembled to carry out the mandates of P&S Law 1993, Chapter 80, as explained in the preceding section.

APPROVED

APR 01 '94

BY GOVERNOR

CHAPTER

80

P & S LAW

STATE OF MAINE

IN THE YEAR OF OUR LORD
NINETEEN HUNDRED AND NINETY-FOUR

H.P. 278 - L.D. 356

An Act to Establish a Study Group on Energy and the Environment

Be it enacted by the People of the State of Maine as follows:

Sec. 1. Externalities study; study group. The Chair of the Public Utilities Commission, the Director of the State Planning Office and the Commissioner of Environmental Protection constitute a study group for the purposes of conducting a study of externalities in accordance with the provisions of this Act.

1. Duties. To the extent possible, within available resources, the study group shall:

A. Create a comprehensive library within the Public Utilities Commission of literature on environmental externalities. In creating the library, the study group shall create a separate file containing available summaries of the literature. The study group shall also identify specifically those portions of the literature that provide methods of evaluating the relative magnitude of different externalities;

B. Summarize state and federal environmental policies and regulations that presently impact the pricing of regulated and unregulated energy resources in Maine. The study group shall attempt, as far as possible, to quantify these impacts;

C. For the various energy resources, identify the most significant categories of environmental impacts that are not currently reflected in current pricing; and

D. Develop recommendations for preferred methods of accounting for the costs to society and the environment of environmental externalities.

For purposes of this section, the term "externalities" means those short-term and long-term impacts, with primary emphasis on environmental impacts, resulting from the extraction, production, transmission, consumption or utilization of energy or energy resources that are not accounted for or quantified in the context of state energy-regulatory decision making. For purposes of this section, "energy resources" includes energy derived from natural gas, coal, nuclear fuel, water, wind, demand-side management, biomass and refuse-derived fuel and petroleum products.

Sec. 2. Consultation. The study group may consult with any state agency, group or person, including, but not limited to, the Department of Transportation, the Maine Waste Management Agency, the Public Advocate and the Department of Human Services, Bureau of Health.

Sec. 3. Reports. On or before January 1, 1995, the study group shall provide an interim report to the joint standing committee of the Legislature having jurisdiction over utility matters outlining its progress in completing its study pursuant to section 1. On or before January 1, 1996, the study group shall provide its final report, with any accompanying recommendations for legislation, to the joint standing committee of the Legislature having jurisdiction over utility matters detailing the results of its study pursuant to section 1.

Sec. 4. Utilities committee authorized to report out a bill. The joint standing committee of the Legislature having jurisdiction over utility matters may report out a bill dealing with externalities to the First Regular Session or Second Regular Session of the 117th Legislature in response to the reports issued by the study group under section 3.

PART II - EXTERNALITIES LIBRARY

A. LIBRARY

The externalities library includes materials in the following areas:

- the economic theory of externalities and environmental policy;
- the methodology of economic valuation of environmental resources;
- proposed methods for considering environmental externalities in electricity planning, and in other areas of planning and policy;
- studies attempting to describe quantitatively the environmental impacts of energy production and use;
- studies attempting to determine appropriate economic values for specific externality damages;
- studies of the methods of externality consideration used in other states;
- important examples of policy recommendations concerning energy and the environment.

The library also includes environmental regulations (with all Federal Codes and all Maine Rules in current form) and summaries of these regulations. It contains a file of summaries of the externalities literature, as well as a file of locations of discussions of externalities methodology as required by the L.D.

There is also a file of existing bibliographies on environmental externalities, which will facilitate the use of interlibrary loan to access titles not in our collection.

Titles in the Study Group collection have been designated EESGL (environmental externalities study group library) in the PUC library's computerized catalog system. A complete print-out of titles in the collection can be made at any time, organized by author, title, or subject, as preferred. About 134 titles already on hand have been designated EESGL, and about 10 more are being acquired at this time. More titles will be acquired in part based on recommendations by the staff working group concerning material that they discovered during the course of their research.

In addition to the designated collection, the PUC library has extensive collections of titles in other areas of interest to the Study Group. These include EMF (electromagnetic fields), the Clean Air Act, energy efficiency, integrated resource planning, energy industry operations, and handbooks of energy industry data and government data.

B. SUMMARIES FILES

STUDY GROUP ON ENERGY AND THE ENVIRONMENT

Consumer Energy Council of America Research Foundation: Executive Summary, from Incorporating Environmental Externalities Into Utility Planning (1993). (Summarizes large report with recommendations from the nation's oldest non-profit public interest energy policy organization.)

Fang, J.M., and Galen, P.S. (for National Renewable Energy Laboratory/DOE): Issues and Methods in Incorporating Environmental Externalities into the Integrated Resource Planning Process (1994). (Useful summaries on most externality issues and concepts - provided in its entirety.)

Jensen, D. (for Office of Technology Assessment, US Congress): Summary and part of Ch 1, from Studies of the Environmental Costs of Electricity (1994). (Describes the methods, assumptions, and policy implications of eight recent cost studies.)

Meyer, H. J., Morthorst, P.E., Schliesner, L. For International Association for Energy Economics): Assessment of Environmental Costs: External Effects of Energy Production (1995).

I.) Niemi, E. (for NARUC): Executive Summary from Environmental Externalities and Electric Regulation (1993).
II.) Niemi, E. (for NARUC): Environmental Externalities: Overview, Concepts, and Categories, from Environmental Externalities and Electric Regulation (1993).

Ottinger, R., and Wooley, D. (from Weaver, J., The Case for Natural Gas, Univ. of Houston): The Environmental Cost of Fuel Choices (1991). (Presents basic policy and methodology issues, with valuation of externality costs for major electric generation resources.)

RCG/Hagler, Bailly, Inc.: New York State Environmental Externalities Cost Study, Report I (1993).

I.) Abstract, Table of Contents, and Executive Summary, with externalities screening categories.
II.) Introduction to the Consideration of Externalities in Electricity Resource Selection.
III.) Economic Concepts and Valuation Methods.

Rose, K., et al (for NRRI): Executive Summary and Economic Rationale for Externality Treatment, from Public Utility Commission Treatment of Environmental Externalities (1994).

C. LOCATIONS OF METHODS FILE

STUDY GROUP ON ENERGY AND THE ENVIRONMENT

LOCATION FILE: Materials discussing methods for "evaluating the relative magnitude of different externalities." (L.D. 356, 1A.)

Bernow, S., et al (Tellus Institute): From Social Costing to Sustainable Development: Beyond the Economic Paradigm (1992?). See p. 1-17.

Connors, S. (AGREA and NARUC): Side-stepping the Adder: Planning for Least-Social-Cost Electric Service (1992).

Fang, J.M., and Galen, P.S. (NREL/DOE): Issues and Methods in Incorporating Environmental Externalities into the Integrated Resource Planning Process (1994). See p. 24-35, p. 62-63.

Freeman, M.A.: The Measurement of Environmental and Resource Values (1993).

Hanley, N., and Spash, C.L.: Cost-Benefit Analysis and the Environment (1993).

Jensen, D. (OTA): Studies of the Environmental Costs of Electricity (1994). See p. 37-43.

Jones, D.E.: Environmental Externalities: An Overview of Theory and Practice (1991). See Ch. III.

Mishan, E.J.: Cost-Benefit Analysis (4th edition, 1988).

Niemi, E. (NARUC): Environmental Externalities and Electric Regulation (1993). See Ch. 3.

RCG/Hagler, Bailly, Inc: New York State Environmental Externalities Cost Study, Report 1 (1993). See Appendix B, and B2.0.

Solow, R.M.: Sustainability: An Economist's Perspective (1991).

D. BIBLIOGRAPHIES FILE

STUDY GROUP ON ENERGY AND THE ENVIRONMENT

This file is intended to facilitate use of the PUC's environmental externalities library and use of PUC interlibrary loan services to access externalities materials. The file contains:

1. A print-out of titles in the PUC environmental externalities library, alphabetically by author, with catalog numbers.

2. Copies of the bibliographies from seven leading studies.

   a. Busch J., Krause, F., and Koomey, J. (LBL, for DOE): Incorporating Global Warming Risks in Power Sector Planning (1992).

b. Consumer Energy Council of America Research Foundation: Incorporating Environmental Externalities Into Utility Planning (1993). (Sixty-three pages, annotated.)

c. Dyn Corporation (for CONEG): Capturing Environmental Externalities and Economic Externalities: Evaluating the Total Fuel-Cycle Impacts of Bio-Mass (Draft Interim Report, 1994).

d. Fang, J.M., and Galen, P.S. (for NREL/DOE): Issues and Methods in Incorporating Environmental Externalities into the Integrated Resource Planning Process (1994).

e. Jones, D.E. (for EPRI): Environmental Externalities: An Overview of Theory and Practice (1991).

f. Niemi, E. (ECO Northwest, for NARUC): Environmental Externalities and Electric Regulation (1993).

g. Rose, K., Centolella, P.A., Hobbs, B.F. (NRRI, for NARUC): Public Utility Commission Treatment of Environmental Externalities (1994).

3. Citation of two additional important bibliographic sources:

a. Ottinger, R.L., et al (Pace University): Environmental Costs of Electricity, Oceana Publications, Inc. (1990). HD9685.E58

b. RCG/Hagler, Bailly, Inc., et al: New York State Environmental Externalities Cost Study, Report 1 (1993). HD9502.U54 N54

PART III - ENERGY RESOURCE INFORMATION

A. INTRODUCTION

P&S Law 1993, Chapter 80 and the Report of the Commission on Compre-hensive Energy Planning indicate that the study group is to consider what is sometimes referred to as the full fuel cycle for each energy resource: "envi-ronmental impacts, resulting from the extraction, production, transmission, consumption ...... of energy".

For fossil fuels, for example, the fuel cycle includes exploration, extraction using mines or wells, processing, transportation or transmission, storage, combustion use of the fuel, and waste disposal. Sometimes facility construction and decommissioning are also important.

At each stage in the overall energy resource production and consumption process there are environmental impacts, often a great many of them. It is also likely that there will be federal and state environmental regulation of many kinds applicable to the cycle at every stage. Compliance with environmental laws will have a cost and a corresponding price impact, probably at every stage. In principle, there could be significant environmental externalities at any stage. The second and third tasks prescribed by P&S Law 1993, Chapter 80, if carried out comprehensively, would involve obtaining a large amount of information about each resource at each stage of its fuel cycle, including information about applicable environmental regulation, its price effects, and any remaining externalities. Fortunately much work on these matters has already been completed, but even attempting to locate it and access it presented an enormous challenge to our staff working group.

In order to provide the most comprehensive and usable report within the limits of available time and resources, the report includes, for each energy resource, a narrative description of the fuel cycle. In addition, for each energy resource (though with varying degrees of detail and completeness), the report includes information about regulation, environmental impacts, price impacts and externalities.

B. COAL

COAL CYCLE EXTERNALITIES

1. Exploration

2. Extraction

a. Surface Mining

Environmental Effects: Solid waste generation, acid runoff and related leaching of sulphur, heavy metals, and Radium 226, temporary and permanent loss of wildlife habitat and recreational opportunities, particulate emission, methane releases, and visual and aesthetic impacts.

Legislation Governing Activity: RCRA, CERCLA, SDWA, CWA, NEPA, NAAQS, 1872 Mining Law, Surface Mining Control and Reclamation Act of 1977, 38 M.R.S.A. §482(2-B)(C), and §§480-A to 480-V, local zoning laws and codes.

Externalities: External costs associated with coal extraction are likely to exist, but have largely been internalized.

b. Sub-surface Mining

Environmental Effects: See surface mining.

Legislation Governing Activity: See surface mining.

Externalities: See surface mining.

3. Processing and Production

Prior to transport, coal is treated to increase its Btu content and decrease its water and sulphur content. Environmental effects, Legislation governing the activity, and conclusions about externalities are all similar to those defined in section II.A.

4. Transportation and Transmission

a. Coal transportation occurs mainly through rail and ship.

Environmental Effects: Environmental effects are mostly related to air emissions resulting from motive power used during transport.

Legislation Governing Activity: NEPA, CAA, CWA, State and Local highway laws, and the Federal Railroad Safety Act of 1970.

Externalities: Externalities for coal transport are associated with the air emissions generated during transport, and are likely to be small relative to the total externalities associated for this energy resource (see Attachment 2).

5. End Use of Coal

Coal use in Maine is primarily limited to combustion in steam boilers in the paper and electric utility industries.

Environmental Effects: Environmental effects arise from effluents generated by on-site storage, atmospheric emission of combustion by-products (NOx, CO2, SO2), particulate matter, and many trace elements including lead, copper, mercury, arsenic, beryllium, cadmium, chromium, manganese, nickel, formaldehyde, and Uranium 238 and Thorium 232. Each ton of coal combusted generates up to 270 lbs. of ash.

Legislation Governing Activity: Include CAA, and CWA.

Externalities: Externalities for coal combustion are substantial and have been quantified in two studies (see Attachments 2 and 3).

Regulation Applicable to the Coal Cycle

The Site Location of Development Law, 38 M.R.S.A. §§ 481-490 regulates drilling activities on land or under water if the area is greater than 60,000 sq. ft.. See 38 M.R.S.A. § 482(2)(B). This threshold was designed to handle off-shore drilling programs for gas and oil. If there were coal mining in Maine, it would be regulated if more than 1,000 cubic yards of product or overburden were removed within 12 successive calendar months. See 38 M.R.S.A. § 482(2-B)(C). If activity occurred within or adjacent to protected natural resources, the Natural Resources Protection Act, 38 M.R.S.A. §§ 480-A to 480-V, would apply.

Other impacts may be scenic issues associated with power plant stacks. Also, power plants can sometimes cause icing on nearby roads.

The Maine Geological Survey regulates mining on state lands (offshore drilling). See 12 M.R.S.A. §§ 547 and 549.

Table 11.5-1. Selected impact-pathways, damages and externalities for the coal fuel cycle in the *Southeast* Reference environment

	Damages (mills/kWh)			Externalities (mills/kWh)			
	Low	Mid	High	Low	Mid	High	Comments
Mining							
Occupational health:							
Fatal accidents	0.015	0.032	0.078	b	b	b	Largely but not entirely internalized
Injuries	0.019	0.031	0.085	b	b	b	Largely but not entirely internalized
Coal dust:							
Black lung disease	b	b	b	b	b	b	Largely but not entirely internalized
Other lung disabilities	b	b	b	a,b	a,b	a,b	
Mine refuse and drainage	a,b,c	a,b,c	a,b,c	a,b,c	a,b,c	a,b,c	Likely very small if in compliance
Transportation							
Coal transport—rail accidents:							
Deaths:	0.19	0.44	0.81	0.17	0.41	0.77	
Occupational	0.0072	0.016	0.030	~0	~0	~0	Largely internalized (occupational only)
Public	0.18	0.42	0.78	0.17	0.41	0.77	
Injuries:	0.03	0.05	0.09	0.0026	0.0052	0.009	
Occupational	0.023	0.044	0.077	~0	~0	~0	Largely internalized (occupational only)
Public	0.0027	0.0053	0.009	0.0026	0.0052	0.009	
Generation							
Occupational health:							
Fatal accidents	a,c	a,c	a,c	a,c	a,c	a,c	
Injuries	0.021	0.037	0.16	<0.021	<0.037	<0.16	Most of damages internalized, except for injury discomfort.
CO_2—global warming potential	b	b	b	b	b	b	Much of literature has range 3-14 mills/kWh; range itself imprecise.
CO_2—changes in forest growth	b	b	b	b	b	b	Enhanced vegetation growth; may be adaptation problems; some areas inundated.
SO_2—mortality:	b	b	b	b	b	b	Subsumed under PM_{10}-mortality association.

From: Estimating Externalities of Coal Fuel Cycles: Report No. 3, Oak Ridge National Laboratory and Resources for the Future

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ATTACHMENT 2[2]
ERI-COAL

Table 11.5-1. Selected impact-pathways, damages and externalities for the coal fuel cycle in the *Southeast* Reference environment

	Damages (mills/kWh)			Externalities (mills/kWh)			
	Low	Mid	High	Low	Mid	High	Comments
SO_2—morbidity:	0.0053	0.018	0.035	c	0	c	Mid estimate is rebuttable presumption reflecting net effect due to CAAA emissions cap.
Children cough-days	0.00038	0.0058	0.015	c	0	c	
Adult chest discomfort	0.0012	0.012	0.026	c	0	c	
SO_2-fertilization:							
-crop growth	a,b,c	0	a,b,c	a,b,c	0	a,b,c	Little effect (either positive or negative) even without CAAA.
-forest	a,b,c	0	a,b,c	a,b,c	0	a,b,c	Little possibility of beneficial effects even without CAAA.
SO_2-effects on material	0.017	0.078	0.14	a,c	0	a,c	CAAA offsets damages to unknown degree.
SO_2-visibility	a,c	a,c	a,c	a,c	0	a,c	Marginal impacts on visibility undiscernable. Cumulative effect important to Smokey Mt. (SE) and Grand Canyon (SW) visibility.
NO_x-morbidity:							
Phlegm days	b	b	b	b	b	b	Comparable to SO_2 morbidity damage if valued at $10/phlegm-day.
NO_x—fertilization:							
-crops	a,c	a,c	-0.0043	a,c	a,c	-0.0043	Bound based on aggregate NAPAP figure.
-forests	a,b,c	a,b,c	a,b,c	a,b,c	a,b,c	a,b,c	May have small benefit for N-deficient forests.
NO_x—Visibility:	a,c	a,c	a,c	a,c	a,c	a,c	Refer to SO_2.
Particulates (PM_{10})—mortality	0.097 0.054	0.28 0.16	0.60 0.32	0.097 0.054	0.28 0.16	0.60 0.32	Second numbers are with threshold (preferred method).
Particulates (PM_{10})—morbidity:	0.12/ 0.074	0.20/ 0.12	0.31/ 0.19	0.12/ 0.074	0.20/ 0.12	0.31/ 0.19	Second numbers are with threshold.

Table 11.5-1. Selected impact-pathways, damages and externalities for the coal fuel cycle in the *Southeast* Reference environment

	Damages (mills/kWh)			Externalities (mills/kWh)			
	Low	Mid	High	Low	Mid	High	Comments
Respiratory hospital admission	0.000031	0.005	0.01	0.000031	0.005	0.01	Numbers are with threshold
Emergency room visits	0.000043	0.00032	0.00063	0.000043	0.00032	0.00063	Numbers are with threshold
Restricted activity days	0.0037	0.016	0.03	0.0037	0.016	0.03	Numbers are with threshold
Respiratory symptoms	0.031	0.073	0.14	0.031	0.073	0.14	Numbers are with threshold
Chronic bronchitis in children	0.000083	0.00041	0.00078	0.000083	0.00041	0.00078	Numbers are with threshold
Asthma attacks	0.00059	0.0038	0.0087	0.00059	0.0038	0.0087	Numbers are with threshold
Chronic bronchitis in adults	0.0037	0.021	0.042	0.0037	0.021	0.042	Numbers are with threshold
Particulates—material damage	a	a	a	a	a	a	
Particulates—visibility	a,c	a,c	a,c	a,c	a,c	a,c	Refer to SO_2
Acid deposition—recreation (fishing)	a,b,c	a,b,c	a,b,c	a,b,c	a,b,c	a,b,c	
Acid deposition—crops	0	0	0	0	0	0	
Acid deposition and ozone— forest	a,b,c	a,b,c	a,b,c	a,b,c	a,b,c	a,b,c	Impacts difficult to isolate.
Acid deposition—materials	a,b,c	a,b,c	a,b,c	a,b,c	a,b,c	a,b,c	
Ozone—mortality:	0	0	0.11	0	0	0.11	High estimate is from mean value based on two epidemiological studies.
Ozone—morbidity:	0.14	0.23	0.36	0.14	0.23	0.36	
Total respiratory restricted activity days	0	0.096	0.20	0	0.096	0.20	
Any-symptom day	0.0056	0.051	0.12	0.0056	0.051	0.12	
Asthma-attack day	0.0037	0.013	0.027	0.0037	0.013	0.027	
Eye-irritation day	0.034	0.072	0.13	0.034	0.072	0.13	
Days of coughing	0.0072	0.024	0.054	0.0072	0.024	0.054	
Cough incidence	0.0087	0.053	0.14	0.0087	0.053	0.14	
Shortness of breath	0.011	0.081	0.23	0.011	0.081	0.23	

Table 11.5-1. Selected impact-pathways, damages and externalities for the coal fuel cycle in the *Southeast* Reference environment

	Damages (mills/kWh)			Externalities (mills/kWh)			
	Low	Mid	High	Low	Mid	High	Comments
Pain upon deep inspiration	0.02	0.096	0.20	0.02	0.096	0.20	
Ozone—crops	a	0.12	a	a	0.12	a	
Ozone—forests (with acidic deposition	a,c	a,c	a,c	a,c	a,c	a,c	
Ozone—effects on materials (with acid dep'n)	a,c	a,c	a,c	a,c	a,c	a,c	
Mercury—aquatic resources	b	b	b	b	b	b	Uncertainty about deposition patterns and effects
Adult health	b	b	b	b	b	b	
Neonatal impacts	b	b	b	b	b	b	
Lead–mortality	0.0041	0.0088	0.015	0.0041	0.0088	0.015	
Adult	0.0041	0.0088	0.015	0.0041	0.0088	0.015	
Neonatal	~0	~0	~0	~0	~0	~0	Two orders of magnitude less than damages to adults.
Lead—morbidity:	a	0.0021	a	a	0.0021	a	
IQ decrement	a	0.0015		a	0.0015		
Hypertension		0.0005	a		0.0005	a	
Coronary heart disease	a	0.000071	a	a	0.000071	a	
Air toxics—morbidity:	b,c	b,c	b,c	b,c	b,c	b,c	Far less than 0.017 mills/kWh estimated by Rae et al. (1991)
Water use:							
Thermal plume—fish loss	a,b,c	0.0031	a,b,c	a,b,c	0.0031	a,b,c	Very approximate estimate.
Consumptive—water loss	0	0	0	0	0	0	
Solid waste:							
Ground water	a,c	a,c	a,c	a,c	a,c	a,c	Imprecise estimates range from 0.004-0.14 mills/kWh
contamination—ecological effects	a,b,c	a,b,c	a,b,c	a,b,c	a,b,c	a,b,c	
Land use change	a,c	a,c	a,c	a,c	a,c	a,c	One estimate in literature of 0.037 mills/kWh is too imprecise

ATTACHMENT 2
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Table 11.5-1. Selected impact-pathways, damages and externalities for the coal fuel cycle in the *Southeast* Reference environment

	Damages (mills/kWh)			Externalities (mills/kWh)			
	Low	Mid	High	Low	Mid	High	Comments
Employment benefits	-1.0	-2.1	-4.4	b	b	b	Benefits should be compared across fuel cycles to obtain NET differences. Whether benefits are externalities is highly contentious, with crucial issue being whether there is structural unemployment in region.

a. An estimate may be possible, with additional analysis.
b. Possibility of estimate limited by state of the science; i.e., new models needed.
c. Possibility of estimate limited by lack of site-specific studies.

