II. TUTORIAL PAPERS

This section of the Proceedings contains five lectures on the five major policy areas addressed by the conference. The paper by Mr. Promisel was not delivered at the conference but was supplied later; in its place, the conferees heard a series of short presentations on various international aspects of materials policy.

The five major areas dealt with in these papers are: the current state of materials information management in the United States; the present condition of U.S. supply of materials; the opportunities for materials conservation through engineering design; the current state of recycling and re-use of materials recovered from municipal solid waste; and the potential contributions of the technical societies in materials fields to national and international goals of society.

Materials Information: An Examination of the Adequacy of Existing Systems

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Introduction

It has been said that the possession of materials, the understanding of materials and the ability to use materials have been the determinants of every civilization the earth has ever known. If this be granted, then *information* on materials is an even more basic building block in a flourishing society. We need to know the amounts and the qualities of the material resources we possess (or lack), we must record, catalog and retrieve the myriad facts, theories and observations that constitute our understanding of materials, and we must have sufficient handbooks, manuals, texts and tutorial works to guide our citizens in their use. Despite this basic and critical position of materials information, we have become all too familiar with what may be called the materials information syndrome among the users of this information. This syndrome comprises bewilderment, apprehension, dismay, frustration, and outrage: *Bewilderment* with respect to the enormous volume and diversity of needed sources of information; *Apprehension* as to the quality and reliability of those facts; *Dismay* at the redundancy, gaps, and lack of coordination between information sources and systems; *Frustration* with the mechanics of search, retrieval and manipulation of information from the general store; and *Outrage* at the cost of seeking and locating needed information.

There appears to have been adequate prior recognition of the importance of this problem and the urgency to do something about it on a comprehensive, coordinated national scale. Looking only at reports and conferences of the several recent national ad hoc commissions addressed to questions of materials policy, we find that the two earlier Henniker Conferences of 1970 and 1972, the 1973 NCMP report, "Materials Needs and the Environment", the 1973 FMS report, "Conservation in Materials Utilization", and the 1974 COSMAT report, "Materials and Man's Needs", all placed this question high on the list of priorities. Unfortunately, these reports offer few specifics in proposals for alleviating the problems alluded to above. Further recognition of the high importance of the problem of materials information was the action by the recently formed Federation of Materials Societies in establishing a standing Materials Information Committee. This Committee was in the early stages of planning and implementing its program of activities when a request came to it from the Office of Technology Assessment to conduct a quick but comprehensive survey of the breadth and intensity of the materials information problem. Such a survey was mounted and this paper is an interim report of some of its preliminary results although the survey is still in progress.

Methodology of the Survey

A four-page questionnaire was designed* and circulated to about 4000 addressees. These were selected from conference registration lists of persons previously evincing an interest in materials information, from nominations by the constituent societies of FMS, from special interest groups such as the Special Libraries Association and from the discipline indices of the 12th edition of *American Men and Women of Science.* This multifaceted approach was taken to ensure reasonable coverage of all elements of a large materials-information matrix embracing all kinds of materials and all types of information. The questionnaire posed both general questions as to the nature and importance of the materials information problem and specific questions about the attributes of certain information sources frequently used and highly valued by the respondent. At the time of preparation of the present paper, about 700 replies had been received, the quantifiable data key-punched and

*Although the membership of the Materials Information Committee of FMS is broader still, those members of the Committee who participated in the design, circulation and analysis of this questionnaire were: J. H. Westbrook (General Electric Company) Chairman; Felice Celli (Chemical Abstracts); Edward Dugger (US Air Force); Franklin Huddle (Library of Congress); Morton Malin (Institute of Scientific Information); Robert Marvin (National Bureau of Standards); Dana Moran (Battelle Memorial Institute); and Theodore Rupprecht (Bendix Corporation).

computer-analyzed. This response was not as great as had been hoped. Many people apparently had difficulty with the questionnaire—some finding it excessively broad and open-ended; others viewing it as much too specific. Nonetheless, it appears that the volume of response is already sufficient and the pattern of replies to individual questions such as to give some useful insights to the general problem.

The Respondents

An early question on the form asked the respondent to characterize himself as to the nature of his disciplinary field, his institutional affiliation, and his function within his institution. The results are summarized in Figure 1. This result is satisfying in that it shows we had a diverse response in all of these respects. It might only have been hoped to have had a larger response from information specialists and design engineers although it is admittedly difficult to identify individuals from these disciplines who simultaneously have an interest in, and some familiarity with, materials and materials information sources.

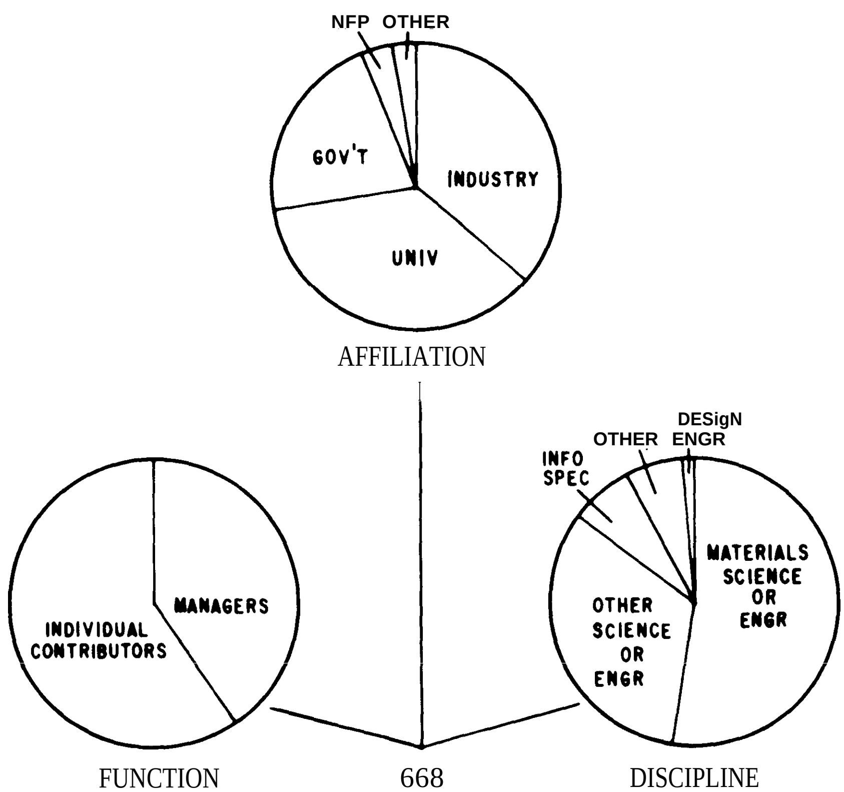

Figure 1. Respondents.

FIGURE 2. RESPONDENTS TO QUESTIONNAIRE.

University	Materials scientists/engineers		[illegible]	88
University	Other scientists/engineers		IC	84
Industry	Materials scientists/engineers		MGR	78
Industry	Materials scientists/engineers			60
Government	Materials scientists/engineers		MGR	40

FIGURE 3.668 USABLE RESPONSES TO QUESTIONNAIRE.

Materials	Engr prop	Sci data	Eval tech	Applic	S/D stat	Supp	Totals
Metals and ores	68	71	15	22	31	29	236
Minerals	11			10	21	7	94
Forest products	13	38	4	10	20	8	93
Polymers	16	28	5	10	2	1	62
Ceramics and glass	16	41	2	12	1	1	73
Textiles and agricultural products	4	13	1	8	2	1	32
Chemicals, lubricants and finishes	4	26	0	6	5	2	44
Semiconductors	7					0	34
Totals	139	277	39	82	82	49	

Figure 2 shows the most heavily populated groupings of respondents when the various combinations of affiliation, discipline, and function are considered. Individual contributor materials scientists/engineers with university affiliation top the list. The distribution of respondents over the materials-information matrix is shown in Figure 3.** Here again the results showed that we had indeed cast our net quite broadly. There are few sparsely populated cells and this defect should be readily remedied in further extension of the survey.

Importance of Materials Information

Asked to assess the importance of improved materials information systems to the national interest, respondents replied as shown in Figure 4. Less than 15% find the present situation satisfactory and more than a third rate it highly critical. These responses were broken down by affiliation, discipline and function as shown in Figure 5 but no significant differences are revealed (too few designers replied to represent their percentage response). Broken down once again by the matrix categories of Figure 3, the replies are distributed according to intensity of need as shown in Figure 6. Better information on Supply/Demand Statistics and Evaluation Techniques on metals and their ores is most keenly felt followed by that for Applications, Engineering Properties and Scientific Data on a wide variety of materials.

***For the purposes of this interim report, some of the columns and rows of the original 9 x 15 matrix were melded together to yield the 6 x 8 form shown here.*

General Views *and Recommendations*

Respondents were asked to specify what they perceived as the greatest deficiency in materials information with respect to the national interest in a free-form response. These responses naturally varied widely in wording and specifics, but after grouping replies into a small number of categories, Figure 7 was compiled. It should be noted that the idealized system filling the greatest perceived need has three distinct attributes: it is comprehensive (at least from the standpoint of one user); it is machine readable, and it is continuously updated. It must be pointed out, as will be seen later, this does not imply a single, all-encompassing computer information bank of all materials information; but rather one which is comprehensive only as regards a single element (or a few closely related ones) of the matrix of Figure 3.

Another question asked for the favored broad objective in improvement of our national management of materials information with the result shown in Figure 8. Less than half the respondents seek an

FIGURE 4. IMPORTANCE OF IMPROVED MATERIALS INFORMATION SYSTEMS.

