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RANKING ENERGY-CONSERVATION MEASURES TO ESTABLISH RESEARCH PRIORITIES: SYNOPSIS OF A WORKSHOP

PAUL D. MOSKOWITZ, TIEN Q. LE AND BARBARA PIERCE

May 1979

MASTER

DIVISION OF REGIONAL STUDIES
NATIONAL CENTER FOR ANALYSIS OF ENERGY SYSTEMS
DEPARTMENT OF ENERGY AND ENVIRONMENT

BROOKHAVEN NATIONAL LABORATORY
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AIRLIE, VIRGINIA

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ABSTRACT

A two-day workshop attended by 29 individuals from within and outside the federal government was convened to assist the Department of Energy's Technology Assessment Division in evaluating the need to prepare additional environmental and social impact assessments of different energy conservation measures. At the Workshop, attendees participated in a decision-making exercise designed to rank 19 different energy conservation measures according to their overall potential for achieving important national goals and their ease of implementation. In this exercise, the participants felt that the most important ranking criteria dealt with questions concerning feasibility (economic, political/institutional, social and technical) and economic efficiency. Other criteria, such as enviromental quality and occupational health and safety received lower weights; possibly because of the widespread belief that most of the conservation measures presented would be environmentally beneficial. In the participants' view, the most promising and feasible conservation measures include new building performance standards, retrofit of existing housing stock, new appliance performance standards and increased use of smaller cars. These measures were considered to be enviromentally beneficial. In contrast, conservation options which ranked rather low, such as diesel engines, coal-fired aluminum remelt furnaces, and cupola furnace modifications were expected to have some harmful environmental and health impacts. Most, but not all, of these impacts are expected to be highly localized and of lesser national concern. Disagreement exists as to the efficacy of funding those projects deemed highly desirable and feasible versus those which are expected to have the greater environmental and social impacts. These differences must be taken into account in the research priorities that are eventually established. While environmental and social impacts of alternative energy conservation measures may prove to be either harmful or beneficial, neither side should be ignored by the policy maker.

ACKNOWLEDGMENT

We thank Mr. M. Owens and Dr. M. Rowe for their assistance in developing Workshop plans and background materials used in this exercise and subsequently in analyzing data collected. Mr. E. Edelson, Dr. M. Olsen and Dr. D. Pilati acted as discussion group rapporteurs and prepared summaries incorporated into this report. Mr. E. Edelson also throughout the course of this effort has provided many constructive comments and suggestions. Dr. V. Coates, Mr. D. Moses, and other members of this project's steering committee furnished constructive criticism to this effort. We are indebted to all Workshop attendees for their active participation in this exercise. To the many secretaries at Brookhaven National Laboratory who typed all the materials required, we extend our thanks.

1.0 Introduction

President Carter has proclaimed energy conservation to be the cornerstone of his national energy strategy. An increase in the efficiency of energy production and end-use is expected to reduce this nation's dependence on imported fuels and to slow the overall growth in demand for energy. Debate, however, continues as to the overall effects of energy conservation on the economy, the environment, and social welfare. Implementation of some conservation strategies may, in instances, conflict with or be impeded by prevailing social, legal, and institutional practices. Moreover, some energy conservation measures proposed may be incompatible with the goal of protecting and improving environmental quality or health and safety. Most of these measures have escaped the intense public scrutiny accorded to proposed energy technologies because they have been almost universally regarded as environmentally benign or even beneficial. Yet potential benefits, problems, or uncertainties associated with these technologies must be identified and understood in order to formulate wise and workable public energy policies.

The U.S. Department of Energy (DOE) must face such issues in developing national energy policy and allocating limited research dollars. Review of past budgetary practices shows that most DOE research, development, and demonstration (RD&D) funding has been directed towards supply technologies. However, more recently, a large number of energy conservation alternatives have attracted attention and received RD&D allocations. The DOE Division of Technology Assessments (DTA), Office of the Assistant Secretary for Environment (ASEV), is charged with assessing energy technologies to assist DOE and the ASEV in formulating policy, defining environmental concerns and research priorities, and providing an information base for use in carrying out other ASEV and DOE responsibilities. To assist DOE-DTA in determining if further environmental assessments are needed in relation to proposed conservation technologies or strategies, Brookhaven National Laboratory (BNL), with assistance from Pacific Northwest Laboratory (PNL), convened a two-day workshop to examine a number of energy conservation measures of interest to DOE. Conservation measures were ranked by assessing their overall feasibility and desirability and subsequently identifying additional technology assessment or environmental impact analyses that may be needed in the area of energy conservation. These follow-on assessments will contribute to DOE development of policies based on the relative environmental benefits and acceptabilities of energy conservation measures; provide a perspective on the relative environmental impacts of energy conservation measures as compared to other RD&D programs; and define needs and priorities for health, environmental, and socioeconomic impact research related to energy conservation measures.

The Workshop was attended by 29 individuals (Table 1) including representatives from DOE, other federal agencies, consumer and environmental public interest groups, industrial labor and utility groups and state and local governments. These individuals were invited to contribute viewpoints representative of their constitutents who are likely to be affected by application of many of the conservation alternatives.

The 19 measures examined at the Workshop (Table 2) were selected by a steering committee providing overall guidance to this project (Appendix A). Within the list are conservation measures presently receiving financial support from the DOE and others deemed sufficiently important and interesting by the steering committee to be included. Some participants believed that the list failed to include several important conservation measures. A minority report subsequently prepared by those participants lists these measures (Appendix B). These measures were not otherwise examined during the course of the Workshop, but will be considered in the final recommendations presented to DOE.

In order to familiarize Workshop participants with all measures to be examined, exploratory technology assessments for each of the different conservation measures were prepared by BNL and distributed in advance to all participants. The exploratory technology assessments highlight existing data describing potential energy savings, environmental damage, institutional/regulatory barriers, economic costs, and social concerns (Appendix C). Data describing the characteristics of each of the measures and the setting within which each would be placed are also included.

In preparation of these assessments, new data were not generated and only limited effort was allocated to preparing each assessment. The quality and quantity of the data presented are therefore quite variable. Potential energy savings, for example, are discussed in most of the reports reviewed and the assessments reflect this level of detail. In contrast, data for some of the criteria, e.g., social impacts are only rarely mentioned. While energy

Table 1
LIST OF PARTICIPANTS

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The Conservation
Foundation

Christian Van Schayk
Motor Vehicle
Manufacturers
Association

Table 2
CONSERVATION MEASURES

Residential-Commercial Sector	Industrial Sector
Heat pumps	Wastes as fuels to cement kilns
New appliance performance standards	Coal-fired remelt of recycled Al
Energy performance standards for new buildings	Cogeneration
Residential and commercial building retrofit	Waste product utilization
District heating	Pulp and paper
Integrated community energy systems	Cupola furnace modification
Modifying land use configurations	

Transportation Sector	Policy Modification
Smaller cars	Load demand management and utility rate reform
Vehicle design change	
Diesel-engine light-duty vehicles	
Car-and van-pooling	
Transportation mode shift	

savings estimates are presented for most of the conservation measures studied, there are inconsistencies in the underlying assumptions. Ideally, all estimates presented should be derived from a single scenario with a consistent set of assumptions, but time and budget allocations did not permit such analyses to be performed.

On the first day of the Workshop participants reviewed the technology assessments, and discussed criteria which could be used to rank the 19 different conservation measures using a decision-making technique. Twelve criteria were selected: eight measure the overall desirability of a particular conservation measure and four measure the overall feasibility (Table 3).

Next, Workshop participants were asked to respond to questionnaires seeking subjective evaluations of the impact levels imposed by each conservation measure for each criterion and to rate the importance of one criterion as compared with another. Conservation measures were ranked that evening via a computer program which summed all responses from all participants to determine the overall feasibility and desirability of the different conservation alternatives.

On the second day of the Workshop, results from the ranking exercise were presented and briefly discussed. Subsequently, groups were formed to discuss critical environmental/social, political/institutional/regulatory, and economic issues related to measures identified as most important by the ranking exercise or through group discussions.

The results of this decision-making exercise and the subsequent group discussions presented below suggest that the most feasible and desirable conservation options include new building performance standards, retrofit of existing housing stocks, new appliance performance standards, and increased use of smaller cars. Most of the top-ranked measures are not expected to produce significantly harmful environmental or social impacts. In contrast, some harmful effects are expected from conservation options ranked rather low such as diesel engines, coal-fired aluminum remelt furnaces, cupola furnace modifications, and waste product utilization. Most, but not all, of these impacts are expected to be highly localized and of lesser national concern. Disagreement exists as to the relative benefits to be derived from funding projects deemed highly desirable (excluding the environmental and social) and feasible versus those expected to have the greatest environmental and social impacts. In the research priorities eventually established, these differences will need to be recognized. The first approach would emphasize the energy, political and economic benefits of a particular technology; the second approach involves reducing the environmental and social costs imposed.

The reader is cautioned that the rank orders presented represent only a mathematically formulated consensus of the individuals present at the conference, and extrapolation of these results to larger populations may be inappropriate. Some participants also expressed doubt that the methodology used in this exercise could accurately represent their values in establishing research priorities.

Table 3

RANKING CRITERIA

I. Desirability Criteria

1. Direct Employment (refers to both the quantity and quality, including upward mobility).
2. National Security (refers to the independence from imported oil and resistance to sabotage).
3. Energy Savings 1985 (refers to net energy savings including response time for measure to take effect).
4. Energy Savings 2000 (same as above).
5. Economic Efficiency (refers to the best use of available resources including minimization of total life cycle costs).
6. Environmental Quality (refers to public health and safety, air and water quality, land use, and aesthetics).
7. Occupational Health and Safety (refers to employment-related impacts).
8. Social Desirability (refers to quality of life including psychological well being, choice of options, and reduction of burdens imposed upon any single economic class of consumers).

II. Feasibility Criteria

9. Economic (refers to financial constraints including return on investments).
10. Political/Institutional/Regulatory (refers to existing rules, regulations, and changes required in the status quo).
11. Social (refers to public perceptions and response).
12. Technical (refers to equipment availability, system reliability, and research and development requirements).

2.0 Methodology

Workshop attendees participated in a decision-making exercise to identify those conservation measures expected to be most effective in achieving the goals of energy conservation and meeting various social and institutional requirements. Conservation measures could be ranked using any single criterion. Decision making exercised by government, industry, and individuals is, however, generally a much more complex process incorporating large amounts of information, broader understanding of the issues, and tradeoffs among competing requirements and value judgments. In DOE, for example, environmental concerns are the particular responsibility of the ASEV and the specific technology development programs. Also, social acceptability in terms of employment, decentralization, consumer costs, and quality of life are of concern not only to DOE, but also to many public interest groups. Finally, efficiency in terms of regulatory, administrative, institutional, and economic feasibility and costs are of critical importance to government, industry, and taxpayers, as is system reliability and national security.

A formal decision-making technique known as weighting summation was used at the Workshop to provide quantitative structure to the large amount of information involved in ranking the conservation alternatives. The technique provides a mechanism for capturing many of the tradeoffs necessary in decision making, in extracting information, in determining critical parameters, in exploring tradeoffs, and in representing conflicting viewpoints.

Weighting summation is one of the more common amalgamation techniques used in decision-making analysis and was applied in this exercise principally because of its ease of application (Hobbs 1978). Rankings are mathematically obtained by adding the products of scaled criterion values and criterion weights over all criteria and participants. In this exercise the votes of all respondents were weighted equally. Appendix D displays the algorithm used to calculate the ranking orders.

In developing ranks via weighting summation, the following constraints were compiled with to the extent practicable (Hobbs and Voelker 1978).

1. Criteria must be independent; they must not contain common elements or double count the same variable;
2. Tradeoffs acceptable to decision makers must be independent of the levels of other criteria;
3. Criterion levels must be certain or decision makers must disregard the different levels of risk for different criteria;

4. Criterion levels must be interval scaled or better: An interval scale has an arbitrary zero point, and differences between numbers are meaningful, e.g., Fahrenheit and Celsius temperature scales;
5. Weights must be ratio scaled; interval scale with a non-arbitrary zero, such as degrees Kelvin.

The criteria and weights used are thus critical features of the ranking exercise and the overall assessment. The criteria must reflect the interests and concerns of the public; the principles of effective conservation and environmental protection; the policy concerns of federal, state, and local decision makers; and the specific needs of DOE. The weights, on the other hand, must reflect the generic tradeoffs that the decision-maker is willing to make between different criteria.

Discussions on pertinent criteria at the Workshop were stimulated by an initial list provided by BNL in advance of the Workshop and by formal papers and presentations prepared by Stanley M. Berman and Laurence I. Moss (Appendix E). Practice exercises at BNL indicated that use of more than 20 criteria would be impractical because of the overall lack of specific data in the literature and the technology assessments subsequently prepared, and the general fatigue which developed in responding to the questionnaires. We, therefore, limited the number of ranking criteria to a maximum of 15. Following several hours of discussion at the Workshop, 12 criteria were selected, which may be divided into two groups: desirability and feasibility. The desirability criteria apply to important national goals. The feasibility criteria relate to the degree of difficulty expected in implementing the conservation measures. Table 3 briefly describes the criteria selected, which represent the concerns expressed by all participants in a round table discussion.

Following dinner on the first day of the Workshop, estimated impact levels for each criterion and each technology were prepared by each participant using a rating technique. Workshop participants were asked to examine the distribution of impacts for each of the criteria listed using the exploratory technology assessments and their personal knowledge of the conservation options as their data base. Desirability criteria were then assigned scores ranging from the most positive or beneficial impact score of +10 to the most severe or negative score of -10. A score of 0 reflected no impact. Feasibility criteria were scored on a scale of 0 to +10 (most feasible). We treat these scaled impact levels as interval measurements.

The Metfessel General Allocation Test was used to obtain ratio scaled weights for each of the criteria (Gum 1976). In this method, respondents were given a fixed number of points (100) and asked to assign them to the various criteria in proportion to their relative importance. The resulting allocation is a set of ratio-scaled weights reflecting the judgment of the respondents. Respondents were asked to weight all desirability and feasibility criteria independently and then to define their estimates of the relative importance of all desirability criteria as compared with all feasibility criteria.

Respondents were also asked to rate or assess their overall state-of-knowledge with respect to each of these criteria. Weights ranging from 0 (absence of knowledge) to a +10 (perfect knowledge) were assigned. Appendix E contains examples of the questionnaires used in this exercise.

3.0 Results

Table 4 displays the results from the overall ranking exercise. Rankings are shown for all desirability and feasibility criteria and amalgamations of the two. Statistical testing using the Freidman's Method for Randomized Blocks shows significant differences in the overall rankings among all Workshop participants at the 95% and at the 99.5% confidence limit (Sokal and Rohlf 1969).

The conservation measures having the highest amalgamated rankings represent a mix of both residential/commercial and transportation sector alternatives. In contrast, the industrial sector conservation measures ranked rather low; possibly because of the lack of participant understanding about these measures or merely disinterest.

A review of the exploratory technology assessments for the conservation measures ranked rather high reveals that the measures can be instituted rather rapidly, are relatively independent of complex government interactions, and are likely to produce nationwide impacts. These measures are also expected to produce the greatest energy savings in 1985 and 2000. Conservation options with the lowest rankings, in contrast, appear to require complex interactions at the federal, state and local levels; relatively long implementation times; and can be expected to produce more localized impacts. Industrial sector measures, although ranked rather low overall, do not always conform to these generalizations. The industrial conservation measures, for example, when compared with district heating or mode shifts, can be installed rather rapidly with limited governmental interaction required. Their impacts are nevertheless expected to be more localized.

Spearman Rank Correlation coefficients were computed comparing overall rankings with and without the use of the uncertainty measure discussed previously (Sokal and Rohlf 1969). No significant difference in the overall rankings was found. Uncertainty has therefore been ignored in all rankings subsequently presented.

Rankings, as previously noted, depend on the weights and scaled-impact levels prepared by each respondent and summed among all participants. Table 5 displays the average criteria weights prepared by all Workshop participants and criteria certainty identified for each criterion. Review of this table shows that weight and certainty appear to be directly proportional to each other, i.e., measures that participants were most knowledgeable about were weighted most highly and vice versa. The rankings may therefore be directly biased by the mix of individuals having different areas of expertise present at the Workshop. The low certainty values noted for occupational health and safety, for example, may reflect such a bias.

Review of Table 5 shows that the most heavily weighted criteria dealt with questions concerning feasibility (economic, political/institutional, social,and technical) and economic efficiency. Other criteria, such as environmental quality and occupational health and safety received lower weights; possibly because of the widespread belief that most of the conservation measures presented would be environmentally beneficial. Environmental quality and energy savings in 2000 for example, received equivalent but lower weights then most of the feasibility criteria. Each exceeded energy savings in 1985 by a multiple of 2. The remaining criteria appeared to be of lesser concern to the participants.

The most significant environmental/social differences between the top- and bottom-ranked measures probably relate to the spatial distribution of impacts expected. The conservation measures ranked among the top 10 will most likely be used throughout the country and may affect many classes of consumers. The issues raised by these measures are therefore of national interest. In contrast, most of the lower-ranked measures, particularly those directed towards energy conservation in the industrial sector, are important only within specific regions and localities. The issues raised are not likely to concern the nation as a whole.

Since the scaled-impact levels presented in Table 6 are based on subjective evaluations made by each respondent, defining the reasoning behind the ratings can be very imprecise. Car- and van-pooling, for example, has obviously been given large positive impact scores for national security because of perceived gasoline savings. Similarly, land use configuration modification was probably rated low in technical feasibility because of the physical constraints imposed by attempting such an alternative. The reasons for other ratings, however, are not as straightforward and are not discussed here, although they are, of course, reflected in the group discussions summarized below.

Table 4
RANKINGS AMONG ALL PARTICIPANTS

Conservation Measures	Desirability	Feasibility	Feasibility & Desirability
1. Building performance studies	1	1	1
2. Small car	4	3	2
3. Retrofit	2	7	3
4. Appliance performance studies	7	2	4
5. Car redesign	5	8	5
6. Rate reform	3	10	6
7. Cogeneration	6	6	7
8. Heat pumps	12	4	8
9. Car/van pool	11	9	9
10. Waste product utilization	9	13	10
11. Mode shift	10	16	11
12. Diesel engine	16	5	12
13. Land use	8	19	13
14. Pulp and paper	15	11	14
15. District heating	13	17	15
16. Cement kilns	17	12	16
17. ICES	14	18	17
18. Al Remelt	19	14	18
19. Cupola furnace	18	15	19

Table 5
CRITERIA WEIGHTS AND CERTAINTIES

		Average Weight	Average Certainty
1.	Economic feasibility	14.7	7.3
2.	Technical feasibility	12.9	7.2
3.	Political/Instit./Reg.	10.7	6.1
4.	Economic efficiency	9.4	6.5
5.	Social acceptability	9.2	5.1
6.	Environmental quality	8.1	5.3
7.	Energy savings 2000	8.1	5.1
8.	Social desirability	6.6	4.5
9.	National security	6.0	5.2
10.	Energy savings 1985	5.6	6.7
11.	Occupational H&S	4.5	4.3
12.	Direct employment	4.1	4.8

Table 6
AVERAGE SCALED IMPACT LEVELS

Ranking Criteria

Conservation Measures	Desirability								Feasibility			
	Direct Employment	National Security	Energy 1985	Energy 2000	Economic Efficiency	Environmental Quality	Occupational Health & Safety	Social Desirability	Economic Feasibility	Political/ Instit.	Social Acceptability	Technical Feasibility
1. Building performance standards	4	6	5	8	7	4	0	6	8	7	8	8
2. Small car	0	9	8	7	6	1	0	2	8	7	6	10
3. Retrofit	8	6	7	5	6	4	-2	5	5	6	7	8
4. Appliance performance standards	4	6	5	8	7	4	0	6	8	7	8	8
5. Car redesign	1	7	6	6	6	3	0	4	6	6	7	8
6. Rate reform	2	5	5	5	7	4	3	6	7	5	5	8
7. Cogeneration	2	5	5	7	6	3	0	4	6	6	8	8
8. Heat pumps	3	4	4	6	4	1	-1	2	7	8	7	8
9. Car- and van-pool	-1	5	3	4	6	5	0	2	7	6	3	9
10. Waste product utilization	5	4	4	5	5	4	-2	4	4	5	8	7
11. Mode shift	2	5	3	4	4	5	1	2	4	5	3	7
12. Diesel engine	1	4	3	4	4	-2	-1	1	7	6	6	9
13. Land use	1	5	1	5	4	4	2	4	4	2	3	6
14. Pulp and paper	2	3	2	3	4	2	-1	1	5	6	7	6
15. District heating	2	5	2	5	3	1	-1	3	3	4	4	6
16. Cement kilns	2	3	2	2	3	1	-2	1	4	7	7	6
17. ICES	2	4	1	4	4	1	0	3	3	3	4	5
18. Al remelt	2	4	2	2	2	-2	-3	1	4	6	7	6
19. Cupola furnace	1	2	2	2	2	0	-1	1	4	6	7	6

4.0 Group Discussions

On the second day of the Workshop, discussion groups having common interests were formed to identify critical concerns for conservation alternatives most in need of additional research. Because of time limitations, each group was asked to discuss eight conservation measures. Since some participants were ill at ease with the rankings produced by the weighting summation technique, or felt that the rankings may not properly reflect research priorities, the rankings were reviewed by each of the groups and sometimes altered to provide a better focus for subsequent group discussions. Concerns identified during the group discussions will be taken under advisement by BNL and DOE in establishing future research agendas.