ATTACHMENT 3[3]
ERI-COAL

TABLE 1

<u>EXTERNALITY COSTS FOR COAL-FIRED UNITS</u>
(Emissions - lbs/MMBTU)

Externality	$/lb	Existing Boiler (1.2% S)	AFBC (1.1% S)	IGCC (.45% S)	NSPS (N/A)
	[A]	[B]	[C]	[D]	[E]
[1] SO_2	$ 2.03	1.80	0.55	0.48	1.2
[2] NO_x	$ 0.82	0.607	0.3	0.06	0.006
[3] Particulates	$ 1.19	0.15	0.01	0.01	0.03
[4] CO_2	$ 0.0068	209	209	209	209
Totals:					
[5] $/MMBTU Input		$ 5.76	$ 2.80	$ 2.46	$ 3.90
[6] Heat Rate (BTU/kWh)		10,000	10,000	10,000	10,000
[7] $/kWh Generated		$ 0.058	$ 0.028	$ 0.025	$ 0.039
[8] $kWh Delivered		$ 0.068	$ 0.033	$ 0.028	$ 0.045

Notes:

[A]: Unit Values derived in Chapter V.
[B][C][D][E]: Emissions are from PLC (1989); SO_2 and CO_2 emissions have been restated as lbs SO_2 and lbs CO_2. All emissions are expressed as lbs/MMBTU fuel input.
[E]: NSPS regulations require 1.2 lbs/MMBTU and 90% reduction for plants with emissions greater than 0.6 lb/MMBTU; for plants with emissions less than 0.6 lb/MMBTU; NSPS requires 70% reduction in emissions.
[1]: No SO_2 scrubbers are installed on the first three plants.
[2]: NO_x emissions are uncontrolled in each case.
[3]: Particulates emissions vary widely and are extremely dependent on the ash content and sulfur content and sulfur content of the coal. NSPS requries 0.03 lbs/MMBTU and 90% reduction.
[4]: CO_2 emissions are derived in PLC (1989).
[5]: Sum of (value x emissions for each externality) for each plant.
[6]: Assumed heat rates for each plant.
[7]: [5] x [6]/1,000,000.
[8]: Assumes 15% marginal energy losses.

3 From Richard Ottinger, et al, <u>Environmental Costs of Electricity</u> (1990).

C. NATURAL GAS

NATURAL GAS FUEL CYCLE

1. Exploration

Deposits of natural gas and oil are located in subsurface geologic reservoirs formed by the deformation of localized rock strata. Exploration for these energy resources is accomplished in two phases.

a. Phase I exploration is conducted through seismology.

Environmental effects: Noise pollution and air borne particulates as a result of detonated explosives.

Legislation Governing Activity: Unknown.

Externalities: Likely to be minimal.

b. Phase II exploration requires drilling of exploratory wells.

Environmental effects: Air born particulate matter, erosion, surface run off, visual pollution, air emissions (SOx, NOx, CO2, VOCs, and methane), solid and liquid wastes, loss of wildlife habitat, limitations on recreational uses.

Legislation Governing Activity: RCRA, CERCLA, SDWA, CWA, NEPA, CAA, Federal Natural Gas and Natural Gas Royalty Act, Federal Land Policy and Management Act, Endangered Species Act, National Trails Systems Act, Fish and Wildlife Co-ordination Act, Wilderness Act, Outer Continental Shelf Lands Act and amendments, and the Toxic Substances Control Act.

Externalities: may exist, but cannot yet be quantified.

2. Extraction

Wells used to extract fossil fuel from proven reservoirs have similar environmental impacts to those listed for Phase II exploratory wells[4].

3. Processing and Production

There are three distinct processing and production activities; dehydration, sweetening, and compression.

a. Dehydration process

Environmental Effects: Waste products including glycol based fluids, condensed waters, and solid desiccants.

Legislation Governing Activity: RCRA, CERCLA, SDWA, CWA, CAA, NEPA

Externalities: May exist but have not been quantified.

b. Removal of non-vapor products

Environmental Effects: Solid and liquid wastes, and releases of CO_2.

Legislation Governing Activity: See III.A.2 above.

Externalities: Process by-products are reclaimed; externalities are likely to be limited.

4 They are more numerous. In 1993 there were an estimated 286,168 producing gas wells in the United States. 1994 Gas Facts p.38

c. Pressurization of gas to pipeline pressure. This is accomplished through the use of either reciprocating engines or combustion turbines.

Environmental Effects: Emission of SO_2, NO_x, ROG's, PM10, and CO_2, as well as solid and liquid waste disposal.

Legislation Governing Activity: See III.A.2 above.

Externalities: May exist but have not been quantified.

4. Transportation and Transmission of Natural Gas

Natural gas is moved through gathering lines to transmission pipelines, and then through distribution lines. Pressurization required to move gas is developed with compressors.

Environmental Effects: Methane leaks, construction impacts on aquatic and terrestrial ecosystems, wetlands impacts, and air impacts from compressors.

Legislation Governing Activity: NEPA, CAA, CWA, Natural Gas Pipeline Safety Act, Article VII of the Public Service Law, and the State of Maine Site Location of Development Law.

Externalities: May exist, but have not been quantified.

5. Natural Gas Storage Facilities

Natural gas may be stored in exhausted oil and gas reservoirs, in salt domes, or as a liquid above ground in storage tanks.

a. Underground storage of natural gas
Environmental Effects: include disposal of solid and liquid wastes, air emissions and solid and liquid wastes from compressor motors, possible contamination of subsurface water supplies.

Legislation Governing Activity: Probably includes many of the previously mentioned laws and acts but is not yet definitively known.

Externalities: may exist but have not been quantified.

b. Liquified natural gas (LNG).
Environmental Effects: Emissions associated with the cooling process, leakage of coolant to the atmosphere, and risks associated with transport of a volatile substance.

Legislation Governing Activity: Legislation is not yet known.

Externalities: may exist but are have not been quantified.

6. End Uses of Natural Gas

Environmental effects corresponding to use of natural gas as a fuel are dependent upon the end use desired. Electric generation may be accomplished through steam turbines, gas turbines, reciprocating engines, or fuel cells. Each technology will result in different air emissions. Commercial and residential heating, cooking, and cooling will have their own characteristic emissions as will natural gas fueled vehicles.

a. Natural gas for electric utility generation or for process steam use in large industrial boilers:

Environmental Effects: will include the emission of various pollutants (see III.C.2 above)

Legislation Governing Activity: Would primarily be the Clean Air Act and Clean Air Act Amendments of 1990.

Externalities: Have been quantified for the combustion of natural gas in utility boilers (see Attachment 2).

Regulation Applicable to the Gas Cycle

The Site Location of Development Law, 38 M.R.S.A. §§ 481-490 regulates drilling activities on land or under water if the area is greater than 60,000 sq. ft.. See 38 M.R.S.A. § 482(2)(B). This threshold was designed to handle off-shore drilling programs for gas and oil. If there were coal mining in Maine, it would be regulated if more than 1,000 cubic yards of product or overburden were removed within 12 successive calendar months. See 38 M.R.S.A. § 482(2-B)(C). If activity occurred within or adjacent to protected natural resources, the Natural Resources Protection Act, 38 M.R.S.A. §§ 480-A to 480-V, would apply.

Other impacts may be scenic issues associated with power plant stacks. Also, power plants can sometimes cause icing on nearby roads.

The Maine Geological Survey regulates mining on state lands (offshore drilling). See 12 M.R.S.A. §§ 547 and 549.

TABLE 3

EXTERNALITY COSTS FOR NATURAL GAS-FIRED UNITS
(Emissions - lbs/MMBTU)

Externality	$/lb	Existing Steam Plant	Combined Cycle	BACT (SCR, SWI)
	[A]	[B]	[C]	[D]
[1] SO_2	$ 2.03	0	0	0
[2] NO_x	$ 0.82	0.248	0.42	0.042
[3] Particulates	$ 1.19	0.003	0.003	0.0002
[4] CO_2	$ 0.0068	110	110	110
Totals:				
[5] $/MMBTU Input		$ 0.95	$ 1.10	$ 0.78
[6] Heat Rate (BTU/kWh)		10,400	9,000	9,000
[7] $/kWh Generated		$ 0.010	$ 0.010	$ 0.007
[8] $kWh Delivered		$ 0.012	$ 0.011	$ 0.008

Notes:

[A]: Unit Values derived in Chapter V.
[B][C][D]: Emissions are from PLC (1989); SO_2 and CO_2 emissions have been restated as lbs SO_2 and lbs CO_2. All emissions are expressed as lbs/MMBTU fuel input.
[1]: SO_2 emissions are zero from gas combustion.
[2]: NO_x emissions are uncontrolled in the first two cases; For the BACT case, Selective Catalytic Reduction and Steam Water injection are assumed.
[3]: Particulates emissions are estimated for CEC (1989). BACT assumes fabric filter control.
[4]: CO_2 emissions are derived in PLC (1989).
[5]: Sum of (value x emissions for each externality) for each plant.
[6]: Assumed heat rates for each plant.
[7]: [5]*[6]/1,000,000.
[8]: Assumes 15% marginal energy losses.

[5] From: Richard Ottinger, et al, Environmental Costs of Electricity (1990)

D. PETROLEUM

Petroleum Products Fuel Cycle Description

Petroleum products include: #6 residual oil (various sulfur contents); #2 distillate oil; kerosene; diesel fuel; gasoline; various aviation fuels; and propane.

Differences in these fuels (and their impurities) and in combustion equipment can result in different air emissions.

The petroleum products fuel cycle consists of: exploration and extraction; processing; transportation and storage, including local handling, delivery, storage, pumping, etc; combustion (many different end uses); disposal of waste (if any).

1. Extraction

Wells can be located onshore or offshore, and can be located in the US or in foreign countries. Impacts of well drilling include:

* Solid waste disposal of several kinds
* Ground and surface water contamination
* Air emissions from drilling, including NOX and VOCs
* Land and water ecosystems and habitat impacts
* Environmental damage from accidents and spills
* Occupational injury and death
* Noise and visual impacts

The New York State Environmental Externality Cost Study (NYSEECS) notes that health and mortality risks are at least partially internalized by insurances and risk premiums in wages. Risks associated with accidents and spills are similarly internalized, at least partially, by insurance and cleanup funds.

Oil extraction does not take place in Maine.

Federal environmental regulations applicable to petroleum extraction include:

* Resource Conservation and Recovery Act (RCRA)
* Comprehensive Environmental Response Compensation and Liability Act (CERCLA)

* Safe Drinking Water Act (SDWA)
* Clean Water Act (CWA)
* National Environmental Policy Act (NEPA)
* Clean Air Act, as amended (CAA)
* Federal Oil and Oil Royalty Management Act (FOORMA)
* Federal Land Policy and Management Act (FLPMA)

Maine environmental regulations applicable to oil extraction:
Please see Attachment 1.

2. Processing

Processing can be domestic or foreign. Impacts of processing include:

* Ground and surface water contamination
* Waste disposal
* Land and water ecosystem and habitat impacts
* Air emissions
* Environmental damage from accidents and spills
* Occupational injury and death
* Odor and visual impacts

Remarks similar to those under Extraction apply. Processing of petroleum products does not take place in Maine.

Federal environmental regulations applicable to petroleum processing: SDWA, CWA, RCRA, CERCLA, CAA.

Maine environmental regulations applicable to petroleum processing:
Please see Attachment 2.

3. Transportation

Transportation can be by tanker, barge, pipeline, or truck. Impacts of transportation include:

* Ground and surface water contamination
* Land and water ecosystem and habitat impacts
* Aesthetic and recreational damage from spills
* Occupational injury and death
* Air quality impacts from spills, including VOCs and toxics

Transportation should be construed broadly to include storage and local handling, delivery, storage, pumping, and so on. If this is done environmental impacts will include air emissions (for example, at gasoline pumps).

The NYSEECS states that spills are the major cause of environmental damage during the transportation stage, and that most of their costs are at least partially internalized through cleanup funds and insurance.

Federal environmental regulations applicable to petroleum products transportation include:

Oil Pollution Act (1990)

Maine environmental regulations applicable to petroleum products transportation include:

Please see Attachments 2 and 3, and Section J.

4. Combustion

Tables based on Maine DEP data, provided in the Final Report of the Commission on Comprehensive Energy Planning (CCEP), show emissions of SOx, NOx, VOC, CO, CO2, methane, and particulates. Ottinger's Environmental Costs of Electricity (ECE) shows numerous metals and toxics (p. 122).

DEP data in the CCEP seems to subdivide combustion into residential, commercial, industrial, utility, and transportation sectors. Breakdowns by fuel type and combustion equipment are also possible.

Federal environmental regulations applicable to the combustion of petroleum products include: CAA

Maine environmental regulations applicable to the combustion of petroleum products include:

Bureau of Air Quality Control regulations applicable to the combustion of petroleum products include Chapters 100, 101, 103, 106, 107, 109, 110, 113, 114, 115, 116, 117, 127, 128, 134, 137, and 138. Summaries of these Chapters can be found in the Attachment to Section M.

Please also see Section J.

5. Waste Disposal

Fly ash is a waste from the combustion of #6 oil in utility boilers. There may be solid wastes from the combustion of other fuels.

Federal environmental regulations applicable to ash and other solid wastes from petroleum combustion:

Please see Section J.

Maine environmental regulations applicable to fly ash and other solid wastes from petroleum combustion:

Please see Attachment 2, section E.

The costs to the petroleum industry of complying with environmental regulations have been documented in a study by the American Petroleum Institute (API), "Petroleum Industry Environmental Performance (excerpts in PUC library). According to this study the industry spent $10.5 billion on environmental protection during 1992, more than the amount that was spent searching for oil and gas. This amounts to $4 per barrel (oil now costs about $16 per barrel, about 42 gallons, amounting to about 10¢ per gallon of crude oil). Some detail can be found in the study. Details on the costs of complying with specific provisions of some Maine regulation can be found in Attachments 2 and 3.

Maine Regulations Applicable to the Petroleum Cycle

Concerning applicable state laws administered through L&W -- If drilling were to occur in Maine, it might be addressed under the Site Location of Development Law, 38 M.R.S.A. §§ 481-490, which regulates drilling activities on land or under water if the area is greater than 60,000 sq. ft.. See 38 M.R.S.A. §482(2)(B). This threshold was designed to handle off-shore drilling programs for gas and oil. If activity occurred within or adjacent to protected natural resources, the Natural Resources Protection Act, 38 M.R.S.A. §§ 480-A to 480-V, would apply.

ATTACHMENT 2
ERI-PETROLEUM

MAINE DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF HAZARDOUS MATERIAL & SOLID WASTE CONTROL
REGULATIONS APPLICABLE TO THE PETROLEUM PRODUCTS FUEL CYCLE

A. Extraction

[no extraction in Maine]

B. Processing

[no processing in Maine]

C. Transportation

1. Summary of Regulations

Maine regulates the importation, conveyance and storage of petroleum products under the Oil Discharge Prevention and Control Act (38 M.R.S.A. §§ 541 et. seq.) and the Underground Oil Storage Facilities and Ground Water Protection Act (38 M.R.S.A. § 561 et. seq.).

a. The Oil Discharge Prevention and Control Act:

- prohibits the unlicensed discharge of oil into coastal or inland waters;
- prohibits the unlicensed operation of an oil terminal facility;
- requires responsible parties to promptly report and remove unlicensed discharges;
- makes carriers of oil liable for spills--state does not need to prove negligence;
- requires the department to develop, revise and follow a of marine oil spill contingency plan; and
- establishes the Maine Coastal and Inland Surface Cleanup Fund to pay cleanup costs and damages, and to pay for maintaining spill response readiness.

The purpose of the act is minimize the adverse environmental impacts of ship-to-ship, ship-to-shore and other transfers of oil. This purpose is accomplished by conferring on the department the power to deal with the hazards posed by oil transfer; by requiring the prompt containment and clean-up of oil spills; and by ensuring prompt payment of spill-related damages.

The Board of Environmental Protection has adopted rules to carry out the act. The rules, among other things: establish procedures and equipment requirements for transfer operations; specify a procedure for reporting spills; require oil terminals to develop and follow a discharge contingency plan; specify minimum safety measures to prevent fire and explosion; and require storage tanks to be surrounded with containment dikes.

b. Underground Oil Storage Facilities and Ground Water Protection Act.

The purpose of the act is to minimize the adverse environmental impacts of oil storage. This purpose is accomplished by conferring on the department the power to regulate the design, installation and use of underground oil storage facilities; by requiring the abandonment or removal of underground tanks that are not constructed of non-corrosive material; by requiring the prompt containment and clean-up of leaks and spills from aboveground and underground storage facilities; and by establishing the Ground Water Oil Clean-up Fund to pay spill-related damages.

The board has adopted rules to carry out those parts of the act aimed at preventing spills and leaks. It should be noted that the act is very specific with respect to the allowed content of the rules. The rules include design, installation, leak detection and overfill protection standards, most of which are derived from nationally-accepted standards in the industry.

Note on Waste Oil: Although waste oil is not mentioned as a possible fuel in an oil-fired electrical generating plant, perhaps because of its uncertain availability, it should be noted that the board has adopted separate rules relating to the transportation, collection and storage of waste oil.

2. Price Impact of Compliance

a. Coastal Conveyance Act

- Fees: Anyone transporting oil into the state by ship, rail or highway must pay a fee of 3¢/barrel as needed to maintain a $6m balance in the Maine Coastal and Inland Surface Oil Clean-up Fund.

- Other Price Impacts: The cost of complying with the pollution prevention and clean-up measures of the Act and regulations is unknown to the study group. Many of the requirements relate to the design and manner of use of equipment that is necessary to accomplish the transfer of oil and that would be used by the industry in the absence of regulation. In such cases, compliance costs are expected to be minor. In many instances, however, the act requires equipment (e.g. containment booms) and actions (e.g. clean-up) that the industry might not use or do in the absence of regulation.

b. Underground Oil Storage Law.

- Fees. Owners of underground tanks must pay an annual registration fee of $35. Fees (44¢ per barrel on gasoline; 4¢ per barrel on #6 fuel oil and 25¢ per barrel on other oil) also must be paid on oil transported into the state by ship, rail or highway as needed to maintain a $15m balance in the Ground Water Oil Clean-up Fund.

- Other Price Impacts: Many of the regulatory requirements specify the type and design of materials used in underground tank installations (e.g. use of corrosive resistant pipes and tanks). Where this is the case, the cost impact is the price difference between the specified material and the material that otherwise would have been used. In many cases, there may be little or no difference. On the other hand, some required measures (e.g. use of a certified tank installer; leak detection equipment) likely would not be done in the absence of regulation. The cost of compliance may be higher in the latter instance, but is more than offset by cost savings from pollution prevention as shown in the cost/benefit analysis.

In most cases, the price impacts of compliance can be expected to be less than the price impacts of cleaning up the additional spills that likely would occur in the absence of regulation. A cost benefit analysis conducted by the department in 1991 found that, for every dollar spent on preventative measures required under department rules, more than 3 dollars in clean-up and damage costs were avoided.

3. Significant Environmental Externalities of Oil Transport

The primary environmental impacts from oil transport are those associated with spills and leaks (see NY State Externality Cost Study). The laws and regulations regarding oil transport and storage are designed to ensure that reasonable measures are taken to minimize the possibility of spills, and to promptly detect and clean up those that occur. However, implicit in this regulatory scheme is the assumption that leaks and spills will occur on occasion.

When a spill occurs, the law provides for prompt clean-up. Transporters are liable for damages and clean-up costs. They must report spills immediately and must undertake containment and clean-up measures. They also must pay fees to the Maine Coastal and Inland Surface Oil Clean-up Fund. The fund ensures that money is available to pay for clean-up and damages from a spill of unknown origin or a spill exceeding the financial resources of the responsible party.

These requirements collectively ensure that most spill-related environmental costs are internalized. However, there always will be a point beyond which clean-up measures are not economically or technically feasible. Each spill will have some impacts that are not internalized and probably not quantifiable. A spill is cleaned up to a point acceptable to the commissioner and we live with the residual damage.

D. Combustion

[no BHMSWC regulations apply]

E. Waste Disposal

1. Summary of Regulations

Maine law classifies oil ash as "special waste," which simply means a type of solid waste that requires special handling. Oil ash and other special wastes, if disposed in Maine, must be placed in a "secure" landfill. A secure landfill is one that includes a liner system, a leachate collection and treatment system, and a final cover system.

The department has adopted comprehensive rules to ensure that landfilling does not pose an unreasonable risk to human health and will not contaminate ground or surface water. The rules accomplish this purpose through inter-related standards governing landfill siting, design, construction, operation, monitoring and closure. For example, the rules:

- exclude landfills from sensitive locations and specify minimum setbacks from important natural resources;
- require that landfills receiving special waste have a liner constructed of both natural (clay) and synthetic (plastic) material;
- require that landfills receiving special waste include a system to collect landfill leachate (liquids that emerge from the waste mass); and
- require the installation and monitoring of sufficient ground water wells to detect any contamination that penetrates the containment systems.

The department also has adopted rules relating to the transport of solid waste. These rules: require haul vehicles to be licensed (unless the waste is hauled in a generator- owned landfill); establish license fees; and require waste to be contained during transport to prevent blowing, spillage or other type of discharge.

2. Price Impact of Compliance

An oil fired electric utility has two options for in-state ash disposal. It can develop its own landfill or take the ash to a licensed commercial landfill. Two commercial landfills in Maine are licensed to receive special waste including ash--the Crossroads Landfill in Norridgewock and the Sawyer Landfill in Hampden. Tip fees at these facilities are between $50 and $60 per ton, not including transportation costs. The development of a secure landfill, as required under current regulations, is a multi-million dollar undertaking. Costs will vary depending on site location, and are reported to range from $50,000 to $100,000 per acre. Few landfills have been developed in recent years, in large part because of the expense, but also due the limited availability of technically suitable and politically acceptable sites. An oil fired utility is unlikely to generate ash in quantities that would justify the construction of a utility-owned landfill.