Assessment	70
Highly critical	36.5
Important	48.5
Satisfactory	11.6
Attention. selected area only	3.3

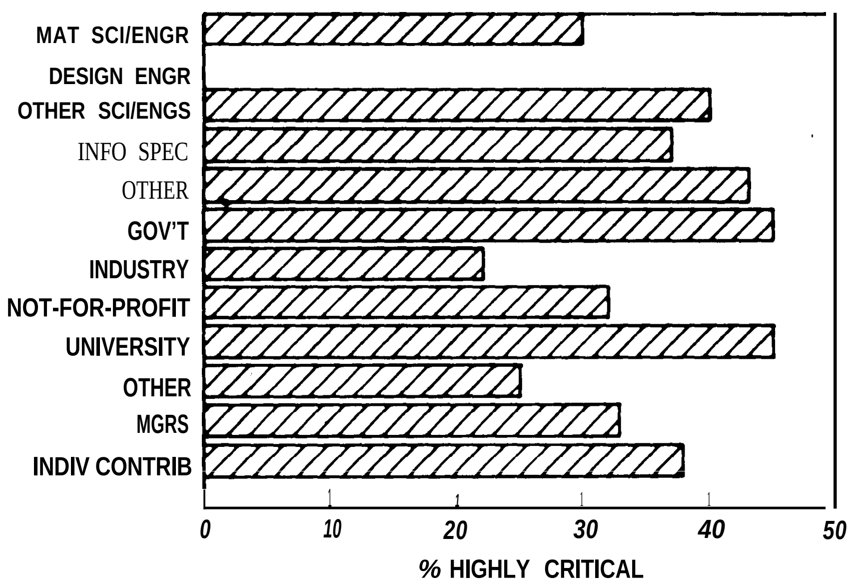

Figure 5. importance

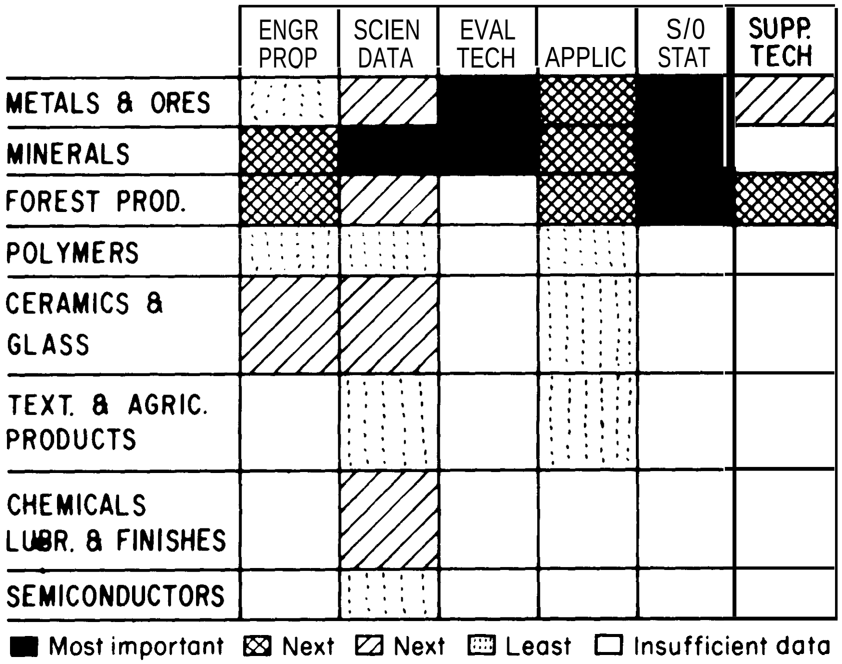

Figure 6. 668 usable responses.

integrated national system and even some of these may be looking at the question in the narrower sense discussed above. There is support for selected improvements to our present pluralistic system.

A common observation, particularly by information specialists, is that lack of awareness on the part of potential users of presently existing information sources inhibits their full utilization. The results of Figure 9 would indicate that while this may be true to a degree, it is spotty rather than general in occurrence. A closely related question sought to discover whether it was important to educate materials specialists in information sources and information handling techniques or correspondingly to educate information specialists in the vocabulary and information needs of materials specialists. Figure 10 shows that both these aspects are held to be important.

Figure 11 supports the widely held view that as far as technology is concerned, we are, indeed, "one world" and we in the U.S. cannot

FIGURE 7. PERCEIVED NEED.

Comprehensive, machine readable, continuously updated information system	111
Handbooks, reviews, compilations with critical evaluation and coordination	107
Lag in availability of information	47
Problem of proprietary information	
Better economic statistics, supply/demand, etc.	42
Problems of coping with foreign information	29

FIGURE 8. FAVORED OBJECTIVE.

Comprehensive, integrated, national system	44.0%
Improved present pluralistic system	43.2
No change	12.8

FIGURE 9, AWARENESS BY USERS.

Sufficiently aware	41 .6%
Some blind spots	44.4
Woefully ignorant	14.0

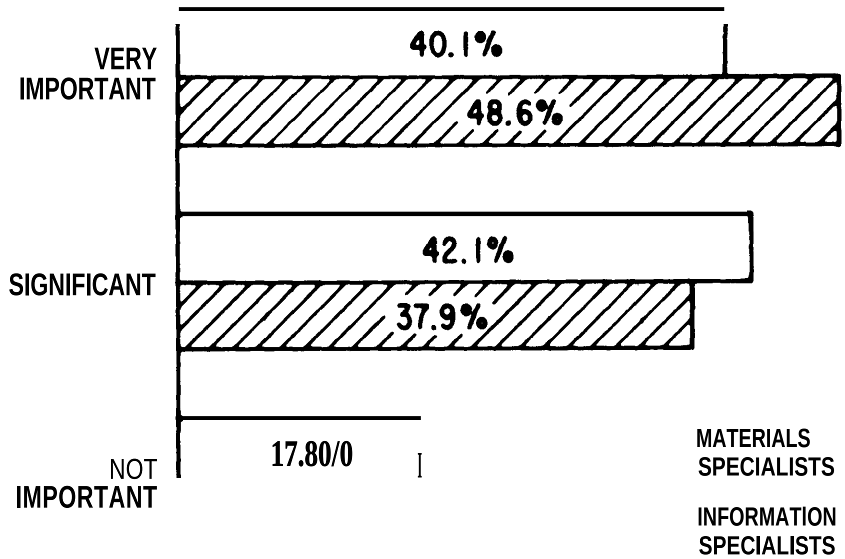

Figure 10. Education.

FIGURE 11. U.S./FOREIGN INFORMATION.

Well coupled	32.0%
Not well coupled	64.5
Not important	3.5

FIGURE 12. WHO SHOULD PAY COSTS?

Shared	54.2%
Government mission agency	22.8
	17.6
Professional societies	3.5
Other	I.9

ignore the materials information generated and organized by foreign sources. Two-thirds of the respondents believe we are not adequately coupled to these sources.

Various schemes for paying the costs of materials information management have been assayed in recent years. The findings of Figure

12 clearly reject the traditional approaches and opt for some form of cost sharing.

Attributes* of *Specific Information Sources or Systems

A major portion of the questionnaire dealt with this topic. The respondent was asked to cite the four most important specific, not generic, sources of systems of materials information in the materials-information matrix category with which he most readily identified himself. Then he was asked to evaluate each source cited with respect to 10 qualities or attributes. Space does not permit inclusion of all these results here, but some of the more interesting will be presented.

The most startling result was that the 668 responses to the questionnaire evoked the citation of 574 unique sources despite the fact that many ignored the direction and cited generic sources such as “the technical literature” or “my Company’s files”. This great diversity of important sources is one of the root causes of the materials information problem. Although the data scatter too widely to permit rank ordering of individual sources, the leading specific sources are listed in Figure 13 and the most important generic sources in Figure 14. Here again the strength of a diverse, pluralistic information base are illustrated both with respect to the form of information collection and to the sponsoring body (government or professional society).

The great number of specific sources cited by respondents precluded the collective assessment of individual sources. Consequently, all that has been possible to this point is to lump all these assessments together. This procedure at least permits an evaluation of the characteristics of materials information sources in general. Figure 15 shows that few sources are complete in the sense of containing all of known information while Figure 16 shows an analogous deficiency in serving the existent national needs for materials information. Quality of information is generally good to excellent with little that is imprecise, unreliable or obsolete (Figure 17). Under the rubric “accessibility” the barriers posed

FIGURE 13. MOST IMPORTANT SPECIFIC SOURCES.

Chemical Abstracts	US Bureau of Mines	ASTM
Journals, American Ceramic Society	US Geological Survey	MCIC
Journal, Polymer Science	US Forest Service	ASM Metals Handbook

FIGURE 14. MOST IMPORTANT GENERIC SOURCES.

Source	No. of citations
Primary literature	513
Abstracts, journals, indices, bibliographies	368
Information centers	358
Handbooks and data compilations	257
Professional societies	127
Review serials	32

FIGURE 15. COMPLETENESS.

100% (approx)	14.7%
75% (approx)	31.0
50% (approx)	27.1
Less than 20%	27.2

FIGURE 16. ADEQUACY.

Classification	
Serves all needs	8.2
Serves most needs	57.9
Many not served	33.9

FIGURE 17. QUALITY.

Excellent	29. 1%
Good, some deficiencies	63.8
Imprecise, unreliable or obsolete	7.1

FIGURE 18. ACCESSIBILITY.

Adequate	56.9%
Limited	32.1
Very limited	11.1

FIGURE 19. SYSTEMS INTERFACE.

Very well	46.9%
In part	42.4
Not at all	10.7

FIGURE 20. RESTRICTIONS

Non-English language	15.67.
Military classification	3.6
Company proprietary	22.4
Specialized terminology or orientation	48.5
Other	9.9

by cost, arrangement of information and time delay in search and retrieval were assembled. Figure 18 shows that less than half the respondents found this factor limiting the utility of the sources cited. Compatibility y of the source in interfacing with other information systems was not found to be a major problem (Figure 19); while user qualifications present barriers to utilization that are held to be of various degrees of importance (Figure 20). Of special significance is the finding that the specialized terminology or orientation of many information sources impedes their full utilization by all potentially interested persons.

Concluding Remarks

This preliminary survey conducted for the Office of Technology Assessment has produced many useful insights into the problems of the management of materials information. The more important of these can be summarized as follows:

1. The critical importance of the materials information problem is recognized broadly.
2. Attention is required for improved evaluation, condensation, presentation and mechanization of materials information.
3. There are special problems with proprietary information, foreign information, and supply/demand statistics.
4. There are educational problems acquainting information specialists with the needs of materials people, teaching materials technologists the tools and techniques of information specialists and in presenting design engineers with materials information in a form they can understand and use.

It is planned that this conference will operate in the mode of parallel task forces addressing themselves to each of the problems selected for study. With respect to the problem of the management of materials information, we would offer the following specific charges to the task forces:

1. Goals
   a) definition of *specific, attainable,* goals
   b) assignment of priorities to these goals
2. Means of implementation
   a) setting up alternative routes toward each goal
   b) choosing between these alternatives
   c) in-depth analysis of a specific plan toward each goal
3. Value of information
   a) how to fix the proper amount of money to be spent for information
   b) how to allocate costs of information
   c) how to demonstrate benefit/cost ratio for information

The success of the Conference with respect to the materials information problem will be measured in large part by the degree to which the task forces have grappled with these specifics.