The groups discussed environmental/ social, economic, and political/institutional/regulatory issues for approximately 2 to 3 hours. The chairmen, rapporteurs, and members of the groups are listed in Table 7. In discussing the conservation measures, the groups were asked to consider the following questions:

1. Is additional research required?
2. What are the most critical issues?
3. What are the local, regional, and national limitations, implications, and inequities of instituting the particular measures in question?
4. Who are the above issues important to and how are they presently responding to these concerns?
5. Are gross national assessments useful exercises? How can they be improved?
6. What options exist to mitigate identified barriers and encourage use of the selected measures?
7. What are the proper roles of the federal government, DOE, and the DOE Assistant Secretary for Environment?
8. How can substantiative public input be incorporated into the research and commercialization of these measures?

The highlights of these group discussions, presented below, are extracted from summaries prepared by the group rapporteurs.

4.1 Environmental/Social

Discussions within this group were directed to the following conservation alternatives: new building performance standards, retrofit of existing buildings, district heating/ICES, cogeneration, land-use modification, waste product utilization, use of diesel engines, and utility rate reform. These

Table 7
DISCUSSION GROUPS

Environmental/Social

Chairman : R. Ferguson
Rapporteur: M. Olsen
Members : D. Beck
S. Dunwoody
J. Powderly
C. Van Schayk

Economic

Chairman : L. Roddis
Rapporteur: D. Pilati
Members : D. Burrows
L. Moss
S. Parker
W. Sessions
T. Le

Political/Regulatory/Institutional

Chairman : G. Thompson
Rapporteur: E. Edelson
Members : S. Berman
J. Brinch
R. Calhoun
R. Liddell
P. Shoop

measures were selected principally because their eventual use was expected to have the most significant environmental and social impacts. The overall rankings produced by the decision analysis exercise were also considered, but only as a secondary screen.

Extensive implementation of each of these conservation measures would raise numerous problems and issues requiring considerable research. The most frequently mentioned issues were: (1) effects on the physical and mental health of individuals; (2) problems of environmental pollution; (3) public acceptance and utilization of conservation measures; (4) resulting alterations in current life-styles and patterns of living; and (5) potential socioeconomic inequities among various categories of people.

Of the eight principal conservation measures identified, the group felt that land-use modification would have the most far-reaching environmental and social impacts, since it could affect housing design and location, industrial and commercial activities, transportation patterns, family life, community organization, and numerous other aspects of national life. The retrofitting of existing buildings, in contrast, would likely have relatively few environmental and social impacts, apart from problems of economic equity among individuals in different income and building-use categories.

All conservation options discussed by this group are expected to have social consequences of various dimensions associated with their application. Principal impacts mentioned include effects and inequities imposed on the elderly, handicapped, and poor. These individuals presently pay a disproportionate share of their income for energy services, yet they are least able to invest in conservation alternatives which would subsequently reduce their energy costs. The magnitudes of these effects should be explored.

Health and environmental impacts highlighted are expected principally from exposure to various air pollutants emitted by many of the conservation technologies discussed. All measures reviewed would have some overall impact on emission levels. District heating, ICES, cogeneration, and waste product utilization may each alter emission patterns. While total system emissions are likely to be reduced by application of these measures, air quality at sites proximate to each of the facilities will probably be adversely affected. Subsequent impacts will depend on the degree of degradation and the types of communities located in the affected areas. Diesel engines, because their emission characteristics differ from those of most automobiles in the existing fleet, may also give rise to unique problems. Large-scale use of diesel-powered automobiles, particularly in urban areas, could further exacerbate present air quality problems and hamper future attempts by state and local officials to bring air quality into compliance with federally mandated ambient air quality standards. Effects on populations living in close proximity to arterials where subsequent changes may be most pronounced may also be significant.

4.2 Economics

The economics discussion group reviewed seven energy conservation options as measured by the overall group ratings (Table 1)[1]. For all options, there was major concern about one or more important economic decision-making factors, including energy pricing, economic decision criteria, information, and financing. Other, less important concerns (from the group's perspective) include technological research, regional vs national disparities, and user acceptance issues.

The most important economic issue is related to energy pricing. If energy conservation were a socially desirable activity, market signals should reflect it. Current energy prices are undervalued in that they are not based on the marginal costs of increased supplies and fail to include all production costs. For example, external social and environmental costs arising from the production, distribution, and use of energy are borne by society-at-large and not included as a financial cost in the use of energy. Since consumers pay artificially low energy prices, they are encouraged to select against conservation options that would otherwise be chosen.

Although economic theory assumes rational behavior, decision makers are not always rational. This is particularly evident among consumers where strong biases towards reducing first costs dominate. A more rational algorithm is to minimize the life-cycle costs of providing the desired service. If some energy-conserving options are more capital intensive then the options they are designed to supersede (particularly true for home appliances) decisions made on a first-cost basis will be biased against conservation. While private sector decisions are usually rational, there is evidence that greater use of the more sophisticated techniques would similarly lead to more efficient resource utilizaton.

---

[1] Time constraints did not permit this group to review eight measures as requested.

Another major source of market imperfections is in the area of information. Both the quality of information and its rate of flow influence economic decisions. Because some conservation options deal with technologies unfamiliar to potential users, these users require new information. However, violators of truth-in-advertising concepts provide misinformation that can result in poor economic decisions, and worse yet, in consumer skepticism towards the potential for conservation. Even correct information requires time for dissemination. Both the absolute amount of information and the degree of specialization of most communication channels restrict the introduction of conservation options to the economic actors.

Many conservation options are capital intensive, requiring access to financial markets. However, these markets too have their imperfections. The cost of capital to an expanding electric utility is less than that to a consumer who wishes to invest in insulation. If space heat can be provided by either expanding electricity supply or installing insulation, present financial markets bias in favor of the selection of expanded supply. Besides the cost of capital, its absolute availability can also bias against conservation investments, especially for smaller economic entities whose access to investment dollars may be severely constrained, and who are more likely to be able to invest in demand reduction than supply expansion.

Little federal hardware-oriented research seems required for the options discussed; however, research is required in a number of "softer" areas. For example, some problems of energy pricing mentioned previously are still unresolved. The following items were also included as unanswered research questions: the effects of utility rate structure revisions, the impacts on electric capacity of extensive use of heat pumps, and the effects of alternative cogeneration financing schemes.

There was a general concensus that too many analyses done at the national level make no allowance for regional effects. To overcome certain market imperfections, mandated efficiency standards for buildings and appliances are being promulgated. Some of these standards are appropriate at the national level (e.g., refrigerator efficiencies) while others are better made at the regional level (e.g., the degree of home insulation). Both utility ratemaking and building retrofit should be left to local option.

4.3 Political/Institutional/Regulatory

The eight energy conservation measures discussed by this group were selected either because they were highly desirable and feasible but had significant environmental, socioeconomic, or institutional problems, or because they were environmentally and socially desirable but were not feasible at this time. Measures selected on the basis of the first condition included new building performance standards, appliance performance standards, heat pumps, small cars and changes in vehicle design, utility rate reform, and waste heat utilization through cogeneration, district heating, and integrated community energy systems. Land-use modification and transportation mode shifts were chosen under the second condition.

Although discussions were organized around the eight measures initially chosen by the group, this summary discusses issues that fall into four general categories:

1. Limitations of the use of standards to conserve energy.
2. Role of heightened consumer awareness.
3. Role of public utility operations.
4. Equity and legal considerations.

Limitations of the standards approach were raised with respect to encouraging the efficient use of energy in buildings through establishing performance standards and retrofit programs, but such limitations also apply to other measures. The difficulties of effective enforcement and proper training of enforcement officials were identified as significant obstacles to the success of the standards approach. Another concern is the realization that although regulators might set a standard as the minimum level of performance, in practice it becomes the maximum level.

Enhancing consumer awareness about the performance and economic competiveness of energy conservation measures was considered an important governmental function. However, there are several barriers to improving awareness including: the lack of quality research on many of the measures, especially for individual applications; the existence of "fly-by-night" firms providing inferior products and services; and the pricing of energy below its replacement value to society. The last encourages private decisions that are not socially optimal.

The role of public utility operations was discussed with respect to several of the measures. For example, the reluctance of public utilities to "cross the meter" and check the efficiency of the appliances powered by their product (gas or electricity) fuels was seen as an obstacle to promoting the use of more efficient appliances. Obviously there is a concern by utilities about consumer reaction to such interference, and the question was raised whether consumers should be encouraged to rethink their relationships with public utilities. Utility pricing, which has historically been average cost declining block rate, was considered with respect to several of the measures besides utility rate reform. This rate design provides the wrong signals to customers about the value of energy. Energy conservation depends on proper pricing. Related to rate design is the issue of what utility investments belong in the utilities rate base. The National Energy Conservation Policy Act's Residential Conservation Program discourages utilities from making investments in residential conservation and thus does not allow such investments to appear in the rate base. Another issue is the allocation of capital investments to a public utility's rate base when the investment is in a technology that produces multiple forms of energy such as electricity and steam.

Questions of equity were discussed with respect to utility rate reform, retrofit programs, and district heating. Similarly, the legal liability of builders under the building performance standards was raised.

5.0 Conclusions

Identifying and establishing funding priorities for research efforts directed at analyzing impacts expected from different conservation options requires a balancing of many different factors and, at times, conflicting interests. Multiobjective decision-making techniques may provide quantitative structure to such exercises. At this Workshop, a list of conservation measures were ranked as to their overall desirability and feasibility. Rankings were also established for each of the 12 criteria including environmental quality, occupational health and safety, and social desirability.

Workshop participants voiced some skepticism regarding the validity of the results produced. A major concern centers on the issue of funding research for analyses of conservation options deemed most desirable and feasible versus those expected to produce more significant environmental and social impacts. Selection of either of these objectives can result in the establishment of different research priorities. The environmental/social group, for example, considered measures that would have significant impacts and that were also deemed to be more desirable and feasible. In contrast, the economics group discussed only those measures deemed most feasible and desirable on the basis of the rankings provided by the exercise. While priorities must be established, there is no correct or absolute criterion which can be used as a guide to allocating limited research dollars. Workshop participants were divided in which scheme they favored.

A number of the measures were discussed by all the groups. Note that in comparison with the overall rankings, these measures were ranked 1,2,3,4,5,6,7,8,14,15, and 17. Comparison of these listings with the scaled impact levels for environmental quality, occupational health and safety, and social desirability shows that most of the measures selected are expected to produce positive environmental and social impacts. In contrast, such options as diesel engines, coal-fired aluminum remelt furnaces, cupola furnace modifications, and waste product utilization are expected to produce the most significant negative impacts according to the decision-analysis exercise. Some but not all of these measures were highlighted by the environment/social group.

The most significant environmental/social differences between the top- and bottom-ranked measures probably relate to the spatial distribution of impacts expected. The conservation measures ranked among the top 10 will most likely be used throughout the country and affect many classes of consumers, irrespective of location. The issues raised by these measures are therefore of national interest. In contrast, most of the lower-ranked measures, particularly those directed towards energy conservation in the industrial sector, are important only within specific regions and localities. The issues raised are not likely to concern the nation as a whole. Subsequently the level of support and focus of future research endeavors should reflect these differences.

In establishing these research programs, the proper roles of the federal, state, and local governments must be recognized. Role differences have all too often been ignored in national analyses, resulting in the masking of significant regional and local impact differences and in conclusions that may be incorrect. State and local governments play major roles in promoting, monitoring and regulating energy conservation options. Energy savings can be achieved only to the extent that individuals, businesses, and organizations alter their energy-consuming practices. Government cannot save energy (except within its own activities); energy conservation must be practiced by private individuals and institutions. As a general rule, people and organizations are most receptive to new ideas and practices that come to them from their immediate environments and are supported by those environments. The role of the federal government, including DOE and the DOE/ASEV, is somewhat different. Critical roles include: establishing national policies; designing operational programs; adopting operational standards and model codes; advocating and supporting conservation efforts; monitoring and assessing new and ongoing conservation programs; information development through RD&D; information dissemination through consumer education programs; incentives like tax credits and increasing rate of returns to industries; and administrative improvements through better integration between federal agencies and other levels of government.

The Workshop participants as a group recognized that most of the conservation measures assessed are not likely to produce significant harmful environmental and social impacts; those produced would certainly be far less harmful than those expected from energy supply options. In contrast, it was generally agreed that implementation of many of the conservation options is more likely to produce significant benefits, which have yet to be fully explored by DOE or others. While the environmental and social impacts of alternative energy conservation measures may prove to be either harmful or beneficial, neither case should be overlooked by the policy maker.

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APPENDIX A

Steering Committee Members

APPENDIX A
STEERING COMMITTEE MEMBERS
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APPENDIX B

Minority Report Presenting Additional Conservation Alternatives

RECEIVED MAY 1 1979

JOHN V. EVANS
Governor

L. KIRK HALL
Director

State Of Idaho
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MEMORANDUM

April 24, 1979

TO: Peter Meier, Paul Moskowitz

FROM: Members of Brookhaven Energy Conservation Technology Assessment Group

RE: Suggested Additions to Your Report

We very much appreciate the opportunity to be present for these deliberations on technology assessment for energy conservation. We would like to present some issues which we feel have been inadequately addressed at this workshop and which might assist you in presenting technology impact research needs to the Department of Energy.

Methodology

We were sent some introductory material prior to attending this workshop. It consisted primarily of a set of energy conservation strategies, together with a listing of environmental, social, economic, and other criteria within which to compare and analyze these strategies. There is some question in our minds about how and why these strategies and criteria were derived.

At the workshop, we attempted to suggest numerous changes to the strategies and criteria, but they proved to be quite difficult and time-consuming.

We would like to suggest an alternative scenario for any future workshops. Allow all workshop participants to prepare lists of strategies and criteria in advance. The Brookhaven staff might then distill them and redistribute these provisional sets of strategies and criteria. At that point, we might critique them and return these comments to Brookhaven, in preparation for the workshop. In this way, we would have input into both the strategies and the criteria; more of a stake in the outcome of this process; and greater satisfaction with the adequacy of the final sets of strategies.

Issues

A number of seemingly important conservation strategies have been ignored in this workshop, which we feel should be considered by the DOE Assistant Secretary for Environment. They are described in the following paragraphs:

Peter Meier, Paul Moskowitz April 24, 1979

1. Industrial heat recovery is a very important energy conservation technology which should receive both technological review and financial assistance from the DOE. It is one of the most accessible and readily available technologies, and would save considerable amounts of energy. It would also have beneficial environmental impacts in that it would reduce waste heat discharged to air or water.

2. The use of coal remains a difficult energy issue. One method of conserving energy which needs further research is burning coal-oil mixtures in industrial boilers. The national policy of shifting from oil to coal has not yet become a reality, for both environmental and institutional reasons. A gradual mixing of coal with oil would conserve oil while phasing in the use of coal. This strategy could provide a more environmentally acceptable use of coal with little or no additional capital investment. We would like to have DOE give immediate attention to this conservation strategy.

3. A number of privately owned utilities have recently decided to invest in conservation by financing home insulation programs. These loans carry no interest, and need not be paid back for ten years, or until the house is sold. These utilities have recognized the fact that conservation can be viewed as an energy resource. The NEA-NECPA makes this approach to conservation very difficult, however. Therefore, we would like DOE to support pilot analyses of these existing programs, encourage such programs among publicly-owned utilities, and secure exemptions to NECPA plans which would permit such conservation investments. It is very important that conservation be seen as an energy resource investment similar to investments in fossil fuel resources.

4. Load management and utility rate reform should have been treated as two separate conservation strategies. They are quite different and deserved separate consideration. We feel they need more exploratory research, demonstration projects, and cost-effectiveness reviews.

5. No agricultural measures were addressed. In particular, we would like to see more DOE-supported research and demonstration on obtaining energy from agricultural wastes, use of renewable resources, irrigation pumping, and model farm practices on small- and medium-sized farms.

6. Possibilities for replacing transportation with electronic communications should have been addressed as an obvious conservation technology. Very little monitoring or pilot work has been done by DOE in this area.

7. The time horizons for oil independence were inconsistent with the transportation technologies addressed in this workshop. The transportation strategies we were provided are all short-term measures, although the desirability criteria included oil independence by the year 2000.

8. The movement toward decentralized, renewable technologies should have been a desirability criterion against which all technological option were measured. We no longer have the time or financial wherewithal to continue with centralized, fossil-fueled energy programs. We are disappointed that this policy issue was not addressed during the workshop.

9. Perhaps the most important criteria omitted, against which all technological issues should be measured, was the value of energy, or the price of delivered BTUs. Economic realities were poorly addressed in the draft background materials and during the workshop itself. This omission resulted in an unrealistic set of recommended strategies, criteria, and resultant rankings. Pricing is one of the most difficult but important issues in energy conservation, and must not be ignored in any assessment of conservation strategies.

Members:

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APPENDIX C

Exploratory Technology Assessments

BACKGROUND MATERIALS
FOR THE
EXPLORATORY TECHNOLOGY ASSESSMENTS OF ENERGY CONSERVATION MEASURES WORKSHOP

April 10-11, 1979

Airlie House

Airlie, Virginia

Prepared by

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I. INTRODUCTION

The Department of Energy (DOE) Office of the Assistant Secretary for Environment, Office of Technology Impacts, Division of Technology Assessments has asked Brookhaven National Laboratory (BNL) and Pacific Northwest Laboratory (PNL) to evaluate and compare a number of promising energy conservation measures to determine their effects on energy use, the environment, and the economy and their overall regulatory, institutional and social acceptability. The comparisons will be used by the Division of Technology Assessments to allocate limited research funds and identify issues critical to the application of these measures.

In support of this effort, the Division of Regional Studies at BNL is convening a two day workshop to rank a set of 19 conservation measures, as to their overall importance. The workshop will be attended by ~35 participants, including representatives from the DOE, other Federal agencies, consumer and environmental public interest groups, industrial, labor and utility groups, state and local governments and other decision-making institutions.

At the workshop, participants will rank conservation measures using a weighting summation technique. Participants will be asked to make subjective evaluations of the level of cost (or benefit) imposed by a particular technology for criteria measuring desirability and feasibility (Section II). Participants will also be asked to prepare numerical estimates of the importance of one criterion as compared with another and provide an estimate of their level of knowledge or certainty for each criterion. Measures will be ranked summing all responses from all participants to determine a measure of environmental desirability, overall desirability and feasibility, and amalgamations of the above.

In order to familarize all workshop participants with the measures to be ranked, exploratory technology assessments for 19 conservation measures have been prepared (Section III). The assessments highlight existing data describing potential energy savings, environmental damage, institutional/regulatory barriers, economic costs and social concerns. Data describing present setting and characteristics to which the measures would be installed and initiatives that could be applied to encourage application of the measures are also included. In preparing these assessments, new data have not been generated; only 1 week's effort was allocated to prepare each assessment. Instead, existing information was compiled from the literature. Participants will have an opportunity at the workshop to comment on the information presented.

The exploratory assessments have been organized into 4 categories; residential-commercial, industrial, transportation and policy modifications. Within each category, measures are presented in increasing orders of technical complexity. In the residential-commercial sector, use of heat pumps, for example, represents the simplest modification analyzed and is placed first. Modifying land use configurations, in contrast, requires complex interactions and is therefore placed last. Other categories are ordered in similar manners.

II. RANKING CRITERIA

Listed below are the initial criteria we have selected for workshop participants to use in the ranking exercise. The criteria may be divided into two groups; desirability and feasibility. Desirability criteria capture important national goals. Feasibility criteria capture the degree of difficulty in implementing conservation measures. All measures will be ranked to determine their overall desirability and feasibility. Overall rankings amalgamating both desirability and feasibility will also be prepared. Specific attention will be directed to the effect of environmental desirability on overall ranking schemes.

Participants will be asked at the workshop to examine the distribution of impacts for each criterion listed below. Desirability criteria may be assigned scores ranging from the most positive impact score (+ 10) to the most severe or negative score (- 10). A score of 0 reflects no impact. A particular score may be given to more than one impact. Feasibility criteria will be scored on a scale of 0 to 10 (best). Criteria weights will be assigned by participants using a allocation technique. This technique will be described in detail at the workshop. Uncertainty criteria reflecting attendees overall state-of-knowledge with respect to all criteria, will be assigned weights ranging from 0 to +10 (perfect knowledge).

Fuller descriptions of the ranking criteria are presented in the Berman and Moss papers to be forwarded and will be discussed at the Workshop. Criteria may be added to or deleted from this list based on Workshop discussions.

Suggested Criteria

I. Desirability
  - A. Direct Employment (Jobs)
  - B. Independence of Imported Oil.
  - C. Energy Savings 1985 (Btu)
  - D. Energy Savings 2000 (Btu)
  - E. Economic Equity or Efficiency ("He who benefits shall be he who pays").
  - F. Productivity (Increased output of goods and services per unit of input).
  - G. Public Health and Safety
  - H. Occupational Health and Safety
  - I. Ecosystem Health and Safety
  - J. Social Equity (Distribution of costs (or benefits) among differing income classes).