The cost of transporting ash from the utility to a licensed landfill is unknown. However, Maine law requires that special waste conveyance be licensed and imposes a biennial license fee. This fee will contribute to transportation costs. The biennial license fees are:

First and second conveyance	$ 100 each
Third through tenth conveyance	$ 70 each
Eleven or more conveyances	$ 50 each

The maximum biennial fee for any applicant is $2,000.

3. Significant Environmental Externalities of Oil Ash Disposal

The primary risk from landfilling of oil ash is ground and surface water contamination. The rules regarding landfill development are designed to minimize this risk by ensuring that ash and other wastes are contained and isolated from the environment. The required liner, leachate collection and leak detection systems are designed to capture contaminants before they leak to the environment and to prevent the spread of any leakage that does occur.

The long-term performance of secure landfills has not been monitored as the technology is relatively new to Maine. Most predict that some contaminants will escape. However, the expectation is that the redundant containment systems preclude the possibility of a contaminant release of sufficient magnitude to adversely impact ground or surface water quality beyond the landfill site.

Department of Environmental Protection
Bureau of Air Quality Control Regulations and Implementation Cost Summary

CHAPTER 111 PETROLEUM LIQUID STORAGE VAPOR CONTROL

SUMMARY: This regulation requires all owners of fixed roof storage tanks, storing gasoline, crude oil or any petroleum liquid whose vapor pressure is greater than 1.52 psia (10.5 Kilo pascals) to install floating roofs to reduce the hydrocarbon vapors lost to the atmosphere.

Petroleum Liquid Vapor Storage Control (fixed roof storage tanks)

- Effective May 1979
- Amended in August 1988 to include the entire state
- EPA approved on February 3, 1992

Costs: Based on 55,000 bbl (2,310,000) medium sized tank with gasoline or crude oil, with true vapor pressure range of 14 to 69 kPa (2 to 10 psia) and 5 to 20 turn-overs per year.

Capital Cost:	$	31,000			
Annualized Cost:	$	70,000	(net savings) - to	$	2,100
Cost Effectiveness:	$	123	(net savings) -	$	73
Source: EPA					

CHAPTER 112 PETROLEUM LIQUIDS TRANSFER VAPOR RECOVERY

SUMMARY: This regulation requires bulk gasoline terminals loading tank trucks or trailers and who pump 20,000 gallons or more of gasoline per day to install a vapor control system. This system must control lost gasoline vapors so transferred.

Petroleum Liquids Transfer Vapor Recovery (bulk terminals)

- Effective May 1979
- Amended in August 1988 to include the entire state
- EPA approved on February 3, 1992
- Amended effective July 11, 1994
- EPA approval expected Spring 1995

Costs: Based on 250,000 gal/day throughput facility.

Capital Cost:	$ 140,000	- $ 195,000		
Annualized Cost:	$ 20,000	- $ 30,000		
Cost Effectiveness:	$ 120	- $ 180	per ton VOC	
Source: EPA				

CHAPTER 118 GASOLINE DISPENSING FACILITIES VAPOR CONTROL

SUMMARY: This regulation requires the control of gasoline vapors emitted during the transfer of gasoline from tank trucks to stationary gasoline storage tanks at gasoline dispensing facilities.

Gasoline Service Station Vapor Control (Stage I)

- Effective September 21, 1988
- Compliance required by October 1, 1989 for some stations, and by October 1, 1991 for other stations
- Amended effective July 11, 1994
- EPA approval expected Spring 1995

Costs: Based on application of submerged fill and vapor balance system to a service station with three tanks.

Capital Cost:	$ 600	
Annualized Cost:	$ 200	(net savings)
Cost Effectiveness:	$ 110	(net savings) per ton VOC
Source: EPA		

Gasoline Service Station Vapor Control (Stage II)

- Proposed for stations with yearly throughput greater than 500,000 gallons per year

Costs: Based on a moderate sized facility dispensing 65,000 gallons per month using multi-product dispensers.

Capital Cost:	$ 24,120	
Annualized Cost:	$ 4,430	
Cost Effectiveness:	$ 1,200	per ton VOC
Source: STAPPA/ALAPCO		

CHAPTER 119 MOTOR VEHICLE FUEL VOLATILITY LIMIT

SUMMARY: This regulation requires that all gasoline that is distributed or marketed by bulk gasoline terminals or is directly imported to gasoline service stations or bulk gasoline plants shall not have a Reid Vapor Pressure greater than 9.0 psi during the period between May 1, 1989 and September 15, 1989 and continuing every year thereafter.

Motor Vehicle Fuel Volatility Limit

- Effective September 21, 1988
- Compliance required by May 1, 1989
- EPA approved on May 3, 1990
- Amended effective July 11, 1994
- EPA approval expected Spring 1995

Costs: The actual costs for compliance with RVP restrictions has been shown to be $. 01 per gallon.

CHAPTER 120 GASOLINE TANK TRUCK TIGHTNESS SELF-CERTIFICATION

SUMMARY: This regulation requires that all tank trucks that transport and receive gasoline from a bulk gasoline terminal and/or plant be maintained leak-tight and must be tested and certified annually.

Gasoline Tank Truck Tightness Self-Certification

- Effective September 21, 1988
- Compliance required by May 1, 1989
- Modified with new effective date of July 11, 1994
- EPA approved April 13, 1992
- Amended effective July 11, 1994
- EPA approval expected Spring 1995

Costs: The Department does not have cost estimates for Tank Truck Tightness and Certification.

CHAPTER 133 PETROLEUM LIQUIDS TRANSFER VAPOR RECOVERY AT BULK GASOLINE PLANTS

SUMMARY: This regulation requires applicable bulk gasoline plants loading tank trucks or trailers to install a vapor balance system or submerged fill.

Petroleum Liquids Transfer Vapor Recovery at Bulk Gasoline Terminals

- Effective date July 11, 1994
- EPA approval in process expected Spring 1995
- Compliance required by May 31, 1995

Costs: Based on 4,000 gal/day throughput facility.

Capital Cost:	$	4,000	- $	10,000	
Annualized Cost:	$	100	- $	1,200	
Cost Effectiveness:	$	9	- $	90	per ton VOC

Source: EPA

TABLE 2

EXTERNALITY COSTS FOR OIL-FIRED UNITS
(Emissions - lbs/MMBTU)

Externality	$/lb	Boiler # 6 oil (.5% S)	Boiler # 6 oil (1% S)	Boiler # 6 oil (2.2% S)	Combustion Turbine # 2 oil (1% S)
	[A]	[B]	[C]	[D]	[E]
[1] SO_2	$ 2.03	0.54	1.08	2.38	0.16
[2] NO_x	$ 0.82	0.357	0.287	0.357	0.498
[3] Particulates	$ 1.19	0.055	0.09	0.174	0.036
[4] CO_2	$ 0.0068	169	169	169	161
Totals:					
[5] $/MMBTU Input		$ 2.60	$ 3.68	$ 6.48	$ 1.87
[6] Heat Rate (BTU/kWh)		10,400	10,400	10,400	13,600
[7] $/kWh Generated		$ 0.027	$ 0.038	$ 0.067	$ 0.025
[8] $kWh Delivered		$ 0.032	$ 0.045	$ 0.079	$ 0.030

Notes:

[A]: Unit Values derived in Chapter V.
[B][C][D][E]: Emissions are from PLC (1989); SO_2 and CO_2 emissions have been restated as lbs SO_2 and lbs CO_2. All emissions are expressed as lbs/MMBTU fuel input.
[1]: SO_2 emissions are uncontrolled in each case.
[2]: NO_x emissions are uncontrolled in each case.
[3]: Particulates emissions are calculated from EPA Ap-42 using the formula: 0.02 + 0.07 x S, where S is the sulfur content in percent.
[4]: CO_2 emissions are derived in PLC (1989).
[5]: Sum of (value x emissions for each externality) for each plant.
[6]: Assumed heat rates for each plant.
[7]: [5]*[6]/1,000,000.
[8]: Assumes 15% marginal energy losses.

TABLE 7

METALS AND TOXIC EMISSIONS
Oil-Fired Plants
(Residual Oil)

	Emission Factor $lb\backslash 10^{12}$ BTU
Arsenic	19
Beryllium	4.2
Cadmium	15.7
Chromium	21
Copper	280
Mercury	3.2
Manganese	26
Nickel	1260
Lead (1).	9.3-47
POM	8.4
Formaldehyde (2)	405
Radionuclides	n.a.

n.a. = not available from source

Source: U.S. EPA, Estimating Air Toxic from Coal and Oil Combustion Sources, Office of Air Quality Planning and Standards, EPA-450/2-89-001, April 1989, Table 4-1, p. 4-2; Table 117, p. 4-175.

TABLE 7 - NOTES

(1) The range for lead represents ESP controlled, and uncontrolled plants. All other emission factors are averages for uncontrolled emissions.

(2) Formaldehyde factors are averages based on very limited and relatively old data.

E. BIOMASS

1. Fuel Cycle Analysis of Woody Biomass Production and Use for Energy in Maine

Biomass Fuel Cycle Stages - Categories and Descriptions This section describes the fuel cycle stages pertinent to wood biomass energy and the general set of conditions or activities associated with each stage. The purpose of this section is to create a structure for the analysis of environmental impacts (and potentially social and economic effects). The life cycle categories are based on a process oriented view that considers the production, processing, and use of woody fuels to generate electricity in Maine. (This analysis does not include residential use of firewood, or wood recovered from municipal waste streams).

The Resource Stage - The resource stage covers the management and culture of Maine's forests and its use as an energy resource. Land ownership objectives and forest management programs will not be covered in detail since these aspects and related activities in general do not have direct impacts attributable solely to biomass energy use. There is, however, a relationship between forest practices and biomass energy development that contributes to forest practice issues and the management and use of Maine's forest resources. To the extent that biomass energy considerations enter into forest management decisions and activities there may be some marginal unaccounted for beneficial or negative effects that could be credited to biomass energy.

> Resource capacity and availability - A critical consideration in the management and use of forests as an energy resource is the capacity of the resource to provide adequate supplies of energy products at a predictable price. Various resource assessments, productivity analysises and cost studies; surveys of ownership objectives and owners plans to harvest; and market place competition for wood serve to help answer these questions of availability and cost. These resource analysis/assessments are seen in a neutral light having no particular effect for this study other than generally providing a green light to proceed, or a yellow light to proceed cautiously, or a red light to halt any further biomass energy development.

Resource management - Forest are used/managed to satisfy a variety of objectives. Forest based biomass energy products are usually produced as a co-product along with logs and pulpwood consistent with meeting management objectives. Management plans and subsequent activities direct the course of actions leading to biomass harvesting, and other silvicultural activities. To this extent resource management programs have a bearing on biomass energy impacts. In particular, decisions on harvesting methods and cutting practices are guided by management objectives coupled with forest conditions and operational situations. The environmental consequences of these decisions, as they relate to energy production, are not included in this study.

Silviculture - Forest cultural practices include harvesting programs that yield marketable products (including energy products), while creating conditions to regenerate a new forest; planting new trees, thinning and improving young stands of trees; and protecting the forest from fire, insects, and disease. Silvicultural activities generally include the use of mechanized equipment for harvesting and timber stand improvement; and the use of pesticides, fertilizers, and fire suppression practices when needed.

Production and Processing (of wood biomass fuel) Stage

This stage in the fuel cycle of biomass fuels includes the production of woody fuels from two primary sources in Maine. Mill residues (the waste products from a wide variety of wood processing mills) which make up a major portion of the wood fuel supply, and logging residues and trees harvested directly from the forest which comprise the majority of biomass boiler fuel. In both cases, however, the ultimate source of the biomass fuel is primarily the forests of Maine. Production and processing activities include the production, storage/collection, and transport of mill residue; and the harvesting, processing, and transport of in-forest materials, in the form of chips.

Mill Residues -

Production - Mill residues suitable for energy use are produced as the waste product of a saw mill or wood products mill in the process of manufacturing wood products, either for additional manufacturing such as lumber or studs, or as consumer goods such as chairs and tables. In an area with a biomass energy demand mill wastes, which are a costly disposal problem for the mill operator, become a valuable market commodity. Thus an energy application turns a problem into an opportunity which can be counted as a beneficial effect.

Storage/Collection/Transport - Mill wastes headed to an energy application are generally separated from unsuitable materials in the production process and deposited directly into a van or some mode of transportation. There is little outside storage anymore. The van is periodically changed and the residues are delivered to the power plant over the public road system by truck.

Forest Sources

Forest based biomass fuels are generally produced from integrated logging operations along with saw logs and pulpwood products. Biomass fuel chips are generally produced from the tops and branches of harvested trees, as well as, cull and poor quality trees, thinnings, and otherwise unmerchantable trees. A limited amount is produced from plantation thinnings, and timber stand improvement cutting.

Harvesting and processing - Biomass harvesting is a heavily mechanized operation with an equipment mix that includes felling machines, skidders, slashers and delimbers, chippers, and tractor drawn chip vans to transport the fuels to a plant. Biomass harvesting is applied using a variety of harvesting systems and cutting practices. Generally in mechanized operations whole trees are cut and skidded to a central landing for processing into appropriate products. Materials to be chipped can be briefly stocked piled for chipping, or in a "hot job" fed directly to the chipper and blown into a parked van. Once the van is full it is replaced and the full load is transported to the customer.

The environmental consequences associated with biomass energy harvesting are the incremental impacts attributable to producing energy chips during an integrated operation. Forest impacts can include - soil disturbance leading to erosion and siltation, damage to residual trees, effects on nutrients, and changes in conditions effecting hydrology, wildlife, visual quality, and conflicts with other uses. On the beneficial side, successful harvesting operations can improve stand quality, tree growth, and forest values; while providing jobs and economic stimulation.

Transportation - In most cases the public transportation system is utilized to deliver the chipped fuel product to a power plant. The impacts of logging trucks on public roads, increased truck traffic, and related impacts are a concern. Again, the impacts attributable to biomass energy developments are incremental to an already established pattern of wood transportation over public roads. Site specific traffic impacts are associated with the construction and operation stage of the biomass fuel cycle.

Generation (combustion) Stage

Biomass power in Maine is currently produced at eight sites using conventional combustion technology, either as co-generation facilities or stand alone plants. Waste steam is water cooled in all cases except for one air cooled facility. Emissions control is achieved with electrostatic precipitators, and fly ash is removed from the exhaust stream and combined with bottom ash for disposal or use.

Storage and handling of fuels - Most biomass power plants maintain an up to two week supply of fuel on-site in uncovered piles, although some facilities operate fully covered systems. Wood fuels are mixed, moved, and delivered to the feed supply system with large front end loaders.

Water use - Biomass power plants use large quantities of water for cooling re-cycled steam, yet they have no waste water discharge because the cooling water leaves the site in the form of water vapor. All facilities except one use water to cool. The other plant uses an air cooling system.

Ashes - Ashes from biomass power plants can be grouped into two types. Clean or pure wood ash that is produced by facilities burning only virgin wood, and ashes produced from multi-fueled boilers that burn a variety of fuels such as coal, tires, and pulping liquors in addition to wood. The clean ashes are generally approved for land application or other beneficial uses, while the other ashes must be properly disposed off in approved landfills.

Air emissions - All biomass power plants are subject to air emission regulations and license requirements. Each plant has an approved operating license that specifies its legal emission of regulated air pollutants. The emission of regulated and other air pollutants is a function of fuel characteristics, boiler technology, combustion control, and emission controls.

Construction/Site Alteration - Plant siting and construction is generally a one time occurrence, although once a site has been developed it remains in that condition for at least the life time of the facility.

Plant Operation - On-going, daily operation of a biomass power plant involves scheduled delivery of wood fuels, activities around the plant, plant noises, and occasional operational procedures such as steam releases and scheduled maintenance.

Transmission and Distribution Stage

Impacts to be determined.

End Use Stage

Impacts to be determined.

2. Environmental Impacts and Effects by Fuel Cycle Stage and Impact Category Related to Biomass/Wood (after RCG/Hagler, Bailly, Inc.) (* = Category I Impacts, i.e. significant and quantifiable effects)

Resource Stage

Capacity and Availability
Management
Silviculture

Harvest Stage

Outdoor Air Emissions
- Particulates *
- SO2
- NOx, Nitrate, NO2 *
- CO
- GHG/CO2

Secondary Outdoor Air Pollution
- Acid Aerosols *
- Acid Deposition *
- Ozone (HC,VOC) *

Surface Water
- None noted in NY analysis
- Erosion and siltation
- Oils and fluids

Forest Conditions
- Stand Quality and Growth
- Nutrients (balance and depletion)
- Wildlife (biodiversity)
- Composition and Structure
- Forest Practices (clearcutting, highgrading, regeneration)

Solid Waste
- Volume/Land use issues*

Construction/Operation
- Land Use/Noise/Terrestrial *
- Explosion/Accident
- Socioeconomic

Transport Stage

Outdoor Air Emissions
- Particulates *
- SO_2
- NOx, Nitrate, NO_2 *
- CO
- GHG/CO_2

Secondary Outdoor Air Pollution
- Acid Aerosols
- Acid Deposition
- Ozone (HC,VOC)

Surface Water Discharges
- Chemicals *

Solid Waste
- None noted

Construction/Operation
- Explosion/Accident
- Use of Public Facilities (traffic and road damage)
- Socioeconomic

Generation (Combustion) Stage

Outdoor Air Emissions
- Particulates *
- SO_2
- NOx, Nitrate, NO_2 *
- Toxics and Metals *
- CO
- GHG/CO_2
- Steam

Secondary Outdoor Air Pollution
- Acid Aerosols *
- Acid Deposition *
- Ozone (HC,VOC) *

Surface Water Discharges
- Chemicals *
- Thermal *
- Consumption *

Solid Waste (Ashes)
- Transportation *
- Volume/Landuse *

Construction/Operation
- Construction
- Land use/Noise/Terrestrial * - scenic intrusions
- Transmission-Land *
- Transmission-EMF
- Explosion/Accident
- Decommissioning
- Socioeconomic
- Road Icing
- Fuel Storage Leachate
- Dust

Summary by Damage Group Related to Biomass/Wood
(after RCG/Hagler, Bailly, Inc. Table 3 - 1)

Air

PM - principally from combustion sources, concern with mortality and morbidity impacts on human health, especially from fine particles and aerosols (2.5 microns, SOx and NOx aerosols). Also soiling of surfaces and equipment, visibility in residential and recreational settings.

NOx, Nitrates - concern with visibility and ozone impacts, from combustion sources.

Toxics and Metals - from combustion sources, concern for toxic carcinogens, and heavy metals lead and mercury.

Ozone - concerned with effects on human health and forest trees from low level ozone formed from NOx and VOCs emissions from combustion (including transportation).

Acid Deposition - the general lack of SOx emissions lowers the importance for biomass, but still an effect. Some acid deposition from NOX and organic acids.

Water

Chemicals - possible impacts on human health from contamination of surface waters via air borne emission and deposition, and surface run-off discharges.

Thermal - from discharges from pass through cooling processes (not closed cycle or air cooled processes).

Consumption - effects on in-stream flows, and general supply reduction.

Land

Solid Waste Transport and Disposal - of ashes (not clean wood) in landfills with possible groundwater contamination, aesthetic effects, and loss of open space and habitat.

Land Use/Noise/Terrestrial - concern for open space/habitat/bio-diversity and aesthetics.

Transmission-Land - land use conflicts.

Other

Because biomass fuels come primarily from waste (logging, mills, municipal) forest resource impacts related to primary wood harvesting are not considered in this study. Furthermore, any incremental costs due to harvesting and transportation of wood is small, uncertain, or partially internalized. Category II impacts.

3. Analysis of Environmental Control and Regulation

Admins. Agency and Law	Applicable Titles and Sect.	Amount of Control/ Sdts.	Cost Unreg./Resid Effects
Harvest Stage			
Surface Water			
Erosion and Siltation			
Oils and Fluids			
Forest Conditions			
Stand Damage			
Nutrients			
Habitats			
Clearcutting			
Regeneration			
Composition			
Age Structure			
Transport Stage			
Operation			
Accidents			
Public Roads			
Combustion Stage			
Air Emissions			
Particulates			
NOX			
Toxics and Metals			
GHG/CO2			
VOC			
Surface Water			
Consumption			
Discharges			
Ashes			
Land Application			
Disposal			
Construction/Operation			
Construction			
Truck traffic			
Fuel storage			
Procurement practices			
Dust/Odors			

Discussion

All of the important impacts that might be associated with biomass energy use in generating electricity in Maine are addressed and regulated by existing environmental laws. The following summary provides an overview of the principle laws and regulations, and the effects they mitigate.

Site Law

Approval for building biomass power plants is required under this State law. Potential impacts on wetlands, surface and ground waters, wildlife/critical resources, adjacent land uses, transportation, and fuel procurement are considered and may become part of a conditioned site alteration permit.

Air Law

The State administers federal air pollution control laws, as well as State requirements for air quality standards. These laws and regulations apply to biomass fueled power plants, and appropriate discharge licenses are issued based on the characteristics of a project. Licenses limit the discharges of particulate matter, carbon monoxide, and in some cases nitrogen oxides and sulfur.

LURC

Any projects developed in the jurisdiction of the Land Use Regulation Commission must comply with zoning regulations as well as obtain development permits. A full array of land use and environmental considerations are taken into account. In addition LURC regulations apply to timber harvesting activities, which would cover biomass harvesting as currently practiced in integrated harvest operations.

Shoreland Zoning and Natural Resources Protection Act

Timber harvesting activities are regulated in the shoreland, wetland, mountain, and wildlife areas cover by these laws.

Solid Waste Regulation

The use and disposal of ashes generated from wood fired boilers is subject to control under the States' administration of Federal solid wastes law. Clean wood ashes are generally cleared for land applications, and mixed fuel ashes are required to be disposed in approved landfills.

Transportation and Public Safety

The transport of biomass fuels across the state's public roads is controlled by State and local road use regulations.

Municipal Powers

Many Maine communities exercise their police powers in land use planning and development controls through municipal ordinances which may apply to biomass energy developments. A few towns have forestry ordinances to limit clearcutting and protect scenic qualities.

Forest Practices Act

The application of clearcutting, and requirements for regeneration are controlled under the States relatively new Forest Practices Act.