THE CURRENT STATUS OF THE U.S. MINING INDUSTRY AND THE NEED FOR BOTH INCREASED PRODUCTION AND INCREASED PRODUCTIVITY

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Abstract

The U.S. economy annually needs over 4 billion tons of new mineral supplies. The value of domestically produced energy and processed materials of mineral origin exceeds $175 billion annually, but domestic production of both raw and processed minerals is not keeping pace with demand.

Mining and agriculture are the primary sources of all new wealth and minerals are the lifeblood of any industrialized civilization. Annually, the economy of the United States now requires over 4 billion tons of new mineral supplies. Two decades ago that tonnage was only half as large, while projections indicate that demand could nearly triple from present levels by the year 2000.

In 1973 the U.S. economy reached a new annual high of $1,288 billion, increasing each quarter. However, there was a relative plateauing in the last quarter of the year, reflecting the impact of the “energy crisis” precipitated by the Arab oil embargo. The value of domestically produced energy and processed materials of mineral origin was estimated to be more than $175 billion in 1973, based largely on mineral raw materials of domestic origin valued at $35 billion, supplemented by imports of raw and processed mineral materials valued at $19 billion. Imports were, however, offset to some degree by exports of raw and processed minerals valued at $11 billion, leaving a net U.S. deficit of the order of $8 billion. This deficit, which has been increasing over the years, is a major factor pointing to the need for increased domestic productivity. As detailed in Figure 1, crude and refined petroleum and iron and steel were the major items contributing to the net deficit position. Imports of both those major materials have been rising steadily over the past two decades, as shown in Figures 2 and 3.

In 1973, domestic production of most major metals, led by a 14 percent rise in domestic raw steel production, was up somewhat and

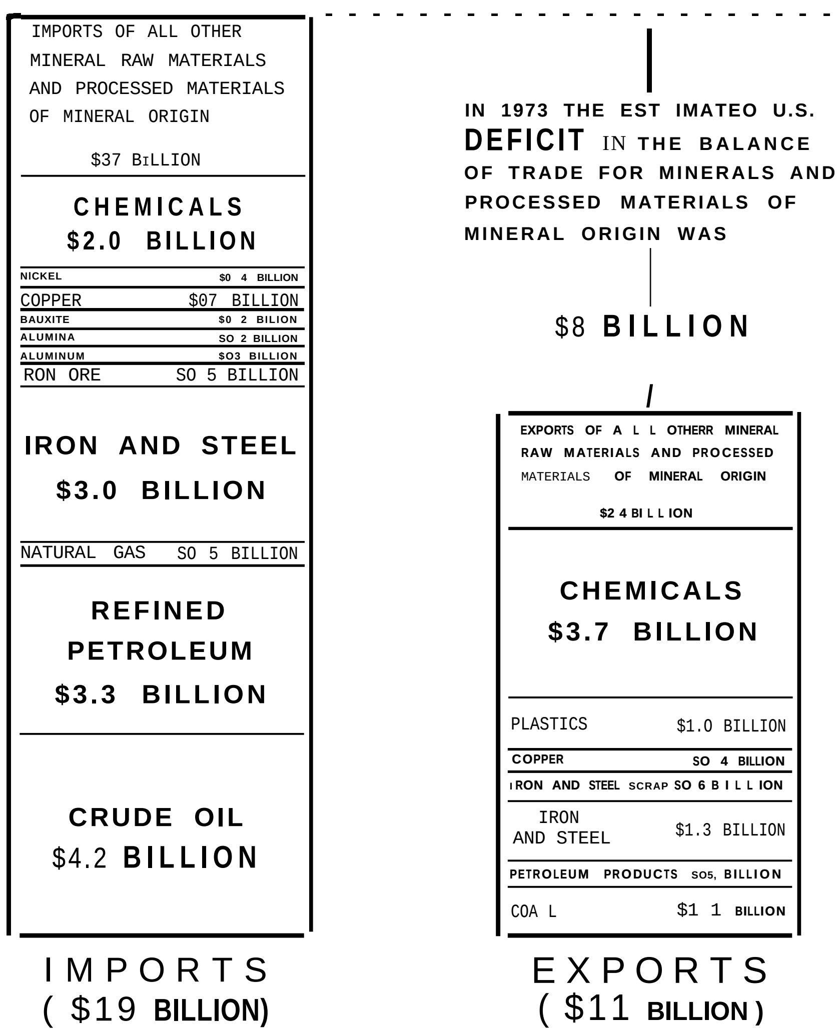

Figure I. U.S. mineral import deficit (1973).

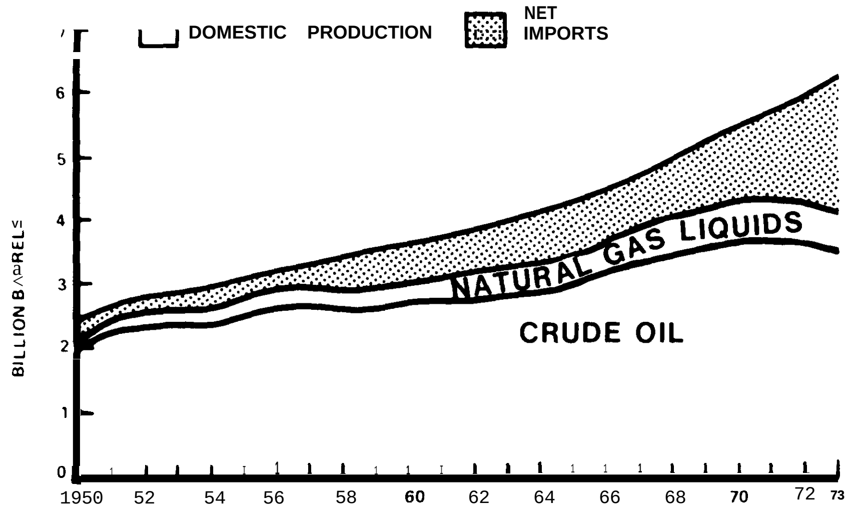

Figure 2. U.S. supplies of petroleum (1950 through 1973).

domestic production of most nonmetallic was also up. However, on an overall basis, domestic mineral production is *not* keeping pace with domestic demand. In 1973 demand for minerals was stimulated in part by business expenditures for new plant and equipment estimated at $100 billion, while the value of new construction put into place was valued at $135 billion. Demand for motor vehicles also stimulated demand for minerals because about one-fifth of our steel and proportional quantities of many other minerals are so used: 1973 production of

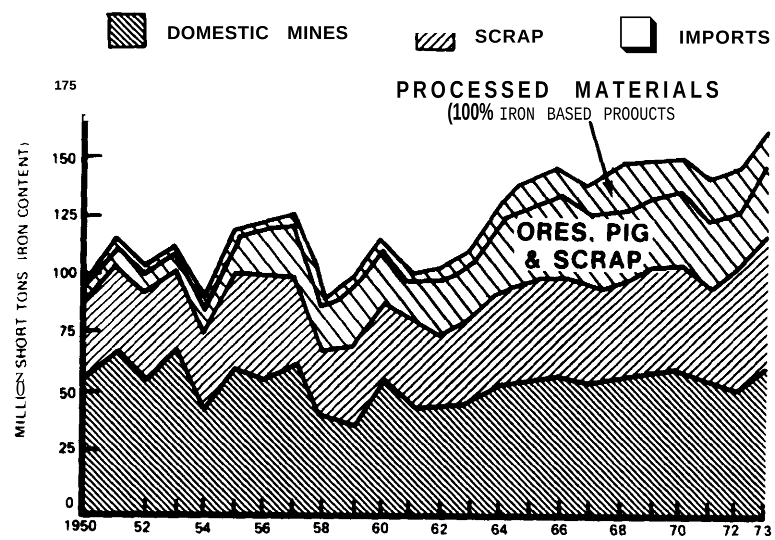

Figure 3. U.S. supplies of iron and steel (1950 through 1973).

new automobiles was up 9 percent to a total of 9,667,000 units and truck production was up 21 percent to a total of 3,014,000 units.

Despite a variety of price controls in effect in 1973 pursuant to the Economic Stabilization Act of 1971, as amended, the wholesale price indexes of major mineral commodity groups increased. The 1973 indexes, based on 1967 = 100, were as follows: metals and metal products, up 7.5% to 132.8; nonmetallic mineral products, up 3.3% to 130.2; chemicals and allied products, up ***5.670*** to 110.0; and fuels and related products and power, up 2370 to 145.5. These price increases are another major factor pointing to the need for increased productivity. Domestic price controls were alleged to have created a number of anomalies in the mineral industry in 1973, including such diverse impacts as creating domestic "shortages" of ammonium nitrate for fertilizers and explosives, of roof bolts for coal mine safety, and of domestic copper, lead, zinc, and other materials in instances where world prices rose significantly above domestic prices and where United States export controls were either not in effect or inadequate. The President, in his February 1, 1974, "Economic Report to the Congress" recognized the importance of free markets, stating:

> "In the past several years, under the pressure of emergency conditions, we have made great, but temporary, departures from reliance on free prices and free markets. In special circumstances and for short periods these departures have been helpful. But taken together, these experiences have confirmed the view that the free market is, in general, our most efficient system of economic organization. and that sustained and comprehensive suppression of it will not solve the inflation problem".

In line with this philosophy, price controls on all metals except steel, copper, and aluminum were lifted completely in December of 1973, and controlled rises in some of these product areas were permitted. All price controls expired on April 30, 1974, except those on petroleum.