II. Feasibility
  - A. Economic (Capital expenditures, labor and materials requirements)
  - B. Institutional/Regulatory
  - C. Social
  - D. Technical

III. RESIDENTIAL/COMMERCIAL SECTOR*

3.1 INTRODUCTION

Energy used by the residential-commercial sector in 1977 was 28.1 x 10^{15} Btu, or 37 percent of the U.S. total. Residential and commercial buildings consumed approximately 52 percent of the total for space heating, 13 percent for air conditioning, 16 percent for nonelectric appliances and 19 percent for electric appliances. Data available strongly suggest that the fuel use trends by residential-commercial customers respond to both energy price changes and other economic factors. Household expenditures for energy use have risen sharply since the early 1970's. Between 1972 and 1975 expenditures per household continued to rise, although, per household consumption declined. More recently prices and consumption per household have both risen. At the present time residential-commercial demands are met by electricity (46 percent), gas (32 percent), oil (18 percent) and other fuel forms (4 percent). Use of energy conservation measures in many households is on the rise. Industry data show that 2-3 million households added 4-5 inches of insulation during 1974-1976. Preliminary 1977 reports suggest a figure of nearly 6 million. In 1975, occupants of 10 million single family detached homes (22 percent of all available housing stock) spent an average of $150 per household on weatherization measures. The number of new heat pumps installed increased rapidly from 61,000 in 1971 to 250,000 in 1976, doubling between 1975 and 1976. Housekeeping changes in schools, hospitals, federal buildings etc. have recently produced significant energy savings.

Presented below are residential-commercial energy demand and fuels consumed in 1972.

	Natural Gas	Oil	Coal	Nuclear	Hydro	(10^{15} Btu) Electric	Methane	Total Direct Use
RESIDENTIAL:								
Space Heat		3.094				.202	3.835	7.131
Air Conditioning						.214	.004	.218
Water Heat & Cooking		.355				.495	1,473	2.323
Misc. Electric						.964		.964
Total		3.449				1,875	5,312	10.636
COMMERCIAL:								
Space Heat		2.149	.320			.096	1.564	4.129
Air Conditioning						.148	.019	.167
Water Heat + Cooking						.096	.565	.662
Misc. Electric						.924		.924
Total		2 149	.320			1.265	2.148	5.882

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* Discussions on energy use in the residential-commercial, industrial and transportation sectors highlight materials presented in the Ninth Annual Report of the Council on Environmental Quality (1978).

3.2 HEAT PUMPS

I. Description

The heat pump operates on the principle of the vapor compression refrigeration machine. It is capable of transferring heat from a cold to a hot reservoir by doing work on the working fluid or refrigerant which circulates in the heat pump coils and compressor. As a conventional air conditioner, the heat pump provides cooling and dehumidification in the summer by pumping heat from the inside of the conditioned space to outside air. In cold weather, the refrigerant flow direction in part of the system is reversed by activating a reversing valve and the heat pump pumps heat from outdoors to indoors. The heat pump accomplishes this task by doing mechanical work of vapor compression on the working fluid. The power to drive the compressor usually comes from an electric motor. A heat pump can also extract heat from a water or earthen source. A heat pump system is most efficient when the temperature difference between the heat absorption and extraction elements (evaporator and condenser) is small.

II. Setting and Characteristics

Heat pumps were unsuccessfully marketed in the 1950's, due to problems with improper sizing and installation. Heat pump efficiency and servicing requirements are more sensitive to proper installation than are conventional systems. However, the growing demand for air conditioning is currently enhancing the market appeal of heat pumps, as is the increasing cost of fuel oil. FEA estimates show that unitary heat pump shipments will increase from 165,000 units in 1975 to between 303,000 and 570,000 units by 1980. Heat pumps are more efficient than other heating systems plus air conditioning, but not necessarily more efficient than heating-only system

Heat pump technology is rapidly developing, with new systems such as solar assisted or solar driven heat pumps, advanced electrically driven heat pumps, and heat pumps incorporating storage (usually water/ice). Performance and reliability data are incomplete at this time.

III. Energy Savings

Total annual energy consumption for heat pumps is smaller than for any combination of central air conditioning with any heating systems studied by FEA (electric baseboard resistance heating, electric furnace resistance heating, gas fired furnace, oil fired furnace). Heat pumps may use only ∿ 55% of the electricity used in resistance heating on an annual basis.

Considering only heating season requirements, substituting a heat pump for electric resistance heating in single family residences conserves primary oil and gas in every part of the U.S.

The effect on primary fuel resources due to substituting a heat pump for an alternative heating system is sensitive to the amount of air conditioning that would normally be used without the heat pump.

a. Substituting a heat pump for electric resistance heating will conserve primary fuel usage only if substantial air conditioning is associated with the heating system. If no air conditioning is used, a net annual increase, or at best, a marginal reduction in primary fuel usage may be expected.

b. Primary fuel resource consumption may be reduced by substituting a heat pump for fossil fuel fired home heating systems, regardless of the extent to which air conditioning is used with the fossil fuel system.

IV. Other Benefits

V. Environmental Problems

Extensive use of heat pumps in small commercial buildings and residences may be an annoyance, especially in previously quiet areas.

Fluids and additives can have serious health effects upon accidental release into drinking water. The primary fuel is freon, but some fluids (especially fluorinol and toleune) are volatile and present inhalation toxicity hazards upon accidental spillage.

Several heat pump working fluids undergo pyrolysis during over temperature and/or fire conditions. Gaseous pyrolysis by-products (especially phosgene, hydrogen fluoride, chloroform, fluoroform, and CO) are more toxic than the unreacted fluids.

Toluene and fluorinol working fluids are highly flammable; accident leakage must be carefully controlled.

VI. Regulatory/Institutional Problems

Utility rate structures penalize systems having lower annual usage with a higher average unit price.

Lack of industry-accepted code of standards covering heat pump installations, to insure reliability.

Builder consciousness to first cost only, plus non-uniform building costs.

Failure of mortagage lenders to consider operating costs or energy conservation equipment.

VII. Economic Problems

VIII. Social Problems

Not affordable by poor.

IX. Other Problems

High market penetration could effect winter electric peak demand and utility load factors in certain regions of the country.

X. Resource Requirement

See tables.

XI. Initiatives

Rate structures to encourage conservation (state).

Consumer education to remove association of heat pumps with high-cost electric resistance heating (federal-state-local).

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XIII. Tabular Materials

Estimated cost of installation of adequate heating and cooling systems (dollars)

City	Heat pump	Electric furnace and A.C.	Direct electric and A.C.	Direct electric and A.C.	Gas furnace and A.C.	Oil furnace and A.C.
Knoxville, Tenn.	2,220	1,760	1,370	800	1,742	1,854
Atlanta, Ga.	2,300	1,843	1,477	890	1,826	1,939
Boston, Mass.	2,437	2,074	1,627	1,011	1,983	2,097
Cheyenne, Wyo.	2,284	1,935	1,571	1,059	1,800	1,917
Chicago, Ill.	2,461	2,188	1,793	1,084	2,110	2,224
Dallas, Tex.	2,240	1,924	1,463	801	1,894	2,007
Kansas City, Mo.	2,545	2,160	1,703	1,008	2,070	2,184
Minneapolis, Minn.	2,490	2,128	1,714	1,104	1,991	2,108
Philadelphia, Pa.	2,352	1,935	1,603	987	1,970	2,084
Phoenix, Ariz.	2,495	2,115	1,608	831	2,146	2,261
San Diego, Calif.	2,212	1,928	1,433	810	1,948	2,051
Seattle, Wash.	2,297	1,927	1,496	892	1,898	1,999
Washington, D. C.	2,297	1,927	1,519	915	1,898	1,999

Source: Delene, 1974.

Energy cost for home heating[a]
($/year)

City	Heat pump	Resistance	Gas[b]	Oil[c]
Atlanta, Ga.	71.73	139.87	61.25	127.10
Boston, Mass.	381.12	703.57	284.64	285.85
Cheyenne, Wyo.	288.49	452.73	91.98	359.54
Chicago, Ill.	240.71	395.84	196.00	337.75
Dallas, Tex.	36.69	79.17	35.18	97.07
Kansas City, Mo.	100.53	183.21	75.58	240.13
Knoxville, Tenn.	78.39	156.61	86.68	174.38
Minneapolis, Minn.	340.17	510.53	218.02	402.51
Philadelphia, Pa.	231.76	378.23	183.58	245.84
Phoenix, Ariz.	23.46	53.04	24.41	48.77
San Diego, Calif.	18.28	47.19	14.05	25.71
Seattle, Wash.	61.57	155.55	158.76	251.02
Washington, D. C.	189.86	361.31	136.06	208.23

[a] Incremental cost over and above basic electric bill and cost of hot water heating.

[b] 60% system efficiency, 0.73-2.30 $/mBtu

[c] 55% system efficiency, 30¢/gal.

Source: Delene, 1974.

3.3 NEW APPLIANCE PERFORMANCE STANDARDS

I. Description

Efficiency of energy use in consumer products can be improved by:

1) Improving the energy efficiency of existing products
2) Improving use of existing products
3) Development of new products, including integrated appliance systems (e.g., using waste heat from air conditioning or refrigeration to heat water)

II. Setting and Characteristics

In 1972 residential primary energy consumption was approximately 11 x 10^{15} Btu, or 15% of total U.S. consumption. End use consumption projections (percent) for the residential sector are:

	- Percent -		
End Use	1980	1990	2000
Space heating	51.8	50.1	48.7
Water heating	14.4	13.8	13.5
Refrigeration and freezing	9.2	10.5	11.7
Lighting	5.4	5.2	5.0
Cooking	5.2	5.1	5.0
Air conditioning	5.3	5.7	5.8
Drying	2.3	2.6	2.8
Other	6.5	7.1	7.7

Recently DOE issued voluntary energy efficiency improvement targets for appliances manufactured in 1980, based on 1972 efficiencies. These are:

	Efficiency improvement target (percent)
Water heaters	23
Home heating equipment (excl. furnaces)	11
Kitchen ranges and ovens	40
Clothes washers	35
Furnaces and boilers	20
Refrigerators and refrigerator/freezers	39
Freezers	28
Dishwashers	25
Clothes dryers	8
Room air conditioners	28
Central air conditioners	21
Television sets	79
Dehumidifiers	19

(Federal Register, 1978)

DOE is now required to establish mandatory efficiency standards by December, 1980.

III. Energy Savings

Increased efficiency is expected to save 5 x 10^{14} Btu in 1985 and 7 x 10^{14} Btu in 2000. Energy savings would be more if standards were established for electric space heating (e.g., heat pumps use only 55% of the electricity used in resistance heating).

Voluntary measures can also result in energy savings. Reducing water temperature from 140° to 120° could save 22% - 27% of annual water heating energy.

IV. Other Benefits

Reduction in fuel bills will exceed increases in capital costs by $5 billion in 2000.

V. Environmental Problems

- Heat transfer fluids and heat storage media (eutectic salts) in integrated and heat storage appliances may expose the general population (especially children) to toxic substances in the home, should leakage occur.
- Flammability of working other than freon freon and heat storage media must be considered so that leakage does not present an undue fire/explosion hazard.
- Water quality effects of disposal of spent fluids.

VI. Regulatory/Institutional Problems

- Enforcement of efficiency standards.
- Accurate testing of appliance efficiencies.

VII. Economic Problems

- Industry start-up costs.

VIII. Social Problems

- Not affordable by poor.

IX. Other Problems

X. Resource Requirements

- Increase in capital cost of appliances, e.g increasing the energy efficiency ratio of a room air conditioner, would raise the cost by $45. per unit. However, this is offset by decreasing operating costs.

XI. Initiatives

- Consumer education, including efficiency labeling (Federal-state-local).
- Taxes to penalize low efficiency products (Federal).
- Mandatory efficiency standards (Federal).

XII. References

Dole, Stephen H., 1975, "Energy Use and Conservation in the Residential Sector: A Regional Analysis".

DOE, 1977, "Environmental Development Plan, Buildings and Community Systems.

Federal Register Vol. 43 No. 70, April 11, 1978.

Federal Register Vol. 43 No. 198, October 12, 1978.

Hirst, E. and J. Carney, 1978, "Effects of Federal Residential Energy Conservation Programs" Science 199 (4331).

XIII. Tabular Materials

3.4 ENERGY PERFORMANCE STANDARDS FOR NEW BUILDINGS

I. Description

Building energy performance standards are being developed in response to and accordance with the Energy Conservation Standards for New Buildings Act of 1976, enacted as Title III of the Energy Conservation and Production Act (Public Law 94-385). The standards will be performance based, i.e. they will include goals to be achieved and applicable requirements criteria and evaluation techniques. They will not include or prescribe the methods, processes or materials to be used to achieve the goals delineated. The standards will be for new construction only, will be aimed at the design stage of the construction process and will apply to buildings rather than their component parts.

II. Characteristics

The United States residential and commercial building sector consumed approximately 16.5 x 10^{15} Btu of energy in 1972. Of this total, 10.6 x 10^{15} Btu were consumed in the residential sector and 5.9 x 10^{15} Btu in the commercial sector. In this sector 68% of the energy consumed was used for space heat, 18% for hot water and cooking, 2% air conditioning and 12% other uses.

III. Energy Savings

By 1985, 30% of all existing residential units and 40% of all commercial units will have been constructed during this decade and thus subjected to the proposed standards. DOE estimates suggest that maximum savings expected from implementation of these standards will be 1-3 quads in 1990. Savings will increase as the proportion of units constructed in compliance with the standard increases in later years.

IV. Other Benefits

Reduction in fuel bills.

V. Environmental Problems

- Health effects arising primarily from increased indoor air pollution or contamination and reduced humidity control.
- Occupational hazards arising from use of selected materials (e.g. insulation).

VI. Regulatory/Institutional Problems

- Adoption, implementation and enforcement of codes may be limited by resources, manpower, capabilities and commitment by local authorities.
- Effective performance may vary significantly from theoretical performance criteria.
- Removal of some decision-making authorities from builders and purchasers regarding initial costs.
- Additional burdens placed on smaller builders with limited design capabilities.
- Possible schedule delays when effective implementation procedures have not been established.
- Negative impacts on selected industries including building equipment and heating, ventilating and air conditioning system suppliers.
- No incentive for builders to exceed minimum performance standards.

VII. Economic Problems

- Financial burden arising from increased capital costs of buildings that are designed to achieve lower life cycle costs.

- Additional emphasis on conceptual design required will result in increased costs.

VIII. Social Problems

Not affordable by poor tenants

IX. Other Problems

X. Resource Requirements

See Table 1. Data presented are for ASHRAE 90-75 standards only.

XI. Initiatives

- Federal financial assistance (e.g. FmHA, HUD minimum property standards) for new housing construction limited to those states which have adopted standards (Federal).
- Guaranteed loans (Federal).
- Income tax deductions or credits (Federal-State).
- Public education increasing consumer and builder sensitivity to life cycle versus first cost criteria (Federal-State-Local).
- Require adoption of standards by local communities in order to qualify for federally aided building programs (Federal).

XII. References

1. Arthur D. Little, Inc., 1976, "Energy Conservation in New Building Design. An Impact Assessment of ASHRAE Standard 90-75, Cambridge, Massachusetts.
2. G. Leotz, 1978, "RUF and Energy Conservation in New Construction", ASHRAE Journal, June.
3. DOE, Office of Conservation and Solar Applicators, 1978, "Energy Performance Standards for New Buildings, Advanced Notice of Proposed Rulemaking and Notice of Public Meeting", Federal Register, Vol. 45, No. 225.

XIII. Tabular Materials

Materials	Total Annual Market ($MM)	Market Affected by ASHRAE 90 ($MM)	Market Affected by ASHRAE 90 (%)	Maximum Potential Impact by ASHRAE 90 ($MM)	Percent of Total Market (%)	Percent of Affected Market (%)
Building Materials Suppliers:						
Insulation:	1,000	595	(60)	+179	+18	+30
• Batt	470	270	(57)	+ 45	+10	+17
• Rigid Board	460	280	(61)	+128	+28	+46
• Loose Fill	70	45	(64)	+ 6	+ 9	+13
Siding Materials	1,000	850	(85)	+ 12	+ 1	+ 1
Flat Glass	1,247	146	(12)	+ 7	+ 1	+ 5
Windows	903	720	(80)	- 19	- 2	- 3
Building Equipment Manufacturers:						
Electric Lamps	1,177	176	(15)	- 16	- 1	- 9
Lighting Fixtures	1,450	830	(57)	-175	-12	-21
Gas and Electric Meters	173	159	(92)	+ 3	+ 2	+ 2
Hot Water Heaters	289	117	(40)	+ 4	+ 3	+ 3
HVA/C Systems Manufacturers:						
HVA/C Equipment	2,308	1,720	(75)	-135	- 8	-11
HVA/C Controls	550	410	(74)	+ 21	+ 4	+ 5

3.5 RESIDENTIAL AND COMMERCIAL BUILDING RETROFIT

I. Description

Residential/commercial buildings retrofit measures include: caulking and weatherstripping of doors; furnace efficiency modifications; clock termostats; ceiling, attic, wall and floor insulation; water heater insulation; storm windows and doors; devices associated with load management techniques; and heating, ventilating and air conditioning redesign or modification. These measures may be applied to all residential/commercial buildings including single family dwellings, multi-family dwellings, low density housing, mobile homes and commercial structures such as office buildings retail establishments, schools, hospitals and light industrial buildings.

II. Setting and Characteristics

Currently, there are approximately 74 million residential units in the United States and 1.5 million non-residential buildings with some 29 billion square feet of floor space. Almost 20 percent of all U.S. energy consumed is used to heat and cool these buildings. Some buildings needlessly waste as much as half of that energy. Many of these existing units are not fully insulated. Before 1950, many units were constructed with no insulation at all. From 1950, until about 1973, there was a gradual trend toward more insulation, more storm windows and doors and generally better weatherization in residential structures, particularly in the colder portions of the U.S. and in electrically heated homes. Until fairly recently, however, many new dwelling units in mild climate areas, rental buildings and speculative housing were still being constructed with minimum insulation.

III. Energy Savings

Estimates prepared by BNL suggest that the potential savings from improving the energy efficiency of existing housing and commercial building structures by installing various retrofit measures could reduce primary energy demand in the residential sector by 5% (1.5 x 10^{15} Btu) and commercial sector demand by 2% (0.6 x 10^{15} Btu) in 1985.

IV. Other Benefits

- Reduced fuel bills
- Employment of local craftsmen

V. Environmental Problems

- Health effects arising from increased indoor air pollution due to decreasing air exchange. Principal sources include smoking, cooking, cleaning and dusting and infiltration from outside sources.
- Effects of fire and safety smoke movement patterns arising from alteration in ventilation.
- Occupational health and safety impacts arising from insulation installation and public health concerns effected by insulation outgassing.
- Possible increase in the number of fires and release of toxic fumes from the combustion of insulating materials (e.g. formaldehyde fumes).

VI. Regulatory/Institutional Problems

- Most building codes do not generally apply to existing residences, unless additions, alterations or repairs which are made during any 12 month period exceed 25 percent of the value of the building. Current building codes may therefore offer limited potential for retrofit of energy-conservative devices.
- Consumers may be unable to secure adequate amounts of quality insulation materials and installation services.
- Landlord-tenant problems could prevent retrofit of existing building. Twenty percent of single family dwelling and 85 percent of multifamily units are not owned occupied.

VII. - VIII. Economic and Social Problems

- Building owners may be unable to finanace retrofit.
- At least 5 million homes occupied by low income persons are inadequately insulated. This increases the energy use by low income persons, particularly the elderly and handicapped, to maintain a healthful environment. Percent income spent on energy by these individuals is almost 3 times that of other individuals.

IX. Other Problems

X. Resource Requirements

- Extension through 1980 of the DOE weatherization grant program for insulating lower income homes at an authorized level of $200 million in FY 1979 and 1980.
- A $5 billion program of federally-supported home improvement loans for energy conservation measures; $3 billion for support of reduced interest loans up to $2,500 for elderly or moderate income families and $2 billion for general standby financing assistance.
- Grants of $900 million over the next 3 years to improve the energy efficiency of schools and hospitals.
- A 2 year $65 million program for energy audits in local public buildings and public care institutions.

XI. Initiatives

- National Energy Conservation Policy Act (NECPA) of 1978 Utility Conservation Program for Residences (Federal).

XI. Initiatives (Con't)

- NECPA Weatherization Grants for Low Income persons (Federal).
- NECPA Energy conservation loan program (Federal).
- NECPA grant program for schools and hospitals (Federal).
- Exclusion of retrofit measures from sales and property taxes (State-local).
- Public education strategies (Fed.-State-local).
- Federal financial assistance (e.g. FmHa, VHA etc.) for buildings limited to these meeting certain prescriptive requirements. FHA-VA could affect up to 10% of the existing family housing stock each year (Federal).
- Increase mortgage capital availability for housing with installed energy-saving measures (Federal).

XII. References

Northwest Energy Policy Project, 1977, "Energy Conservation Policy-Opportunities and Associated Impact," Northwest Energy Policy Prospect, Portland Oregon.

Federal Energy Administration, 1975, "Retrofitting Homes for Energy Conservation - A Business Guide," National Technical Information Service, PB-250-061.

Department of Housing and Urban Development, 1975. "Technology Assessment of Residential Energy Conservation Innovations", Washington, DC.