Cost of Regulation

No available information or data on the specific cost of complying with applicable laws and regulations. General opinion holds in the forestry sector that the existing set of regulations have become standard operating procedure thus obscuring cost specifically attributable to a regulation. Obviously required emissions control equipment adds cost to a project and hence the price of electricity, but the principle concern is that Maine based facilities are not unevenly burdened compared to competitors.

In the case of clean wood ash, these residuals have become a valuable product whose use is controlled but allowed. Could be viewed as a positive effect of regulation.

Significant Unregulated or Residual Effects

Based on a study conducted by the SPO, the significant potential environmental impacts of biomass energy development are accounted for under existing laws and regulations. To the extent that licensed emission and approved impacts do have an effect on the environment, then there are some unaccounted for impacts. The significance and hence the cost of these impacts is generally yet to be determined, and the effect of tighter controls on the cost of electricity is unknown.

Future changes in environmental regulations already in process, such as the requirement to consider a long list of currently unregulated air emissions, brings a large uncertainty into the discussion. As environmental standards change, and new societal concerns arise, there may be some aspects of biomass energy development and use that will require additional controls and hence costs.

F. WASTE TO ENERGY FACILITIES

Waste to energy facilities burn municipal solid waste (MSW) to process the refuse and to produce electricity. They are the alternative to burying the municipal solid waste in landfills. In effect, they reduce the volume of the MSW so that waste to energy facilities are a viable alternative in those areas where landfill space is at a premium such as in large metropolitan areas or in those areas where there are few suitable locations for multiple MSW landfills due to local environmental conditions.

The cycle of waste to energy includes the municipal solid waste generation which is the fuel, collection by truck, delivery to the waste incinerator by truck, combustion of the MSW, transportation of the incinerator ash, disposal of the ash in a landfill. Whether the MSW is to be landfilled directly or brought to an incinerator the front end transportation is similar. The similarities end at the incinerator where the MSW is burned to produce heat to make steam which drives a steam turbine generator producing electricity. Each ton of MSW can produce approximately 500 Kwh of electricity. Plant sizes range up to 2000 tons per day with electrical generating capacities of up to 60 Mw.

1. Fuel Transportation

Typically the MSW which is fuel for the waste to energy facility is collected from residential, commercial, and industrial sources by truck. It is then delivered directly to the waste to energy plant or to an intermediate transfer station and then to the plant. The collection is similar to that of MSW going directly to a landfill. The environmental impact for the transportation portion of the fuel cycle is primarily air emissions from the truck exhaust gases.

2. MSW Combustion

The combustion of MSW in a waste to energy plant yields heat to produce steam, combustion gases and ash. The combustion gases include sulfur dioxide and nitrogen oxides as in the combustion of fossil fuels. In addition, trace metals including lead, cadmium, copper, arsenic and mercury in the MSW are concentrated in the fly ash and bottom ash. Waste to energy plants also emit some level of dioxin and furans, as well as mercury vapor.

The environmental impacts related to the emissions of sulfur dioxide and nitrogen oxides include contributions to acid rain formation and, in the case of nitrogen oxides contribute to the formation of ground level ozone which, at elevated levels, can cause adverse effects to the human respiratory system. The impacts related to the emissions of certain metals, dioxins and furans are human health related.

Waste to energy plants require a cooling water system similar to that of an oil fired powerplant. This is non-contact cooling water designed to dissipate waste heat. The thermal impact to the receiving water can effect aquatic populations, as can the intake system through entrainment of aquatic organisms. State and Federal regulations require design and operating measures to minimize these impacts.

3. Ash Disposal

The incinerator ash includes both fly ash trapped in air pollution control devices and bottom ash which is the solid residue that falls to the bottom of the facility after MSW combustion. This ash can contain toxic components including heavy metals that can leach into ground- water. Other pollutants of interest are dioxins and furans which are formed during the combustion process.

In Maine, all incinerator ash is disposed in special waste landfills licensed by the State of Maine to accept such ash. The design and operation of these landfills are regulated by State and Federal rules.

The environmental impacts due to the disposal of the ash is the potential to leach metals and other toxic materials into groundwater and the potential for ash to become airborne. Airborne ash could be inhaled leading to human exposure to toxic materials resulting in adverse health effects. Metals leaching into groundwater could expose humans to the effects of these materials if local groundwater is a potable water source. However, low permeability liners beneath the landfills and leachate collection systems can prevent movement to groundwater.

Note: Maine has four commercial waste to energy facilities which produce electricity and sell it to Maine's electric utility companies:

Maine Energy Recovery Corporation, Biddeford
Penobscot Energy Recovery Corporation, Orrington
Mid Maine Waste Corporation, Auburn
Regional Waste Systems, Westbrook

ENVIRONMENTAL EXTERNALITIES
WASTE TO ENERGY

ISSUES	LAW/REGULATION
Solid Waste Collection	
Transportation	
Solid Waste Combustion	
Air Emissions	40 CFR Part 60, Subpart Ca Emission Guidelines and Compliance Times for Municipal Waste Combustors 40 CFR Part 60, Subpart Ea Performance Standards for Municipal Waste Combustors MDEP Chapter 104 Incinerator Particulate Emission Standard MDEP Chapter 121 Emissions Testing of Resource Recovery Facilities
Wastewater Discharge	Maine Wastewater Discharge Federal NPDES
Ash Disposal	
Ash Disposal	State of Maine Solid Waste Management Regulations

G. NUCLEAR FUEL CYCLE

1. Mining and Milling of Natural Uranium

Description

The majority of the mining of uranium no longer occurs in the U.S. In 1993, U.S. uranium concentrate production totaled 3.1 million pounds of U_3O_8, while U.S. contract imports of uranium for the same year totaled 21.0 million pounds of U_3O_8.

There are several processes used to mine or recover uranium for use as nuclear fuel. There is open pit or surface mining, in situ leaching mining (ISL), and recovery of uranium as a byproduct from the processing of uraniferous phosphate ore. As of 1993, no conventional mills in the U.S. were operated, and most of the uranium concentrate (yellow cake) was from in situ leach plants, and the manufacture of wet-process phosphoric acid.

The process of ISL mining consist of the extraction of uranium from the host sandstone by chemical solutions, and the recovery of uranium at the surface. A typical leaching agent injected into the ore zone is a combination of sodium bicarbonate and carbon dioxide. The principle advantages (other than economic) of ISL mining is the elimination of crushing, grinding, and other conventional milling operations, the elimination of large-scale excavations, elimination of hauling and stockpiling of ore, very little radioactivity reaching and contaminating the surface, and lower worker radiation doses. The primary disadvantage is the potential for contamination of ground water.

All methods of uranium mining are highly regulated in the U.S. Restoration of the ground water is required after ISL mining is completed. Safety and environmental regulations on mining uranium vary in different countries, and may not be as strict as those in the U.S.

Pathways

Conventional Mining

Air - Public exposure to Radon gas from storage of mill tailings.
- Occupational exposure to Radon gas.

Water - Radioactive and toxic materials from tailings may lead to contamination of surface and ground water and the food chain.

ISL Mining

Air - Occupational radiation exposure

Water - Chemical or radiological contamination of ground water from mining process
- Hazards from low-level radioactive waste and chemical wastes produced from purging of leach solutions.

Regulations

- 10 CFR Part 20 - Radiation protection for workers and public
- U.S. Mine Safety and Health Administration register mines and submit safety plans
- Approval from appropriate federal agency if located on federal land
- 40 CFR Part 192 Health and Environmental Standards for Uranium and Uranium Mill Tailings

2. Fuel Fabrication

Description

After uranium is milled, the U_3O_8 is converted to uranium hexafluoride (UF_6). The UF_6 is then shipped to a gaseous diffusion plant where the uranium is enriched (with a higher concentration of U-235). The enriched UF_6 is then sent to a fuel fabrication plant where the UF_6 is converted to uranium oxide pellets that are inserted into zirconium tubes to make up a fuel assembly.

From the enrichment process small amounts of radionuclides are emitted to air and to water, and the same is true during fuel fabrication. For this entire process, the radiation doses to the public and to workers is small.

Pathways

Gaseous diffusion

Air - releases of gases containing uranium to atmosphere from waste gas treatment system.

Water - small amounts of effluents discharge, but no realistic exposure pathway has been identified.

Fabrication

Air - releases of gases containing uranium to atmosphere from waste gas treatment system

Water - small amounts of effluents discharge, but no realistic exposure pathway has been identified

Regulations

- 10 CFR Part 20 - Radiation protection for workers and public
- 40 CFR Part 190 - 25 millirem dose maximum to public member from nuclear fuel cycle.

3. Power Production

Description

The operation of a nuclear power plant results in continuous and controlled emissions to the atmosphere of radioactive gases, and controlled releases of radioactive effluent into waterways. These releases are very small, typically less than 1 millirem per year as is the case for Maine Yankee.

Pathways

Air - releases of radioactive gases results in internal and external radiation doses. Some radioactive gases decay into particulates which settle to the ground and may enter the food chain.

Water - releases of radioactive liquid effluents to waterways may result in radioactive material concentrating in marine life or vegetation possibly entering the food chain resulting in internal radiation dose to members of the public.

Occupational Exposure

- Workers can receive radiation dose from inhalation of gases, external radiation exposure, or internal and external contamination. Doses are monitored and kept below regulatory limits.

Regulations

- 10 CFR 20
- 40 CFR 190

4. Waste Disposal

The operation of a nuclear power plant results in the production of low-level radioactive wastes, and high-level radioactive wastes. The toxicity and regulations for the disposal of high level and low level wastes differ and are discussed separately.

Low-Level Radioactive Waste

Description

Low-level radioactive waste is generated by nuclear power plants but is also generated from the use of radioactive materials in hospitals, laboratories, and other institutions. Low-Level waste is categorized as Class A, B, or C, where Class A is the least toxic and Class C represents the maximum toxicity for low-level radioactive waste. To date, all low-level radioactive waste has been disposed by shallow land burial. Because some of the waste sites have failed to contain the waste resulting in the radioactive contamination spreading outside the site boundary, any new site under construction must meet new regulations that are more strict.

The risks associated with the disposal of low-level radioactive waste are the transporting of the material to a processing or disposal site, and the potential of radioactive material migrating from the site via ground water, surface water, or outgasing into the atmosphere. Historical experience has shown the risks to the public are quantifiable and very small for both transportation and disposal of low-level radioactive waste.

Pathways

Air - releases of radioactive gaseous and resuspension of particulates. Releases have the potential to enter the food chain.

Water - contamination of ground water, and potential of entering the food chain.

Occupational Exposure

- Workers can receive a radiation dose from inhalation of gases or internal and external contamination. Doses are monitored and kept below regulatory limits.

Regulations

- 10 CFR Part 20 and Part 61
- 40 CFR Part 191
- 49 CFR Part 171 to 177

High-level Radioactive Waste

Description

The fissioning of the nuclear fuel used in nuclear power plants results in a high-level radioactive waste called spent fuel. Spent fuel remains toxic for thousands of years and requires long term isolation from the environment. The United States requires spent fuel to be disposed in a geological repository. Presently, no repository is operable to accept spent fuel. Spent fuel is now being stored on-site at all nuclear power plants predominantly in specially designed pools containing borated water. Many plants with pools that are full to capacity are moving to dry cask storage technology. Dry casks are federally approved shielded metal canisters holding spent fuel that are stored in the outdoors on a concrete patio in a secure area.

There is no history to quantify the long term risks to the public and environment from a repository. Risks can only be theoretically quantified.

Pathways

Air - Potential radioactive gaseous emissions.
Water - Potential of radioactive material resuspension, ground water contamination, and uptake into food chain.

Regulations

- 40 CFR Part 191
- 10 CFR Part 60
- 10 CFR Part 72
- 49 CFR Part 171-177

5. Decommissioning

Description

All nuclear power plants in the U.S. require a decommissioning plan and fund to remove the radioactive materials from the plant site. Decommissioning can be prompt dismantlement of the plant when the operation ceases, entombment with delayed dismantlement, or mothballing with delayed dismantlement. All options require the disposal of high level and low-level radioactive wastes as previously discussed. Most of the decommissioning bulk will be non-radioactive building debris as in any other type of demolition.

Some nuclear power plant sites may have areas (grounds or underground water) contaminated with radioactivity that will place the site to restricted use only to prevent undue radioactive dose to the public.

During the decommissioning of radioactive components of a power plant, there is a potential for releases of radioactivity to the atmosphere in the form of gases and particulates and exposure to the public. Workers are subject to radiation dose within regulatory limits when performing the decommissioning.

Pathways

Air - releases of radioactive gases and particulates to the atmosphere.
Water - migration of radioactive contaminants to ground water.

Regulations

- 10 CFR Part 20
- 10 CFR Part 61

6. Transportation Shipments

Description

Within the nuclear fuel cycle there are five major transportation steps. They are (1) U_3O_8 shipments between a uranium mine/mill and a conversion plant, (2) UF_6 shipments from a conversion plant to an enrichment plant, (3) enriched UF_6 shipments between the enrichment plant and the fuel fabrication facility, (4) shipments of newly assembled fuel (fresh fuel) from the fuel fabrication facility to the nuclear reactor plant, and (5) radioactive spent fuel shipments from the nuclear reactor plant to a spent fuel storage facility.

In addition to transportation risks that are present for all modes of transporting cargo, transportation of nuclear materials present a radiological risks in accident situations and in normal transport (incident free). In addition, in an accident situation, the shipment of UF_6 can present a chemical toxicity risk.

Spent fuel shipments are the dominant source of transportation risks due to the fact of the high radioactivity of the material. The DOE estimates public health damages due to radiation exposure from transportation can result in an annual cost ranging from 0.0003 mills/kWh to 0.002 mills/kWh.

Regulations

- 49 CFR Parts 171-179 Federal Hazardous Materials Regulations
- 10 CFR Part 71 NRC Packaging and Transportation of Radioactive Material

7. Nuclear Accident

Description

Nuclear power plants are designed and operated to prevent a severe accident. Even though the probability of a plant having an accident is low, a potential exist and has been demonstrated by the Three Mile Island -2 accident in March 1979, and Chernobyl in 1986. In assessing the probability and impact of a nuclear accident, the Chernobyl accident has limited usefulness when applied to U.S. and other western nuclear power plants. Significant differences in reactor physics, safety features, regulations, and operator control exist between the Chernobyl reactor and western reactors. However, the impact to the public and environment, both immediate and long term, resulting from large releases of radioactivity from a power plant can be assessed from the Chernobyl experience and compared to the maximum credible accident assessed for western reactors.

The impact of an accident includes both health and economic consequences. The health impacts are primarily radiological, with non-radiological health effects relatively small. The economic impacts include personal injury or damage, and monetary loss due to a radioactive release.

An assessment of externalities associated with a severe nuclear accident has been performed recently by the Department of Energy (DOE) in a comprehensive report entitled "Estimating Externalities of the Nuclear Fuel Cycle - April 1995". The DOE assessment examined the accident impact of a Westinghouse pressurized-water reactor design situated in the Southeast and the Southwest. The power plant located in the Southeast is assumed to be surrounded by a larger population than in the Southwest. Two nuclear accident scenarios are analyzed. The most severe type of accident is the case in which the containment fails (the Massive Containment Failure or "MCF" case) followed by a major release of radioactivity. The other type of accident analyzed is the less severe accident where a reactor core meltdown occurs, but the containment does not catastrophically fail. This case is termed the "Limited Containment Failure" or "LCF" case. In these case there is some release of radioactivity, but not to the extent of the MCF case.

For both accident scenarios and both power plant locations, DOE estimated the total damages, health and non-health, if the event where to occur. The costs range from $3.1 to $7.8 billion for the MCF case, and $494 million to $743 million for the LCF case.

Nuclear power plants carry two levels of coverage for liability in the event either of the two accident scenarios were to occur. The first level is a requirement that individual nuclear operators carry $200 million in private liability insurance against damages to third parties. The second level is achieved for damages in excess of $200 million through a pooling of liability shared equally among all nuclear operators, (of which there are 111 operating nuclear reactors in the U.S.) Every operator is potentially liable for up to a maximum of $63 million that can be assessed at a maximum of $10 million per year. The 111 operating nuclear power facilities provide approximately $7 billion for liability coverage. For all damages beyond this amount ($7 billion), the Price-Anderson Act provides an explicit exemption from liability for individual operators, the plant owners, builders and parts suppliers and the industry as a whole. Thus, amounts of liability in excess of $7 billion may be born by the U.S. Government.

It is clear that the first level of coverage, the $200 million in private insurance, is internalized and included in the cost of electricity. However, there is no requirement that a plant owner set aside money in advance to cover the potential $63 million liability in the unlikely event of a catastrophic accident at any nuclear facility. Thus, the present cost of electricity does not reflect the possibility of this payment in the present or the future, which may suggest a cost that is not internalized.

There are two ways to account for externalities; (1) assume only the $200 million is available and accounted for in the cost of electricity; or (2) assume that the industry does provide for the $7 billion in the event of an accident, and the cost will be incurred by the owners of the facility.

In the case where the nuclear industry provides for the $7 billion in coverage, as required by the Price-Anderson Act, the expected annual externality of severe reactor accidents (according to the DOE report) ranges from $13,163 to $384,315, or 0.002 mills/kWh to 0.047 mills/kWh, respectively. In the case where only the $200 million in liability coverage is available, the expected annual externality varies from $146,955 to $506,664, or 0.018 mills/kWh to 0.062 mills/kWh.

It is important to note that the expected externality for severe reactor accidents is extremely variable, and the impact to the public and environment are dependent upon the many factors including the population density, weather conditions, and quantity of radioactive material released. For this reason, the determination of externalities due to a severe reactor accident must be site specific.

Discussion of Findings

This brief description of the nuclear fuel cycle is an attempt to consolidate an extremely complex investigation to identify areas of the cycle where health and environmental impacts are controlled by regulation, and those areas where an externality may be present. Within this investigation, only the more obvious and significant impacts and externalities have been described. Without doubt, other externalities do exist. However, many are common to all electric generating sources (such as transmission lines), and others are difficult to quantify such as externalities associated with the nuclear fuel enrichment process which requires considerable electrical power needs that may be generated from a multiple of electrical generating sources.

To date, the most comprehensive attempt to define and quantify externalities associated with the nuclear fuel cycle has been accomplished by the Department of Energy and the Commission of the European Communities in the recent publication entitled "Report 8 - Estimating Externalities of the Nuclear Fuel Cycles" - April 1995. This Report demonstrates a methodology called the damage function approach (DFA) whereby the damages and benefits of the nuclear fuel cycle can be estimated in quantify able terms.

The Report concluded "that the negative externalities of the nuclear fuel cycle are very small, especially compared to the average cost of nuclear power, which is 5-6 cents/kWh." The major benefit of the nuclear fuel cycle was that of employment at a nuclear power plant, due to large staffing at nuclear plants, large construction cost per MW of capacity, for nuclear power plants, and the number of persons employed during the plant's life cycle is relatively large (on a per MW basis) compared to other power generation fuel cycles. This benefit is internalized and reflected in the price of electricity. The value of this benefit is estimated to vary from 0.99 mills/kWh to 2.1 mills/kWh.

Principle damages associated with the nuclear fuel cycle are from radiation exposure to nuclear workers and the public. Damages from radiation exposure to the public were found to be very small except in the case of a severe reactor accident.

Occupational exposures to radiation workers was found to be 0.029 mills/kWh, and public cancer fatalities due to reactor accidents were estimated to have a damage of 0.021 mills/kWh. Other damages evaluated in the Report include the loss of the utility asset from a severe accident, emissions of radon from uranium mining, and transportation of nuclear materials.

The externalities identified by the Report for the nuclear fuel cycle are few since all occupational damages are internalized through legislation and private insurance, except for the decrease in quality of life. Latent health effects were noted as an externality that may not be internalized, but could not be properly quantified. The Report found reasonable evidence that in the case of severe reactor accidents, the portion of the cost that is greater than the $200 million of liability insurance carried by the nuclear plant owners can be considered an externality. The portion of the accident cost that is not internalized is estimated from 0.018 mills/kWh to 0.062 mills/kWh.

The results of the DOE Report outlined above cannot be applied to any particular nuclear power plant, any where in the world. The methodology utilized in this study considers variables that are site specific, and thus can not be generalized. However, the study does present the more significant damages and benefits of the nuclear fuel cycle, and most important, a methodology that can be use to evaluate the externalities of a nuclear station at a specific site. Also, the report stresses that the results found for the nuclear fuel cycle, are estimated from modeling pressurized light-water-reactor plant of a design that is currently in operation in the U.S. The new generation of nuclear power plants will likely result in lower severe accident probabilities and damages.

Summary of Regulations

- 40 CFR 61 EPA Air Emission Standards for Radionuclides
- 40 CFR 141 EPA Interim Drinking Water Standards for Radionuclides
- 40 CFR 190 EPA Environmental Standards For Uranium Fuel Cycle
- 40 CFR 192 Health and Environmental Standards for the Remedial Actions at Inactive Uranium Processing Sites
- 10 CFR 40 Uranium mill tailing regulations; Conforming NRC requirements to EPA standards
- 40 CFR 191 EPA Environmental Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes.
- 40 CFR 440 Ore Mining and Dressing Point Source Category Effluent Limitations, Guidelines and New Source Performance Standards.
- 10 CFR 20 NRC Basic Standards for Protection Against Radiation
- 10 CFR 60 NRC Requirements for Disposal of High-Level Radioactive Waste in Geologic Repositories.
- 10 CFR 61 NRC Requirements for Land Disposal of Low-Level Radioactive Waste.
- 10 CFR 50 Numerical Guides for the design Objectives and Limiting Conditions for Operation to Meet the Criterion "As Low As Is Reasonably Achievable" For Radioactive Material In Light-Water-Cooled Nuclear Power Reactor Effluents.

H. Hydro

Estimating Externalities of Hydropower Fuel Cycles

Definition

Hydropower can be characterized as a very simple, direct relationship between the raw fuel of water and the force of gravity resulting in the generation of hydroelectricity. Hydropower is the energy captured from falling water. When water experiences a large elevation change, a cumulative increase in velocity results as it flows through an intake into a hydroelectric plant. Flowing down through a penstock or channel at a dam, it exerts a strong force that can drive turbines which in turn drive the generator to make electricity. This physical relationship can be expressed mathematically in the following equation:

$$P = k(H)(Q), \text{ where}$$

- P represents power, the capacity to do work such as generation of electricity
- k signifies a factor of efficiency
- H indicates the head or difference in elevation between head and tailwaters at an impoundment
- Q quantifies the flow or rate of water movement downstream.