In mid-1973, the Secretary of the Interior issued his "Second Annual Report Under the Mining and Minerals Policy Act of 1970. " Stating that "development of domestic mineral resources is not keeping pace with domestic demand, " he cited nine major problem areas confronting the mining, minerals, metal, mineral reclamation, and energy industries as follows:

(1) Mineral imports have an unfavorable impact upon the U.S. balance of trade and upon the U.S. balance of payments;

(2) Expropriations, confiscations, and forced modifications of agreements have severely modified the flow to the U.S. of some foreign mineral materials produced by U.S. firms operating abroad, and have made other materials more costly;

(3) U.S. industry is encountering greater competition from foreign nations and supranational groups in developing new foreign mineral supplies and in assuring the long-term flow of minerals to the United States;

(4) Development of the U.S. transportation net is not keeping pace with demand, thus seriously affecting the energy and minerals industries;

(5) Removal of billions of tons of minerals annually from the earth contributes to a variety of disturbances;

(6) The U.S. mining, minerals, metal, and mineral reclamation industries are encountering increasing difficulty in financing needed expansion of capacity and the introduction of new or improved technology;

(7) Management of the resources of the public lands, including the continental shelves, must be improved;

(8) The factual basis for the formulation and implementation of environmental regulations must be improved, so that man and nature are properly protected with minimum dislocation of important economic activities; and

(9) The U.S. Government information base for the conduct of its mineral responsibilities is grossly inadequate.

A number of corrective legislative recommendations were made, including creation of a Department of Energy and Natural Resources, provision of an organic act for the Bureau of Land Management, revision of the mineral leasing laws, regulation of surface mining activities, amendment of the Natural Gas Act, construction of deep-water ports, and modification of right-of-way limitations, but only the latter, as the Alaska Pipeline Bill, was enacted into law in 1973, and the other recommendations were carried forward into the considerations of the Congress in 1974. Also in mid-1973, the National Commission on Materials Policy issued its "Final Report" which made 177 detailed recommendations, those affecting minerals being in close agreement with the Mineral Policy Report. Perhaps, the most significant recommendation of the NCMP was that—

> "it should be the policy of the United States to rely on market forces as a prime determinant of the mix of imports and domestic production in the field of materials but at the same time decrease and prevent wherever necessary a dangerous or costly dependence on imports".

While our economy has grown over the years, that of the world has increased even more, so that today we are finding ever increasing competition when it comes to acquiring needed raw materials, while, at the same time, we are also finding it increasingly difficult to sell many manufactured articles in world markets to pay for imported raw materials. Two decades ago, the United States produced about one-half of the world's steel as shown by Figure 4, whereas today, despite growth, we now only produce one-fifth. Similarly, as shown by Figure 5, where we once produced larger fractions, today we produce only one-fourth of the world's refined petroleum, and one-third of the world's aluminum metal. And, as shown by Figure 6, we are dependent upon imports for substantial portions of a number of important mineral materials. Lessening such dependence by increasing domestic production and/or productivity would be highly desirable.

The natural resources of the United States are vast, but to be useful to man natural resources must be found, developed, and processed. The natural resources of any nation are related to its size, its geology, and its location on the earth. Only one nation—the Union of Soviet

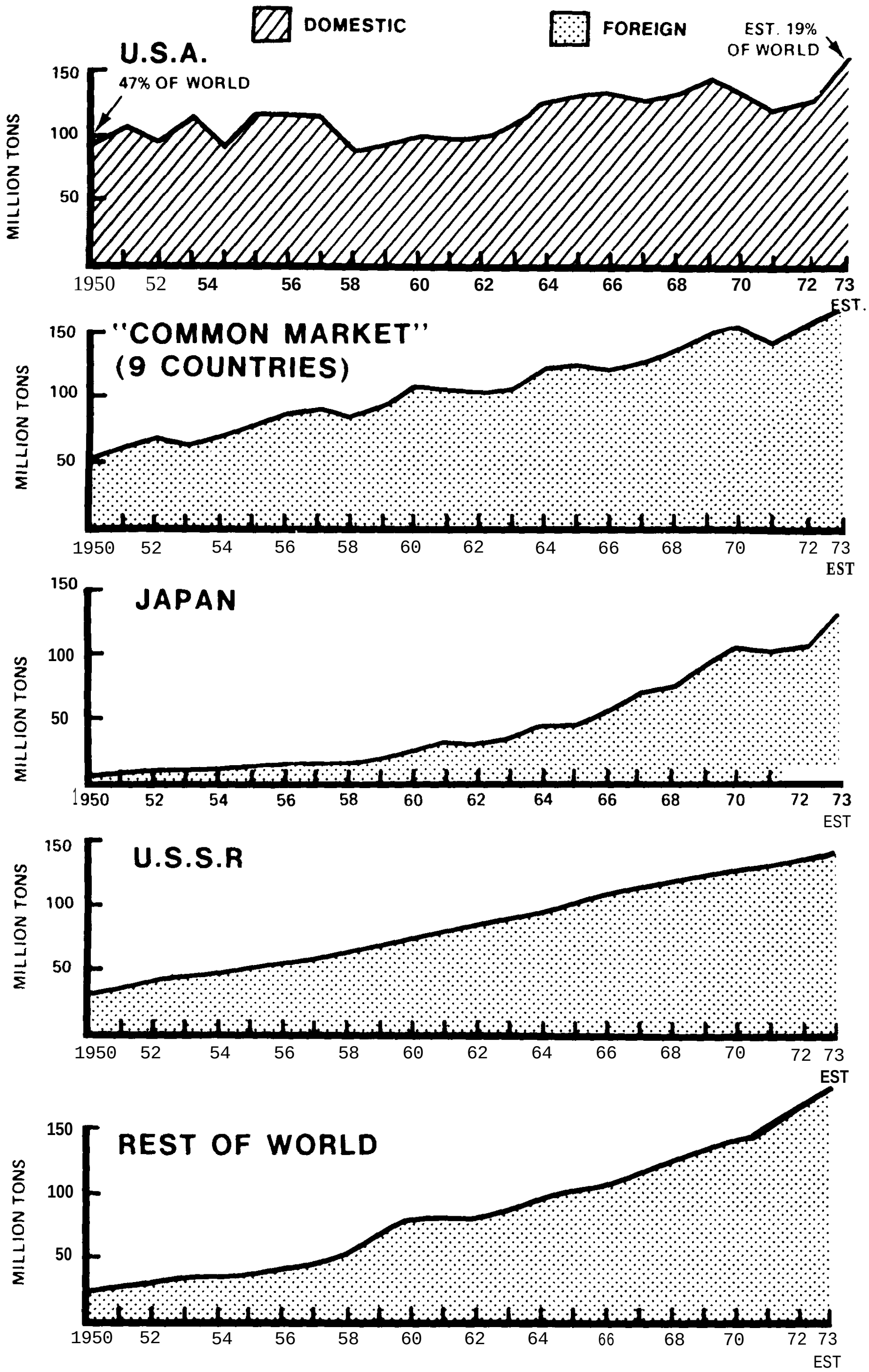

Figure 4. World steel production (1950 through 1973).

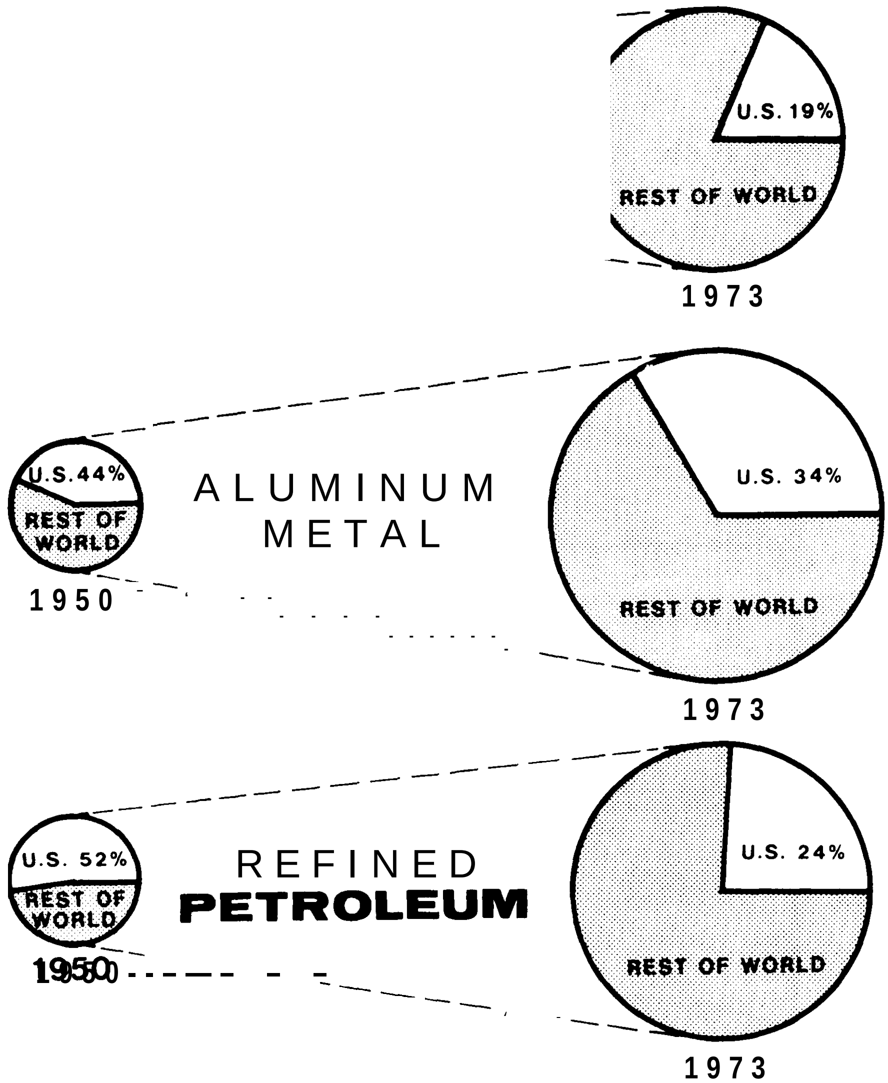

Figure 5. U.S./world production (1950 and 1973).

Socialist Republics—substantially exceeds the United States in land area, and only four other nations—the People's Republic of China, Canada, Brazil, and Australia—have land areas about the size of the United States. In addition to its land area, the United States has extensive continental shelves and direct access to the seas and the seabeds of the world. The United States has almost every type of geologic formation within its borders. As a consequence of its size, geology, and geography, the United States has vast resources of rocks and minerals, soils, subsurface fluids (including oil and gas), waters, and air.