XIII. Tabular Materials

VALUE OF ENERGY SAVINGS COMPARED TO THE COST OF ENERGY CONSERVATION
MEASURES FOR SELECTED CASES, RESIDENTIAL SECTOR IN THE PACIFIC NORTHWEST*

Conservation Measure Representative Situation	Cost of Conservation Measure ($/adopter)	Annual Energy Savings (Million Btu/Hsld/year	Annual Savings per $ Invested 1976 Prices ($/yrs/$)	Expected Useful Life (years)	Discounted 1976 Energy prices ($/$)	B/C Ratio Double 1976 energy price ($/$)	Private Capital 1976 energy prices (years)	Private Capital Double 1976 energy price (years)
Retrofit Ceiling Insulation to maximum profitable level								
Case I (now R-0 to R-19)	240	95	1.19	20	14.9	29.8	1	.5
(now R-11 to R-19)	156	5	0.09	20	1.13	2.26	> 100	9
Case II (now R-0 - R-30)	348	125	1.08	20	13.5	27.0	1	.5
(now R-11 - R-30)	252	10	0.12	20	1.5	3.0	19	6
Retrofit Other								
Insulate under floors to R-19								
Case I	360	14	0.12	20	1.50	3.00	19	6
Case II	360	18	0.15	20	1.87	3.74	11	5
Insulate walls to R-13								
Case I	435	50	0.34	20	4.25	8.50	4	2
Case II	435	65	0.45	20	5.62	11.24	3	1.3
Add Storm Windows								
Case I	350	16	0.14	20	1.75	3.50	13	5
Case II	350	21	0.18	20	2.25	4.50	9	4
Add Storm Doors								
Case I	210	4	0.05	10	.44	.88	>100	25
Case II	210	5	0.07	10	.54	1.08	>100	13
Weather Strip								
Case I	180	17	0.28	5	1.20	2.40	5	2
Case II	180	22	0.37	5	1.59	3.18	4	1.7

TABLE (Continued)

<u>Improved Conventional Heating Systems</u>								
SEaled Combustion Units, oil and gas								
Case I (retrofit)	230	40	.52	10	4.0	8.0	2	1
Case II (retrofit)	250	57	.68	10	5.25	10.5	2	1
Insulate heat ducts or pipes any central heating system								
Case I	48	25	1.56	20	19.5	39.0	.7	.3
Case II	48	35	2.19	20	27.4	58.8	.5	.2
Chimney Heat Savers, older oil-fired units								
Case I	150	9	.18	10	1.39	2.78	9	3.5
Case II	150	13	.26	10	2.0	4.0	5	2
Electric Pilot Lights, gas units								
Case I	50	6	.36	10	2.78	5.56	3.5	1.6
Case II	50	6	.36	10	2.78	5.56	3.5	1.6

* Source: BUTCHER, Walter, et al., 1977, <u>Energy Conservation Policy Evaluation, Final Report to the Northwest Energy Policy Project</u>, Volume II: Detailed Report of Analyses, Portland.

Case I is a 1200 sq. ft house in W. Washington or W. Oregon, heated by natural gas or fuel oil.
Case II is a 1200 sq. ft house in E. Washington, E Oregon or Idaho heated by natural gas or fuel oil.

3.6 DISTRICT HEATING

I. Description

Residential, commercial, and industrial process space and water heat can be supplied through large scale district heating systems. In these systems, water is heated to about 165-300°F in centralized plants and distributed through a grid of buried transmission and distribution pipes. At the sites of end use, heat exchangers are used for process and space heat or the production of domestic hot water.

II. Setting and Characteristics

Space and water heating together account for 19% of the total U.S. energy demand. Each year ~ 5.8×10^{15} Btu of oil and 7.1×10^{15} Btu of natural gas are consumed in the U.S. to meet these demands. District heating, although popular in Europe, has not been implemented to any significant degree in the U.S. At present, steam electric plants produce waste heat in amounts exceeding the total U.S. space and water heating demand; some of this waste heat could be captured and used for district heating purposes. Cost estimates suggest that in urban areas retrofit application of district heating systems would be ~ $4.79/$10^6$ Btu. In comparison projected costs for newly installed coal electric systems, direct fired oil and gas furnaces are ~ $15, $4.34 and $2.72/$10^6$ Btu, respectively. Since oil and natural gas supply more than 85% of the total residential heat demand, significant savings of these fuels forms could accrue.

III. Energy Savings

Estimates prepared for DOE suggest that heat for ~ 61 million people could be economically supplied by district heating systems. The total conservation potential is 4.0×10^{15} Btu

IV. Other Benefits

- Allows cutback in net fossil fuel consumption.
- Decentralizes discharges of waste, heat, thereby reducing subsequent environmental impacts.
- Could decrease system emissions via reduction in area source emissions; more efficient supervision of discharges; higher chimney height; and, application of pollution control devices.
- Facilitates use of more expendable fuels, i.e. coal, and possibly municipal solid waste.

V. Environmental Problems

- Increased population exposures to emissions arising from proximity of new utilities in population centers.
- Possible increase in emissions if dirty fuels (e.g. coal) substitued for clean fuels (e.g. natural gas).

VI. Regulatory/Institutional Problems

- General acceptance by a large group of end users must exist or alternatively, the government must require the use of such a system.
- Additional electric capacity may be required to compensate for losses arising from cogeneration.
- Streets in existing downtown areas are already filled with similar distribution networks, i.e. electric, telephone, gas. Traffic disruption and existing networks may increase problem of putting in a district heatin grid system.
- District heating option must be instituted in fairly large blocks, thus precluding a step-wise approach that other alternatives could follow.
- Residential/commercial users are given priority use of some scarce fuels; this will delay implementation of this option.
- Overall supply is dictated by maximum capacity of the local supply facilities. Interconnection, as practiced by electric utilities, is not available.

VII. Economic Problems

- Costs increase rapidly as the housing density diminishes. Economics select against supplying district heating to single family lots over 5000 sq. ft.
- Substantial initial investment required.
- Sunk capital costs of converting some existing heating systems to district heating, e.g. electric resistance.

VIII. Social Problems

- Consumer opposition to large utilities.
- Loss of freedom by the consumer to choose a particular heating form.
- Consumer reluctance or inability to finance retrofit of end use device to replace existing heating equipment.
- Consumer acceptance of risk associated with failure of a centralized facility to provide needed heat.

IX. Other Problems

- Only applicable to existing steam electric plants in densely populated areas.

X. Resource Requirements

XI. Initiatives

- Provide government funds and loans for district heating schemes (federal).
- Mandate connection of all buildings within a given area and under certain conditions to a district heating system (state-local).

XI. Initiatives (Con't.)

- Provide local authorities with planning monopoly in connection with heating alternatives to be used in new housing construction (state-local).
- Incorporate energy planning into all planning processes (federal-state-local).

XII. References

Karkheck, J., J. Powell and E. Beardsworth, 1976 "Prospects for District Heating in the United States,"BNL 21941, Upton, NY.

Karkheck, J., E. Beardsworth and J. Powell, 1976, "Technical and Economic Aspects of Potential U.S. District Heating Systems, BNL 21287," Upton, NY.

Santini, D.J., A.A. Davis and S.M. Marden, 1978, "Costs of Urban Area Retrofit to District Heating and Cooling Systems", North-Central Cities. ANL/ICES-TM-9, Argonne, ILL.

3.7 INTEGRATED COMMUNITY ENERGY SYSTEMS (ICES)

I. Description

ICES refers to the onsite use of combined package electric power plants, smaller than conventional electric power plants, to provide communities of limited size with electricity, heating and air conditioning, and liquid and solid waste disposal. ICES can take many forms. They could, for example, employ internal combustion piston engines or gas turbines, oil, coal or solar energy, heat pumps, solid waste incineration or pyrolysis or physical-chemical or biological treatment of liquid waste. Potential markets include university campuses, medical complexes, urban renewal projects, new developments, entire downtown areas, military bases, state or local government, and commercial complexes.

II. Setting and Characteristics

Demand for multifamily housing presently represents ~55% of all new housing construction starts. Some estimates suggest that such starts will decline to 35-40% of the units by 2000. Rapidly increasing land costs for single family housing, materials costs and modifications in public attitudes, however, suggest that demand for multifamily houses will remain at higher levels.

The energy needs of multifamily units of developments ranging from ~300-5000 units can be met by ICES units. This market could consist of 280,000 to 500,000 units per year based on total construction rates of 420,000 to 750,000 units per year.

ICES to accomodate the electric energy demands of these units would have low electrical generating efficiencies ranging from ~20 to 30%. The range for conventional systems is higher, ~30-35%. The lowered ICES generating efficiencies, are however, offset by negligibly small transmission distances and losses, and by recovery of rejected heat for use in small district heating and cooling systems, resulting in high overall efficiency of fuel utilitization (∿50-55%).

III. Energy Savings

DOE estimates suggest that the ICES concept applied to new construction of university campuses, medical complexes, downtown renewal areas, new residential or commercial development could save ~1.9 x 10^{15} Btu/year by 2000. Estimates for 1985 are not readily available.

IV. Other Benefits

- Potential for substituting abundant or renewable energy sources for scarce fuels such as gas and oil.
- Reduce energy waste by more closely matching thermal and electrical energy production to community demand at given times.
- Permits development in geographically remote areas.
- Preserves open spacing by reducing land needs for services imposed by conventional utilities.
- Reduces transmission losses.
- Reduces solid waste disposal problems and thermal pollution.
- Distributes impacts directly to consumer thereby promoting equity.
- Improves operating practices of owner operated equipment.

V. Environmental Problems

- ICES emissions may degrade air quality in local areas.
- Local odor and noise problems
- Aesthetic intrusions arising from plant location and increased population density.
- Increased vehicular conjestion associated with deliveries.

VI. Regulatory/Institutional Problems

- Environmental regulations governing ICES construction and operation impose greater responsibility on the unit developer.
- Private support facilities are taxed differently than municipally owned and are not eligible for federal-state or local subsidies.
- Certain standards and restrictions in zoning and subdivision regulations could exclude some attractive ICES concepts.
- Local building codes tend to inhibit innovative design.
- ICES may be classified as a public utility and would then be regulated by State Public Service Commissions.
- ICES require more complex implementation and management mechanisms then do separate energy-supply systems.
- Difficulty of incorporating energy conservation principles into community development processes.
- ICES system compatible only with large installations staffed with adequate and competent operating personnel.
- Builders may have limited or no incentive to install ICES concept.
- Opposition to ICES by utility groups, likely to occur where installed capacity not fully utilized.
- ICES construction could increase competition between various building groups and labor unions.
- System reliability and independence may be significantly different from present utilities

VII. Economic Problems

- ICES development dictated by economy of size limitations. ICES may be economically competitive only in units above ~300 per development.

VII. Economic Problems - Continued

- Initial capital investment more costly for onsite components but balanced by reduced transmission and distributing costs.
- ICES population would pay entire cost of capital equipment plus some part of conventional utility systems costs for which they would receive no direct services.
- ICES as a private corporation would be ineligible for federal, state or local funds.

VIII. Social Problems

- Negative attitudes of individuals and interest groups toward ICES could effect acceptance.

IX. Other Problems

X. Resource Requirements

Capital Investment	\$400 to \$1200 per KW_e \$3000 to \$3800 per residential unit for full ICES (electricity, heating, cooling (domestic hot water, refuse system)
Operating Cost	\$.008 to \$.020 per KWh_e
Energy Cost	\$.02 to \$.05 per KWh_e
Capacity Factor	.40 to .60
Practical Life	15 to 25 years

Expected Annual System Efficiency	1980	1985	1990	2000
	.62	.67	.73	.80

XI. Initiatives

XII. References

National Consumer Research Institute, 1976, "Proceedings of the Energy Research and Development Administration Conference on: Cogeneration and Integrated Energy/Utility System," ANL-Conf. 770632, Argonne, ILL.

Mixon, W.P. et al., 1976, "Technology Assessment of Modular Integrated Utility Systems-Vol. 1, Summary Report", ORNL/HUD/MIUS-24, Oak Ridge Tenn.

Kennedy, A.S., et al., 1978, "Factors that Influence the Acceptance of Integrated Community Energy Systems", ANL/ICES-TM-G, Argonne, ILL.

Energy and Environmental Systems Division, 1978, "Financial Overview of Integrated Community Energy Systems", ANL/ICES-TM-5.

U.S. Department of Energy, 1978, "Integrated Community Energy Systems", DOE/CS-0037.

XIII. Tabular Materials

3.8 MODIFYING LAND USE CONFIGURATIONS AND HOUSING TYPES

I. Description

Land use plays an important role in structuring the basic patterns in which energy is consumed in many areas of the U.S. The uses to which land is put and the associated spatial arrangements can also influence the energy technologies, and production, conversion and distribution facilities which are used to provide energy to residential, commercial and industrial users. The choice of sites for household residences (this also applies to commercial and industrial facilities) in a region, size and construction type (e.g. single family attached vs. attached family unit vs. multifamily vs. high rise apartment) represent key decisions which will determine overall life-time transportation and space energy consumption requirements. The energy consequences of such decisions remain in effect for the inhabitable lifetime of the dwelling.

II. Setting and Characteristics

The United States residential and commercial building sectors consumed ∿ 10.6 and 5.9 quads of energy, respectively, in 1972 In 1970, there were approximately 68 million residential units and 22 billion square feet of commercial floor space. For 1970, Table 1 lists 5 types of residential and commercial units, a breakdown in the total number of units of each building type and their annual energy use. An energy intensity coefficient which provides a measure of the energy use per unit is also provided. The coefficient is based on the numbers presented in this table and reflects different assumptions concerning floor space, insulation, heating equipment types, etc.

III. Energy Savings

National opportunities to save energy through modifications in building types and land use configuration are difficult to make outside the context of a complete energy scenario. With increased population densities, apartment living is more common, allowing potential savings through fewer external walls, better insulation, more efficient heating systems and reduced shopping trip travel.

Shifts in new home construction from single family detached to low density, multifamily low rise and multifamily high rise can reduce space heating demands by ∿ 20, 50, and 40% respectively. Approximately 20% energy saving could further be obtained by encouraging use of malls rather then strip development. Associated reductions in travel can result in a declining rate of energy consumption of 20% for each additional increment of passenger miles travelled.

IV. Other Benefits

- Preservation of open space
- Lower demands on energy, water, sanitation and other services
- Increased opportunities for more effective utilization of waste products
- Reduction in travel deaths and injuries
- Reduced capital construction requirements

V. Environmental Problems

- Interspersion of industrial, commercial and residential land use activities, could lead to increased pollutant exposures to the general public
- Higher levels of ambient noise and congestion
- Aesthetic intrusion
- Increased health risk in the event of disasters (e.g. fire)

VI. Regulatory/Institutional Problems

- Actions taken to effect changes in use of building types and land use configurations can take years and even decades to produce significant changes
- Fragmented jurisdiction situation between authorities who make zoning decision and those responsible for siting of power plants roadways, etc. makes it difficult to formulate policy strategies directed towards producing "optimal" land use strategies
- Liklihood of achieving or bringing about wholesale changes in current land use patterns to accommodate national energy goals by direct policies of federal intervention does not seem feasible
- Regional transportation systems are considered with only minimal knowledge about long range energy consumption resulting from their adoption
- Control of land use is predominantly a local affair, determined in large part by the boundaries of political jurisdictions involved. The control of many components of energy flow falls within the decision domain of local utilities, federal agencies and other political jurisdictions
- Principal driving forces behind land use are exogenous to energy matters and include regional preferences with respect to industrial development, open space etc.
- Little incentive exists for individual regions or communities to utilize the land use planning power to reduce energy use without some sort of standards.
- Public reluctance to accept housing types other than single family detached

VII. Economic Problems

VIII. Social Problems

- Increases in land values may act to limit occupancy by certain social groups or industries
- Loss of freedom on the part of individuals to choose independent life style.
- Increased requirement for regional regulation of land use may necessitate change in legislation.
- Implementation programs may be limited to areas qualifying for redevelopment.

IX. Other

X. Resource Requirements

XI. Initiatives

- Control and regulation of public transportation and roadway network systems to limit sprawl development (Federal - State).
- Alteration of zoning regulations to permit higher density development (State - Local).
- Financing incentives cognizant of energy savings potentially offered by modified building types and land use configurations (Federal).
- Modified real estate assessments and tax levies (State - Local).

XII. References

- Donovan, Hamester and Rattien, Inc., 1978, "Environmental Effects of Energy Conservation", Washington, DC
- Carroll, U.T. et al., 1977, "Land Use and Energy Utilization - Final Report", BNL 50635, Upton, New York
- Conklin et al., 1976, "Reading the Energy Meter on Development. The Interaction of Land Use and Energy Conservation", PB-273-496, National Technical Information Service

XIII. Tabular Materials

Table 1

Residential - Commercial Energy Use In 1970

Building Type	No. of Units (X10^3)	Total Energy Use (10^{12} Btu's)	Energy Use Per Unit (Btu/unit)
Residential			
Mobile Homes	2073	209	1.01 X 10^8
Single Family Detached	44801	8567	1.91 X 10^8
Low Density	10997	1670	1.52 X 10^8
Multi-Family Low Rise	6533	589	0.92 X 10^8
Multi-Family High Rise	3295	376	1.14 X 10^8
Commercial	(10^6 sq..ft.)	(10^{12} Btu's)	(Btu/sq.-ft.)
Office	3380	617	1.82 X 10^5
Retail	4210	658	1.56 X 10^5
Schools	5040	799	1.58 X 10^5
Hospitals	1500	379	2.53 X 10^5
Others	7480	922	1.23 X 10^5

IV. INDUSTRIAL SECTOR

4.1 INTRODUCTION

In 1977, the industrial sector accounted for approximately 37 percent of the nations total energy demand, 27.8 x 10^{15} Btu. Despite a 3.6 percent increase in production, energy use declined by 0.1 percent from the 1976 level. The combination of increased industrial output with local energy consumption results largely from continued efficiency improvements. The DOE reported that in 1976 net energy efficiency in the top 10 industrial consumers (food and kindred products, textile mill products, paper and allied products, chemicals and allied products, petroleum and coal products, stone, clay and glass products, primary metals, fabricated metals, machinery except electrical equipment and transportation equipment) was running 3 percent above the 1972 base level. An estimate of the first half of 1977 shows continued progress; energy efficiency for the year is projected to be about 9.3 percent above the 1972 base level. The annual savings yielded by the improvement amount to about 1.4 x 10^{15} Btu, which is the equivalent of 7 percent of the U.S. current level of gas consumption, 11 percent of coal use, 44 percent of hydropower and geothermal demand, or 88 percent of nuclear power generation.

Presented below are industrial energy demands and by activity types and fuels consumed in 1972.

Industrial Energy Demand and Fuels Consumed in 1972 (10^{15} Btu)

	Natural Gas	Oil	Coal	Nuclear	Hydro	Electric	Methane	Total Direct Use
INDUSTRIAL:								
Aluminum			.082			.242	.050	.374
Cement		.077	.192			.036	.230	.535
Iron and Steel		.177	2.025			.139	.679	3.020
Proc. Heat		1.365	1.266				7.545	10.176
Elec. Drive						2.155		2.155
Elec. Generation		.414	.330				.366	1.110
Feedstocks		3.389	.127				.674	4.190
SUBTOTAL		5.422	4.022			2.572	9.544	21.560

4.2 WASTES AS FUEL TO CEMENT KILNS

I. Description

Hydraulic cement is a powder made by burning lime, silica, alumina, iron and magnesia together in a kiln and then pulverizing the product. It reacts with water to bond rock or sand and gravel into concrete. During 1973, 139 x 10^6 tons of raw materials were used to manufacture 85 x 10^6 tons of cement; i.e., 1.6 tons of raw materials are needed to produce 1 ton of cement. Weight is lost during calcination in the kiln when moisture, carbon dioxide and other gases are driven off. There are four steps in the processing of raw materials into finished cement: crushing, grinding, clinkering, and finish grinding. In the dry process raw materials are dried before being ground and blended; in the wet process, water is added to the raw materials, which are then ground wet. In the clinkering step, the accurately controlled mixture of raw materials reacts chemically at high temperatures in the kiln to produce clinker, which is subsequently ground into cement.

The kiln is the heart of the cement plant: at least 80% of the energy used in cement manufacture is consumed in the kiln for heat. Substantial energy can be saved if fuel produced by converting solid waste (RDF) is used in conjunction with conventional fuels (co-firing). The fuel production facility essentially consists of a shredder where the raw refuse is converted to a relatively homogenous mixture, with uniform size, heating value and moisture content. The RDF is then transferred to the cement manufacturing plant where it is fed to the kiln. Cofiring with 20%, 30%, and 40% RDF and gas has been tried.

II. Setting and Characteristics

In 1974, 53 companies in 41 states and Puerto Rico produced more than 79 million short tons of cement, which brought about $2.1 billion in net sales. Of all the hydraulic cement products shipped, more than 90% was portland cement; the remainder was masonry, natural, or pozyolanic cement.

In 1974, the U.S. hydraulic cement industry consumed more than 490 x 10^{12} Btu of fossil fuels and about 11 x 10^9 Kwh of electricity, which is about 1% of all energy used in the U.S. A wet process concrete plant consumes 5.5 to 6.0 MM Btu/ton of finished product. Energy is one of the biggest costs in the manufacture of cement, accounting for 25 to 38% of the selling price for concrete. The trend in energy consumption for the cement industry between 1972 and 1976 has been away from natural gas and towards coal as the primary fuel type. Natural gas dropped from 45% to 32% of total energy consumption, and coal increased from 36% to 57%. Oil demand has dropped only marginally from 12% to 10%. The bulk of the oil used is bunker & crude oil for kilns in 6 plants, which consume about 118,000 BBL/day of crude oil. Data for the entire industry is:

Fuel Type	No. of Plants	% of Total Capacity
Coal	44	29
Coal/gas	41	23
Coal/oil/gas	23	17
Oil/gas	18	13
Coal/oil	16	13
Gas	10	3
Oil	6	2
	158	100

Source: BNL, 1978.