There is no waste in the use of water as fuel in this cycle. Water used in the generation of hydropower is 90% efficient, renewable, essentially inexhaustible and available on-site. There are a few stages to the hydroelectric fuel cycle compared to conventional fuel cycles and the externalities are confined primarily to the construction and operation of the project itself.

Most hydropower facilities are associated with some type of structure, such as a dam or impoundment, that redirects, stores or otherwise concentrates the energy in flowing water. There are several different types of hydropower projects each one utilizing a different combination of river attributes to maximize the amount of power that can be generated.

Low-head run-of-river projects utilize the natural flow of the river's water and the flow is not altered. This type of project maximizes the flow factor in the power equation. Retrofitting existing or former dams for hydroelectricity was the primary hydro development activity in Maine during the mid-1980's under the benefits of PURPA and most were run-of-river projects.

Diversion projects utilize a large change in elevation , such as a river flowing down a mountain, to maximize the head portion of the power equation. Diversion projects actually divert part or all of a river's water completely from the channel. The displaced water then flows down a penstock to the powerhouse, where the kinetic energy of the water is transformed to mechanical energy or is put under pressure to drive a turbine-generator. When this type of project is generating an entire section of river can be by-passed or diverted and then reenter the river channel in the tailwaters below the powerhouse. Most of the by-pass reaches in Maine were there originally to sluice logs. Some high head diversion projects were developed in western Maine during the mid-1980's to make advantage of the natural elevation changes in mountain streams.

Storage projects do not attempt to maximize either part of the power equation. A storage project consists of a large dam that effectively blocks and limits the amount of water that can flow downstream. Consequently, behind this dam a large amount of water accumulates and forms a reservoir which can be drawn upon as necessary for power generation. Many of the storage projects in Maine were built for flood control and to provide fuel for generating projects downstream of the storage project. Another potential use for storage projects in Maine is for pumped storage. This method of peak power production is well-suited to Maine which has so many rivers and lakes in close proximity yet at different elevations.

The majority of the hydroelectric projects in Maine are low head run-of-river projects which utilize the natural flow of the river's water without diverting or altering its flow. In Maine we have 122 hydroelectric generating dams. Together these hydro projects,which provide utility, industrial and self-generating facilities, supply 731MW of installed capacity.

Abundant and steady water supply and the realization of several large hydro projects (Worombo, Lewiston Falls, West Enfield and Hydro-Kennebec) and development of many PURPA projects caused hydro to reach its pinnacle in 1991 with 4,051,318 Mwh. The decline in hydro production in 1992 and 1993 may be due in part to a shortage of water caused by natural meteorological conditions. In the period from 1970 through 1989, hydroelectric production in Maine grew by 115% and increased by 182MW of installed capacity.

Special Aspects of Hydroelectric Fuel Cycles

The nature of hydroelectric projects makes them different in a number of ways from other fuel cycles. The hydroelectric fuel cycle is similar to most other renewable energy sources in that the fuel is essentially inexhaustible and available on-site and it does not involve combustion. There are fewer stages in the hydro fuel cycle compared to conventional fuel cycles. There is no mining or other extraction, fuel processing or fuel transportation and essentially the only externalities are associated with construction and operation of the hydro project itself.

Not only are there fewer impacts simply because of fewer stages in the fuel cycle but the nature of the impacts is different from those found in other fuel cycles. The impacts are mostly to the natural environment rather than to human health, as in other conventional fuel cycles.

Hydroelectric fuel cycles share a major characteristic with other fuel cycles: their impacts are generally site-specific. But often with hydro externalities, intangible or non-use values are a major consideration. Non-use valuation can more effectively value the remoteness, pristine nature and undisturbed habitats of some of the potential sites for hydroelectric projects. The tangible values of greatest concern are the impacts on fish populations, disturbance of endangered species' habitats, intrusion into wilderness areas, disruption of water flow (such as a waterfall), in addition to disturbance of areas of unquantifiable (cultural or spiritual) value. There is no generic method for valuing these types of impacts. Quantifying externalities and identifying priorities for these qualitative intangible values is challenging for its inherent implicit subjectivity.

Federal and State Environmental Regulation

Through the licensing process required for new hydroelectric projects, many constraints are enforced to mitigate environmental or human safety effects. These constraints take the form of license conditions which might specify generic design and operational minimum flow requirement necessary to protect aquatic resources. Protection of water quality and improvements to recreational facilities for fishing or boating (eg., improved access, parking) are also usual/common conditions. Because of the license requirements, the possibility of achievement of minimal net adverse impacts at most northeast hydro sites is possible and must be determined on a case-by-case basis.

The development of new hydropower projects is controlled by one of the most complex sets of federal and state regulatory processes confronting any fuel cycle. Non-federal projects are regulated primarily by the Federal Energy Regulatory Commission (FERC), as specified in the Federal Power Act (FPA) and its amendments. However, many other federal and state agencies have the authority to mandate license requirements and impose other conditions on developers. For example, state or federal fisheries agencies may require a hydropower project to build a fishway under its fishway prescriptions provisions or as a condition of a license.

The DOE National Energy Strategy Report concluded that, " conflicting and overlapping regulatory and environmental regulations prevent hydropower from competing effectively as an electricity resource." (DOE 1991) One of the other results of the current regulatory process is that hydroelectric projects cannot be developed without incorporating a high degree of environmental mitigation and enhancement into project designs.

Federal Licensing Process

The Federal Energy Regulatory Commission (FERC) regulates the construction and operation of hydropower projects pursuant to the Federal Power Act, first enacted in 1920. FERC's jurisdiction extends to all projects on navigable waters and to projects on non-navigable waters constructed or modified after 1935. This includes projects that store and release water for power generation at downstream dams. A river is considered navigable if it is or has been used to transport persons or property in interstate or foreign commerce. The historic floating of logs to sawmills or paper mills is sufficient to establish navigability. A project on a non-navigable waterway must affect interstate or foreign commerce in order to trigger federal jurisdiction. Such affect is assumed when project electricity is conveyed to the public utility power grid or when the hydroelectricity produced displaces purchases from the grid.

The initial licenses for most hydro projects nationwide were issued by FERC during the 1950's and 1960's. Before the end of the 1950's, FERC did not concern itself with hydropower licensing or navigability questions. However, the courts expanded FERC's jurisdiction during the 1950's. These early licenses were backdated and set for expiration between 1987 and 1993 by the Federal Power Commission, the forerunner of today's FERC. Maine is currently in the midst of relicensing 45% of its indigenous hydropower capacity, which is equivalent to 10% of the total electricity supply in Maine. The Federal Power Act allows for competition during relicensing. Two or more competing applications for a new license may be filed for the same project. FERC will issue a license for the project judged to be the "best adapted to a comprehensive plan for improving or developing a waterway." (1) Alternatively, FERC may recommend a federal takeover of a project. This must be authorized and funded by an act of Congress.

Non-federal hydroelectric projects must obtain either a license or an exemption from licensing from the FERC before construction can begin. Although FERC has defined a practical exemption process, the vast majority of projects proceed in the full licensing process, which has traditionally involved multiple steps, starting with a preliminary permit which grants a potential developer authority to reserve a site while studying its potential for development. Following receipt of a preliminary permit, a developer must proceed through a multi-stage consultation and application process that includes extensive interactions with state and federal natural resource management agencies, environmental studies, and responses to requests for mitigation and enhancement measures.

FERC's regulations require that all potential applicants for hydropower licensing participate in a detailed pre-filing consultation process with the appropriate state and federal resource agencies. Typically this three-stage consultation process requires three to five years for each project and involves a considerable effort in compromise and consensus by all parties involved at the end of which the FERC staff initiate compliance with the National Environmental Policy Act (NEPA) by preparing either an environmental impact statement (EIS) or an environmental assessment (EA). The EIS process includes public scoping meetings, additional information requests and it supplements the official written record for licensing decisions, but it is only one of the regulatory processes that a developer must satisfy. Hydroelectric projects must also obtain state water quality certificates and dredge and fill permits as specified by the Clean Water Act, sections 401 and 404. Maine and some other states have made increasing use of the 401 water quality certification authority to address environmental mitigation requirements such as designated uses and aquatic life standards.

1. Federal Power Act, 1986 Amendments, Electric Consumers Protection Act

When FERC finally makes its licensing decisions, including appropriate terms and conditions to protect the environment, FERC is required by amendments made to the FPA, to give equal consideration to power and nonpower uses of a river system and to issue licenses which are consistent with any comprehensive multiple-use plans for development of that system that have been produced by federal or state agencies. The licensing of hydroelectric facilities under the Federal Power Act was amended with the enactment of the Electric Consumer Protection Act of 1986, or ECPA. The ECPA expressly states that energy conservation, fish and wildlife, recreation and other aspects of environmental quality are to be given equal consideration and value with power production in hydropower licensing proceedings.

Maine has a Comprehensive Rivers Management Plan, three volumes of which was submitted to FERC spring of 1987 as fulfillment of the state's obligation for comprehensive hydropower planning. This compendium of documents includes the Maine Comprehensive Hydropower Plan, the Maine Rivers Study and the subsequent laws, orders and plans affecting hydropower development and permitting since 1983. FERC officially recognized Maine's Plan as a comprehensive plan in November of 1988. The State has since submitted two additional volumes of the Comprehensive Rivers Management Plan to FERC in 1993 which further refine its intentions and summarize statutory activities with regard to river planning in Maine since 1987.

The FERC licensing process culminates with the issuance of a license that allows a developer to construct and operate a project for a period of thirty to fifty years. When the license period ends the developer must apply for a new license and begin the licensing process over again. Most of the licensing activity in Maine in the last decade has been for relicensing of existing operational hydro plants and for the retrofitting or expansion of old, previously hydro mechanical sites for electricity in the early 1980's under the benefits of PURPA (Public Utilities Regulatory Policy Act).

An effect of the licensing process is that many generic constraints are placed on the design and operation of hydropower projects to protect against environmental or human safety effects including the following:

a. equipment (turbine) efficiency
b. project design efficiency - maximization of flow and head capabilities of project
c. generation efficiency - matching flow with demand
d. instream flow requirement - minimum flow release necessary to protect aquatic resources (water not stored for power generation)
e. recreational mitigation/enhancement - often a developer is asked to improve facilities for recreational use such as fishing or boating with new access, parking etc.
f. other environmental mitigation - routinely required to build fish passage facilities, provide for water quality improvements such as aeration (Gulf Island Project in Maine), implement erosion control practices during and after construction and protect wildlife habitat.

The standard format for EIS's as delineated by NEPA includes the following socio-economic descriptors; population, economic base (employment and income), housing, government services, transportation, land use, water sources and uses, historic, cultural and archeological features. Environmental parameters include the hydrology of both surface and ground water, water quality, meteorology, air quality, noise, geology, seismology, aquatic ecology and terrestrial ecology.

State Regulatory Process

A permit is required under the Maine Waterway Development and Conservation Act (MWDCA) for the construction, reconstruction or structural alteration of a hydropower project. The MWDCA is administered by the Department of Environmental Protection (DEP) and Land Use Regulation Commission (LURC) in their respective jurisdictions. Statutory review criteria include consideration of financial capacity and technical ability, public safety, public benefits, traffic movement, LURC zoning, environmental impacts and mitigation and energy benefits. This permit is affectionately referred to as one-stop shopping because it eliminated the requirement for several permits under varying review criteria. A water quality certification is required under Section 401 of the Clean Water Act for the licensing or relicensing of a hydropower project. The certification process is administered by the state pursuant to water quality standards reviewed and approved by the Maine State Legislature and the U.S. Environmental Protection Agency. Certification is granted if there is a reasonable assurance that the construction and operation of a project will not violate applicable water standards. Standards include water quality criteria (e.g., minimum levels of dissolved oxygen) and designated uses of the state's waters (e.g., fishing, recreation in and on the water, aquatic habitat).

The Maine Department of Environmental Protection (DEP) is responsible for certifying compliance with applicable water quality standards pursuant to Section 401 of the Clean Water Act, P.L. 92-5000 (as amended) 33 U.S.C. §1341 (1988), for all activities located in whole or in part within organized municipalities subject to DEP's regulatory jurisdiction. By the authority granted in Executive Order #16, FY91/92, the Land Use Regulation Commission (LURC) is responsible for certifying compliance with applicable water quality standards pursuant to Section 401 of the Clean Water Act, P.L. 92-5000 (as amended) 33 U.S.C. §1341 (1988), for all activities located in unorganized territories and townships. Governor McKernan's Executive Order of June 1, 1992 (#16) is a clarification of Executive Order #8,85/86, which it supersedes. This designation of LURC as the certifying agency for all activities located wholly within areas of its regulatory jurisdiction made it clear which agency is responsible for relicensings which do not require a State Hydro Permit under the MWDCA.

It should be noted that the State's regulatory jurisdiction in hydropower licensing and relicensing is limited in most cases to issues of water quality. A State hydropower permit (MWDCA) is only required for new dams or hydropower facilities or if project redevelopment or expansion is proposed in conjunction with relicensing. Rather, the State's authority to condition the operation of most hydro projects upon relicensing is contingent upon Section 401 Water Quality Certification

In addition to these permits, an applicant for a new dam or hydropower project must file for a Dredge and Fill Permit with the U.S. Army Corps of Engineers under Section 404 of the Clean Water Act. For utility facilities, the Public Utilities Commission (PUC) must issue a Certificate of Public Convenience and Necessity. The PUC conducts hearings on a Certificate and according to statute a decision must occur within 15 months of filing.

Decommissioning

Under current law FERC can order decommissioning even if the licensee is requesting a new license term. FERC has discretionary authority regarding decommissioning. FERC has exercised the right to be mandatory regarding decommissioning in relation to matters of non-performance but discretionary in matters of economic viability. FERC is currently investigating decommissioning issues. Hydro projects are issued 30-50 year licenses. Decommissioning/dam removal could have environmental impacts difficult to quantify, such as toxics behind dam.

Price Impact

The license for a hydropower project is a valuable commodity. The license has economic value based on the costs implicit in the licensing process. Archeological and other studies associated with licensing, fishways and recreational facilities are the most costly aspects of licensing and are generally responsible for price impacts on utility revenues. Although it varies from project to project, the expenses incurred by an applicant for studies leading to project licensing breakdown roughly into the following categories and percentages of the total licensing cost.

40% archeology (most often it is 50-70%)
40% fishery (studies, mitigation, passage)
8% recreation (improved access)
7% Engineering (design)
5% Miscellaneous

These ratios to the total costs of licensing are based on the SPO's investigation into the recent experiences of applicants and consultants in Maine. Archeology is always the most expensive aspect of hydropower licensing and often the least apparent aspect to the public. Fishways and recreational facilities are just easier to relate to than pits in the earth. When archeology extends into the 50-70% category the fishery cost category usually shrinks, not as a function of high archeology costs but in comparison to them.

Fishway Costs

The cost of building a fishway varies drastically from project to project. Recent experience in Maine with fishway construction has borne out an approximate rule of thumb of $10,000 per vertical foot. However, one of the most elaborate and recent fishways in the state in Brunswick resulted in a fishway with a price tag of approximately $35,000 per vertical foot in 1993 dollars. The Brunswick fish passage/protection mitigation costs (vertical slot fish ladder and downstream by-pass pipe) totaled $7,778,000 for a twenty year analysis period in 1993 dollars. The costs per kilowatt-hour, based on a reported annual generation of 105,200 Mwh is 3.7 mills, or about four-tenths of a cent. The major cost item (56%) is the up-front capital cost of constructing the facilities.

The 500-foot long, 42 step vertical slot fish ladder and the trapping and holding facility at Brunswick cost $4.3 million. The construction cost for the by-pass pipe contributed 2.2 mills per kilowatt-hour to the cost per kilowatt hour generated at

Brunswick. The annual operations and maintenance costs and the annual reporting cost were estimated to be $36,000. or 0.3 mills per kilowatt-hour. The lost generation flows for upstream passage/protection through the ladder ($93,000.) and for the downstream passage/protection through the by-pass pipe ($30,000.) are estimated at $123,000 annually or 2.1 mills per kilowatt-hour. The annual reporting costs related to upstream and downstream passage/protection were estimated by the licensee to be $3.000. with an annual cost per kilowatt-hour of 0.03 mills.

Capital costs of fishways are approximately half of the real costs of operating the fishway. The other half is the cost of operations and the foregone energy from use of the water for the fishway instead of hydro generation. In order to calculate foregone costs one might use the following method indicated by sources at CMP. There is a rule of thumb used by the USFWS which suggests that 2% of the downstream and 3% of the upstream, combined to a 5% of the maximum turbine flow capacity must be allocated for the use of the fishway. Station factor is the long term average of kwh/cfs. A high station factor indicates a high efficiency. Station factor is the ratio of kwh/cfs. To calculate the cost foregone of energy sacrificed to the fishway one must perform the following equation. Hypothetically, assume an efficient project with a 3kwh/cfs station factor and flows of 150 cfs. Multiply 150 cfs x 3 = 450 kw/hour

x 24 (hours in a day)
x 7 (months of operation)
x 30 (days/month)
x 2.5 (estimated levelized avoided cost/1995 dollars)
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cost of energy foregone

The lost generation costs for Brunswick can be calculated in the following manner. The fish ladder has continuous water releases of 100 cfs from May 1 through November 30 (214 days x 24 hours x 100 cfs =513,600 cfs) and 30 cfs from December 1 through April 30 (151 days x 24 hours x 30 cfs = 108,720 cfs. Based on the project's annual power generation of 105,200 Mwh and the annual flows through the turbines of 4,000 cfs, the kilowatt-hour value per cfs of water is 3.0 kilowatt-hours/cfs [105,200,000/(4000 cfs x 365 days x 24 hours) = 3.0]. the actual power value is unknown so a per kilowatt-hour value of $0.05 is used to compute the lost generation cost for upstream fish passage/protection-related water releases of $93,000. [513,600 cfs + 108,720 cfs) x 3.0 kilowatt-hour/cfs x 0.05 = $93,348]. This is a per generated kilowatt-hour cost of 0.9 mills.

The downstream passage lost generation costs at Brunswick are calculated in the following way. Fifty cfs of continuous flows are released through the down-stream by-pass pipe from June 15 through November 30 (168 days x 24 hours = 4032 hours). Based on the per cfs of water value of 3.0 kilowatt-hours (discussed above), the losts generation is $30,000. (4032 hours x 50 cfs x 3 kilowatt-hours/cfs x $0.05 = $30,240). This is a per generated kilowatt-hour loss of 0.3 mills.

This example does not include the cost of trapping and hauling fish and does not attribute the cost of trapping and hauling to Brunswick as an operations cost. If the developer did pay this $150,000 cost, the cost per generated kilowatt-hour would increase to 1.4 mills. It seems apparent from this example that environ-mental compliance can easily increase the cost of electricity provided by using hydro facilities. Fishways are one of potentially many costly measures to ensure environmental compliance whose generic cost per kwh is in the range of 2.1 mills per kilowatt-hour.

Environmental Externalities

Damages and Benefits

It is very difficult to generalize the environmental impacts related to hydro facili-ties because the impacts are very site specific and dependent upon geology, river flows, aquatic species, riparian ecology and human infrastructure. Extensive site analysis is required before a new facility is approved or an existing facility relicensed. Many of the potential impacts can be identified and mitigated during this process.

Damages/Adverse Impacts

From Project Operation

Production of hydropower can cause depletion of dissolved oxygen in the water, curtailment of nutrient flows, interruption or possible elimination of fish migrations, fish entrainment and impingement, disruption of down-river exchange of genetic material, separation of terrestrial habitats from one another and alteration of instream conditions for aquatic life. It can also result in loss of other water-based recreational benefits, disturbance of valued habitats of threatened and endangered species and alteration of natural resources of intrinsic value to native Americans.

Extreme fluctuation in water levels even in natural cycles is adverse for nesting wildlife and furbearers. Impacts caused by hydro peaking facilities can have the impacts associated with inundation, plus the "tidal" effects related to the flushing action of fluctuating flows. Fish habitat is altered downstream of peaking facilities as well. The fluctuating water levels have a deleterious effect on macroinvertebrates, the major food base for many fish. Fluctuating flows have been shown to cause a substantial decrease in invertebrate density and diversity. (N.Y. VI-37) The tidal effect of rapidly changing river levels can strand many invertebrates in dry areas, causing both a decrease in food supply to fishes as well as decreased usable habitat. The remaining invertebrate community is then forced to inhabit the deep channel rather than the preferred wetted perimeter of the stream channel, which results in a very different community structure. The change of habitat and food availability can adversely impact the downstream fishery.

The impact of an existing dam impoundment includes stratified temperatures and nutrient levels as a result of a lack of mixing during winter and summer. Dissolved oxygen (DO) levels often may drop below minimum DO standards.

Dammed rivers cause physical habitat changes that can alter the existing fishery. Upstream of a dam the impoundment often changes a cold water fishery into a warm water (i.e. pond) fishery. Cold water fish, such as salmonids, are replaced by warm water species such as bass and pickerel. Some fish cannot tolerate the low DO levels in an impoundment leading to suffocation. Often the nutrient lags behind the dam causes algal blooms, further diminishing fish habitat.

Turbine entrainment is a major threat to some fish that cannot be redirected by fish screens or that become trapped on the fish screen or trash rack. The effects of dropping through turbines may include physical impairment from contact with the equipment, low pressure damage, shearing, excessive turbulence, cavitation damage from exposure to partial vacuums and overall stress to the organism. In areas where anadromous or migrating fish species are present, the presence of dams is prohibitive to movement of these fish and can drastically affect their reproductive cycle and the ability of these fish to sustain their populations.

From Project Construction

Sedimentation effects from erosion are not a concern at existing locks and dams but these emissions and residuals are a major concern at sites where steep topography and unstable soils often make risk of erosion high. Increased sedimentation of streams associated with resident trout and anadromous fish populations (whose reproduction can be affected by increased turbidity and sedimentation) must be carefully evaluated in new hydropower developments.

A project which involves replacing part or all of an existing dam could result in short-term local impacts to the water quality. Sediment loads to the tailwaters can result from erosion at a construction site and the accidental release of excavated materials into the stream. There is a risk of small fuel spills resulting from the use of construction equipment near the streambed. Contaminated sediments existing at a dam may be disturbed and redistributed by construction. If construction of the powerhouse requires temporary cessation of flow releases, organisms could be killed by toxic levels of contaminants. Uncontrolled sedimentation could reduce the amount of aquatic habitat around and downstream from the construction site.