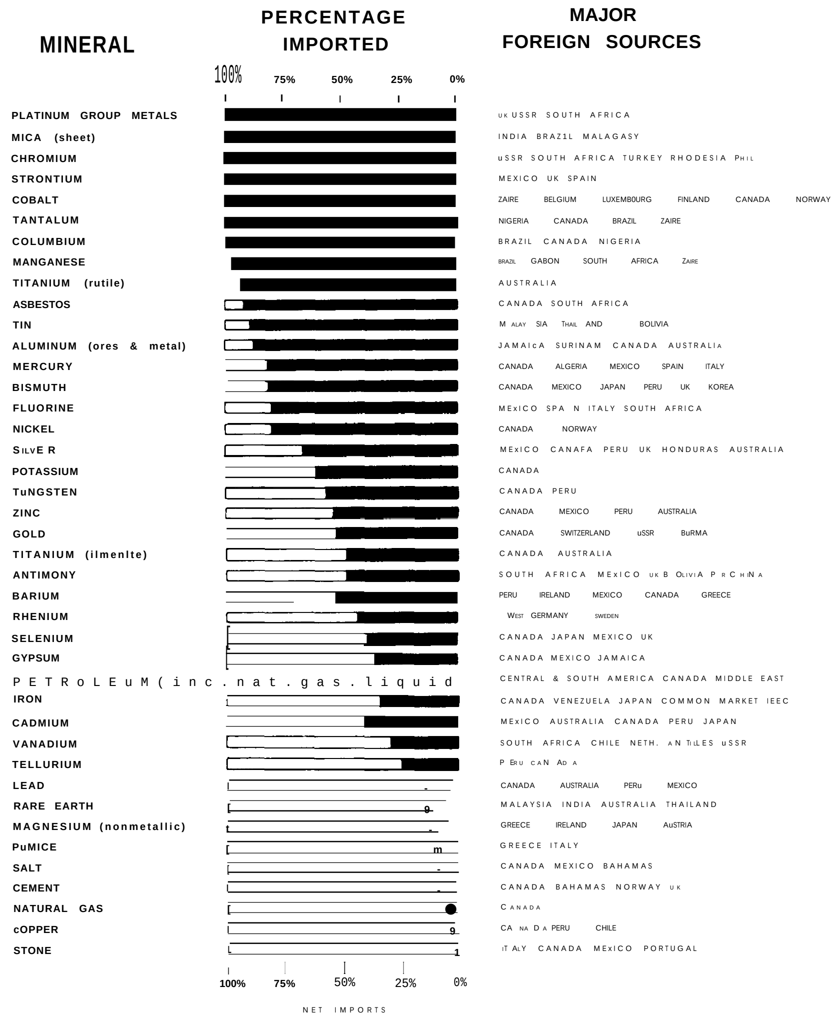

Figure 6. U.S. dependence upon imports (1973)

However, to convert natural resources into useful materials technology must be continuously improved; the technology must be workable at reasonable prices; the processes must be compatible with environmental regulations and industrial health and safety standards; and the business must yield profits comparable with other economic activities. Examination of Figure 7 covering debt/equity ratios and of Figure 8 covering profits as a percent of stockholders' equity indicates that some major segments of the mineral industry are not in as satisfactory position as ''all manufacturing' as a whole. Consequently, improvement of productivity is essential.

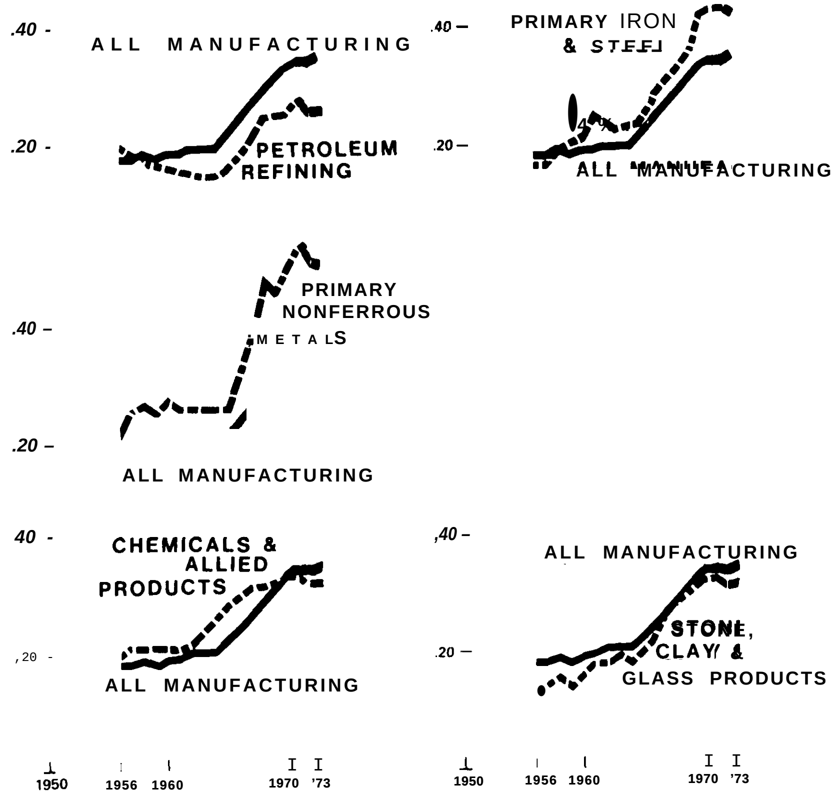

Figure 7. **Debt/equity ratios (1956 through 1973). Numbers are ratios** of dollars involved.

Mineral deposits generally are harder to find and assess than agricultural resources, because most mineral deposits are located out of sight below the earth's surface. Our deepest mines have penetrated only somewhat beyond a mile in a few places and our deepest wells only to about six miles in a few places. Our deepest dredges now operate in only a few hundred feet of water; yet it is nearly four thousand miles to the center of the earth. Through the study of geological maps and the making of complex geophysical and geochemical measurements skilled geologists can, in some cases, infer what lies below the surface. Obviously, in areas where the rock strata are relatively uniform and cover many square miles, inferences as to what may be found below are better than in areas of very complex geology where heat, pressure, and earth movements have greatly deformed the rocks. Mineral deposits that have been found, adequately drilled to determine their content of valuable minerals, and that can be mined, processed, and converted into useful materials with known technology at reasonable prices are commonly called "reserves. " (Example: the rocks of the earth's crust average 5% iron, the United States has vast "resources" of rocks

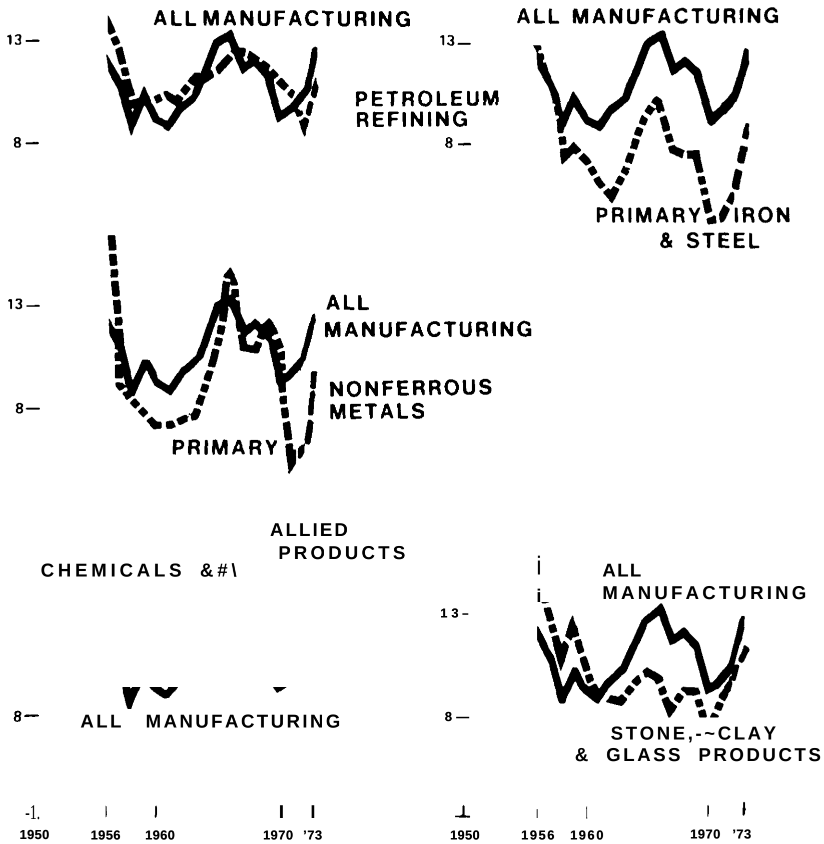

Figure 8. Profits as a percent of stockholders' equity (1956 through 1973). Numbers are percentages.

containing more than 5% iron; the iron ore "reserves" of the United States are 10,000,000,000 tons, which in turn contain 2,000,000,000 tons of recoverable iron metal, compared to U.S. steel production of 151,000,000 tons in 1973). Agricultural materials are generally renewable in relatively short time spans, in that some crops can be raised four or five times a year, annual cycles are common, and softwood trees can be raised on fifteen to twenty year cycles. Mineral deposits, however, normally are formed only over much longer periods of time—usually tens of millions or hundreds of millions of years. Consequently, the total supply of all minerals accessible to man in the earth's crust is, to all practical purposes, relatively fixed; consequently, mineral materials are generally of greater concern to nations with heavy industry.

Other than in nuclear processes, elements are neither created nor destroyed—man's processing merely combines them in certain ways, recombines them, or reduces combinations into elemental form. Thus, the materials industries are engaged in extracting elements from natural materials, and/or combining or recombining them into forms useful to man. Nature itself is constantly engaged in vast processing activities, in which the ‘‘carbon-oxygen” and “nitrogen” and “hydrologic” cycles are major examples.

For many purposes interchangeabilities in materials are possible. (For example: rubber can be made from: natural latex from rubber trees, carbon and hydrogen from alcohol from grain or other agricultural materials, carbon and hydrogen from hydrocarbons from petroleum, natural gas, coal, etc.; and buildings can be constructed from: steel, aluminum, copper, glass, stone, slate, concrete, tile, wood, plastics, plywood and many, many other materials.)

However, in specialized technological applications in which a multiplicity of properties are required, (for example: a combination of strength, electrical conductivity, temperature resistance, corrosion resistance, and creep resistance) the available materials are much more limited. If we are to achieve substantial breakthroughs in metallurgy, chemical processing, and energy generation, we must have greatly improved temperature-resistant materials, yet Figure 9 shows that there are only a very limited number of elements which possess such properties. Here, too, the “productivity” of our alloys and refractories must be improved.