III. Energy Savings

Co-firing RDF with gas in the three trial burns produced 8500 tons of cement and saved approximately 12 million ft^3 of gas, which at 30% RDF is approximately a 28% savings. The fuel savings depend on the moisture content of the RDF, which can vary. The clinker produced in these trial burns was of good quality. Total saving < 0.01 x 10^{15} Btu.

IV. Other Benefits

A 72 hour trial burn using 30% RDF consumed 455.7 tons of RDF, thus saving the corresponding amount of land used for landfill.

V. Environmental Problems

- Problems associated with front-end garbage processing operations.

- Apparent increase in particulate emissions. When firing 20% RDF, there was an increase in emissions of 25% over natural gas alone; at 30% RDF there was a 20% increase, at 40% RDF a 50% increase. Even with such increases, the particulate levels did not exceed existing standards.

VI. Regulatory/Institutional Problems

- Strength and quality of cement produced using RDF must meet industry standards.

- Plants must be located in areas of sufficient population density.

VII. Economic Problems

VIII. Social Problems

IX. Other Problems

X. Resource Requiarements

- Cost for adapting existing plants to accept and feed RDF.

XI. Initiatives

- Removal of legal and political constraints at municipal level (state-local).

- Economic incentive to industry to make necessary capital investments (Federal-state).

XII. References

BNL, 1978, "Emergency Energy Conservation Program," Upton, N.Y.

Environcon, Ltd., 1976, "Solid Waste for Industrial Fuel".

Industrial Environmental Research Laboratory, 1976 "Environmental Considerations of Selected Energy Conserving Manufacturing Process Options: Vol. X Cement Industry", Washington, D.C.

Jones, James R., 1977, "Co-Firing RDF and Natural Gas in a Cement Kiln", Progress Report for ERDA, May 1, 1975 - Aug. 31, 1977.

XIII. Tabular Materials

4.3 COAL-FIRED REMELT OF RECYCLED ALUMINUM

I. Description

The main processing method used in the secondary aluminum industry is reverberatory (reverb) melting of aluminum scrap. The reverb furnaces are either gas-fired or have duel firing (gas and oil) capability.[1] The switch to use of coal-fired reverb furnaces would not reduce total energy consumption, but would reduce dependence of the industry on oil and natural gas.

II. Setting and Characteristics

Recovery of aluminum from scrap over the past ten years has been about 23 percent of domestic ingot supply. In 1977, domestic supply of aluminum was about 4.54 million tons from primary production and 1.56 million tons from secondary recovery.[2] About 55 percent, or 840,000 tons of aluminum scrap was processed in secondary smelters.

Reverb furnaces fired with natural gas or oil are used in the melting process. A typical charge to the furnace consists of 35% virgin aluminum and 65% scrap.[3]

There exists potential for use of coal-fired furnaces in the aluminum remelting process. DOE has called for the testing of a prototype facility by August 1979. First commercialization of the technology, however, would not come until after 1981.[4]

III. Energy Savings

About 15 x 10^{12} Btu of natural gas and oil was consumed in 1977 in the secondary aluminum remelting processes.[5] It is uncertain to predict to what extent coal will replace natural gas and oil in the remelting processes.

IV. Other Benefits

V. Environmental Problems

Potential for particulates and sulfur oxide pollutants in proportion to the ash and sulfur content of the coal used.

Disposal of fly ash and slag. Both can be expected to contain a wide variety of trace toxic materials from the coal and will therefore require special control in handling and disposal.

Land use for storage of coal and solid wastes/

VI. Institutional/Regulatory Problems

Federal, state and local pollution control requirements must be satisfied.

VII. Economic Problems

VIII. Social Problems

IX. Other Problems

X. Resource Requirements

Pilot projects are required to test the feasibility of the technology.

Costs associated with conversion from existing gas-fired furnaces to coal-fired furnaces.

XI. Initiatives

DOE has called for bids for the testing of a prototype coal-fired aluminum melting furnace by August 1979.

The rising costs and shortage of natural gas and oil will be the biggest incentive for industrial users to switch to use of coal.

XII. References

1. A.D. Little, Inc., 1978, "Energy Use Patterns for Metal Recycling", report prepared for Bureau of Mines, NTIS-PB-284-855.

2. The Aluminum Association, 1977, "

3. A.D. Little, Inc., note 1, supra, page 27.

4. DOE, "Environmental Development Plan, Industrial Energy Conservation FY 1977", Report No. DOE/EDP-0019.

5. About 12 x 10^6 Btu of energy per ton of product was consumed in the furnace melting of aluminum scrap to alloy 380 ingots (A.D. Little, note 1, supra, page 26). Thus total annual energy use = 12 x $10^6 \frac{\text{BTU}}{\text{Ton}}$ x 840,000 tons x $\frac{1.00}{0.65}$ = 15 x 10^{12} Btu.

XIII. Tabular Materials

4.4 COGENERATION

I. Description

Cogeneration is the joint production of electrical or mechanical power and useful thermal energy from the same primary energy source. Extraction steam turbines, gas turbines and diesel engines are the principal technologies used to jointly produce electricity and process steam. Because of the high steam production to electricity production ratios, steam turbines have historically constituted the majority of the cogeneration systems installed. In this system, high pressure steam is generated in a boiler and expanded through a turbine; extracted low pressure steam is used for industrial process heating needs. In comparison, gas turbines and diesel engines drive electrical generators directly and waste heat is recovered from the exhaust and cooling jacket for process heat needs.

II. Setting and Characteristics

The industrial sector consumed approximately 22 x 10^{15} Btu of energy in 1972. Approximately 25% of the primary energy used by the industrial sector is rejected as waste heat, while about 67% of the energy consumed to produce electricity is dissipated to cooling waters or the atmosphere. In 1975, waste heat from these sources was equivalent to more than 13 x 10^{14} Btu per year which was comparable to the average U.S. oil-import rate. In the industrial sector nearly 45% of the energy consumed is used for steam generation, while ∿ 29% is used for fueling process heat needs. Approximately 60% of the industrial energy needs are supplied by natural gas and petroleum fuels. According to the President's National Energy Plan, cogeneration supplied 15% of the U.S. industrial energy needs as recently as 1950, but contributed only 4% by 1977.

III. Energy Savings

DOE estimates the energy conservation potential of cogeneration to be 0.9 x 10^{15} Btu per year by 1985 and 2.5 x 10^{15} Btu per year by 2000. DOW Chemical Co. estimates that by 1985, U.S. industry might supply 50% of its electricity needs by cogeneration which would save the energy equivalent of approximately 4.3 - 6.2 x 10^{15} Btu per year.

IV. Other Benefits

- 5-30% reduction in fuel use compared with independent generation of electric and process heat.
- Net reduction in capital expenditures for electric power plants by 1985 of about $9 to $25 billion.
- Total pollution emissions reduced proportional to fuel saved (i.e. 5-30%).
- Planning and construction time reduced to 1 to 2 years for retrofit of cogenerating units (compared to about 10 years for centralized electricity plants).
- Overall costs of electricity production reduced.

V. Environmental Problems

- Possible increase in NO_x, particulate and hydrocarbon emissions at cogeneration site.

VI. Regulatory/Insititutional Problems

- Lack of regulatory criteria which recognize reduced system pollutant emissions and fuel savings at the cost of increase emissions at the cognerating site.
- Present regulations in many areas to prohibit industry sales of electricity.
- Need to match time-dependent demands for electricity and steam production.
- Equitable costs for utility standby power and purchasing price of steam by industries or electric by utilities must be established.
- Elimination of possible regulation of electricity rates and firms engaged in cogeneration.
- Minimizing differences in industry and utility planning horizons and need for long term agreements.
- Matching reliability requirements for both industry and utilities.

VII. Economic Problems

Raising additional capital to install cogenerating units.

VIII. Social Problems

IX. Other Problems

X. Resources

- Operation and maintenance costs are ∿ 3 mills/KWH

XI. Initiatives

XII. References

1. Resources Planning Associates 1977, "The Potential for Cogeneration Development in Six Major Industries by 1985", Washington, DC.

2. Thermo Electron Corporation 1976, "Study of Inplant Electric Power Generation in the Chemical, Petroleum Refining and Pulp and Paper Industries," Waltham, Massachusetts.

3. E. Edelson 1978, "Analyses of the Major Insitutional Constraints for Implementing Industrial Cogeneration in California", in T. Nejat Veziroglu, Editor, Solar Energy & Conservation Symposium Workshop, University at Miami, Florida.

4. DOE, 1978, "Environmental Readiness Document-Cogeneration," Washington, DC.

5. L. Icerman and D. M. Staples, 1979, "Industrial Cogeneration: Problems and Promise,"

XII. References (Cont.)

Energy, Vol. 4, pp. 101-118.

XIII. Tabular Materials

4.5 WASTE PRODUCT UTILIZATION

I. Description

Energy and materials can be recovered from residential-commercial solid wastes and sewage sludge by:

1) mechanical separation
2) incineration
3) co-combustion of RDF (refuse-derived fuel) and coal or oil
4) pyrolysis
5) bio-conversion

The end products are usually steam or electricity and recovered materials, e.g. iron, glass, and/or aluminum. Other methods include composting, hog fuel boilers (wood waste), and advanced combustion systems.

II. Setting and Characteristics

The present rate of waste generation in the U.S. is over 1300 lbs. per person per year; less than 7% of the total waste is presently recovered. In 1976 the cost for collection and disposal was $30/ton. By 1985 it is estimated that 200 million tons of urban waste will be generated per year. Of this, 60%-70% is in large cities and thus available for recovery. This represents approximately 1.0 x 10^{15} Btus per year. Shredded refuse has a heat value of 4000-7000 Btu/lb compared to 12,000 - 13,000 Btu/lb for coal. Different processes recover fuel at 20%-80% efficiency. As of mid-1976, there was 21 operational resource-recovery plants (many of them pilot or demonstration projects), 10 under construction or in final stages of contract negotiation or procurement, 33 in "advanced planning", and 54 localities at the early stages of having commissioned feasibility studies.

III. Energy Savings

DOE goal is to recover 0.33 x 10^{15} Btu/year by 1985 and 2 x 10^{15} Btu/year by 2000.

IV. Other Benefits

EPA estimates that 25% of total discards could be recycled, compared to about 6% to 7% currently. From 1985 projections of 200 million tons, this could yield 45 to 50 million tons of paper, metals, glass and rubber.

Materials and energy recovery reduces waste to 25% of original weight, or 10% by volume, thus reducing landfill requirements and associated problems.

Sulfur emissions from co-combustion are lower than for coal alone.

Hydrocarbon, CO, and NO_x emissions may be less from co-combustion than from coal alone.

V. Environmental Problems

- Higher lead and other trace elements than coal.
- High chloride emissions.
- Unknown potential for toxic leachates in waste process residuals.
- Incomplete characterization of potential water pollution.
- Health effects of certain emissions are not well understood.
- Workers exposed to dust, noise, toxic and hazardous chemicals, and pathogens.

VI. Regulatory/Institutional Problems

- Standards for many emissions are subject to change or do not exist.
- Need for tax or other economic credit.
- Municipalities may lack legal authority to finance certain long-term projects.
- Lack of market and/or market instability for recovered materials.
- Variable heat content of waste over time

VII. Economic Problems

VIII. Social Problems

- Local resistance to facility siting.

IX. Other Problems

X. Resource Requirements

- 40-60 employees required to operate a 1000 ton/day recovery plant.
- Capital investment estimates range from $5,000 to $50,000 per ton of daily processing depending on type of process, plant size, etc.
- Operating costs $10-15/ton for combustion-incinerations, with no energy or dumping revenue.

XI. Initiatives

- EPA is currently investigating the concept of 'product charge', an excise tax which would reflect the actual cost of disposal on a per product basis and credit the use of recycled materials (Federal).
- Federal government sponsorship of research, development and demonstration of various technologies (Federal).
- Financing. (Federal-State).
- Market development for end products and recovered materials (Federal-State).
- Lack of available landfill space (State-Local).

XII. References

U.S. Environmental Protection Agency, 1977, Office of Solid Waste Management Programs, "Resource Recovery and Waste Reduction; fourth report to Congress".

2. DOE, 1978, "Environmental Development Plan-Buildings and Community Systems".

3. DOE, 1978, "Environmental Readiness Document-Urban Waste Energy Recovery".

4. Midwest Research Institute, 1977, "Environmental Assessment of Waste-to-Energy Processed Source Assessment Document", U.S. Environmental Protection Agency.

XIII. Tabular Materials

4.6 PULP AND PAPER INDUSTRY

I. Description

A number of energy conservation options exist in the pulp and paper industry. These include the following:

- Energy conservation as a result policing or "housekeeping";
- Increased use of on-site power generation and "total energy" system techniques;
- Better waste heat utilization;
- Steam generation by alternative fuels; (e.g., use of coal in place of oil or gas)
- Air drying and vapor recompression;
- Alkaline-oxygen pulping;
- Deinking of old newsprint;
- The Rapson Kraft pulping process;
- Hydropyrolysis of black liquor from Kraft pulping process;
- Basic Extractive Sludge Treatment (B.E.S.T.) process.

In this mini-assessment, we will limit our discussions to the last four options which have been found to be most significant in terms of energy savings.[1]

II. Setting and Characteristics

- The manufacture of paper is a two-stage process: pulp-making and paper making.[2] Basic types of chemical pulp-making are Kraft (alkaline sulfate), sulfite, and semi-chemical. In these, wood chips are digested in hot chemical solutions to remove part or most of the lignin which binds the wood fibers together. In mechanical pulp-making, a suspension of pulp is spread onto a porous surface which allows the water to drain and a mat of fibers to form. For pulp drying, the mat is lightly compacted by rolls and usually dried by hot air while suspended on a porous belt.

- The Paper and Allied Products industry group ranks among the top five energy consumers in all U.S. manufacturing categories.[3] Total energy consumed by this industry was 2.15 x 10^{15} Btu in 1972. Note that about 40 percent of the total energy was derived from the combustion of wood wastes and spent pulping liquors, the largest single source of fuel. The other major fuel sources were fuel oils (0.47 x 10^{15} Btu), natural gas (0.45 x 10^{15} Btu), and coal (0.25 x 10^{15} Btu).

- Pulp production from old newsprint: The deinking of old newspaper for newsprint manufacture is a well established commercial practice. It was chosen for analysis because the production of newsprint containing deinked news now accounts for less than 5% of total newsprint consumed in the U.S., and its broader application could significantly affect the energy and environment systems. There are currently four U.S. mills making newsprint entirely from deinked news, with total capacity in excess of 450,000 tons per year. On a smaller scale, a number of mills produce newsprint by blending recycled fiber with virgin mechanical fiber. The pulping process of old newsprint consists of two steps: a) washing, i.e., separation of the ink particles and b) thickening of the aqueous slurry to increase the concentration of the fibers in the slurry. The resultant deinked fiber then goes to the paper making operation, where it is treated much like conventional virgin fiber.

- Rapson Kraft pulping process: The Rapson process involves a number of changes in the conventional kraft pulping process to eliminate effluents. These changes include partial replacement of chlorine by chlorine dioxide in the first stage chlorination step, counter current washing in the beach plant, reuse of all beach-plant effluents, etc. The Great Lakes Paper Co. has built a Rapson-type plant at Thunder Bay, Ontario which has performed well.

- Hydropyrolysis of black liquor from Kraft Pulping: About 35% of the total energy used by the industry is obtained by burning waste liquors from paper pulping processes. Since about 70% of the total production of pulp is by the Kraft process, increasing the energy recovered from black liquor (the waste liquid remaining after wood has been chemically dissolved and the pulp removed) burned in the Kraft process could yield significant energy savings.[4] The hydropyrolysis process developed by St. Regis Paper Company in Pensacola, Florida is one of several new technology systems for energy and chemical recovery of black liquor. In the hydropyrolysis process, black liquor is heated under pressure and in the absence of added oxygen to a temperature sufficient to decompose the organics to a carbonacious char and a gas containing hydrocarbons, hydrogen and organic sulfur compounds.[5]

- The B.E.S.T. Process: The pulp and paper industry treats large quantities of waste water and generates large volumes of sludge, with resulting high demands for energy The B.E.S.T. process, developed by Resource Conservation Co., in Washington, could reduce by 50% the required energy in sludge drying. The process essentially uses a solvent to dewater sludge, with the resultant product to be used as fuel. The current conventional pull mill sludge disposal practice is mixing damp sludge with wood chips and burning the resulting mixture in incinerators or boilers.[6] Pilot plant scale development work on the B.E.S.T. system was carried out in 1978.

III. Energy Savings[7]

Extimates for energy savings potential of various processes are given as follows (in 10^{12} Btu)

	1985	2000
Pulp production from old newsprint	5	14
Rapson pulping	10	80
Hydropyrolysis	40	324
B.E.S.T.	5	30
All four processes	60	448

IV. Other Benefits

- Recycle of old newsprint by the pulp and paper industry helps conserve forestry resource and reduce the quantity of municipal solid waste.

- The Rapson process eliminates the BOD, suspended solid, and color that characterize effluents from the chlorine/caustic bleaching system used with conventional kraft process. In addition, investment and operating costs are estimated to be slightly lower for the Rapson process.

V. Environmental Problems

- The raw waste loads for suspended solids and colorings are significantly higher for deinked pulp than for the virgin pulps. However, the industry reports no major problem in complying with water effluent control regulations.

- Possible air emission effects due to high concentrations of ash and nitrogen in the B.E.S.T. dried sludge.

VI. Regulatory/Institutional Problems

VII. Economic Problems

VIII. Social Problems

IX. Other Problems

The constraint in broader application of reuse of old newsprint by the pulp and paper industry is the number of metropolitan locations with sufficient volumes of old newsprint.

X. Resource Requirements

Demonstration projects are needed to help commercialize newly-developed processes, such as Rapson, Hydropyrolysis, and B.E.S.T.

XI. Initiatives

DOE has sponsored a pilot plant project for the B.E.S.T. process.

XII. References

1. Much of this technology assessment has been based on information from a U.S. EPA report, namely, "Environmental considerations of selected energy conserving manufacturing process options: Vol. V. Pulp and Paper Industry Report", EPA-600/7-76-034e, December 1976.
2. S. Kaplan, "Energy Use and Distribution in the Pulp, Paper, and Boardmaking Industries:, Oak Ridge National Lab report ORNL/TM-5884, August 1977.
3. Ibid., Page 5.
4. Fred Vaslow, "More efficient energy recovery from waste liquor", Argone National Laboratory, September 1977.
5. "St. Regis Hydropyrolysis Process" paper presented by R. L. Myers and R. L. Miller at a Forum on Kraft Recovery Alternation held at Appleton, Wisconsin, April 1976, sponsored jointly by the Pulp and Paper Research Institute of Canada and the Institute of Paper Chemistry.
6. Hams H. Peters, "Demonstration of a New Energy Saving Pulp and Paper Industry Sludge Disposal System", August 1978, Resources Conservation Co.
7. Assumptions for energy saving estimates:

a) Pulping of old newsprint

- Purchased energy saved is 8.10^6 Btu/ air dry ton
- In 1975, about 600,000 tons of pulp was produced by using old newsprint. Productions for 1985 and 2000 are estimated respectively at 1,200,000 tons and 2,400,000 tons.

b) Rapson pulping process

- Purchased energy saved is 5.3 x 10^6 Btu/ADT
- Kraft pulp production was 34 million tons in 1977
- 2% annual growth rate of pulp production
- 2% decay rate of Kraft pulp mills
- Rapson pulping mills will replace 50% of retired Kraft pulping mills, after 1982

c) Hydropyrolysis

- Heating value of black liquor liquid equals 20 x 10^6 Btu/ton of unbleached pulp
- Recovery of energy from black liquor using conventional processes, is 8 x 10^6 Btu/ton
- Recovery of energy from black liquor using hydropyrolysis is 10 x 10^6 Btu/ton of pulp
- For every ton of dry pulp produced, about 10 tons of black liquor is generated
- Kraft pulp production was 34 x 10^6 tons in 1977. Annual growth rate of 2% consumed thereafter
- Market penetration of hydropyrolysis being 5% and 30% of black liquor in 1985 and 2000 respectively.

d) B.E.S.T. process

- Resource Conservation Company estimated that if the process is used industry-wide, annual energy savings could be up to 6.3 million barrels of oil (about 36 x 10^{12} Btu). We assume that annual growth rate of pulp and paper sludge to be 2% and that B.E.S.T. process would handle 10% and 50% of total sludge generated respectively in 1985 and 2000.

XIII. Tabular Materials

4.7 CUPOLA FURNACE MODIFICATION[1]

I. Description

A cupola is a vertical, cylindrical furnace used in the production of iron for casting. The furnace emits carbon monoxide which is usually removed by combusting it in a natural gas-fired incinerator. Modification of the cupola furnace would eliminate the natural gas-fired incineration step, thus saving natural gas.

II. Settings and Characteristics

Iron foundries include establishments engaged in manufacturing iron castings. There are over 1400 iron foundries in the country. Well over half of the number and output of iron foundries is located in the Great Lakes region, as well as in California, Texas and Alabama. The major metallic raw material is ferrous scrap, which is combined with pig iron, ferra alloys, and fluxes, and are melted in cupola furnaces or electric furnaces. About 75 percent of the iron is melted in cupolas.[2]

The cupola consists of a shaft furnace lined with refractory bricks. A fuel, usually coke, is used to melt the iron, and a flux is added to slag the ash and impurities. Melted iron is conveyed to sand molds for castings. The gas rising from the combustion zone contains approximately 12 percent carbon monoxide. In addition, particulate matter consisting of ash and unburned carbon is also present. The flue gas is conveyed to a heating zone where it's temperature is raised by burning natural gas to oxidize the remaining carbon monoxide to carbon dioxide.