Mitigation procedures are available to minimize or avoid impacts associated with construction activities at hydro projects. Federal and state water quality agencies require erosion and sedimentation control plans to prevent adverse affects on water quality. Similarly, spill control and countermeasure plans can reduce the risk of water quality degradation by spills of toxic contaminants. As an End-Use fuel hydro can have adverse impacts on water and land resources, but many of these potentially adverse conditions can be mitigated or compensated for to some degree.

Benefits

Hydropower dams often provide benefits to recreation and fisheries resources that could not be enjoyed under naturally occurring conditions. Because a dam or hydro project exerts control over the water flow regime of a given river and because resource enhancements (recreational facilities) are required during licensing, many hydro projects provide conditions more conducive to desired rafting and boating activities than that provided by a river which goes dry under natural flow conditions in the summer.

Project flow operations often enhance the conditions necessary for fish and wildlife spawning. Maine fisheries agencies have made effective compromises on minimum flows for improvement of the quality of habitat by instream modifications. The addition of boulders, attractions or other structural devices and rebuilding of substrate has been negotiated to substitute for increased flows from a hydro project but only as a last resort. Stream modifications in combination with optimized flows are the preferred outcome. Fuel (water) storage is usually beneficial to wetlands.

It is frequently the case that State and Federal fisheries agencies do not have the financial capability to implement their management and restoration plans. At times these agencies have accepted funding for their programs by the hydro industry in exchange for acceptance of an unconventional mitigation proposal. When integrity and objectivity remain in tact, this is appropriate to ensure the health of the resource. It is essential to realize judicious compromises which can benefit all parties, especially the fishery resource.

A major advantage of the hydroelectric fuel cycle is its lack of emissions to the atmosphere, which benefits air quality. The fuel for hydropower is not extracted in the sense that combustible fuels are by mining. Secondary emissions from the production of materials used to construct a hydroelectric project are minimal (use of steel, concrete etc...). (A hydro diversion project is two orders of magnitude less than the emissions from a bench mark coal fuel cycle.

Indirect or secondary emissions refer to the pollutants released during the manufacture of the materials required to construct energy production projects. In the hydro fuel cycle secondary atmospheric emissions have been found to be relatively insignificant. Steel and concrete constitute the largest portion of the materials required to construct hydropower projects and are the major sources of indirect emissions. Other raw materials which require examination are aluminum and copper used in the wiring and transmission and the rubber used for wire insulation. Included in construction materials required for water conveyance are those materials that make up diversion structures, pipelines and penstocks. Included in the materials required for electricity generation are the materials for the powerhouse structure, the turbines and generators and the electrical and mechanical equipment housed within the structure. Included in the material required for transmission are the cables, transformers and switchyards. See table for generic descriptions of indirect emissions of these materials.

Transportation/Transmission

Two pathways that are not routinely evaluated for other fuel cycles can be quantified for the hydroelectric fuel cycle; the acreage affected by new transmission lines and access roads. Damages to road surfaces are sizeable in fuel cycles that require heavy truck traffic, such as coal, biomass or oil transport. These damages do not arise in the hydroelectric fuel cycle because there is no need to transport fuel. The construction of a new transmission corridor may have its effects on the environment. Increased electromagnetic field near areas of human or animal habitation is under public scrutiny. Rangeway spraying is hazardous to human and animal life.

There is little or no difference between electrical transmission from any form of electrical generation; what matters is the landscape through which the transmission lines run. The more environmentally sensitive an area is, the greater the potential for adverse impacts. Transmission towers and lines can reduce the scenic quality of near and distant vistas. Clearing and maintaining rights of way can affect the character of the open space and may affect habitat, biodiversity and terrestrial ecology. High voltage transmission lines may produce a noise due to corona, which vary with weather conditions and type of current, but which may disturb nearby residents and visitors passing by. Proximity to high voltage transmission lines may also have detrimental impacts on radio reception.

Health Impacts

Health impacts are negligible for the hydropower fuel cycle. There is essentially no risk in terms of the possible effects of CO_2 on global climate change. However, hydro does impose health effects generic to all electricity transmitting fuel cycles. Exposure to electric and magnetic fields (EMF) generated by electric transmission lines, including both high voltage transmission lines and low voltage distribution lines, may be linked to health impacts in humans and animals including cancer, reproductive impacts, neurological disorders, hormonal and behavioral changes, skin melanoma and cardiovascular impacts. Existing studies have been unable to prove a causal relationship between EMF and these various health endpoints. More research is necessary to establish a conclusive link. (NY Study, VIII-15)

Public safety issues are important in dam construction. Employment benefits are sizeable during construction but most modern plants are primarily automated. The hydroelectric fuel cycle involves mature technologies and future projects in Maine are likely to be retrofits of existing dams used primarily for flood control, navigation or other uses and pumped storage projects. Neither of these types of projects involves construction of new dams with large reservoir storage volumes - the scenario with the most adverse impact in hydro fuel cycles.

Sources

In addition to several publications of the Maine State Planning Office, three other sources of information were used in the development of the hydro section of this report and are listed below.

Estimating Externalities of Hydro Fuel Cycles, Report 6, Prepared by the Oak Ridge National Laboratory and Resources for the Future for the U.S. Department of Energy and Commission of the European Communities, December 1994

New York State Environmental Externalities Cost Study, Report 1: Externalities Screening and Recommendations, Prepared by RCG/Hagler, Bailly, Inc., December 1993

Environmental Mitigation at Hydroelectric Projects, Volume II. Benefits and Costs of Fish Passage and Protection, U.S.Department of Energy, Idaho Operations Office, Idaho National Engineering Laboratory, January 1994

Hydro Fuel Cycle Matrix

Fuel Cycle Stage	Potential Impacts	Federal/State Regulation	Price Impact	Environmental Externality
Siting	Dam structure redirects water causing flooding and dewatering.	FERC license MWDCA permit	Licensing 40% of project cost	Secondary emissions from steel and concrete minimal.
Construction	Possiblity of erosion and sedimentation effecting water quality and fish populations. Coffer Dams used during construction could affect public safety in a flood event.	401 permit under CWA 404(COE) permit/ CWA PUC Cert. of Convenience & Necessity	Capitol and Fishway costs affect value of power.	Depletion of Dissolved Oxygen, curtailment of nutrient/ genetic materials, habitat disruption, interruption of fish migration, fish entrainment, impacts to aquatic life/wildlife.
Operation and Maintenance	Water fluctuation can dewater or flood riparian areas, affect aquatic life, fishery, and wildlife (detailed on pp. 90-91)	Fed. Power Act or FERC license	Flows Fishway operation affect cost via lost generation power foregone.	
Transmission	Little or no impact of fuel transport (via roads). Use of transmission system for electricity transport may increase risk of EMF-related heath risks to humans and animals.	FPA laws relating to transmission.	Long transmission corridor could reduce value of power or cause project to be economically unfeasible.	Construction of new transmission corridor near areas of human & animal habitation could cause increased electromagnetic field (EMF) which may pose health risk & could cause a reduction in scenic quality. Rangeway spraying is hazardous to human & animal life.

I. Wind

Wind Power Fuel Cycle

Central or dispersed wind facilities connected to a utility's T&D grid are not yet a significant source of energy in the U.S., but estimates of future energy requirements suggest that significant growth in wind and other renewable energy sources is likely. The viability of wind projects depends on proper siting and weather conditions for maximum wind exposure. In Maine, the western mountains and to a much more limited degree some coastal locations offer the greatest potential for siting wind power.

Wind power is generally considered an environmentally benign source of energy. Wind plants do not use fuel and thus produce no air pollution emissions. Advocates often cite an additional advantage of including wind energy in a utility's resource portfolio, that of the concomitant displacement of non-renewable energy sources, thus reducing dependence on fossil fuels as well as decreasing net air emissions.

The primary environmental impact of wind facilities is related to land use. Numerous studies suggest that the following impacts are potentially of concern: loss of natural resource areas, erosion in fragile areas, aesthetic issues, noise from turbine operation, and bird kills. Other impacts not unique to wind power are occupational hazards during the construction and dismantling of facilities, and transmission line considerations, such as EMF effects on human health, and visual impacts.

Fuel Cycle

The "fuel cycle" described below is generic to wind facilities (wind farms, wind hybrid systems, and dispersed turbines) connected to a utility's T&D grid.

Fuel Cycle Stage	Potential Impacts	Federal/State Regulation[6]	Price Impact	Environmental Externality
Siting	conflict with protected natural resources or recreational uses	M.R.S.A. 38 §480(A) et. seq.	could vary considerably	potential damage to or loss of fragile soil and/or eco-system
Construction	accidents, erosion	OSHA; M.R.S.A. 38 §480(A) et. seq.	minimal	potential damage to fragile systems
Operation & Maintenance	visual impacts, noise, bird kills	(local ordinances)	unknown	loss of avian life
Transmission	emf, aesthetics	(local ordinances)	unknown	little/none

1. Siting

The siting of central wind farms can have significant environmental impacts. Many proponents of wind power note the positive land use impacts that wind facilities, particularly large wind farms, can offer. Because turbines take up such a small proportion of the acreage at a given site, dual use is possible, particularly for agriculture. However, in Maine, where wind energy projects have been proposed in the western mountains, agricultural use is unlikely. The thin, highly erodible mountain soils can make it difficult to construct on the site as well as build stable roads to the site without causing damage. When wind power projects are located in fragile mountain areas (as defined in the Natural Resources Protection Act, 38 M.R.S.A. §480-B(3)), or located in, on, over, or adjacent to other types of protected natural resources, such as wetlands, a permit is required.

[6] In addition, wind facilities can be subject to the Federal Clean Air Act and Clean Water Act.

For example, Kenetech Windpower is seeking a permit from LURC to develop the Boundary Mountain wind farm along the Maine-Quebec border, the first large scale wind project in the state. The permitting process, as widely reported, has been controversial, and undoubtedly more expensive than some or most of LURC's other preliminary permit cases. According to a LURC staffer, Kenetech has paid an undetermined sum for studies and consultants to assist the Commission in analyzing the project. In a letter to the Maine Times (6/2/95), it was noted that Kenetech offered to protect an "equivalent" fragile mountain site at cost of $300,000.

2. Construction

Construction of wind power facilities, just as any significant building project, can have some impact on human health, principally through occupational accidents. Federal OSHA regulations address these concerns. Additionally, during the construction phase, human and machinery activity is concentrated, and the impact on natural resources is often at its highest point during this phase of the "fuel cycle."

3. Operation & Maintenance

In some cases, aesthetic concerns regarding the visual impact of turbines and transmission lines in pristine locations have been raised by environmentalists and/or local residents, especially for projects sited visibly along mountain ridges and passes. Generally these concerns can be alleviated in whole or part through careful placement of turbines out of the line of sight of residents or away from areas designated for recreational use.

When wind turbines spin, they create significant noise which can be heard up to one-quarter of a mile away from a site. In an attempt to address this concern, the manufacturers of the most recent turbine technology have reportedly reduced the total decibel level of operations significantly over first- and second-generation turbines. Local regulations regarding noise levels may address this problem; siting the facility in remote areas can make this concern moot.

There is considerable debate in the wind power literature about the impact of spinning turbines on bird populations. For example, while a large project in northern California (the Altamont Pass) had documented cases of avian kills, particularly raptors (an endangered species), similar facilities in southern California did not experience significant bird kills. Biologists and others continue to study the issue; some environmentalists suggest that at a minimum, local bird population studies be included as an integral part of a siting review.

4. Transmission

Transmission access to potentially remote locations raises the same type of concerns, such as the impact on natural resource protection areas and aesthetic considerations, as the siting of the wind facility itself. The same regulations would likely apply to the siting and construction of transmission lines that are located in or near fragile ecosystems.

Transporting the electricity generated (by any source, including wind plants) along transmission lines is in itself a concern to some. To the extent that wind power facilities are often located in isolated and unpopulated areas, some of those concerns, such as exposure to EMF, might be lessened, compared to facilities which are sited in more populated areas.

A fuller discussion of transmission can be found in Section III, K.

Sources of information

Section 10.5, "New York State Environmental Externalities Cost Study Report 1: Externalities Screening and Recommendations, December 1993," RCG/Hagler, Bailly, Inc.

Lehr, Ronald et. al, editors, "Wind Energy for Regulators," AWEA 1994.

Sweezy, Blair, and Sinclair, K., "Status Report on Renewable Energy in the States," NREL/TP-462-5175, 1992.

"Efforts Under Way to Develop Solar and Wind Energy," GAO, 1992.

Staff members of CMP, DEP, LURC, and NRCM.

J. Utility Generation

OIL FIRED GENERATION

The combustion of oil to produce electricity causes environmental impacts related to the entire fuel cycle. Typically, the oil is burned for boiler fuel to make steam which then drives a turbine-generator or, more directly, in a combustion turbine where the fuel is burned and directly drives the turbine-generator. In either case, the fuel cycle is essentially similar for the utility company operations. Electric utility oil fired powerplants typically range in size from 25 megawatts up to several hundred megawatts.

The fuel cycle for the utility company usually begins with the purchase of oil which is delivered to the powerplant via ocean going tanker or barge. The oil is then transferred to a land based tank farm, at the powerplant, where it is stored until needed. The oil is then piped to the powerplant from the tanks. In a steam electric powerplant heavy oil is commonly used as boiler fuel for large central station plants. The fuel oil is burned in the boiler to produce steam. Products of combustion include gases which are removed through a stack thence to the atmosphere and ash, some of which goes to the stack as fly ash and some of which goes to the bottom of the boiler and piped to a holding pond as bottom ash. In a combustion turbine lighter distillate oils are commonly used as fuel which produce stack gases but very little or no ash.

Each part of this fuel cycle is subject to an extensive set of State and Federal regulations which ensure that wastes and emissions to the environment are minimized.

OIL TRANSPORTATION

When delivering the fuel via tanker, the potential environmental impacts include the tanker traffic itself, but more importantly the consequences of an oil spill. The effects of an oil spill include damages to water quality, fish and wildlife, marine plants as well as aesthetic resources. In each case there is an economic consequence because the organisms affected are likely connected to commercial fisheries and to recreational activities. Currently, both State and Federal laws regulate tanker and barge operations including the transfer operations from marine conveyance to the land based oil terminal. Design features of the tankers, permitted operational conditions, as well as regular contingency planning are required. The Oil Pollution Act of 1991 resulted in very stringent oil spill prevention requirements for both tankers and terminals.

The oil tanks themselves which can store tens of thousands barrels of oil are regulated as oil terminals by State and Federal regulations and require significant primary and secondary containment to keep the oil from the environment. Extensive schedules of inspections, training, and equipment maintenance are required by these regulations.

OIL COMBUSTION

Air Quality

The combustion of fuel oil results in environmental impacts to the air and water. The air emissions resulting from the combustion of oil is regulated by a comprehensive body of regulations, most notably by the recent Clean Air Act Amendments of 1990. The emitting of combustion gases including sulfur dioxide, nitrogen oxides, carbon monoxide, as well as airborne particulates are limited by these regulations. In addition to these emissions, hazardous air pollutants including heavy metals are now regulated. Combustion modifications, fuel chemical content, and back end technologies including electrostatic precipitators are all employed to meet these regulatory limits. Sophisticated monitoring systems known as Continuous Emission Monitors are required of powerplants and provide real time monitoring of emission levels.

The environmental impacts due to emissions from the combustion of oil are human health and natural resource related. Sulfur dioxide and nitrogen oxides when mixed with precipitation are contributors to the formation of acid rain which has been linked to crop and forest damage as well as to reductions in freshwater fish reproduction. Nitrogen oxide is one of the precursors of ground level ozone formation when combined with certain organic compounds in the presence of sunlight. Elevated ozone concentrations have been linked to human respiratory system related health affects, as well as damage to crops and forests. Likewise, respirable sized particulate matter has been linked to respiratory system health affects.

Water Quality

Significant amounts of cooling water are required for plant operation. This is non-contact cooling water which is used to remove waste heat from the combustion process. For a once-through cooling water system the environmental impact is the discharge of warmer water to the cooler receiving body of water such as the ocean. Warm water discharges can result in impacts which affect the population of marine organisms near the thermal discharge. In addition, marine organisms can be killed if entrained in the intake system. The Clean Water Act regulations as well as State regulations limit the amount of temperature increase of the cooling water system discharge and provide for operational and design controls to limit entrainment.

In addition to the cooling water discharge impact to receiving waters, waste-water associated with plant operations, including ash holding ponds, is discharged to a receiving body such as the ocean. The chemical content of these discharges is regulated by State and Federal rules. Limits are imposed on the concentration of chemicals including metals and petroleum products. These limits are monitored periodically and reported to State and Federal Agencies.

ASH DISPOSAL

Oil ash is generated whenever oil is burned. Some is trapped as fly ash by the electrostatic precipitators and some comes out as bottom ash. This ash contains unburned carbon as well as the trace metals that were present in the fuel oil. All of this ash is collected into ash holding ponds. It is periodically excavated and trucked to a special waste landfill for final disposal. The commercial landfill is subject to State and Federal regulations which help ensure that the ash remains isolated from the environment to prevent the leaching of metals into the groundwater. These regulations require frequent covering of the ash to prevent ash from becoming airborne and also require leachate collection systems to prevent groundwater contamination.

The environmental impacts due to groundwater contamination with certain heavy metals has been linked to human health effects if the groundwater is used as a source of drinking water.

ENVIRONMENTAL EXTERNALITIES
OIL FIRED GENERATION

ISSUES	LAW/REGULATION
Air Emissions	
Fuel Sulfur Content	State of Maine MDEP Chapter 106 EPA NSPS 40 CFR 60 Subpart D
Control Technology for NOX Emissions	State of Maine MDEP Chapter 138 NOX RACT
Emissions Monitoring	Continuous Emission Monitors (CEMS)
Carbon Dioxide	
Carbon Monoxide	
Particulates	
Hazardous Air Pollutants	
Fuel Oil Handling	
Oil Storage Contingency Planning	
Oil Storage Tank Inspection/Improvements	
Oil Tanker Delivery	
Oil Ash Handling	
Wastewater Discharge	
Circulating Water System Thermal Effects	

K. Utility Transmission

TRANSMISSION LINES

Provided below is a brief discussion of the environmental impacts that are associated with the regulation of construction of transmission lines in Maine. Even though each of the issues is addressed as part of the routine permitting for the transmission line, some of the issues become major issues which may cause rerouting of the transmission line. The usual effect of rerouting a transmission line due to environmental considerations is additional length of the line, and therefore increased cost of construction. It is also likely that some issues become controversial and require a study, e.g. visual assessment which would also increase the cost.

The following are features of transmission lines that result in an environmental impact. All are regulated by state and federal rules[7] with the exception of EMF and property valuation.

ROADS

Temporary and permanent road construction may cause environmental impacts on vegetation, wildlife habitat, and wetlands/water bodies. This can be minimized by carefully designing access to limit the amount of clearing, and installing appropriate erosion and sedimentation control measures.

TEMPORARY AND PERMANENT EROSION AND SEDIMENTATION CONTROL

Erosion and sedimentation may effect aquatic habitat. Erosion and sedimentation control typically become issues when associated with transmission line access construction. Because of the linear nature of transmission lines and the Maine

7 Site Location of Development, 38 M.R.S.A; Natural Resources Protection Act, 38 M.R.S.A.; Army Corps of Engineers, Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act; and the Federal Insecticide, Fungicide and Rodenticide Act.

terrain, it is likely that at least one part of the access will be near or through a wetland and may also be constructed on some steep slopes. In these situations, appropriate designs for erosion and sedimentation control measures are used during construction or the transmission lines are rerouted to avoid wetlands or steep slopes.

GROUNDWATER

Contamination of groundwater can occur if proper planning is not done in both construction and maintenance of transmission lines. The location of any sand and gravel deposits is identified in relation to the project location. If the project is located over or near such an aquifer, specific design, construction, operational and monitoring specifications and procedures are followed. This situation is most commonly associated with the substation which is part of a transmission line project. If such a substation involves the use of a certain level of petroleum products, a Spill Prevention, Control and Countermeasures Plan is required. This plan details the response effort in the event of a petroleum spill.

A municipality may have a well-head protection zone, which may prohibit routine right-of-way maintenance using herbicides. In this situation, hand trimming may be required for line clearance.

SOLID WASTE

Improper disposal of solid waste produced by construction of a transmission line may have an environmental impact on wetlands/ water bodies or wildlife habitat. Disposal areas are delineated on the site plan, and locations for burning or other disposal of woodwaste and land clearing debris are not be located within 300 feet of a classified body of water.

BUFFERS

Buffers are needed to maintain shading of water bodies, and as screening to reduce the visual impact. Buffers, either retained natural or newly planted, are required near most water bodies, road crossings, and as screens from other uses.

HISTORIC SITES

The Maine Historic Preservation Commission (MHPC) determines if there are any historic sites, structures, or archaeological sites that have been designated on the site or in the immediate vicinity. It is likely that an archaeological site will be found somewhere within the proposed right of way. These archaeology sites are not to be disturbed during project construction and the sites may need to be monitored to prevent vandalism.

UNUSUAL NATURAL AREAS

The Natural Heritage Program determines if there are any unusual natural areas located on or near the site. If there are any such sites, the utility prepares a plan detailing the methods that will be used to protect them.

VISUAL QUALITY

Transmission lines, due to their height and linear nature, may impact visual quality. In some situations, a Visual Impact Analysis is prepared. The transmission lines are designed to minimize the visual impact to the surrounding area. Reduction of the structure height, use of an alternative structure, placement of structures behind a tall stand of trees vs through an open meadow, relocation of a water crossing, and changing the angle of a road crossing are some of the measures that can be taken to reduce the impact on visual quality.

WILDLIFE AND FISHERIES

Transmission lines may impact wildlife and fisheries habitat located on, and surrounding the site. The Department of Inland Fisheries and Wildlife is contacted for determination of potential fisheries and wildlife habitat impacts. In order to minimize impacts, utilities have rerouted transmission lines, selectively cut trees, specified the use of low-impact construction equipment, adjusted the construction schedule, and planted trees.

SURFACE WATER QUALITY

This issue is closely related to the groundwater issue. The main concerns that must be addressed are erosion and sedimentation control, controlled herbicide use, and no treated wood structures in standing water.