Today improvement of productivity in the mining, minerals, metal, mineral reclamation, and energy industries requires accelerated development of new and improved technology and rapid introduction thereof into all stages including:

Exploration
Mining and petroleum and natural gas production
Processing
Use
Recovery and Recycling

In all of the above appropriate provision must be made for the health and safety of workers and for environmental enhancement through: minimizing air, water, and land pollution; land restoration; and esthetic improvement.

Further, because many important minerals are initially large bulk items, mineral production is heavily dependent on the United States transportation infrastructure. Minerals account for:

90% of all U.S. waterborne imports
50% of all U.S. waterborne exports
85% of all domestic waterborne commerce
70% of all railroad traffic
1OO% of all pipeline traffic

Consequently, improvements in rail and water transportation are of direct concern to major segments of the domestic mineral industry.

The resources of industry, government, and of academia, must be brought to bear on current major problems, including:

Discovery and assessment of resources presently untouched by our deepest mines and wells.

Development of safe and efficient coal mining systems to significantly

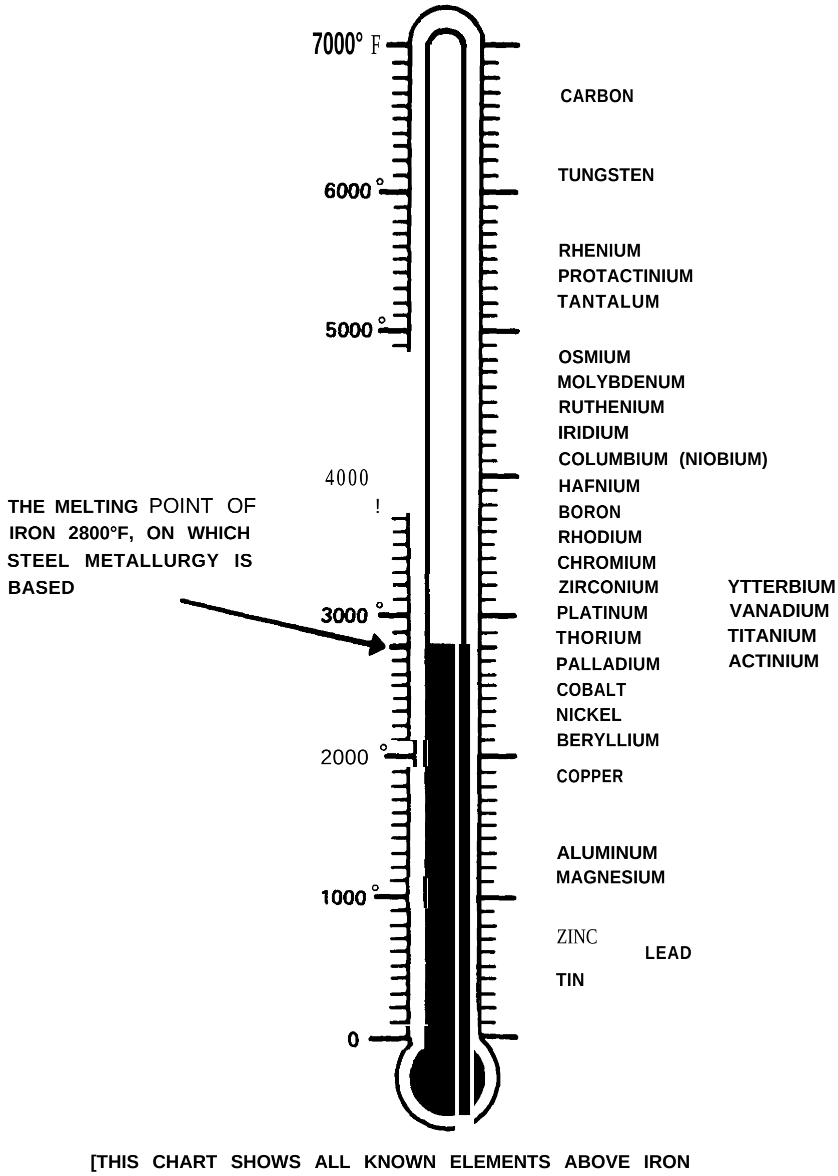

Figure 9. Melting points of selected elements.

increase underground extraction ratios from the present level of about one-half.

Development of improved petroleum recovery methods to significantly increase extraction ratios above the present level of about one-third.

Development of underground and surface mining methods to minimize degradation of the land surface, subsidence, and harm to surface and subsurface waters.

Development of clean burning solid, liquid, and gaseous fuels from coal, petroleum, and other energy materials.

Improvement of combustion processes to increase efficiency and to reduce emissions of fumes and particulate.

Improvement of electricity generation, transmission, and conversion methods.

Development of new energy sources including geothermal and solar.

Development of stronger, lighter, corrosion-resistant and temperature-resistant materials.

Improvement of recycling techniques to conserve natural materials and energy, and to promote environmental enhancement.

Stimulation of measures to conserve energy and materials in actual or potential short supply.

In the Department of the Interior, the Geological Survey, the Office of Coal Research, and the Bureau of Mines, under the immediate direction of the Assistant Secretary—Energy and Minerals, and the Secretary, are working closely together in furtherance of the above objectives to improve our domestic minerals position.

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University of Missouri--Rolla,
Pennsylvaniu State University,
University of *Arizona).*

THE DESIGNER AND MATERIALS CONSERVATION

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Introduction

One cannot help but be in complete accord with the intent of this conference and with the growing awareness of impending materials scarcity in our society. I certainly do not have to reiterate for this audience the need for laying in the proper course for our materials future. Nor must I acquaint you with the complexity and breadth of the issues which surround that task. We in the United States are just beginning to realize that the proper use of our materials heritage, and the preservation of that heritage for future generations, are issues that require a more farsighted and objective treatment than they can get through the raw instincts of supply and demand. These issues are also highly dependent on such unpredictable forces as national and international politics, cultural and esthetic factors, and society's attitudes and values. Their proper resolution will require the continuing effort of a lot of very capable and knowledgeable people. But the raw materials issues are so vital to man's future, and the proper course so difficult to define, that it is imperative for us to begin serious efforts to formulate practical policies,

My remarks today deal with the potential for improved materials conservation in product design. The growing prospects of shortages in resources vital to our society's needs has led to closer scrutiny of our design use of materials. The opportunities and basic principles for resource conservation through more effective utilization of materials in product design and manufacture are documented in a number of papers and committee proceedings. Perhaps the best summary statement of these principles is to be found in the definition of "materials effectiveness" introduced in the report of the Federation of Materials Societies to the National Commission on Materials Policy:

> "In the most general sense and in relation to materials use and conservation, it means that in a given application or product, our aims are:

1. To develop, select and design into products materials that most efficiently meet application requirements, that have optimum durability and life, and that are recyclable.

2. To process and fabricate materials so as to consume, waste, or disperse the least amount of materials for equivalent performance.

Now these principles are well considered and hardly subject to dispute. Accordingly, I don't feel it would be useful for me today to reintroduce, or rephrase, or rederive them. Instead, I will address two issues which appear tome to be critical to the ultimate exploitation of the opportunities for improved materials conservation through design. They are:

1. What must we do to provide the individual product designer with the tools, the training and motivation to implement this shift in design philosophy towards materials conservation?

2. As new materials and processes emerge from our research and development laboratories which might better serve materials conservation, what must we do to overcome the traditional reluctance to apply new materials and manufacturing techniques?

I must draw most of my basic examples from the aerospace industry since that is the turf I have played on for the past thirty years and is where I feel most at home. To put the aerospace industry into perspective as to its raw materials use, Figure 1 identifies three primary materials most widely used in our industry. It includes the total national consumption, the amount consumed by the total aerospace industry, both military and commercial, and the percentage that the aerospace use is of the total.

In general, the aerospace industry is not a materials "intensive" industry. It is, however, extremely materials "sensitive, " since, after all, the construction of a flying machine depends on the application of high-performance, light-weight materials.

Let's consider the first issue, shifting the design philosophy. In the end, the actual implementation of a design philosophy depends on the individual designer—the man sitting before a clean sheet of paper with a pencil in his hand, attempting to lend shape and function to his concepts. His world is complex and demanding. He must balance conflicting requirements of product performance and cost, risk and benefit, innovation and experience, often within a compressed time schedule. In order that he may effectively perform his function, he

FIGURE 1. AEROSPACE MATERIALS CONSUMPTION, 1973.

Materials	National use	Aerospace use	%
Aluminum (Million tons)	7.3	0.440	6,000
Steel (Million tons)	111.4	0.069	0.062
Titanium (Thousand tons)	14.5	12,500	86.000

relies on extensive libraries of design data and codes which serve to augment his experience and lend quantitative discipline to his creative imagination. One needs only to flip through a Marks' Mechanical Engineering Handbook or the civil engineer's steel code or concrete code to gain some feeling for the massive body of detailed technical and economic information from which the designer draws.

How might we characterize the designer's current environment? Our system is set up to motivate the designer to produce an item which reflects a given customer appeal and which can sell at the lowest price. The product's customer appeal is derived from the characteristics of its life cycle—appearance, performance, reliability, maintainability, durability and life. The product cost is the sum of a number of elements, including development, overhead, direct labor, marketing and, of course, the cost of the raw materials.

Where elements of the current design philosophy of maximum customer appeal and minimum price are consistent with materials conservation, we need not be concerned. Such correspondence exists in principle. For example, given all else equal, the designer will choose a material or process which inherently provides for a greater ''materials utilization factor:—or the ratio of the amount of raw materials purchased to the amount used in the product. Also, there frequently is some correlation between the cost of a raw material and its scarcity. However, raw material costs may comprise such a small portion of the total product cost that they will not have sufficient "punch" to drive the design economics towards cheaper or more abundant materials.

Where the "Dollar Economy" design philosophy is *not* consistent with materials conservation, we have a problem. We can identify some mechanisms which can help promote more materials conservative designs. They include:

1. A shift in customer appeal. Simply, this is getting the customer to choose products because they conserve materials, This could be quite a chore with the private and commercial customer.
2. A reordering of the "Dollar Economy". The introduction of a carefully considered system for assessing the true value of a material to our society such that the price of a product would better reflect its total materials impact.
3. The application of artificial constraints and controls such that the traditional principles of maximum appeal at minimum cost are forcefully "overridden" in favor of resource conservation.