Under a DOE-sponsored pilot-plant project, a modification of the cupola is being studied whereby the carbon monoxide will be oxidized by raising the flue gas temperature to 1600°F with hot air blowing into the cupola below the charging door. In effect, the charging area will act as an afterburner acting as a natural incinerator.

III. Energy Savings

Use of energy in the production of iron castings is about 15×10^6 Btu per ton of shipment. Based on shipments of 8.77×10^6 tons for the iron castings in 1972, total energy use was about 0.14×10^{15} Btu.

About 5.0×10^{12} Btu of natural gas is used in environmental control in iron foundries produced. Assuming that respectively 10% and 50% of current iron castings production will come from modified cupolas, annual savings in natural gas will be approximately 0.5×10^{12} Btu in 1985 and 2.5×10^{12} Btu in 2000.[3]

IV. Other Benefits

- Reduction in carbon monoxide flue gas emissions; 1.5 percent of CO for the modified cupola compared with 4 percent of CO for the existing cupola. This should facilitate compliance with EPA air regulations.
- Reduction in coke usage.

V. Environmental Problems

- Effects on NO_x and particulate matter emissions are unknown. Stack gas will also need to be monitored to determine any increase in the level of carcinogens.
- Additional noise will be generated by a blower used to circulate the oxidizing hot air.

VI. Regulatory/Institutional Problems

VII. Economic Problems

- Capital requirements to cupola modification will cost approximately \$100,000 per \$5 million previously invested. Estimates suggest that these costs could be recovered in several years.

VIII. Social Problems

IX. Other Problems

X. Resource Requirements

- The concentrations of particulates, SO_x, CO, NO_x and HC in the flue gas need to be quantified under representative operating conditions.

XI. Initiatives

XII. References

1. Information on this topic can be found in ERDA, "Environmental Development Plan (EDP), Industrial Energy Conservation. FY 1978", September 1977.

2. Battelle Columbus Laboratory, "Draft Target Report on Developments and Establishment of Energy Efficiency Improvement Targets for Primary Metal Industries; SIC 33-Volume I" Report to FEA, August 1976.

3. About 0.5 x 10^6 Btu of natural gas per ton of product is used in environmental control in cupola furnaces.

XIII. Tabular Materials

V. TRANSPORTATION

5.1 INTRODUCTION

In 1977, transportation energy use was 19.9 x 10^{15} Btu, 3.1 percent more than in 1976. Energy use within the transportation sector by vehicle type is shown below. Transportation relies on petroleum to meet its energy demand and the highway mode is almost exclusively dependent on petroleum. In 1973-1974, the energy use trend in transportation showed marked variability. It declined absolutely in 1974 and barely rose in 1975. Not only was petroleum in short supply during the 1973-1974 oil embargo, but prices also jumped. Simultaneously, real incomes and real GNP declined, reinforcing the negative impact of increased prices. Additional impetus for reducing energy consumption came from government policies and programs including 55 miles per hour speed limits; encouragement to carpool and use public transit. An important measure whose impact is only beginning to be realized is the Energy Policy and Conservation Act of 1975 which set minimum fuel economy standards for 1978 cars.

Summary of Transportation Energy Demand by Activity

and Fuels Consumed in 1972

(10^{15} Btu)

	Natural Gas	Oil	Coal	Nuclear	Hydro	Electric	Methane	Total Direct Use
TRANSPORTATION:								
Automotive		9.121						9.121
Bus		.125						.125
Truck		3.668						3.668
Rail + Subway		.597				.018		.615
Air		2.201						2.201
Ship		.713						.713
TOTAL		16.425				.018		16.443

5.2 SMALLER CARS

I. Description

Small cars generally consume less fuel than large cars. Increasing the market share of sales of compact and sub-compact motor vehicles is an important way to reduce energy consumption in the automobile sector.

II. Settings and Characteristics

- Small cars tend to use less fuel for many reasons, including less weight (less vehicle weight and low passenger load), manual versus automatic transmission, fewer power options, less acceleration capability, smaller frontal areas (less aerodynamic drag), etc.
- Use of energy by the automobile transportation sector accounts for 13% of total energy consumption in the U.S. in 1972 or 9.1 x 10^{15} Btu. Increased use of small cars could reduce gasoline consumption in the transportation sector
- Fuel economy of a small car can be as high as over 40 m.p.g., whereas m.p.g.'s of larger cars are usually in the teens.
- An automobile can be classified as small, medium, or large depending on its weight being in the range of under 3050 lbs., between 3050-3500 lbs., or over 3500 lbs. respectively.
- Shares of new car sales in 1973 were 24.5%, 41.6%, and 33.8% respectively for small, medium, and large cars.[1]
- The Energy Policy and Conservation Act of 1975 (EPCA) requires that beginning in 1978 the average fuel economy of each car manufacture's new car fleet meet the minimum fuel economy standards.[2] The standards for 1978-1985 start at 18 m.p.g. and gradually increase to 27.5 m.p.g. by 1985. Increase in sales of smaller cars in an important strategy for car manufacturers to comply with the requirements.

III. Energy Savings

- Savings in gasoline consumption

The EPCA fuel economy standard requirements are estimated to result in a total savings in automobile gasoline consumption of 3.5 x 10^{15} Btu in 1985 and 6.3 x 10^{15} Btu in 2000.[3] If we assume that three-fifths of the savings will be achieved through smaller car sale option, this will amount to 2.1 x 10^{15} Btu for 1985 and 3.8 x 10^{15} Btu for 2000.

- Reduction in energy requirements to produce a car

Almost 100 x 10^6 Btu of energy are required to produce a typical 3,600-lb. American car.[4] (Most of the energy requirements are in the mining and processing of steel and iron). If the average car's weight is reduced from 3,600 lbs. to 2,500 lbs., a production energy savings of 25 x 10^6 Btu/car is expected. If annual automobile production rate is 10 million cars/year, annual energy savings will be 2.5 x 10^{14} Btu.

IV. Other Benefits

The reduction in automobile gasoline consumption will result in reduction in auto air pollutant emissions. Emission reduction in 1985 is estimated to be 16% of total emissions from the automobile transportation sector in the same year.

V. Environmental Problems

- Increase in traffic deaths and injuries.

Smaller cars do not offer as much protection for passengers in the event of car accidents as larger cars do. Contributors to this inherent deficiency include:[5]

- Less weight and mass which, according to laws of physics, serves to protect the passengers .
- Less exterior space with which to absorb impacts.
- Less interior space in which occupants can sustain the force of deceleration.

A study done for U.S. Department of Transportation found that a doubling of the market share of compacts and subcompacts could increase the average facility risk for occupants of all cars in 1985 by as much as 15 percent.[6] There is a need to improve designs in small cars for more protection capacity (e.g. maximum padding and minimum protruding objects inside the car).[7]

VI. Regulatory/Insitutional Problems

- Need to review federal automotive safety standards applicable to small cars to insure proper protection for passengers.
- Car manufactuers view shift to small cars as a threat to their profitability (profits per unit have typically been greater for larger cars).

VII. Economic Problems

- Effect on the steel industry

The annual statistical report for the steel industry indicates that the motor vehicle industry uses 21 percent of all steel production[8] (45 percent of all cold rolled sheet steel produced, and over 30 percent of other sheet and strip products). Increased use of smaller cars could result in reduction of about one-fourth of current steel requirements by the automotive industry, i.e. a 5 percent reduction in steel production by the steel industry.

VIII. Social Problems

Many American motorists have been accustomed to the comforts and conveniences which are available only in larger cars (e.g., spacious interior, fast acceleration, less vibration, etc.)

IX. Other Problems

X. Resource Requirements

Car manufacturers need capital to redesign cars and production plants.

Increased aluminum required, as well as plastics.

XI. Initiatives

- Major incentive is the Federal EPCA fuel economy standard requirements mentioned above. In addition, the rising cost of gasoline has induced many car buyers to turn to smaller cars (Federal).
- Increase in state taxes on gasoline sales (State).
- Increases in annual registration fees for large sized cars (State).

XII. References

1. U.S. Dept. of Transportation, Transportation Systems Center, draft, "Preliminary Base Period Fleet Projections for Fuel Economy Improvement Program - Motor Vehicle Goals Beyond 1980".

2. USEPA, Office of Air and Waste Management, 1978, "Fact Sheet, Automobile Fuel Economy".

3. Assuming that:

- Average fuel economies of automobile fleet in the years 1975, 1985, and 2000 are 13.5 m.p.g., 19.0 m.p.g., and 27.5 m.p.g. respectively.
- Energy content of gasoline is 125,000 Btu per gallon.
- Average annual mileage of a car is 10,000 miles/year then, compared with the base year 1975, reduction in gasoline consumption in automobile transportation will be 27 x 10^6 Btu/Vehicle/Year for 1985, and 47 x 10^6 Btu/Vehicle/Year for 2000.
- Assuming further that there will be 116 million cars and 135 million cars on the road in 1985 and in 2000, total savings in gasoline consumption due to the EPCA fuel economy requirements will be:

Year 1985: 27 x 10^6 Btu/vehicle x 116 x 10^6 vehicle = 3.1 x 10^{15} Btu

Year 2000: 47 x 10^6 Btu/vehicle x 135 x 10^6 vehicle = 6.3 x 10^{15} Btu

4. J. Tien, et. al., 1975, "Reducing the Energy Investment in Automobiles", article in Technology Review, M.I.T.

5. Donovan, Hamester & Ratien Inc., 1978, "Environmental Effects of Energy Conservation", report prepared for DOE.

6. Center for the Environment & Man Inc., 1977, "Analysis of the Future Effects of Fuel Shortage & Increased Small Car Usage upon Traffic Deaths & Injuries", NTIS-PB-251-892.

7. *Ibid*.

8. For a good description of use of steel by the automotive industry, see for example, "Industrial and Economic Impacts of Improving Automobile Fuel Efficiency" Urban Institute, prepared for National Science Foundation, April 1976, NTIS-PB-253-448.

XIII. Tabular Materials

5.3 VEHICLE DESIGN CHANGES

I. Description

Vehicle design changes to increase the fuel economy of automobiles include:

- Design changes[1] in the engine (e.g., reduction of vehicle power/weight ratio, varying the compression ration, improving carburetion, reducing internal friction, eliminating idling, etc.), transmission, rear axle, tires, etc.
- Reduce energy loss from aerodynamic drag, friction and accessory use.
- Reduce vehicle weight by use of lightweight materials.

II. Setting and Characteristics

The Energy Policy and Conservation Act (ESPA) of the 1975 requires that, beginning in 1978, the average fuel economy of each car manufacturer's new car fleet meet the minimum fuel economy standards. The standards for 1978-1985 start at 18 m.p.h. for 1978 and gradually increase to 27.5 m.p.g. by 1985. Vehicle design changes play an important role in meeting the standards.

Auto engines operate at efficiencies from about 10% to 30%, depending primarily on factors such as air-fuel ratio, compression ratio, engine load-factor, engine speed, spark timing.[2] There exists potential for improving engine efficiency by design changes in the engine.

The average weight of automobiles in the U.S. is about 3,600 lbs., including 2,550 lbs. of steel, 520 lbs. of cast iron, 84 lbs. of aluminum, and 100 lbs. of plastics.[3] The recent trend in the car manufacturing industry has been to increase the use of aluminum, plastic, and high-strength low alloy steel (HSLA) to increase steel and iron, thus reducing automobile weight. It is estimated that use of aluminum and plastics in a car will increase to 200 lbs. of aluminum and 300 lbs. of plastics by 1980.[4,5] A pound of aluminum material could replace 2 pounds of steel, whereas a pound of plastics replaces 2.5 pounds of steel.[6] Thus the weight of a car could be reduced by about 415 lbs. by extensive use of aluminum and plastics.

III. Energy Savings

Savings in energy consumption

The EPCA fuel economy standard requirements have been estimated to result in a total savings in automobile gasoline consumption of 3.1×10^{15} Btu in 1985 and 6.3×10^{15} Btu in 2000.[7] Assuming that two-fifths of the savings-minus savings due to introduction of diesel engine vehicles--will be achieved through vehicle design changes, this will be savings of 0.9×10^{15} Btu in 1985 and 1.6×10^{15} Btu in 2000.

Note that replacement of steel and iron materials with aluminum and plastics involves an increase in energy consumption in car manufacturing. The reason is that production of aluminum and plastics is several times more energy consuming than production of steel or iron. This energy penalty, however, is only one-tenth of the equivalent energy savings due to gasoline consumption reduction.[8]

IV. Other Benefits

Corresponding decrease in automobile pollutant emissions per mile.

V. Environmental Problems

- Flammability of plastic components in a car.
- Toxicity of plastic components when ignited (e.g., in an accident).

VI. Regulatory/Institutional Problems

Need to revise federal auto safety standards to insure protection for passengers in light of increase in use of aluminum and plastics.

VII. Economic Problems

Strains on the aluminum industry

We estimate an annual increase demand of 600,000 tons of aluminum if aluminum use is increased from 84 lbs./car in 1973 to 200 lbs./car in 1980. Shortage of aluminum is anticipated. Total U.S. demand for aluminum should grow from 7.6 million tons in 1979 to about 10 million tons four years from now.[9] On the supply side, aluminum capacity in the U.S., which is now 4.8 million tons a year, will increase to only 5.1 million tons by 1983.

Reduction in demand for steel.

Increased use of aluminum and plastics will result in an annual decrease of steel requirement of 3.1 million tons. This corresponds to a reduction of 2.3% in U.S. steel production in 1970.

VIII. Social Problems

Car buyers will have to pay extra for costs due to vehicle design changes (e.g., about $60/car for increase in use of aluminum and plastics).[10]

Perceived loss of vehicle quality when lightweight materials are introduced.

IX. Other Problems

X. Resource Requirements

Annual demand of 600,000 tons of aluminum and one million tons of plastics.

Research and development efforts by car manufacturers to improve fuel economy by design changes can cost millions of dollars.

XI. Initiatives

Major incentive is the federal EPCA fuel economy standard requirements mentioned above. (Federal)

XII. References

1. U.S. EPA, Office of Air and Water Management, "Fact Sheet, Automobile Fuel Economy".
2. See, for example, U.S. EPA, 1976, "Factors Affecting Automotive Fuel Economy".
3. Data obtained primarily from "Reducing the Energy Investment in Automobiles" by J. Tien et. al., article in M.I.T.'s Technology Review, February 1975.
4. The New York Times, January 17, 1979, "Lighter Cars Add Problems."
5. Urban Institute, 1976, "Industrial and Economic Impacts of Improving Automobile Fuel Efficiency", report prepared for National Sciency Foundation, NTIS-PB-253-448.
6. Ibid.
7. See Note 3 of "Smaller Car" conservation sheet.
8. Assuming:

   i) Primary energy consumption (in MMBtu/ton product) is about 19 for raw steel as compared with 173 for primary aluminum and 95 for plastics.

   ii) Use of aluminum and of plastics in automobiles ate 84 lbs. and 100 lbs. respectively in 1973 and will jump to 200 lbs. and 300 lbs. respectively by 1980.

   iii) A pound of aluminum and a pound of plastics will replace respectively 2 pounds and 2.5 pounds of steel in car manufacturing.

   iv) Annual car production in the U.S. is 10 million cars/year.

   then:

   a) The increase in car manufacturing energy consumption due to increase use of aluminum will be

$$= \frac{173 - 19 \times 2}{2000} \frac{\text{MMBtu}}{\text{lb}} \times (200 - 84) \frac{\text{lb}}{\text{car}} \times 10^{7} \frac{\text{car}}{\text{year}}$$

$$= 8 \times 10^{13} \text{ Btu.}$$

   b) The increase in car manufacturing energy consumption due to increase use of plastics will be

$$= \frac{95 - 2.5 \times 19}{2000} \frac{\text{MMBtu}}{\text{lb}} \times (300 - 100) \frac{\text{lb}}{\text{car}} \times 10^{7} \frac{\text{car}}{\text{year}}$$

$$= 7 \times 10^{13} \text{ Btu.}$$

   c) Thus total increase in energy use in car manufacturing due to increase use of Al and plastics will be 1.5×10^{14} Btu/year.

9. The New York Times, note 4, Supra.
10. Using the following material production in costs in 1972: $155/ton for steel, $500/ton for plastics, and $700/ton for aluminum (Reference: NTIS-PB-253-448).

XIII. Tabular Materials

5.4 DIESEL-ENGINE LIGHT-DUTY VEHICLES

I. Description

A diesel engine is an internal combustion engine in which the fuel is sprayed directly into the combustion chamber and ignited by the high temperature to which the air in the combustion chamber has been heated during the compression process.[1]

Since the 1973 oil crisis, there has existed prospects for wide application of diesel engines in light-duty vehicles since a diesel-powered engine gives better fuel economy than a gasoline powered engine.

II. Setting and Characteristics

In the U.S., diesel engines have mainly been used in heavy-duty trucks and buses, ships, and in stationary power systems. In 1975, over one million diesel-powered heavy-duty trucks and buses consumed in excess of 1.3 x 10^{15} Btu of diesel fuel.[2]

Use of diesel engines in passenger automobiles has been very limited, with annual sales of about 20,000 per year. Since 1978, however, there have been signs of increasing sales of diesel-powered vehicles in the U.S. market. General Motors set a sales target of 100,000 vehicles for 1978, Volkswagen initiated import of their diesel Rabbit at a low volume rate. In addition, many automotive companies have initiated diesel development activities.

The reason for interest in diesel engine light-duty vehicles is their superior fuel-economy performance. In terms of miles-per-gallon, a vehicle using diesel fuel can be 40% more efficient than a conventional vehicle using gasoline.

In a diesel engine, air alone is compressed in the cylinder, and the fuel is then injected into the heated air towards the end of the compression stroke. The temperature developed during compression is sufficiently high to ignite the fuel immediately upon injection. Thus spark plugs, distributor, and carbureator are eliminated in the diesel, but a high-pressure, fuel-injection system is required. Since the compression-ignition process demands high compression ratios, the current diesel engines are generally heavier and bulkier than equivalent spark-ignition engines.[5]

Diesel fuel varies greatly in its characteristics, ranging from light distillates to residual fuels. The energy content of a gallon of diesel fuel is about 10% higher than that of gasoline.

III. Energy Savings

- Reduction in petroleum consumption by the transportation sector.

Diesel engines have been expected to account for 8-10 percent of the domestic passenger car market by 1985.[6] EPA expects as much as 25% of all new light-duty vehicles by late 1980's to be diesel-powered.[7]

Assuming that (i) there will be respectively 3 million and 27 million diesel-engine light-duty vehicles in the U.S. in 1985 and 2000; (ii) a diesel-powered engine is 35% more energy efficient than a gasoline-powered engine; (iii) fuel economy of the U.S. automobile fleet in 1975 was 13.5 m.p.g.; then it is estimated that savings in petroleum consumption due to use of diesel-engine vehicles would be 0.1 x 10^{15} Btu in 1985 and 0.9 x 10^{15} Btu in 2000.

IV. Other Benefits

V. Environmental Problems

Diesel engines may have important adverse implications for air quality especially if these account for a large portion of the private automobile population.

Emission of CO and HC from diesel-engine light-duty vehicles satisfy federal standards.[8] Of more concern are emissions of NO_x and particulates.

NO_x emissions of current technology diesels exceed the projected 0.4 gm/mi standard and no practical method has been demonstrated to meet that level.[9]

Diesel engines emit significant amounts of particulates, of 1-2 microns. These particles are easily trapped in the human lungs. These particulates serve as the transport mechanism for small amounts of adhered gaseous liquid, or solid substances, some of which are believed to be mutagenic or carcinogenic. Of particular concern are the polycyclic organic matters, POM.[10]

The EPA proposed particulate emission standards for light-duty vehicles are 0.6 gm/mi for 1981 and 0.20 gm/mi for 1983 and beyond.

At present, particulates emissions from small diesel engines (i.e. engine displacements less than 3 liters) are in the range 0.2-0.4 gm/mi; while larger diesel engines' emissions are in the range 0.6-1.0 gm/mi.[11]

- Diesel powered engines are somewhat noisier than most ignition engines.
- Diesel exhaust has distinctive unpleasant odors ("smoky" and "oily kerosene").
- The larger particulates in the exhaust stream of diesel engines will scatter light and increase the opacity of the urban atmosphere.

VI. Regulatory/Institutional Problems

Consumer acceptance of diesel-engine vehicles could be affected by the following properties of diesel engines: hard to start (especially in cold weather), slow acceleration, noise, unpleasant odors.

Diversion of home heating oil to run diesel vehicles to avoid highway taxes and circumvent gas rationing.

The future of diesel engine vehicles in the U.S. depends in part upon the strictness of federal standards for emissions of NO_x and particulates.

The question of when, or if, a 0.4 gm/mile NO_x standard will be imposed awaits an US EPA report on public health implications of NO_x emissions, due to Congress in July 1980.[12] It is not clear whether large-size diesel-engine light duty vehicles will be able to meet the EPA proposed standard for particulate emissions.

VII. Economic Problems

Diesel engines are costlier to produce than ignition engines. The sticker price of diesel powered automobiles is between $195 and $1300 [13] above the price of equivalent gasoline-powered automobiles. Future mass productions, however, should reduce production costs of diesel engines.

VIII. Social Problems

IX. Other Problems

X. Resource Requirements

For an annual production rate of 1 million units of diesel engines, car manufacturer's requirements for capital investments may range from $0.5 to $1 billion.[14]

Research and development for reduction of diesel engines emissions may cost millions of dollars.