ELECTROMAGNETIC FIELD (EMF) EFFECTS

Many studies have been conducted during the past twenty years to identify the effects of EMF on human health. The specific issue relates to 60 mHz powerline frequencies. Some of the claimed adverse health effects are increased risk of certain cancers. However, neither the State of Maine nor the federal government have yet developed any definitive policies regulating EMF.

PROPERTY VALUATION

Another issue producing significant and frequent concern from property owners at municipal proceedings is that their property value may be devalued by the construction of a transmission line near their properties.

TRANSMISSION LINES

ISSUES	LAW/REGULATION[8]
Roads	Site, NRPA, Municipalities, ACOE
Temporary & Permanent Erosion and Sedimentation Control	Site, NRPA, Municipalities, ACOE
Groundwater	Site, NRPA, Municipalities
Solid Waste	Site, NRPA, Municipalities
Buffers	Site, NRPA, Municipalities
Historic Sites	Site, Municipalities
Unusual Natural Areas	Site, NRPA,
Visual Quality	Site, Municipalities
Wildlife & Fisheries	Site, NRPA, Municipalities
Open Space	Site, Municipalities
Vegetation Management	FIFRA, State
Wetlands/Water Bodies	NRPA, Municipalities, ACOE
Water Quality	NRPA, Municipalities, ACOE
EMF	Not Regulated
Property Valuation	Not Regulated

8 Site refers to the Maine Department of Environmental Protection's (DEP) Site Location of Development Law. NRPA is the DEP's Natural Resources Protection Act. The laws and regulations associated with municipalities vary according to the municipality and physical location of the proposed transmission line. The laws and regulations may include site review, shoreland zoning, and/or land use regulation for zoning restrictions. ACOE is the army Corps of Engineers.

L. DSM

DSM Energy Resource

Demand side management (DSM) is considered an energy resource from an integrated resource planning perspective because demand reduction can function as a substitute for additional generation resources or for the operation of existing generation resources. DSM programs include:

* weatherization
* efficient lighting
* efficient HVAC equipment
* efficient appliances
* efficient motors
* efficient refrigeration
* load shifting (for example, from peak to off-peak)

Because of its reliance on energy efficiency and conservation, DSM results in the avoidance of generation and its associated emissions. It is therefore heavily favored by those with strong environmental concerns. Nonetheless, and in keeping with IRP's consistent treatment of supply and demand side resources, the environmental impacts of DSM have been studied.

A full fuel cycle approach has been used for the other energy resources discussed in this Report. The fuel cycle typically has extraction, transportation, combustion, and waste disposal as its principal stages. An analogous concept for DSM equipment is the life cycle. A full life cycle approach would identify the following stages in the use of DSM resources:

* Manufacture of DSM equipment (including resource extraction, waste, etc), sometimes referred to as "upstream"
* Installation of DSM equipment
* Operation of DSM equipment, sometimes referred to as "in use"
* Disposal of DSM equipment and of products replaced in DSM programs, sometimes referred to as "downstream"

It should be noted that the life cycle concept is applicable to electric generation and transmission facilities, indeed to any manufactured product. Thus when environmental concerns are raised about, say, the disposal of hazardous materials in DSM equipment, a consistent comparison of supply side and demand side resources would involve consideration of any hazardous wastes encountered in the disposal of electric generation and transmission facilities.

Tellus Institute has prepared for the Electric Power Research Institute (EPRI) an excellent study, The Environmental Impacts of Demand-Side Management Measures, which includes case studies that quantify environmental impacts of various DSM programs and compare them to the impacts of avoided generation. We will draw on these studies to provide brief illustrations of DSM environmental issues and their analysis, choosing an example from each of the stages: upstream, in use, and downstream.

One important DSM measure is the use of high efficiency motors. An upstream problem associated with the manufacture of efficient motors is the use of greater amounts of copper and steel than is needed for less efficient motors. This means more air emissions associated with processing these metals. Tellus has quantified this emissions difference, as well as the emissions from electric generation avoided by use of the more efficient motors. They found that the avoided generation emissions are at least 80 times as large as the increased manufacturing emissions. Thus this environmental impact of DSM, upstream, is more than offset by the impact of avoided generation.

Another important DSM measure is insulating and tightening building shells. An in use environmental impact of concern in the past was the release of toxic formaldehyde from some foam insulation. The solution is to detect toxicity and avoid the use of toxic products. This insulation is in fact no longer used for buildings. Similarly, tighter building shells reduce air exchange and can increase the concentration of indoor air pollutants. Here the solution is to remove the source of the problem - for example, formaldehyde products or improperly vented kerosene heaters - steps which "should be taken on their own merit." For impacts such as these, diligence is required, but once discovered they can be controlled.

A third important DSM measure is efficient lighting. All types of fluorescent bulbs contain mercury, which is a toxic hazard and must be disposed of properly. Tellus quantifies mercury releases from a fluorescent bulb and compares them to mercury emissions from avoided coal generation. Mercury releases from bulbs are less than a fifth of those in coal generation emissions for the avoided generation. Proper disposal, which possibly can be facilitated in a well-run utility program, reduces risks from mercury in the bulbs. Disposal of compact fluorescents releases an extremely small amount of radiation. Greater amounts of radiation would be released from coal combustion for the avoided generation.

These results for analyses of environmental impacts of DSM are fairly typical. A somewhat different case is load shifting, where loads are moved from peak to non-peak periods. The result can sometimes be increased used of fossil fuel base-load generation plants, which would be undesirable from an environmental point of view. This phenomenon illustrates an important general principal about DSM: its environmental effects depend on what changes in the operation of the generation system it results in. Load shifting is not typical in this respect. More often the result of DSM on system operations is avoided generation, but the specific effects depend on exactly what type of plant is not operating, a function of both the characteristics of the load avoided and the utility system's resource mix and overall load patterns.

The SGL library contains Ottinger's Environmental Costs of Electricity and the New York State Environmental Costs Study, which summarize research that has been done on the environmental characteristics of DSM resources. They also provide extensive bibliographies on the sources of information about these resources. The SGL library also contains Tellus Institute's study (for EPRI) The Environmental Impacts of DSM (cited above).

In general, these works conclude that the environmental impacts of DSM are not significant (with the exception of load shifting), and are capable of mitigation with proper handing of hazardous materials and wastes. The Study Group's research on DSM resources probably can rely on the works just cited. In most instances the environmental impacts of DSM are manageable and small compared to the benefits (avoided generation). From a policy point of view, they can be treated as negligible. In practice, of course, they must be considered carefully in the design and implementation of DSM programs.

The environmental impacts of DSM are of the same type as those for any manufactured product, and perhaps should be classified as problems in manufacturing and waste disposal, rather than as problems in the use of energy resources.

Consequently the relevant regulations are for the most part those concerned with the health and safety characteristics of manufactured products and with the disposal of wastes and hazardous materials. Compliance costs in turn are the costs of meeting these standards. We have not attempted to document regulations and price impacts for DSM resources.

M. Appendix on Environmental Regulations

The number and complexity of federal and Maine environmental regulations applicable to energy resources is staggering. The PUC Library has resources that could be helpful for anyone wishing more information than we have been able to provide in this Report.

Our collection contains all federal codes pertaining to Protection of the Environment (11 volumes), Energy (5 volumes), and Power and Water (4 volumes). It also contains all of the rules of the Maine Department of Environmental Protection (8 volumes, updated monthly). It also has several volumes of FERC regulations pertaining to the licensing of hydro-electric facilities.

Most readers will find these codes and rules extremely difficult to work with. The PUC Library collection contains many volumes that summarize, explain, or discuss various environmental regulations. Examples would include: Clean Air Act Handbook, 4th edition, 1995; American Petroleum Institute Environmental Guidance Document; "Environmental Law," text for the MSBA Continuing Legal Education program, October 1994.

Attached to this Appendix is the Maine Bureau of Air Quality Control's complete list of its rules, with brief summaries of each.

ATTACHMENT 1
ENVIRONMENTAL
REGULATION

BUREAU OF AIR QUALITY

TABLE OF CONTENTS

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DEPARTMENT OF
ENVIRONMENTAL PROTECTION (06)

BUREAU OF AIR QUALITY CONTROL (096)

CHAPTER 100 DEFINITIONS REGULATIONS
SUMMARY: This regulation provides definitions for those terms used in the air pollution control regulations and emission standards.

CHAPTER 101 VISIBLE EMISSIONS REGULATION
SUMMARY: This regulation establishes opacity limitations for emissions from several categories of air contaminant sources.

CHAPTER 102 OPEN BURNING
SUMMARY: This rule provides for the prohibition of the open burning of specific materials and certain open burning activities. In addition, the rules prohibits all open burning activities which are not specified as permissible open burning with or without an open burning permit.

CHAPTER 103 FUEL BURNING EQUIPMENT PARTICULATE EMISSION STANDARD
SUMMARY: This regulation establishes a limitation on the amount of particulate matter allowed to be emitted from fuel-burning equipment. The amount of particulate matter permitted is dependent on the type of fuel being burned and whether or not the source is new or existing.

CHAPTER 104 INCINERATOR PARTICULATE EMISSION STANDARD
SUMMARY: This regulation establishes a limitation on the amount of particulate matter allowed to be emitted from each of several categories and sizes of incinerators and a limitation on the opacity of emissions from all incinerators.

CHAPTER 105 GENERAL PROCESS SOURCE PARTICULATE EMISSION STANDARD
SUMMARY: This regulation establishes a limitation on the amount of particulate emissions allowed from any general process source determined on the basis of the size and rate at which the process operates. Also included are specific emission limitations on Kraft pulping processes based on the tons of pulp produced.

CHAPTER 106 LOW SULFUR FUEL
SUMMARY: This section establishes the maximum sulfur content of fossil fuels allowed to be burned in various air quality control regions in the state unless the source is equipped with sulfur dioxide controls or subject to more stringent sulfur limitations by other requirements.

CHAPTER 107 SULFUR DIOXIDE EMISSION STANDARDS FOR SULFITE PULP MILLS
SUMMARY: This regulation establishes a limitation on the amount of Sulfur Dioxide allowed to be emitted from process sources for sulfite pulp mills based on the sulfite pulp production of the mill.

CHAPTER 108 EMISSION LICENSE REGULATIONS
Deleted. Chapter 108, the former Emission License Regulation, is no longer needed because all sources are currently being processed under Chapter 115. No sources are subject to Chapter 108. FILED JANUARY 24, 1983 - DELETED July 10, 1990

CHAPTER 109 EMERGENCY EPISODE REGULATIONS
SUMMARY: This regulation is intended to prevent air pollution from reaching levels that would cause eminent and substantial harm to the health of persons, by restricting emissions during periods of air pollution emergencies.

CHAPTER 110 AMBIENT AIR QUALITY STANDARDS
SUMMARY: This regulation establishes ambient air quality standards that are maximum levels of a particular pollutant that is permitted in the ambient air. This regulation also establishes ambient increments which define the maximum

ambient increase of a particular pollutant that can be permitted for a given area depending on the classification of that area. Area classification is dealt with in another regulation. On November 23, 1982, the Board adopted Section 12 establishing ambient air quality standards for hexavalent chromium and total chromium until acceptable analytical procedures are available for hexavalent chromium.

CHAPTER 111 PETROLEUM LIQUID STORAGE VAPOR CONTROL
SUMMARY: This regulation requires all owners of fixed roof storage tanks, storing gasoline, crude oil or any petroleum liquid whose vapor pressure is greater than I .52 psia (10.5 kilo pascals) to install floating roofs to reduce the hydrocarbon vapors lost to the atmosphere.

CHAPTER 112 PETROLEUM LIQUIDS TRANSFER VAPOR RECOVERY
SUMMARY: This regulation requires bulk gasoline terminals loading tank trucks or trailers and who pump 20,000 gallons or more of gasoline per day to install a vapor control system. This system must control lost gasoline vapors so that not more than 35 milligrams of vapor escapes for each liter of gasoline transferred.

CHAPTER 113 GROWTH OFFSET REGULATION
SUMMARY: This regulation defines how ambient air quality standards will be maintained and how additional emissions will be permitted in areas where standards are being violated or the increment has been consumed. In such areas new sources of emissions will be required to obtain offsets. Generally, this is done by finding other emissions within the area that will be reduced or whose impact will be reduced to the previous level.

CHAPTER 114 CLASSIFICATION OF AIR QUALITY CONTROL REGIONS
SUMMARY: This regulation determines those areas that have been officially found to be exceeding the ambient air quality standards and are therefore nonattainment areas. It also designates which class of increment that will apply in each area.

CHAPTER 115 MAJOR AND MINOR SOURCE AIR EMISSION LICENSE REGULATIONS
SUMMARY: This regulation implements Section 590 of Title 38 Maine Revised Statutes for those minor sources that require a license and those major sources that are not yet licensed as a Part 70 source under Chapter 140 of the Department's regulations. It specifies who must obtain an air emission license, what information an applicant must submit and what standards and criteria must be complied with. This Chapter supersedes Chapter 2 of the Department's regulations, where applicable.

CHAPTER 116 PROHIBITED DISPERSION TECHNIQUES
SUMMARY: This regulation specifies stack height and dispersion techniques requirements in the licensing of air emission sources. This regulation also defines where air quality standards have to be met.

CHAPTER 117 SOURCE SURVEILLANCE
SUMMARY: This regulation specifies which air emission sources are required to operate continuous emission monitoring systems (CEMS), and details the performance specifications, quality assurance requirements and procedures for such systems, and subsequent record keeping and reporting requirements.

CHAPTER 118 GASOLINE SERVICE STATIONS VAPOR CONTROL
SUMMARY: This regulation requires that all gasoline service stations and any other entity, governmental or private, that stores gasoline in underground tanks and refuels vehicles with the gasoline stored in these tanks and that have an annual throughput greater than 100,000 gallons of gasoline must install a submerged fill pipe by October 1, 1989. Those facilities with a throughput in excess of 250,000 gallons of gasoline per year shall install a vapor balance system by October 1, 1989 if that date corresponds with the underground storage tank removal schedule specified in 38 M.R.S.A. Section 563-A subsection 1 & 9. Others with an annual throughput greater than 250,000 gallons of gasoline must install a vapor balance system by October 1, 1991. Record keeping requirements on gasoline dispensed

are specified for all gasoline dispensing facilities in the State. In addition, service stations in York, Cumberland, and Sagadahoc counties with an annual throughput greater than 1,000,000 gallons of gasoline must install Stage II vapor recovery equipment prior to November 15, 1995.

CHAPTER 119 MOTOR VEHICLE FUEL VOLATILITY LIMIT
SUMMARY: This regulation requires that all gasoline that is distributed or marketed by bulk gasoline terminals or is directly imported to gasoline service stations or bulk gasoline plants shall not have a Reid Vapor Pressure greater than 9.0 psi during the period between May 1, 1989 and September 15, 1989 and continuing every year thereafter.

CHAPTER 120 GASOLINE TANK TRUCK SELF-CERTIFICATION
SUMMARY: This regulation requires that all tank trucks that transport gasoline with a true vapor pressure of greater than I.S psi at 60 degrees F or a Reid Vapor Pressure of 4 psi (27 kilopascals) and receives gasoline from a bulk gasoline terminal subject to Chapter 112 of the Department's regulations be maintained leak-tight and must be tested and certified annually.

CHAPTER 121 EMISSIONS TESTING OF RESOURCE RECOVERY FACILITIES
SUMMARY: This regulation establishes stack emission testing and reporting requirements for resource recovery facilities.

CHAPTER 122 CHLORINE AND CHLORINE DIOXIDE EMISSION STANDARD
SUMMARY: The regulations establishes an emission limit for bleach plants of pulp and paper mills.

CHAPTER 123 PAPER COATING REGULATION
SUMMARY: This regulation establishes consistent requirements for testing, evaluating and limiting volatile organic compound emissions from paper coaters.

CHAPTER 124 TOTAL REDUCED SULFUR CONTROL FROM KRAFT PULP MILLS
SUMMARY: This regulation establishes emission standards for total reduced sulfur (TRS) from existing Kraft - pulp mills.

CHAPTER 125 PERCHLOROETHYLENE DRY CLEANER REGULATION
SUMMARY: This regulation establishes the control technology required for all perchloroethylene using dry cleaners in the State of Maine.

CHAPTER 126 CAPTURE EFFICIENCY TEST PROCEDURES
SUMMARY: This regulation specifies the test procedures required to measure how much of the total volatile organic compound (VOC) emissions from the regulated source is captured and delivered to the device that destroys the VOC.

CHAPTER 127 NEW MOTOR VEHICLE EMISSION STANDARDS
SUMMARY: This regulation establishes motor vehicle emission standards for new passenger cars and light duty trucks. This regulation also specifies performance standards for emission control system replacement parts.

CHAPTER 128 MOTOR VEHICLE EMISSION INSPECTION PROGRAM
SUMMARY: This regulation establishes a program to test biennially the emissions of gasoline powered motor vehicles that are model year 1968 and newer and have a gross vehicle weight of 10,000 pounds or less.

CHAPTER 129 SURFACE COATING FACILITIES
SUMMARY: This regulation establishes consistent requirements for testing, evaluating and limiting the emissions of volatile organic compounds (VOC) from selected surface coating operations. Surface coating facilities can select one of three compliance methods: low solvent content coating technology, daily-weighted averaging, and add-on air pollution control devices.

CHAPTER 130 SOLVENT DEGREASERS

SUMMARY: This regulation establishes consistent requirements for testing, evaluating and limiting volatile organic compound (VOC) emissions from solvent degreasers, and sets minimum requirements for equipment and operation standards in order to reduce VOC emissions.

CHAPTER 131 CUTBACK ASPHALT AND EMULSIFIED ASPHALT

SUMMARY: This regulation applies to the mixing, storage, use, and application of cutback and emulsified asphalts.

CHAPTER 132 GRAPHIC ARTS - ROTOGRAVURE AND FLEXOGRAPHY

SUMMARY: This regulation restricts the volatile organic compounds emissions from graphic arts operations.

CHAPTER 133 PETROLEUM LIQUIDS TRANSFER VAPOR RECOVERY AT BULK GASOLINE PLANTS

SUMMARY: This regulation requires applicable bulk gasoline plants' loading tank trucks or trailers to install a vapor balance system or submerged fill.

CHAPTER 134 REASONABLY AVAILABLE CONTROL TECHNOLOGY FOR FACILITIES THAT EMIT VOLATILE ORGANIC COMPOUNDS

SUMMARY: This regulation establishes Reasonable Available Control Technology (RACT) requirements for facilities that emit Volatile Organic Compounds.

CHAPTER 135 HEXAVALENT CHROMIUM PARTICULATE EMISSION STANDARD

SUMMARY: This regulation establishes a limitation on the amount of hexavalent chromium allowed to be emitted from any potential source of hexavalent chromium and a limitation of the amount of total chromium until a technique for measuring hexavalent chromium can be demonstrated.

CHAPTER 136 ASBESTOS ABATEMENT REGULATIONS

NOTE: This regulation was replaced, effective January 1, 1994, with Department regulation Chapter 425, Asbestos Management Regulations, which follows:

SUMMARY: This Chapter establishes the rules of the Board and the Department for the licensing of business and public entities and the certification of individuals engaged in asbestos abatement activities. These rules also set forth notification and work practice requirements for asbestos abatement activities. Storage of asbestos waste is also regulated by this chapter. This Chapter supersedes former Chapter 136, Asbestos Abatement Regulations and the storage requirements only of Chapter 405 Section 4.

CHAPTER 137 EMISSION STATEMENTS

SUMMARY: This regulation establishes requirements for the annual reporting of pollutant emissions from stationary sources of air pollution.

CHAPTER 138 REASONABLY AVAILABLE CONTROL TECHNOLOGY FOR FACILITIES THAT EMIT NITROGEN OXIDES

SUMMARY: This regulation establishes Reasonably Available Control Technology (RACT) standards for stationary sources of Nitrogen Oxides (NOx) which have the potential to emit quantities of NOx equal to or greater than 100 tons per year.

CHAPTER 140 PART 70 AIR EMISSION LICENSE REGULATIONS

SUMMARY: This regulation identifies the sources of air emissions that require a Part 70 air emission license and incorporates the requirements of Title I, Title IV, and Title V of the Clean Air Act, as amended, 42 U.S.C. 7401, et seq.; and 38 MRSA, Section 344 and Section 590. This Chapter supersedes Chapter 2 of the Department's regulations, where applicable.

PART IV. POLICY

A. Concepts of Externality Consideration

P&S Law 1993, Chapter 80 asks the Study Group to locate "methods of evaluating the relative magnitude of different externalities," and to recommend preferred "methods of accounting for the costs to society and the environment of environmental externalities." We will refer to these activities as externality assessment and externality consideration, respectively.

This section will provide a brief informal introduction to the basic problems and methods in externality assessment and consideration. For convenience, a familiar example will be used, the coal energy resource, looking only at air emissions in the combustion stage of its fuel cycle. Facts will be cited without documentation and are for purposes of illustration only. [9]

1. Externality Assessment

What would have to be done in order to assess the magnitude of any externalities due to air emissions? Externalities assessment can be viewed as having three steps: first, scientific description of damages, tracing and verifying causal pathways leading from emission to damage, and measurement of such damage in physical terms; second, economic valuation of the damage (placing a monetary value on it); third, externality determination, determining the degree (if any) to which damage costs are reflected in prices.

Scientific description is a multi-disciplinary endeavor. It would begin with an attempt to identify air emissions from coal combustion, which would involve chemical and engineering studies of what goes into the combustor and what comes out. The next step would be determining what happens to emissions once they enter the atmosphere. Here chemistry, physics, climatology, and meteorology would be prominent. Next it must be determined what happens to

9 Facts cited for illustration are documented in the New York State Environmental Externalities Cost Study, Report 1, 1993.

non-living and living things near the earth's surface when they come in contact and interact with the atmospheric effects of emissions. Effects on non-living things would be studied by chemists, physicists, engineers, geographers, and others. Effects on living things would be studied by biologists, ecologists, bio-chemists, geneticists, toxicologists, epidemiologists, and others.

Air emissions from coal combustion include sulfur dioxide (SO2), various oxides of nitrogen (NOx), carbon dioxide (CO2), particulates, mercury, and a great many other substances.