Each of these alternative implies that our designers (our front line soldiers, so to speak) must be equipped with new tools, training and motivation.

The designer's motivation to use any given set of design principles is derived from the consumer—either directly, or indirectly. There's little reward in designing an automobile that can last 500,000 miles if it is known that most consumers will discard it after 40,000 miles because of styling or what. Thus, while it must be acknowledged that there are isolated examples of trend setting design, in general the designer's motivations are a reflection of the consumer's values. It's apparent, then, that a prerequisite to a shift in design philosophy towards materials conservation is the reorientation of the customer's attitudes. Such a reorientation implies, at the least, a massive public education program. Whether or not the attitudes of the private or commercial consumer could be changed in the near term to the point that a designer could count on "conservation of materials" for sales appeal is a dubious supposition. It's certainly a goal worth striving for, but since time is so important, we should also seek out other and more immediate solutions.

Now, on the other hand, the Federal Government—and it is the single largest customer—could elect to follow a procurement policy which includes materials conservation requirements.

Also, Federal and local governments could implement materials conservation through product design codes or requirements in the same vein as current environmental legislation. Personally, this last proposal makes me, as a producer, very nervous. One has only to look at the rather qualified success of environmental legislation to gain some appreciation for the complexity and scope of the task.

Motivation, as important as it is, is only part of the job. Exhorting the designer to be more materials conservative is useless unless he has the necessary tools. What is the nature of the tools he uses now? In general, extensive libraries of design data and codes provide performance and cost information at the fundamental level for different structural configurations, materials, and manufacturing processes.

Let's take an example. Several years ago, the Department of Defense initiated a program called "design-to-cost". We in the aerospace industry

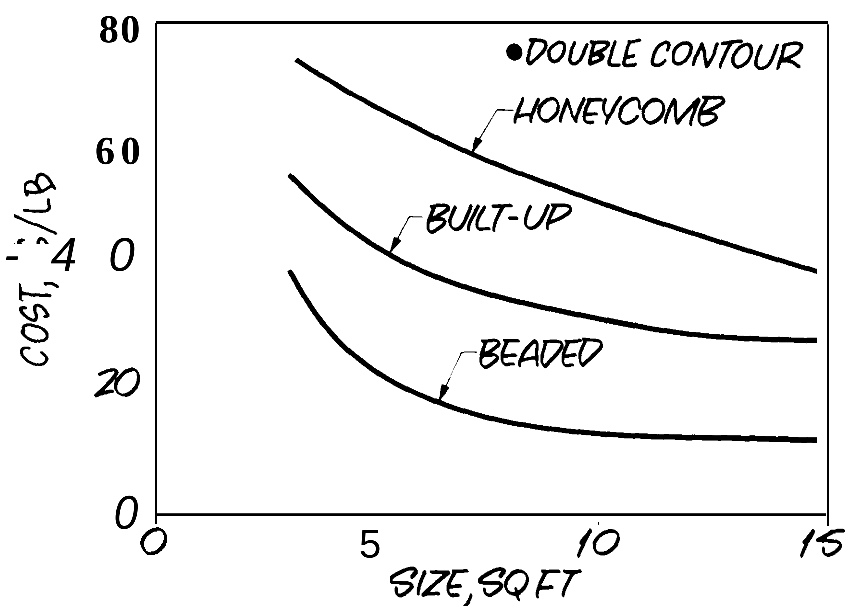


Figure 2. Equipment access doors, structural cost per lb.

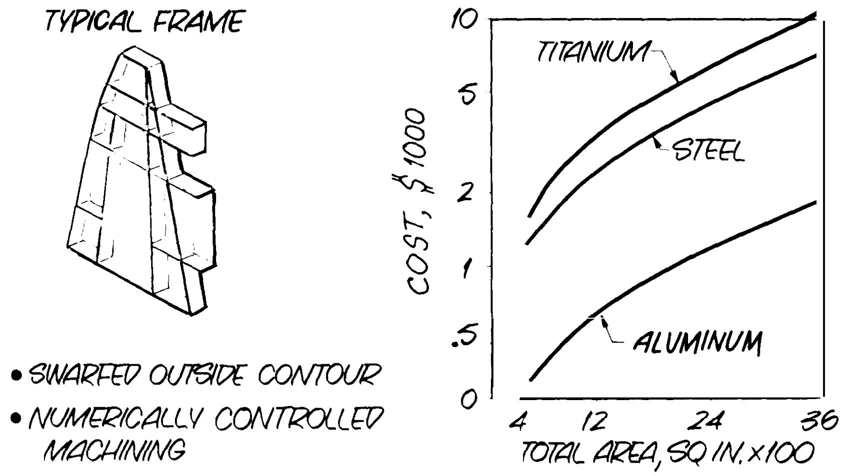
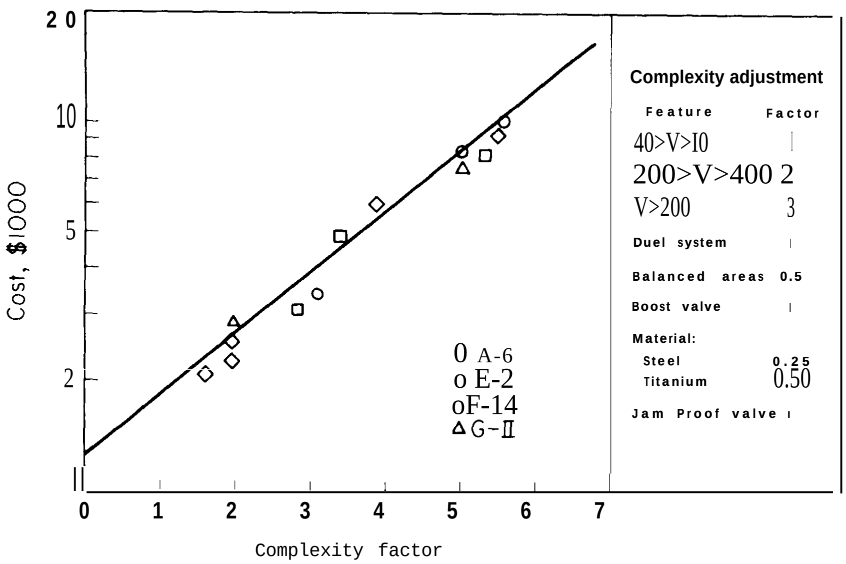


Figure 3. Frame/bulkhead costs.

have never been insensitive to cost. However. for obvious reasons, our heaviest emphasis has been on achieving maximum performance: cost was a result, not a totally integrated design parameter. With the growing concern over cost overruns in weapon systems procurement, the DOD felt it necessary to introduce a policy to provide more rigid control over costs right down to the subcomponent level. Design-to-cost does not mean better cost estimates, but rather how best to integrate cost into the design process so that the end product meets pre-defined



Figurc 4. Cost of flight actuators.

cost goals with the least degradation in performance. Supporting this program has not been a trivial chore. Grumman has already invested over $2 million in providing the training and tools to our designers in order to implement this policy.

Figures 2, 3, 4 and 5 are some examples typical of the sort of design data we've prepared for our design engineers to support the DOD shift to a design-to-cost philosophy. Note that the format is one of dollars plotted or tabulated against a material, a process, or a subassembly configuration. Other parts of the "designer's notebook" provide the performance counterparts—such as strength, reliability, durability and so on. What is the significance of these design tools, the data and codes, to the designer? *They provide him with a way to keep score.* They quantify at the very basic design level the costs and the performance of the building blocks which will eventually comprise his completed design. They provide a matrix, a framework within which the designer can best direct his judgment and experience in the creative process. Our current method of keeping score, of course, reflects the "Dollar Economy".

Here, then is our first challenge in providing our designers with the tools they need to implement a shift in design towards materials conservation. We must establish the ground rules, the scorekeeping methods, which permit the designer to make intelligent decisions

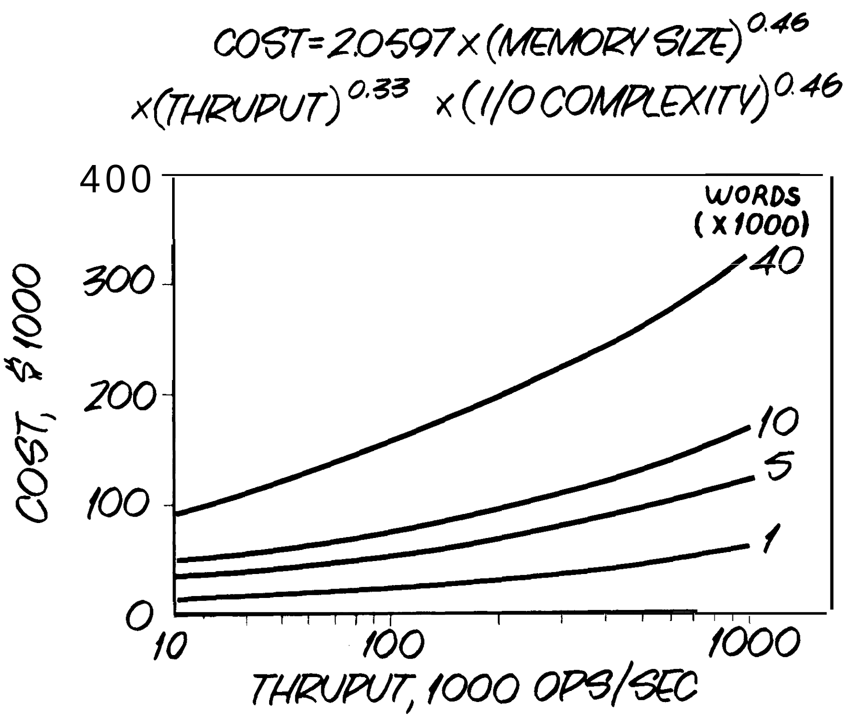


Figure 5. Avionics computer costs vs performance.