XI. Initiatives

Major incentive for introducing diesel-engine light duty vehicles by domestic car manufacturers is the Energy Policy and Conservation Act (EPCA) of 1975 setting minimum fuel economy standards for each car manufacturer's new car fleet (federal).

XII. References

1. D.B. Shonka, et al, 1977, "Transportation Energy Conservation Data Book: Edition 2" Oak Ridge National Laboratory report ORNL-5320, Oak Ridge, Tn.

2. Aerospace Corporation, 1978, "Review of the Research Status on Diesel Exhaust Emissions, their Health Effects, and Emission Control Technologies", Aerospace report No. ATR-78 (7716)-3 Reissue A, prepared for U.S. Department of Energy, Division of Environmental Control Technology.

3. Aerospace Corp., note 2, ibid.

4. U.S. EPA, 1976, "Factors Affecting Automobile Fuel Economy".

5. Aerospace Corp., Section 3.1, note 2, supra.

6. Donovan, Hamester and Rattien, Inc., 1978, "Environmental Effects of Energy Conservation", report to U.S. Department of Energy, Division of Policy Analysis.

7. U.S. EPA, 1979, "Control of Air Pollution from New Motor Vehicles and New Motor Vehicle Engines; Certification and Text Procedures--Particulate Regulations for Light-Duty Diesel Vehicles", Federal Register.

8. Federal Light-Duty Vehicle Emission Standards (in grams/mile)

Model Yr.	HC	CO	NO_x	Particulates
1978-79	1.5	15.0	2.0	-
1980	0.41	7.0	2.0	-
1981	0.41	3.4	1.0 (possibly 0.4)	0.60 (Proposed)
1983	0.4	3.4	1.0 (possibly 0.4)	0.20 (Proposed)

9. Aerospace Corp., note 2, supra.

10. Donovan, Hamester and Rattien, Inc., note 6, supra.

11. Aerospace Corp., note 2, supra, figure 1.3.

12. " " , Section 4.1

13. " " , Section 3.3.2.

14. " " , Section 3.9

XIII. Tabular Materials

5.5 CAR-AND VAN-POOLING

I. Description

Car-pooling is an arrangement by which a number of automobile commuters take turns in driving themselves and the others in home-to-work trips. In van-pooling, a van is usually provided by an employer for his employees' convenience in commuting to work. The idea of car and van-pooling is to save gasoline consumption by increasing the passenger load factor in automobiles.

II. Settings and Characteristics

Use of energy by the automobile transportation sector accounts for 13% of total energy consumption in the U.S. in 1972. About 34% of vehicle-mile auto travel is for home-to work purpose[1]. Thus commuting to work by automobile accounts for 4.4% of total U.S. energy use.

At present, about 12% of automobile commuters participate in car-pooling[2].

III. Energy Savings

- Savings in gasoline consumption:
  If the current figure of 12% of automobile commuters participating in car-pooling is doubled to 24% by 1985, it is estimated that this will result in a 2.8% savings in total gasoline consumption in the automobile transportation sector[3]. Thus:

  1985 potential energy savings is:
  0.26×10^{15} Btu

  2000 potential energy savings is:
  0.25×10^{15} Btu

IV. Other Benefits

- Decrease in auto pollutant emissions.
  For 1985, reduction in emission of auto air-pollutants are[4]:

  7.7×10^4 tons of NO_x, 3.9×10^3 tons SO_2,
  5.2×10^4 tons HC, 5.5×10^5 tons CO ,
  1.9×10^7 tons CO_2, 1.6×10^4 tons particulate

  These emission reductions are equivalent to about 3% of total emissions from automobile transportation.
- Reduction in traffic congestion and accident rates due to decrease in number of cars on the road at rush hours.
- Lower auto operating costs to auto-pool participants due to reduction in auto mileage traveled. (About 7.5 billion dollars saved in 1985 if we assume auto operating cost of 18¢/mile.)

V. Environmental Problems

- Possible increased auto traffic fatality rates due to increased auto load factors (vehicle occupancy).

VI. Regulatory/Institutional Problems

- Decrease in employment in the auto service industry due to decrease in auto usage.
- Costs to employers to purchase and maintain vans.

VII, Economic Problems

VIII. Social Problems

Many commuters regard ride-sharing as a restraint on their freedom of movements.

IX. Other Problems

X. Resource Requirements

Fuel: None
Materials: None
Monetary: Programs to promote car pooling may cost from a few hundred to thousands of dollars. Also costs of purchase and maintenance of vans. In 1978, DOE spent $3.4 million through various state and municipal car and van pool grants.

XI. Initiatives

- Public education and advertisement (Federal, State, Local).
- Car-pool matching programs (Local government, employers).
- Discount in highway tolls for car poolers (State).
- Increase in area-wide parking costs (Local).
- Exclusive reserved lanes on highway for cars carrying more than one passenger (State, Local).
- Programs by governments and industries to procure automobiles specifically for use in car and van-pooling programs. (Federal-private).
- Discounts in auto insurance rates for carpool motorists (state).

XII. References

1. U.S. Dept. of Transportation, Federal Highway Administration, 1974, "Nationwide Personal Transportation Study" Report No. 10.
2. Figure 1.40, "Regional Transportation Energy Conservation Data Book" 1978 Edition 1, D.L. Greene et al., Oak Ridge National Laboratory ORNL-5435.
3. If we assume that:
   - Average number of passengers in a car-pool auto is 3 persons/car
   - Average trip length of a home-to-work car-pool trip is 1.2 times that of a non-car-pool trip (since a car-pool automobile usually has to go around to a number of houses to pick up and drop passengers)

XII. References - Cont.

- National rates of auto commuters participating in car-pools being 12% for base year 1975 and 24% for 1985 and beyond.
- About 34% of vehicle-mile auto travel is for home-to-work trips

Then percentage savings in automobile gasoline consumption due to increases in car-pool participation can be calculated as follows;

% savings =

$$\frac{\left[\left(\frac{12}{3} \times 1.2\right) + (100 - 12)\right]\left[-\left(\frac{24}{3} \times 1.2\right) + (100 - 24)\right]}{\left[\left(\frac{12}{3} \times 1.2\right) + (100 - 12)\right]} \times 0.34 \times 100 = 2.8\%$$

XIII. Tabular Materials

5.6 TRANSPORTATION MODE SHIFT

I. Description

Passenger transportation modes include automobile, rail, bus, air, bicycle, walking, etc. Here we discuss the energy conservation option of mode shift from automobile usage to mass transit (rail, bus) in the passenger transportation sector.

II. Setting and Characteristics

Until the oil crisis, usage of public transit modes (bus, rail, subways) has declined steadily. Ridership on urban public transit fell sharply, from 19 billion trips in 1945 to 5 billion in 1973.[1] Transit modes have a very modest share of the passenger transportation sector for both local and intercity travel.[2]

Buses and rail are approximately twice as energy efficient as automobiles whose energy intensiveness averaged 7,000 Btu/Passenger-mile in 1973.[3]

III. Energy Savings

Mode shift from automobile usage to mass transit results in reduction in gasoline consumption and increase in diesel and electricity consumption. Assuming that due to mode shift options, projected energy consumptions in mass transit-as given, in note 2--will be doubled, then the gasoline savings in the automobile transportation sector would be about 0.14 x 10^{15} Btu in 1985 and 0.24 x 10^{15} Btu in 2000.

IV. Other Benefits

Improved air quality and traffic congestion due to reduced automobile usage

V. Environmental Problems

- Possible increase in urban noise pollution (due to increased activity at rail and bus terminals and bus stops)
- Increase in particulate emissions (from diesel powered buses and electric utilities)

VI. Regulatory/Institutional Problems

Need for effective mechanisms to channel federal, state, and local funds to finance mass transit improvement projects.

VII. Economic Problems

- Loss of local revenues (gasoline and vehicle taxes, tolls, licenses, etc.)
- Land use patterns in many growing suburban areas make feasibility of mass transit economically uncompetitive with automobile transportation mode.

VIII. Social Problems

Inherent inferior qualities of mass transit compared with automobile transport; mass transit are slower, offering less choices in terms of time and place of departure and destination; personal privacy and comfort.

IX. Other Problems

X. Resource Requirements

Many transit improvement measures (e.g. fare reduction, increase of bus fleet) require some forms of financial assistance from governments. It has been estimated that doubling the fraction of urban travelers carried by transit from 2.5 percent in 1973 to 5.0 percent in 1980 would require 100,000 new buses during this 7-year period, compared with the 1973 fleet of 45,000 buses.[4]

The National Mass Tranportation Assistance Act of 1974 provides $11.8 billion over the next 6 years for use in both capital and operating expenses, and the Federal Highway Administration has a smaller but significant transit assistance program of its own.[5]

XI. Initiatives[6]

- Transit incentives: time and service improvements (e.g. exclusive bus lanes, priority traffic signals, improved scheduling, improved routing, para-transit, park-and-ride), cost reduction (e.g., reduced fares, revised fare structure, employer-subsidized fares) (state-local).
- Automobile discentives: time (auto-banned zones, reduced freeway lanes), costs (gasoline taxes, parking taxes, highway tolls) (Federal-state-local).

XII. References

1. Federal Energy Administration, 1974, "Project Independence and Energy Conservation: Transportation Sectors".

2. Fuel Consumption in the Passenger Transportation Sector (in 10^{12} Btu)

	Local		Inter-City				
Year	Auto	Bus	Local	Air	Auto	Bus	Rail
1972[a]	6650	41	21	994	2420	30	13
1985[b]	8480	59	33	1870	2900	40	13
2000[c]	14300	102	57	3490	4700	64	19

[a,b] Data inferred from Federal Energy Administration, note 1, ibid.

[c] Assuming an average annual growth rate of 3.7% for 1990-2000.

3. Mayo Stuntz, Jr., 1975, "Potential of Urban Mass Transit", Federal Energy Administration, NTIS-PB-249-336, (Figure 4).

XII. References (Cont.)

4. American Public Transit Association, 1975, "74-75 Transit Fact Book", as reported by M. Stuntz, note 3, supra, page 22.

5. M. Stuntz, "Mass Transit and Energy Conservation", 1975, Federal Energy Administration, NTIS-PB 246-232 (Page 5).

6. M. Stuntz, note 3, Ibid, table 6.

XIII. Tabular Materials

VI. POLICY MODIFICATION

6.1 INTRODUCTION

Utility rate reform represents a policy modification with energy saving consequences. The measure is not demand sector specific. Rate reform is broadly concerned with conflicts between marketplace prices and price signals incorporated into the present rate structures. It has been argued that these rates fail to encourage energy conservation choices by consumers because of improper price signals incorporated in the existing methods of average cost pricing. Reduced consumption of electric energy could have far reaching effects in encouraging the more efficient use of present generating capacities and reducing the need for new capacity. In 1977, 21.14 x 10^{11} kWh of electric energy was generated. Seventy-seven percent of this power was generated from fossil fuel sources, resulting in a consumption of 17.6 x 10^{15} Btu oil and gas. Shown below are estimates of the fossil fuels consumed. By sector, 55 percent of the electricity produced was delivered to residential-commercial, 45 percent to industrial and < 1 percent to transportation sector customers.

Fossil Fuel Deliveries to Electric Utilities in 1977

Fuel	Deliveries (10^{15} Btu)
Coal	10.5
Oil	3.83
Gas	3.19

Summary of Electric Utility Energy Demand and Fuels
Consumed in 1972 (10^{15} Btu)

	Oil	Coal	Nuclear	Hydro	Methane	Total Direct Use
Electric Utilities	3.1	7.8	0.6	2.9	2.1	12.8

6.2 LOAD DEMAND MANAGEMENT AND UTILITY RATE REFORM

I. Description

Electrical energy is difficult and expensive to store, so a utility's need for plant and equipment is largely determined by its peak demand. If electricity consumption during peak periods were reduced, fewer costly new additions to utility capacity would be required. Equally important, since peaking units commonly burn oil and natural gas, a reduction in peak demand would reduce use of these scarce fuels. Additional energy would also be saved by increasing the use of base load facilities with high operating efficiencies and decreasing the use of peaking plants with low operating efficiencies.

Present utility pricing strategies tend to discourage application of load management techniques. The smallest users commonly pay the highest unit prices due to practices such as declining block rates. Rates often do not reflect the costs imposed on society by the actions of utility consumers. The result is waste and inequity.

The Public Utility Regulatory Policies Act of 1978 requires state regulatory authorities and utilities to consider various rate design standards and other utility practices, including time of day rates, seasonal rates, cost of service pricing, interruptible rates, prohibition of declining block rates and lifeline rates and determine if they are appropriate for conservation, efficiency and equity, as well as consistent with state laws.

II. Setting and Characteristics

In 1977, the demand for electric energy rose to a new record of 7.25×10^{15} Btu (21.14×10^{11} Kwh). Production of this energy by fuel type is shown in Table 1. Also shown are fossil fuels deliveries to the electric utilities to meet this demand. Oil and natural gas consumed to meet peak demands amounted to 2.39×10^{14} Btu (1.4%) and 9.7×10^{13} Btu (0.5%) of all fossil fuels consumed, respectively.

III. Energy Savings

Estimates of total energy savings and savings of gas and oil arising from load demand management and rate reform implementation are not only difficult to make but are also utility specific. Increased potential for conservation by load management appears to be somewhat sensitive to fuel costs. Estimates presented in the National Energy Plan suggest that import energy savings of 3.39×10^{14} Btu/year in 1985 could be expected from implementation of various rate reform strategies.

IV. Other Benefits

Analysis conducted by the FEA suggest that rate reform, by reducing the need for incremental generating capacity, could save at least $50 billion nationally in net cumulative capital costs by 1985. Studies prepared by BNL of the Con Edison System suggest that use of load management techniques could reduce fuel costs for residual oil consumption by as much as 1.2% and #2 oil and kerosene by -6%.

- Reduced use of oil and gas
- Improved thermal efficiency
- Increased economic equity (efficiency) among consumer categories
- Increased plant utilization balance, minimizing the need for new generating capacity
- Reduced costs to most consumers
- Reduced need to construct new generating capacity reduces impacts arising from such construction
- Increased use of other conservation measures

V. Environmental Problems

- Peaking units installed and used in the private sector to level demand could increase and aggrevate local air quality problems.
- Small changes in utility air pollutant emissions: <2% increase in NO_x, SO_x and Particulates; ~3% decrease in HC and CO emissions.

VI. Regulatory/Institutional Problems

- Legal challenges to state public service commissions to time-of-day pricing because of assumed discrimiminatory nature and disturbance of the status quo
- Opposition to rate reform by utilities, industries and consumers
- State public service commission acceptance and implementation of rate reform measures
- Modification of current philosophy which requires utilities to supply their customers with whatever amount of power they wish to purchase at anytime

VII. Economic Problems

- Costs of meter installation, operation and maintenance
- Hardware costs to permit load levelling by end-users
- Increased costs to some industrial facilities away from day to night work shifts and cost differentials

VIII. Social Problems

- Possible invasion of privacy by government or others
- Lifestyle impacts on consumers, employers and employees responding to time-of-day pricing strategies

IX. Other Problems

X. Resource Requirements

XI. Initiatives

- State Public Service Commission require utilities to:
  - Phase out promotional, declining block and other rates that do not reflect costs.
  - Offer daily off-peak rates to customers willing to pay metering costs or install direct load management systems.
  - Offer lower rates to customers who are willing to have their power interrupted at times of highest peak demand.
  - Eliminate use of single meters for multi-unit buildings (State-private).
- Increase availability and reduce costs of control equipment and peaking turbines to manage demand (Federal-private).
- Intervention in state regulatory hearings (Federal-private).
- Financial support to assist state PSC in implementing rate reform (Federal).
- Tax incentives to utilities and consumers to encourage load management (Federal-state).
- Public Education (Federal-State-Local).

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XIII. Tabular Materials

Table 1

Production of Electric Energy by Fuel Type and Deliveries of Fossil Fuels to Electric Utilities in 1977

	Generation (Btu x 10^{15})	Deliveries (Btu x 10^{15})
Coal	3.36	10.5
Oil (Steam)	1.22	3.659
(Peaking)		0.24
(Subtotal)		3.83
Gas (Steam)	1.04	3.09
(Peaking)		0.10
(Subtotal)		3.19
Nuclear	0.86	-
Hydro	0.75	-
Other	0.01	-
Total	7.25	17.6

APPENDIX D

Weighting Summation Algorithm

APPENDIX D

Weighting Summation Algorithm

Rankings were prepared from the raw scores ("suitability factors") computed via the following algorithm:

Suitability factor for each technology =

$$\sum_{p}^{23} \left[D_p \sum_{cd=1}^{8} \left(I_{p,t,cd} * W_{p,cd} \right) + F_p \sum_{cf=9}^{12} \left(I_{p,t,cf} * W_{p,cf} \right) \right]$$

where

p = participant

t = technology

D_p & F_p = overall desirability and feasibility weights

cd = desirability criteria

cf = feasibility criterion

$I_{p,t,cd}$ = scaled impact level for desirability criterion cd and technology t assigned by participant p.

$W_{p,t,cd}$ = weight for criterion cd assigned by participant p

$I_{p,t,cf}$ = scaled impact level for feasibility criterion cf and technology t assigned by participant p.

$W_{p,cf}$ = weight for criterion of assigned by participant p.

APPENDIX E

Criteria for Evaluating Energy Conservation Measures: Perspectives of an Industrialist and an Environmentalist

CRITERIA FOR EVALUATING ENERGY CONSERVATION MEASURES: PERSPECTIVES OF AN INDUSTRIALIST AND AN ENVIRONMENTALIST

Prepared by

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April 10-11, 1979
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DRAFT

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Preface

This report presents perspectives of an environmentalist and an industrialist on criteria which could be used to evaluate and rank different conservation measures. Mr. Berman, now president of Penta International and past Director of Energy and Resources for the National Association of Manufacturers prepared the paper presenting an industrialist's view. Mr. Moss, a private consultant and former President of the Sierra Club, prepared the paper presenting an environmentalist's perspective. These papers were commissioned by Brookhaven National Laboratory - Division of Regional Studies for presentation at the Workshop.

In preparing these papers, the authors were asked to identify important criteria which should be incorporated in this Workshop's exercise designed to rank a large set of energy conservation options. The prepared papers, as such, do not present exhaustive nor definitive lists of criteria which should be or were used. The principal purpose of these papers was to present differing perspectives which would identify possibilities and difficulties in developing and applying criteria for evaluating energy conservation measures and also serve as a vehicle for stimulating discussions at the Workshop.

The multiobjective decision making exercise, as previously noted in the text, is critically dependent on the criteria employed in the evaluation of different impacts and the relative weights assigned to each criteria. The assignment of such weights transcends the limits of a strictly objective process, as no such process can lead umabiguously to a determination of the value of maintaining various degrees of independence of U.S. foreign policy, or of environmental quality, or of control by the family unit over the provision of desired energy services, or of avoiding morbidity and mortality, to name just a few of the concerns around which adherents have assembled. Attempts were made to discuss some of these concerns at the Workshop.

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I. AN INDUSTRIALIST'S PERSPECTIVE

by

Stanley M. Berman

A. INTRODUCTION

This paper outlines an industrial perspective of possible criteria to be used a the decision making exercise and a discussion of industrial considerations which subsequently can be used in developing criteria and weights. The approach taken is to:

- Identify the major categories of criteria from a public policy point of view and describe them in terms of the detailed considerations;
- Describe the industrial decisionmaking considerations in relation to energy conservation measures; and
- Relate the criteria and industrial considerations.

B. MAJOR CRITERIA - PUBLIC POLICY PERSPECTIVE

Energy conservation in either sense used here is not an end in itself. Energy conservation must be couched in terms of its benefits and costs, or impacts on national goals and values. Therefore, the criteria and associated weights can only be developed in relation to national goals and values if the energy conservation measure were to be implemented. The following is an attempt to group national goals and values into four major categories. The descriptions probably do not include all of the specific considerations which could come under these headings. However, they are a starting point. The major criteria and the "descriptors" proposed are as follows:

The Economy

Production and Income

Employment

Prices and Costs

Balance of Trade, of Payments

Distribution by Sector, Income Class and Location

Adaptability and Flexibility

Social and Institutional Values

Civil Rights/Consumer Choice

Regulation and Centralization of Government

Life Styles

Equity

Small Business/Anti-Trust

Social Institutions

The Physical Environment

Public Health and Safety
Occupational Health and Safety
Recreation and Esthetics
Resource Conservation

National Security/Foreign Policy

National Security
World Order and Stability
World Economic Growth and Stability
Peace

1. The Economy

Production and income, employment, prices and costs, the Balance of Trade and Balance of Payments are all measures of our economic well-being. Adaptability and flexibility ar important to the U.S. economy in its ability to respond to a rapidly changing society and world economy; it therefore relates to future economic well-being. Even aside from the question of equity, distribution of costs and benefits can have important impacts on the economy.

2. The Physical Environment

Health and safety for the public generally, and in the work environment, have been accorded a priority in the U.S. Recreation and esthetic values have received increasing consideration as our standard of living has risen and availability of recreational time has increased. The criteria have become measures of our physical well-being. Resource conservation represents a measure of our ability to assure future physical well-being. However, resource conservation also relates to our ability to maintain future economic well-being.