Atmospheric scientists and climatologists have found that SO2 emissions result in acid rain and fine particulate matter; that NOx reacts in sunlight with other chemicals to form ozone; and that CO2 accumulation can reduce the rate of global cooling, which could in turn destabilize the world climate, with somewhat unpredictable but potentially devastating effects of many kinds. These atmo-spheric and climatological phenomena are very complex and may not be entirely understood.

Epidemiologists have found relationships between exposure to particulates and elevated levels of mortality and chronic respiratory diseases. They have found relationships between exposure to gaseous SO2 and asthma symptoms. They have found that exposure to ozone is associated with minor and acute respira-tory illness and with increased risk of premature mortality.

Biologists have learned that acid rain can alter the chemistry of streams and lakes, changing them ecologically and harming animals and plants, perhaps resulting in loss of habitat and species extinction in some cases. Mercury released into the atmosphere will also enter lakes and streams, accumulating in the fish that inhabit them, and causing severe health problems to humans who ingest too much mercury by eating these fish.

Gaseous SO2, NOx, and ozone can all cause reduced crop yields. Acid rain also can cause damage to metal and stone, including historic structures. Particulates and other air pollutants can cause loss of visibility and aesthetic degradation of urban and recreational areas (such as the Grand Canyon).

This unsystematic tour has taken us from five pollutants, through a dozen or so sciences, to an almost bewildering variety of damages. These include:

a. damages to crops and buildings
b. loss of a traditional food source (fresh water fish)
c. damages to cultural treasures (sculpture, public buildings)
d. illness
e. premature death
f. toxic contamination of water resources
g. altered habitat and species loss
h. loss of visual aesthetic enjoyment of nature.

In principle, the various sciences can verify the causal pathways from some emission to various kinds of damage, and they can measure in physical terms the extent of damage resulting from such and such a quantity of emissions. In practice, there is a vast body of excellent work already done, but also an incredibly large job yet to be completed. From the point of view of a policy maker, scientific description of environmental damages will often be uncertain and controversial. Our knowledge in this area is already very great, but it is also incomplete, and certain to remain so, because the same process of scientific inquiry that answers today's questions creates tomorrow's.

Given scientific data on damages, the second step in externality assessment is economic valuation of the damages. Any attempt to achieve consensus on these calculations, however, is likely to be daunting in light of the complexity of the effects.

Valuation methods essentially rely on the economist's theory of consumer behavior. Consumers make choices, based on their values or preferences, from which their dollar valuation of various alternatives can be determined, either by direct observation or by inference. The easiest case is direct observation of market prices that consumers are willing to pay. If Jones will pay $15 for a ticket to a concert, then attending the concert is worth (at least) $15 dollars to him. The prices established in competitive markets can reasonably be used to value some damages, for example to crops and buildings, above. Using the same procedure to value the loss of a traditional food source is possible, but less satisfactory, since some will feel that something valuable is left out. Market prices for medical care and lost wages might also be used to value illness. Here, many would hold that this method ignores things that are important, such as discomfort and lasting bodily harm. There are markets, however, for labor in risky occupations and for insurance against accident claims in which there are prices that have relevance to the value of discomfort and bodily harm. Examples can be found where individuals have been explicitly willing to accept discomfort and bodily harm in voluntary exchange for money. Examples are common where individuals have been willing to accept an increased risk of death in voluntary exchange for money. This data can be used to calculate an implicit dollar valuation of their lives. Used with ingenuity and grounded in economic theory, direct observation of market prices and of voluntary exchanges for money can lead to fairly reasonable economic valuations of a surprisingly broad range of damages.

One might also be able to set up an artificial market in which it could be directly observed how much people would be willing to pay for something that no market yet exists for. For example, researchers have made cash offers to buy hunting licenses in an attempt to value the right to hunt. [10]

Besides direct observation of prices actually paid, valuations can also be based on indirect observation of choices made where no money exchange is involved. If some item is chosen over another, one can infer that the chooser values it at least as highly. If we know a dollar value for the item not chosen we have a good start. For example, Jones may drive three hours to get a better view, less smog. He preferred the better view to the time and money spent driving. These can be valued using market prices, and then a plausible inference can be made about the dollar value of the reduced aesthetic enjoyment at the smoggy site not visited. With ingenuity, the economic theory of choice can be used to indirectly infer values for damages not valued in markets. What is needed is some choice or preference relationship to another item that can be more easily valued. (This method might work for cultural treasures.)

[10] New York State Environmental Externalities Cost Study, Report 1, p. B2-2)

Besides the direct and indirect observation methods, there is another approach to valuation, known as contingent valuation, that uses survey techniques. Hypothetical questions are asked in the form, "What would you be willing to pay for ...?" or "Which do you prefer ...?" Assuming the respondent knows her preferences, she should be able to tell us what she would pay, or what she would choose, in hypothetical situations. In theory, this is an alternative method to observing actual choices for identifying an economic agent's preference and valuation structure. In practice, there are difficulties about whether the hypothetical questions really are conceptualized by the respondent in a manner that brings into play/conflict the same preferences that a real choice situation would activate. Answers to survey questions have sometimes seemed to vary with how a question is put. There are many practical difficulties in designing valid and reliable contingent valuation studies. Many practitioners believe, nonetheless, that carefully done contingent valuations can be useful. Hypothetical models may provide the only available method for some types of damage.

As we have seen, there is a considerable body of methodology based in economic theory that can be used to place a dollar value on environmental and health damages. Some valuations are quite plausible. Others make assumptions that are not entirely convincing, or at least do not seem so to everyone. For that reason, the second step in externality assessment is also (like the first) sometimes controversial and plagued by scientific uncertainties.

Let us assume that the first two steps have been completed success-fully: we have a scientific description and measurement of damages (1,000 tons of lost crops, three cancer deaths, etc), and a dollar valuation as well (crop damage, $1,000,000; mortality, $12,000,000). What remains to be done in the process of externality assessment?

Externality determination is necessary because the externality concept is not a synonym for environmental damage. A damage is an externality only if its cost is not reflected in the price paid for whatever consumption activity caused the damage. In complex modern legal systems there are many ways in which the costs of environmental damage may be reflected, fully or partially, in prices.

There may be a law requiring compensation of society or a private owner for the environmental damage. There may be a tradeable emissions permit required, which pays for equivalent pollution reductions elsewhere. There may be fees for permits that reflect environmental costs. There may be taxes designed to reflect environmental costs. There may be clean-up liabilities and required insurances. Or there may be nothing of the sort.

The externality cost is the dollar value of environmental damages that is not reflected in price. The third step in externality assessment - externality determination - is to determine the degree to which damage costs are not reflected in prices. This step too can be tricky and controversial. Yet there are often reasonable ways of answering this question.

2. Externality Consideration - Tools and Techniques

Suppose we have reasonable externality assessments, including dollar valuations, for energy resources. (This would be the work of economists and other scientists.) How might we consider externalities in making decisions about energy planning and policy? (This would be the work of policy analysts and policy decision makers.)

This section will review some techniques for externality consideration that have been developed for planning in the electric utility industry (the industry for which this endeavor has been most intensively carried out). It will also review a variety of policy tools that are available for addressing externality problems.

a. Techniques of Externality Consideration

Planning in the electric utility industry is generally highly quantitative and rigorous. Planning software has been developed that makes it possible to develop meaningful resource comparisons on a ¢/kwh basis. These calculations can take into account many factors that distinguish resources and have a bearing on their value and cost. The least cost resource meeting current system needs would normally be selected. Alternatively, competitive bids could be solicited on a ¢/kwh basis. The lowest bid would normally be selected. The costs considered normally do not include external environmental damage costs.

A variety of techniques have been developed for incorporating externality costs into utility resource planning. The simplest is to list and perhaps categorize externalities for resources being compared and to give some sort of qualitative consideration to the externalities. Externality differences that appear significant on a common-sense basis can be given some weight, even if measurement and valuation are fairly incomplete. This could change the choice among resources from that which would have been made if externality differences between competing resources were ignored.

A second simple technique is to give percentage credits to environmentally favored resources and/or percentage penalties to disfavored resources. This might mean, for example, reducing a bid from a renewable resource provider by 15% for the purposes of selecting the winning bid.

A third technique would be to use weighting and ranking schemes. For example, a list of environmental concerns could be provided and each resource given a score for each concern. The total environmental score could be used to adjust cost or bid price according to some predetermined rule.

Pro: All of these techniques are easy to apply, and don't entail substantial data requirements.
Con: They involve an unavoidable element of subjectivity and arbitrariness.

If full externality assessment is available a tool known as adders can be employed. Here the emissions associated with producing a kwh of electricity are known for each resource and are given a ¢/kwh external cost value. This value is then used to adjust costs or bids upwards, to arrive at a full social cost that includes both internal and external costs for each resource. The least full social cost resource is then selected.

The same adders can also be used in system operation, to dispatch units on a least full social cost basis, instead of on a least internal cost basis, as is normally done. The current approach to dispatching the electric generating system seeks to minimize the internal costs of operating the system. This is achieved by ranking generation units according to variable cost per kwh of generation. When additional load must be served, plants are brought into service in the order of increasing cost, beginning with the lowest cost available unit. As load falls, plants are backed down in the order of decreasing cost, beginning with the highest cost unit in operation.

If a cents per kwh value could be developed that is an accurate measure of the external costs per kwh of generation for each generating unit, it would be possible to add this value to the internal cents per kwh cost of generation. The number resulting would give the full variable cost (internal plus external) per kwh of generation for each plant. Plants could then be ranked in order of full social costs per kwh of generation. The same logic of dispatch just described would then minimize the full costs of operating the system. This modification of traditional dispatch is known as full cost dispatch. It has been employed in Southern California as a strategy to address their vary severe ozone problem.

Pro: Operates the electric system efficiently.
Con: May not be the most cost-effective way of achieving its level of emissions reductions.

The adders method has a strong rationale in economic theory, assuming that reliable externality assessments are available. This assumption, how ever, places tremendous scientific burdens on those who would develop the adder values, which in general are quite controversial (which is not to say that none of them are reasonable). As an alternative to damage cost adders, some have suggested that control cost adders be used instead. These are the ¢/kwh costs of reducing the emissions associated with a generation resource to some standard or level that regulators or society has decided is acceptable. They are then used in decision making just as damage cost adders are used. The advantage of control cost adders is that they can be established accurately without the need for the extensive scientific work done in externality assessment. Some argue that they can be considered a reasonable proxy for damage cost adders. The rationale is that in requiring emissions to be controlled at acceptable levels society has revealed how much it is willing to pay to avoid environmental damages. There is some analogy here with how the market behavior of individuals reveals willingness to pay damage valuations, but the differences between political processes and efficient markets are also very great. Many practitioners feel that control cost adders are theoretically flawed, even if easier to implement than damage cost adders.

Pro: Strong rationale in economic theory for damage cost adders.
Con: Overwhelming scientific burden.

Tables from The Case for Natural Gas, University of Houston, 1991:

Table 3

SUMMARY OF EXTERNALITIES
EXPRESSED IN CENTS/KWH GENERATED

	Existing Power Plants			
	Existing Unscrubbed Coal Plant	Existing Scrubbed Coal Plant	Nuclear Power Plant	Combustion Turbine #2 Oil .3% Sulfur
Pace University	10.3	4.0	2.91	2.6
Massachusetts Dept. of Public Utilities	7.7	5.2	-	4.0
California Energy Commission In-State	30.3	10.9	-	5.3
California Energy Commission Out-of-State	3.8	2.2	-	1.5
New York Public Service Commission	2.5	1.4	-	0.8
Nevada Public Service Commission	7.9	5.3	-	3.9

Table 4

SUMMARY OF EXTERNALITIES
EXPRESSED IN CENTS/KWH GENERATED

	New Power Plants			
	Combined Cycle Firm Gas	Coal: AFBC .5% S	Coal: IGCC .45% S	Waste to Energy
Pace University	0.77	2.6	2.1	4.019
Massachusetts Dept of Public Utilities	1.4	3.6	3.0	-
Calif. Energy Commission In-State	0.6	5.9	3.8	-
Calif. Energy Commission Out-of-State	0.4	1.4	1.0	-
New York Public Service Commission	0.3	0.7	0.5	-
Nevada Public Service Commission	1.4	3.7	3.0	-

Another technique for externality consideration is multi-attribute tradeoff analysis. Here software is used to identify and graph the combination of cost and emissions characteristics of a large number of possible utility system resource portfolios. An efficiency frontier of possible systems (or resource portfolios) is identified by eliminating all points that are worse than some other point in both cost and emissions. (The resource portfolio efficiency frontier is similar to the production possibility curve for guns and butter that may be familiar from introductory economics.) A selection of a preferred resource portfolio along the frontier can be made without assigning externality values to emissions.

Pro: The shape of the frontier makes explicit the tradeoffs between cost and environmental quality that decision makers are considering. In practice, examination of the frontier will tend to reveal a range within which environmental improvements are fairly inexpensive, and a range within which they become increasingly unattractive. Multi-attribute tradeoff analysis is an extremely powerful and sophisticated tool.
Con: If emission externalities are not assigned dollar values the choice of a preferred point on the resource frontier will contain an irreducible subjective element. Massive information input and modeling requirements.

The techniques just described have been developed for planning decisions in electric utility regulation. However, they can readily be adapted to decision making in any policy area where some form of cost analysis is used.

b. Other Policy Tools for Addressing Externality Problems

A common approach to externality reduction is command and control regulation. An emitter is required by law to install such and such control measures. This is straightforward (pro), but will not achieve a given level of total reduction at minimum cost (con).

Another approach is emission standards or targets. Emitters are required by law to limit emissions to certain levels. They have some flexibility in how they achieve this, and therefore some ability to minimize costs. Effectiveness may depend on monitoring and enforcement.

Another approach is the use of emission fees and fuel taxes. Such charges can be designed to control emissions and use at desired levels, assuming that the demand curves for rights to emit and for fuels are known. This approach provides an incentive to the user to reduce emissions and/or fuel consumption to the greatest extent that he can do so cost-effectively. Fees and taxes of this sort can be designed to increase economic efficiency, and in theory could be used to replace the revenues from other kinds of taxes that interfere with economic efficiency (thus increasing the economic benefit).

Pro: Strong efficiency rationale in economic theory.
Con: Some difficulty in identifying optimal charges.

Tradeable emission allowances are another tool that can be used to reduce externalities in an efficient manner. A cap on total emissions of P is defined, based on some standard of health or economic efficiency, and a number of allowances to emit so much P are issued, with total allowed emissions equal to the cap. These allowances are distributed to emitters on some rationale. Those whose expected emissions exceed their allowances must either install control technology or buy additional allowances. It is expected that they will choose the less expensive alternative. Those for whom control is relatively expensive will try to buy allowances. Those for whom control is relatively cheap will do so and thereby become able to sell their excess allowances.

Pro: In theory, this approach will achieve the required reductions at the lowest possible cost, by providing a mechanism through which those who can reduce least expensively will profit from doing so.

Con: Some difficulty in deciding how many allowances to issue, and how to distribute them. Assumes that the location of emissions doesn't matter to the policy maker.

Additional tools include subsidies for environmentally favored activities, such as recycling, and liability for environmental damages caused. These and other tools and techniques are discussed more fully in the literature cited in the Library's Location File.

c. Some Complications

A number of related problems can arise when externalities are internalized in only one sector of the economy, or in only one geographic region, rather than uniformly over the entire economy. They have come to be know as piecemeal problems.

For example, if externality adders were used internalize the externalities of utility electric generation, but not the externalities of non-utility generation, then non-utility generation might be more attractive, even if its direct (and also full) costs were higher. Similarly, if adders were used in one state, but not in its neighbor, then electricity in the non-adder state might be more attractive, even if its direct (and also full) costs were higher.

Piecemeal problems like these are often used to argue against internalizing externalities. It is important to notice that the problems do not arise because there anything mistaken in environmental costing. They arise because it is incomplete in scope. An appropriate response would be to call for comprehensive extension of internalization to all sectors and all regions. (This was the approach taken in the May 1992 Report of the Commission on Comprehensive Energy Planning.)

LIST OF ABBREVIATIONS

AFBC	atmospheric fluidized bed combustion
AGA	American Gas Association
Al	aluminum
ALARA	as-low-as-reasonably-achievable
API	American Petroleum Institute
AQ	air quality
As	arsenic
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
ASTRAP	Advanced Statistical Trajectory Regional Air Pollution Model
B	boron
BART	best available retrofit technology
bbl	billions of barrels
bcf	billion cubic feet
BCF	bioconcentration factors
BEIR V	biological effects of ionizing radiation
BPA	Bonneville Power Administration
Br	bromine
Btu	British thermal unit
BWR	boiling water reactor
CAA	Clean Air Act
CAAA	Clean Air Act amendments
CAC	command and control
$CaCO_3$	calcium carbonate
CASAC	Clean Air Science Advisory Committee
CC	combined cycle
Cd	cadmium
CDM	Climatological Dispersion Model
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CFC	chlorofluorocarbon
CFR	Code of Federal Regulations
CGL	comprehensive general liability
ci	curies
CO	carbon monoxide
Cr	chromium
CRTN	Thermal and Nuclear Research Center
CSF	cancer slope factors
CT	combustion turbine
Cu	copper
CVM	contingent valuation method

LIST OF ABBREVIATIONS
(Continued)

CWA	Clean Water Act
dB(A)	decibels acoustic
DOE	U.S. Department of Energy
DPS	New York State Department of Public Service
DPU	Department of Public Utilities
DSM	demand side management
EIS	environmental impact statement
EKMA	Empirical Kinetics Modeling Approach
EPA	U.S. Environmental Protection Agency
EPRI	Electric Power Research Institute
ESEERCO	Empire State Electric Energy Research Corporation
ETS	environmental tobacco smoke
EXAMS	Exposure Analysis Modeling System
F	fluorine
Fe	iron
FERC	Federal Energy Regulatory Commission
FOWL	Fossil Fuel Combustion Waste Leaching Model
GBD	gas bubble disease
GCC	global climate change
GCM	general circulation models
GHG	greenhouse gases
GLI	Great Lakes Initiative
GNP	gross national product
GSP	gross state product
GWh	gigawatt hour (10^6 Kwh)
GWP	global warming potential
HEAST	Health Effects Assessment Summary Tables
Hg	mercury
HNO_3	nitric acid
HSDB	hazardous substance data base
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
IEA	International Energy Agency
IGCC	integrated gasified combined cycle
IMPLAN	U.S. Forest Service impacts assessment and planning model
IPCC	Intergovernmental Panel on Climate Change
ISC	Industrial Source Model
ISCLT	Industrial Source Complex Model - Long Term
ISCST	Industrial Source Complex Model - Short Term
kg/ha	kilograms per hectare

LIST OF ABBREVIATIONS
(Continued)

km	kilometer
kV	kilovolt
kW	kilowatt
kWh	kilowatt hour
lbs	pounds
Li	lithium
LLW	low level waste
LOAEL	lowest observable adverse effects level
LULU	locally unwanted land uses
MB	megabyte
MCC	marginal control cost
mmBtu	million British thermal unit (10^6 Btu)
mmcf/d	million cubic feet per day
mmcf	million cubic feet
Mn	manganese
MPC_e	marginal private cost of producing electricity
mR	millirem
MSA	Metropolitan Statistical Area
MSC_e	marginal social cost of producing electricity
MSW	municipal solid waste
Mtons	million of tons
MTons	mega tons (10^6)
MV	mechanical ventilation
MW	megawatt hour (10^3 Kwh)
MWe	megawatt electric
$MWTP_e$	marginal willingness to pay curve for electricity
MYGRT	leachate migration and groundwater contamination
NAAQS	national ambient air quality standards
NAPAP	National Acid Precipitation Assessment Program
NAS	National Academy of Science
NCLAN	National Crop Loss Assessment Network
NEPA	National Environmental Policy Act
Ni	nickel
NIH	National Institute of Health
NIOSH	National Institutes of Occupational Safety & Health
NO	nitrous oxide
NO_2	nitrogen dioxide
NO_x	nitrogen oxide
NRC	U.S. Nuclear Regulatory Commission
NSPS	new source performance standards

LIST OF ABBREVIATIONS
(Continued)

NTIS	National Technical Information Service
NUREG	nuclear regulation
NY	New York
NYCRR	New York codes, rules & regulations
NYPA	New York Power Authority
NYPP	New York Power Pool
NYS	New York State
NYSDEC	New York State Department of Environmental Conservation
NYSEO	New York State Energy Office
NYSEQRA	New York State Environmental Quality Review Act
NYSERDA	New York State Energy Research and Development Administration
OAQPS	U.S. EPA Office of Air Quality Planning and Standards
OECD	Organization for Economic Coordination and Development
OPA	Oil Pollution Act
OSHA	Occupational Safety and Health Administration
OZIPP	ozone isopleth plotting package
Pb	lead
PbB	baseline blood lead levels
PCB	polychlorinated biphenyls
pCi/g	picoCuries/gram
pCi/m2s	picoCuries/meter^2 second
pCi	picoCuries
PEL	permissible exposure limits
PFBC	pressurized fluidized bed combustion
pH	measure of acidity
ppm	parts per million
PRA	probability risk assessments
PS	pumped storage
PSC	New York State Public Service Commission
PSD	prevention of significant deterioration
PV	photovoltaic
PWR	pressurized water reactor
RADM	Regional Acid Deposition Model
RCG	RCG/Hagler, Bailly, Inc.
RCRA	Resource Conservation and Recovery Act
RDF	refuse-derived fuel
REL	recommended exposure limits
REMI	Regional Economic Models, Inc.
RfC	inhalation reference concentrations
RfD	reference dose

LIST OF ABBREVIATIONS
(Continued)

RfF	Resources for the Future
RIMS II	Regional Input/Output Multiplier Systems
ROR	run-of-river
SDWA	Safe Drinking Water Act
Se	selenium
SNAAQS	state/national ambient air quality standards
SO_2	sulfur dioxide
SPR	strategic petroleum reserve
Si	silicon
Sr	strontium
TEP	tradeable emission permit
Th	thorium
Ti	titanium
Title IV	Title IV (Acid Deposition) of CAAA
TSCA	Toxic Substances Control Act
U	uranium
U.S.DOE	U.S. Department of Energy
U_3O_8	uranium oxide
UAM	Urban Airshed Model
UF_6	uranium hexafluoride
UNEP	United Nations Environment Program
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
V	vanadium
VOC	volatile organic compound
WASP	Water Quality Analysis Simulation Program
WTF	water treatment facilities
WTP	willingness-to-pay
WTRISK	Water Emissions Risk Assessment Model
Zn	zinc