3. Social and Institutional Values

This category includes criteria which represent values established by society. Some, if not all, are basic philosophy, i.e. they have no other basis than the fact that we have placed a value on it. Civil rights and consumer choice, as well as a restrained level of government regulation, and decentralized goverment have been a part of our value system for two hundred years. At the same time, we have tended to value small enterprises. This has led to anti-trust and related regulation.

Life styles and social institutions are intended to describe the manner in which we live and operate as individuals and as groups. This includes educational and religious institutions, for example. The criterion of equity is important when discussing the impact of government policy and programs.

4. National Security and Foreign Policy

Within this general category we should include those goals of national security and the associated values which contribute to national security, for example world economic stability and growth, and world political order and stability. In addition, we have always valued peace as a goal.

Energy Conservation measures may have little or no impact on some values, except in a very indirect way. In other cases, energy conservation will have a direct and significant impact. In all cases, however, impacts could be positive or adverse in relation to our goals and values.

C. INDUSTRIAL DECISION-MAKING AND ENERGY

1. The Industrial Process and Concerns

The industrial process is described below in a very simple way showing the major inputs and outputs.

Inputs	Outputs
Management	Products
Know-how	Services
Manpower	
Plant and Equipment	
Materials	
Energy	

Business enterprises must provide a return to owners/investors commensurate with risk to stay in business and continue to obtain equity and borrowed capita. Therefore, factors affecting risk, and those affecting costs or revenues are of paramount concern to an industrial enterprise. That is not to say other considerations are not important, but these are essential for survival.

The major industrial concerns with regard to the inputs are; availability and adequacy of the input, reliability, quality and characteristics, prices and costs, rates of utilization of fixed inputs, technical efficiency of use, and obsolescense of plant and equipment. In addition, mangement is concerned with any outside constraints on use of these inputs, such as environmental and occupational safety and health regulations.

On the output side, management is sensitive to product selling prices, quality, quantity, characteristics, competitive position, company growth and regulatory constraints such as imposed by the Federal Trade Commission, the Justice Department or the Consumer Product Safety Commission. Of course, taxes as a cost of business can not be ignored.

Since the measure of imputs and outputs is in dollars, the return is a measure of efficiency of use of all imputs. Then, a change in return implies a change in efficiency in the use of inputs. The significance of this is that energy conservation measures or any other investment that has an overall adverse impact on a company's return implies a less efficient use of all inputs taken together.

2. Industry, Energy and the Criteria

From the point of view of an individual firm, there are certain criteria which must be met. These criteria are technical feasibility and economic feasibility.

Technical feasibility is defined as having the means for achieving energy conservation. It includes availability of equipment, know-how, manpower, etc. Economic feasibility requires an excess of revenue over costs. However, economic feasibility must also consider the availability of capital. These two criteria for the firm must also be met for society.

3. Technical Feasibility

In the industrial context, technical feasibility demands that the equipment, know-how, and operating manpower be available on a commercial scale. These inputs must be available now or on order within a reasonable time and in commercial quantities. The technology must be proven and reasonable warranty provided for the equipment or technique. These concerns are important because of the large investments which may be required for the measure itself, but more importantly, because of the costs associated with downtime due to unreliable equipment or technology.

In certain instances, energy conservation potential may be tied to use of a particular fuel. In these cases, technical feasibility must include availability of the specific fuel.

4. Economic Feasibility

Evaluation of prospective investments in energy conserving measures involves two considerations: The rate of return on investment (ROI) and the availability of capital for investment. Because net income is a measure of efficiency of use of inputs, an energy conservation measure must be evaluated in terms of its impact on net income. An ROI evaluation is the devise to do that. The rate of return is important not only for determining whether the investment is of net benefit, but also for establishing priorities and selecting the energy conservation measures to be pursued within a limited capital budget.

An ROI of 15 percent has been widely accepted by industry for use as a minimum or hurdle rate for project evaluation. However, many companies use higher rates, in part to inject a risk factor. Some firms have lowered the ROI criterion for energy conservation projects because of a perceived lower risk factor for this type of project.

In assessing capital availability, all sources of funds must be considered, i.e. funds from internally generated cash flows, from borrowing, or from equity financings. All competing uses of the funds must also be assessed to determine availability of discretionary funds. Energy conservation measures can reduce capital requirements for plant capacity increases in some circumstances. Therefore, a comprehensive study of the measure's impact must be made.

Energy conservation measures may also contribute to greater supply security by reducing overall energy requirements. This aspect can and should be introduced into the determination of the ROI. It can be done by estimating the energy conservation measure's contribution to reducing the probability and cost of supply interruption.

Equipment may reach its maximum efficiency at only one level or within a very narrow range of operation. For a company facing frequent changes in market demand, equipment with a narrow range for efficient production would likely be inappropriate and inefficient even in the strict engineering sense. And in such circumstances, energy conservation measures requiring large capital outlays will have a difficult time meeting economic feasibility criteria.

5. The Economy

Industry's major concern is that energy conservation not adversely affect the economy by causing economic decline or by limiting future economic growth. Energy plays a key role in the production process and consequently energy in some form is a necessary condition to maintaining production, income and employment. This relationship has been apparent through time in the U.S. and elsewhere. The relationship depends on the mix of products and services, the technology and the stage at which inputs enter the manufacturing process. Change in any one of these factors will affect the energy demanded. The concern is particularly directed at artificial means of changing requirements or usage.

Escalating energy prices and costs have been major factors in the rising cost of living as well as major factors in the adverse Balance of Trade. Energy conservation may have some important contributions to make here if properly framed and pursued.

The impact of energy problems has been variable on different sectors, income classes, and locations. This is due to the uneven regulation of the several energy forms by government, regional variation in use of the energy forms, the different sources of supply, etc. Some approaches to energy conservation could concentrate the burden on narrow segments of society.

Adaptability and flexibility in the economy to adjust to variations in the relative availability of different fuels is important. Some exists now, but more is being sought both by industry and as a matter of public policy. Energy conservation measures linked to a particular energy form would therefore be in conflict with this goal.

6. The Physical Environment

Industry is greatly concerned that it not be placed in unworkable and untenable situations between conflicting government programs. Energy conservation may conflict with environmental goals and values. A simple example is the conflict that could arise between reduced lighting levels and OSHA standards in a manufacturing plant. Similar situations pertain to other programs. Industry must, however, take environmental goals as given, especially in so far as they are embodied in statues and regulations.

7. Social and Institutional Values

Industry's main concerns are:

- The use of regulation to achieve energy conservation;
- The impact of energy conservation of life styles and the ultimte impact on the structure and growth of the economy, and
- The relation of energy consevation to anti-trust regulation.

The use of regulatory mechanisms to achieve energy conservation must focus on a unit such as a household, plant, or an industry. The unit in attempting to comply in good faith may take action in such a way as to simply push the energy consumption on some other unit. For individuals, car rental would be an example. For a company, purchase of materials which have been processed further is an example. If energy efficiency were the only standard, old equipment might be discarded for newer more efficient equipment without regard to cost or without regard to the energy component of the capital good being discarded. The impact on life styles and thereby on the economy need not be labored over further.

Anti-trust regulation can constrain energy conservation efforts. An example is where a group of merchants would meet to agree on store hours. In addition, information sharing of energy conserving measures among manufacturers, if not a breach of anti-trust statutes, is clearly anti-competitive.

II. AN ENVIRONMENTALIST'S PERSPECTIVE

by

Laurence I. Moss

A. INTRODUCTION

This paper is from an environmental perspective, prepared by one who values highly (although not to the exclusion of all other values) the protection and enchancement of environmental quality, preservation of relatively natural ecsoy stems and wise use of resources. Identified and discussed are criteria deemed sufficiently important to be included in the decision making exercise designed to evaluate and compare a number of promising energy conservation measures. As a point of departure, an initial list of criteria provided by Brookhaven National Laboratory are evaluated and potential criteria weights discussed.

B. THE INITIAL LIST OF CRITERIA

1. Effective Criteria

The intital list of potential evaluation criteria (Table 1) was intended to be suggestive and to spur discussion and revision. In this spirit I shall comment on it and propose certain modification.

The list begins with the question of the effectiveness of each proposed energy conservation measure, in terms of its:

- Potential reduction in energy demand;
- Potential for increased efficiency in energy utilization;
- Potential for reduction of energy dependency

The question of cost arises later, under the heading of social acceptability. I would introduce it here, for the following reasons: Energy is not the only scarce resource nor is it the only resource the use of which involves significant adverse social and environmental impacts. There is a point, in the provision of the goods and services made possible by the use of energy, beyond which additional efforts to conserve energy will not be in the national interest. That point will change over time in response to changes in (a) marginal supplies of energy; (b) the availability of new options in more efficient end-use technology; and (c) the perceived environmental and social costs of both supply and end-use options.

Table 1

INITIAL LIST OF CRITERIA

1. Effectiveness Criteria
   - Potential reduction in energy demand
   - Potential for increased efficiency in energy utilization
   - Potential for reduction of energy dependency
2. Environmental Criteria
   - Impact on public health and safety
     Impact on air quality
     Impact on water quality and water availability
     Impact of solid waste generation and disposal
     Impact of land use
   - Impact on occupational health and safety
3. Social Acceptability Criteria
   - Impact on employment, industry, and costs to consumer
   - Impact on the efficient allocations of resources
   - Degree of local autonomy (decentralization) permitted
   - Impact on lifestyles and consumr choice
4. Institutional/Regulatory Criteria
   - Impact on utilities and public services
   - Amount of institutional change required
   - Amount of regulatory change required
   - Administrative and enforcement feasibility
   - Administrative and enforcement costs
5. Reliability Criteria
   - Adaptivity to changing environmental and socioeconomic conditions
   - Systems vulnerability to natural disasters or climatic changes
   - Systems vulnerability to accidental or deliberate disruption.

Under present circumstances, it should be noted, the above statement is more of academic interest than of immediate concern. Most energy in the U.S. is priced at well below the costs of the marginal supplies, this is a result of a rather dubious effort to promote "equity." We will return to this question of equity as a value to be considered, but the point to be made here is that the failure of users of energy to see the marginal cost of supplies in the prices they pay has caused, and continues to cause, a gross underinvestment in (marginally-priced) more efficient end-use technology. Such investment would be economic from the standpoint of the nation, but it appears uneconomic from the standpoint of the user. Thus we are nowhere near the point of optimum conservation refered to above, and almost all of the measures now under serious consideration to improve the efficiency of energy use are economically justified.

Nevertheless, to avoid the stigma of advocating conservation (of efficiency, or reduction of imports) for its own sake, it is useful to restate the effectiveness criteria as follows:

- potential for reduction in the (life-cycle) costs of desired energy services.

Indeed this criterion can be thought of as the principle under which all of the criteria on the initial list can be organized, if the concept of "cost" is broadened to include environmental, social, and national security costs. The question of the relative weights to use in assessing such costs still remains.

2. Environmental Criteria

The second category on the initial list is that for environmental criteria, but only those concerning health and safety are mentioned. I would suggest that the list be broadened to include esthetic impacts, impacts on relatively natural ecosystems, and property damage. The importance of these (especially the first two) in the public mind has, I think, been consistently undervalued by many policymakers, and this has led to successful grass-roots efforts to guard against such impacts. The movement to prevent significant deterioration of air quality in those regions of the country enjoying relatively clean air is an example.

3. Social Acceptability Criteria

The third category, social acceptability criteria, makes no mention of the question of equity. I think this should be addressed here, since the concept of equity might well be invoked to block the implementation of otherwise desirable energy conservation measures. The previously mentioned failure to prove energy at marginal or replacement costs is an example.

"Equity" is much talked about but seldom defined. In the context of energy policy there are at least three possible interpretations to be considered:

1. He who benefits should pay the full costs; or
2 Any policy, in this case energy policy, should not widen the gap between the "haves" and the "have-nots"; or
3. The economic status quo should be maintained.

Interpretation #1 is consistent with the organizing criterion previously listed, since it would encourage a more optimum balance between energy supply and demand. I believe that interpretation #2, though it addresses itself to a serious policy issue, goes too far in requiring energy policy to carry the burden of maintaining or narrowing the present gap in wealth and income. That burden is to heavy for energy policy alone; other, more direct measures will be needed. This is not to minimize the problem; rather it is to admit that energy policy is a relatively ineffective and inefficient means by which the condition can be ameliorated, and attempts to do so are likely to so destroy energy policy that its own policy goals are unattainable.

Interpretation #3, if this were the year 1900, might be thought of as a policy to maintain the welfare of the manufacturers of buggy whips. So stated, it sounds ridiculous, but the political force behind maintaining the status quo can be formidable. Indeed, a good case can be made that this value has driven U.S. energy policy for at least the last five years. For example, with all the talk about how the increasing reliance on oil imports was jeopardizing the national security, one might have expected a successful initiative to price imported oil in the U.S. market above the world oil price, to reflect these additional security costs. (This could be done with import fees or the auction of a limited amount of rights to import). In fact, exactly the reverse has occurred: through the entitlements programs, refiners of (price-controlled) domestic oil are required to transfer money to refiners of imported oil, so the effective price of the imported oil in the U.S. is well *below* the world oil price.

Interpretation #3, it should be noted, is much broader than #2. In the example just given, many of the refiners historically dependent on imported oil are on the list of Fortune 500; even those that are not are well above the proverty line.

What is particularly important in the context of the present discussion of energy conservation measures is that some of the most promising of them might well threaten the status quo--with respect to corporate, income class, or regional interests--and thus give rise to powerful opposition. The potential for this should be evaluated and appropriate measures to aid implementation should be developed.

Certain of the social acceptability criteria on the initial list related to cost and efficient allocation of resources; these concerns are included in the broadened effectiveness criterion previously suggested. On the question of local autonomy (decentralizaiton), many people would no doubt be willing to pay some premium to have important energy services under their immediate control. Furthermore, equity interpretation #1 would be advanced by such systems, since when sources are near users, the users are more likely to be aware of and more fully consider any residual external costs. This will make it more likely that users will consider external costs in deciding when marginal supply costs equal the perceived marginal costs of conservation and improved efficiency. User choices, in other words, are likely to be better informed. Thus, to the extent that energy conservation measures could improve energy efficiency to the point where decentralized sources become practical, a valuable purpose would be served.

4. Institutional/Regulatory Criteria

To the extent that energy conservation measures threaten to affect the status quo of institutional practices and arrangements, this should be evaluted and appropriate countermeasures taken. Certainly, no highly promising energy conservation measure should be dropped simply because it does not fit easily within the context of existing institutions.

The easiest measures to implement will be those that either (a) do fit easily within the structure of existing institutions providing energy services, or (b) bypass such institutions entirely. The most difficult measures to implement will be those requiring significant changes in existing institutions.

Administrative and enforcement feasibility and costs are of enormous importance, though usually given little forthought. In terms of potential energy conservation measures, consideration of such feasibility and costs usually indicates the need for price and market mechanisms to achieve implementation. Conservation by regulation, though valid in clear cases of market failure, can easily burden govenrment regulators with an impossible load of information--gathering and decisionmaking requirements.

5. Reliability Criteria

These criteria seem reasonable, and, if there are large differences in adaptivity or vulnerability among proposed systems, these should be evaluated.

C. RELATIVE WEIGHTS

In selecting among the energy conservation measures, each of the workshop participants will (most likely implecitly rather than explicitly) apply his or her weights to these and other criteria. There is nothing wrong with this process, but it does raise the question of whether a group of different individuals, or society at large, would produce the same or a different result.

Over the longer term, it would seem useful, for those responsible for this and other technology assessments where evaluating impacts is central to the process, to develop a "data bank" of quantitative evaluation. One approach would be to examine certain important national decisions and policies, each established after extensive and thorough debate, and deduce from the estimated costs of implementation what society seems (at least for the time being) to be willing to pay to reduce certain adverse impacts or to promote desired results. Most such decisions are made under uncertainty, and this could be carried through the analysis using probabilistic techniques. Laws and regulations dealing with land use, air and water pollution, occupational health and safety, air traffic safety, highway safety, and radiation protection are examples of those which might be so examined.

One would not expect a consistent pattern to emerge from such an evaluation. It might be, for example, that society seems willing to spend much more to avert a premature death from radiation arising from the nuclear power industry than from radiation arising from medical applications, or death from emphysema arising from pollutants emitted from a coal powerplant. Most of us, I suspect, if required to choose for ourselves, would be hard-pressed to state a clear preference. But any such lack of consistency, if well documented, might encourage decisionmakers to reflect upon the implications of their decisions and thus produce more consistent future actions. From the standpoint of the technology assessment, the full range of valuations can also be treated in a probabilistic manner.

This approach, with all of its obvious shortcomings, may be the best we have in evaluating and rendering commensurable the intangible impacts.

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APPENDIX F

Sample Questionnaires

NAME ____

MEASURE OF UNCERTAINTY

Examine the definitions of the criteria. Assign to each criterion a number from 0 to 10, which reflects both the state of the art of prediction in that area and your personal knowledge of that area. In other words, make an estimate of the general quality of the criterion impact levels you have just scaled. If you think that there is limited ability to predict an impact, then you have limited confidence in your impact estimate; if you believe that predictions may be fairly good but your knowledge of the technology and its potential impacts is limited, then you also would have limited confidence in your estimate; etc.

A 0.0 level of confidence indicates either that it is impossible to predict anything or that you have zero knowledge. (We hope you don't think you have zero knowledge after reading the technology assessments.) A 10.0 level of confidence is equivalent to the best that can reasonably be expected. We define this level to be that of a high-quality engineering cost estimate as understood by the engineer who made that estimate.

Uncertainty levels should reflect ratios of relative confidence; a level of 5, for example, should be half as confident as 10.0 and 5 times as confident as 1.0.

CRITERION	UNCERTAINTY
I. Desirability	
A. Direct Employment	________
B. Independence from Imported Oil	________
C. Energy Savings 1985	________
D. Energy Savings 2000	________
E. Economic Equity	________
F. Productivity	________
G. Public Health and Safety	________
H. Occupational Health and Safety	________
I. Ecosystem Health and Safety	________
J. Social Equity	________
K.	________
II. Feasibility	
A. Economic	________
B. Institutional/Regulatory	________
C. Social Acceptability	________
D. Technical	________
E.	________

NAME ______________________________

CRITERION WEIGHTING

I. Desirability

Examine the definitions and ranges of the desirability criteria. In the space below allocate relative importance "points" to each criterion, where a higher number means you care more about that criterion, in such a manner that the total number of "points" over all desirability criteria is equal to 100. A weight of 40 for one criterion and 20 for another should mean that a unit of the first criterion is twice as important as a unit of the second. A weight of 0 would mean you don't care at all about that criterion, and every other criterion is infinitely more important.

When you have completed preliminary allocation, examine the ratios among different criteria. Adjust the allocation as necessary to preserve both the desired ratio and the total of 100 points.

CRITERION	RELATIVE IMPORTANCE
A. Direct Employment	________
B. Independence from Imported Oil	________
C. Energy Savings (1985)	________
D. Energy Savings (2000)	________
E. Economic Equity	________
F. Productivity	________
G. Public Health and Safety	________
H. Occupational Health and Safety	________
I. Ecosystem Health and Safety	________
J. Social Equity	________
K.	________

The total number of points must equal 100. Are the point ratios correct?

NAME ______________________________

CRITERION WEIGHTING

II. Feasibility

Examine the definitions and ranges of the feasibility criteria. As before, allocate 100 points in proportion to the relative importance of each criterion.

CRITERION	RELATIVE IMPORTANCE
A. Economic	________
B. Institutional/Regulatory	________
C. Social Acceptability	________
D. Technical	________
E.	________

The total number of points must equal 100. Are the point ratios correct?

III. Desirability vs. Feasibility

Again using 100 points, what is the relative importance of desirability to feasibility?

	RELATIVE IMPORTANCE
A. Desirability	________
B. Feasibility	________

The total number of points must equal 100. Are the point ratios correct?

NAME ______________________________

SCALING

Examine the distribution of impacts for each criterion. Next carefully examine the scores assigned to each impact on the accompanying scale. If you wish to change any of the values, place your new number in the space provided. For the desirability criteria 0 means no impact and a positive or negative number reflects positive or negative impact, respectively. For the feasibility criteria, 0 means not feasible and a higher number means more feasible.

NAME________________________________

SCALING

-10 to + 10, 0 = no impact

DESIRABILITY CRITERION:________________________

Conservation measure	Score -10 0 +10	Revised Score
1. Heat pumps		1. ________
2. New appliance performance standards		2. ________
3. New building performance standards		3. ________
4. Residential and commercial retrofit		4. ________
5. District heating		5. ________
6. Integrated community energy systems		6. ________
7. Modifying land use configurations		7. ________
8. Wastes as fuel to cement kilns		8. ________
9. Coal fired aluminum remelt		9. ________
10. Cogeneration		10. ________
11. Waste product utilization		11. ________
12. Pulp and paper		12. ________
13. Cupola Furnace		13. ________
14. Smaller cars		14. ________
15. Vehicle design change		15. ________
16. Diesel engines		16. ________
17. Car and van pooling		17. ________
18. Transportation mode shift		18. ________
19. Utility rates reform		19. ________
20.		20. ________

NAME ______________________________

SCALING

0 to 10, 0 = not feasible

FEASIBILITY CRITERION: ____________________

Conservation measure	Score	Revised Score
	0 10	
1. Heat pumps		1. ________
2. New appliance performance standards		2. ________
3. New building performance standards		3. ________
4. Residential and commercial retrofit		4. ________
5. District heating		5. ________
6. Integrated community energy systems		6. ________
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17. Car and van pooling		17. ________
18. Transportation mode shift		18. ________
19. Utility rates reform		19. ________
20.		20. ________

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