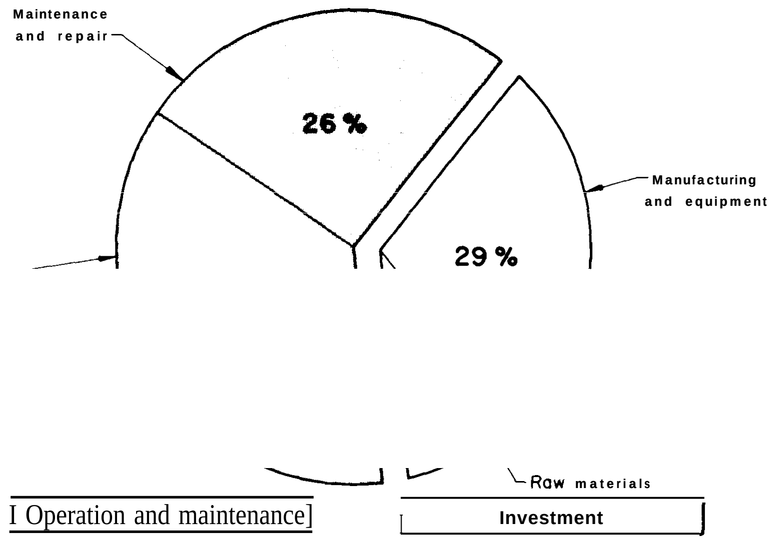


Figure 6. Automobile life-cycle costs (10 yr/ 100,000 miles).

concerning competing concepts, materials and processes.

One possible means of providing such a "score-keeping" system is to expand the concept of life cycle costs to include a measure of the product life cycle impact on broader materials and environmental issues. The distribution of life cycle costs for a typical automobile might provide some of the flavor of this concept. It's based largely on the results of a survey made by the Federal Highway Administration in 1972. Figure 6 shows that over a 10-year, 100,000-mile life cycle, the cost to produce the automobile, less profit, constitutes roughly one-third of the total—the balance going to fuel, maintenance and repairs. This fraction would be still less had I included other owner-incurred costs such as depreciation, taxes, tolls and insurance; these costs, however, are less liable to the product design than those I did include.

While far short of the comprehensive life-cycle costs model we'll need in order to implement an effective "design-to-conserve' philosophy, it does indicate the trend of thinking required: the cost of providing the customer with 10 years and 100,000 miles of transportation is not limited to the raw materials which comprise the vehicle. There are additional inherent materials costs. In this case, for example, there is an inherent cost of more than 7000 gallons of gasoline—a resource whose limits were all too apparent earlier this year. Note that the actual vehicle raw materials cost comprises some 8 to 10% of the total,

Figure 7 shows a corresponding life cycle cost distribution for a modern fighter aircraft. As with the automobile, the vehicle's raw materials costs are a small fraction of the total—about 5%. However.

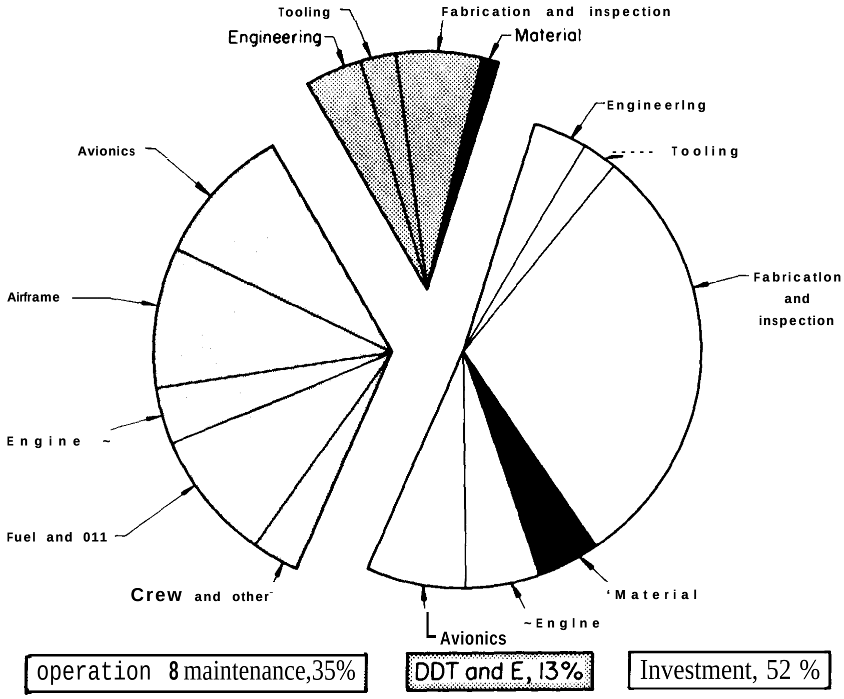


Figure 7. Fighter life-cycle costs.

as indicated by the lightly shaded areas, the materials choice made during design impacts elements responsible for an overwhelming 75% of the life cycle costs. The materials chosen affect the size of the aircraft and engines, what it will cost to produce it, how much fuel it will burn in its lifetime, what it will cost to maintain and repair it, and so on.

Obviously, raw materials costs do not provide an effective measure of the life cycle costs, much less the broader implied materials and environmental costs.

Whatever the scoring method devised, our next step is to introduce the technique into the "designer's notebook". This might best be accomplished by generating data analogous to the cost-oriented information discussed earlier, that is, derive and assign incremental materials impact costs to the designer's basic building blocks of subassembly structural concepts, materials and processing choices. The qualitative materials conservation benefits and costs of many individual design and manufacturing techniques have already been defined in the literature. *Quantitative* definition is required to permit the designer to prepare a total materials, environment and product cost statement and to provide for the reasoned application of materials conservative design philosophies.

The know-how and technology for such a comprehensive cost versus benefit analysis are available, though admittedly never applied on perhaps such a large scale. Construction and implementation of this ''score-keeping' system, and the provision of the associated design tools, requires the long-range continuing efforts of a permanent materials policy body with the support of all concerned groups from industry, the government and the academic world.

Let's turn now to the second issue critical to materials conservation through design, accelerating the utilization of new materials and processes. Many new and advanced materials and processes offer significant opportunities for materials conservation through improved "materials effectiveness. The new high strength metal alloys and advanced fiber composites can provide for less materials intensive products at equivalent performance. Their improved corrosion resistance and fracture strength imply increased product life. The composites in particular appear to offer the potential for less waste in manufacture. Advances in high integrity casting and powder metallurgy can provide for net and near-net shapes, allowing for less materials consigned to the scrap barrel. These are but a few of the emerging technologies which, properly exploited, offer large potential materials savings.

Unfortunately, the time span involved in the progress of an advanced material or process from the stage of a laboratory curiosity to widespread product application has proven to be on the order of 10 to 15 years. Apart from the impacts on the evolutionary development of improved product performance and costs, this sort of delay has obvious implication to continued materials waste.

The continuing development of the advanced composites is an excellent example of the scope of the time and effort which attends the introduction of a new material. I think that composite materials should be of particular interest to us here today. For the structural designer, they represent a significant departure from the materials he's used to working with, that is, the metals. Accordingly, their introduction to the designer or manufacturer, traditionally reluctant to apply new materials, represents a considerable challenge. Moreover, they have significant materials conservation potential. Again, I'll quote from the Federation of Materials Societies Report:

> "The concept of designing materials themselves to perform functions or to meet specific application requirements in principle leads to maximum materials effectiveness, Composites hold out great promise for the development of materials in this direction. They can be constructed by combinations of different materials and different constituent forms, such as fibers, particles or layers. The possible combinations are endless, and by proper choice of materials and constituents, property systems can be designed to meet specific requirements".

In order to acquaint those who may not be familiar with this rather classic example of the forced development of a new material, I will briefly review our progress. The case history of the introduction of advanced, high strength/modulus composites to the aerospace industry began in 1959. It was then that Texaco Experiment, Inc. reported for the first time the high strength and stiffness of continuous boron

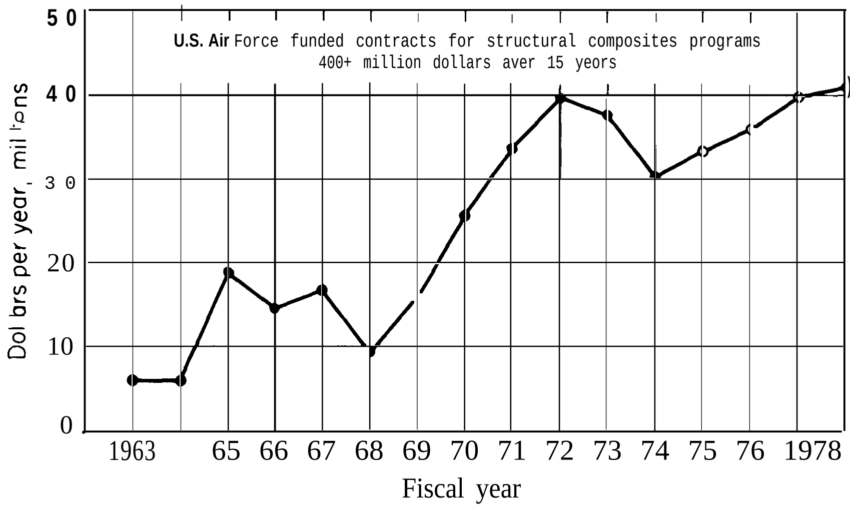


Figure 8. USAF funding for advanced composites.

filaments. Later experiments with boron fiber reinforced plastics suggested a latent potential for the development of structural materials with greatly increased strength-to-weight and stiffness modulus. Recognizing this potential and its value to advanced aircraft, the Air Force Materials Laboratory in 1960 initiated programs to characterize boron-epoxy composites. In the early 60's, the Air Force undertook a major commitment to accelerate the development and exploitation of these materials—a commitment which extends through the present and into the future.

Figure 8 attempts to give you some measure of that commitment—over $400 million in 15 years. The role of the Federal Government in the development of these remarkable materials has been vital. Their development to date is evidence that composites will fulfill their promise of 15 years ago. Cost and weight savings have been demonstrated in certain applications, and their broadened usage, attended by reduced costs, will come as a matter of course.

The message of this case history is both exciting and discouraging. It is a reaffirmation of man's ability to make significant strides in the development and application of the materials that serve him. At the same time, it is a discouraging comment on the overwhelming time and effort he must expend to do so.

Nor are composites unique in this respect. Some 719 government supported research contracts distributed over the 20-year period from 1945 to 1965 were devoted to the characterization and development of titanium—to say nothing of the substantial development effort expended by the titanium and aerospace industries.

In 1971, the National Materials Advisory Board undertook for the National Academy of Sciences and the National Academy of Engineering a study of the factors which promote or inhibit the introduction of new materials in national programs. They identified the major causes of delay as:

a) Technical: including uncertainties in performance and reliability in service and the limited initial availability of design and fabrication data and product forms.

b) Economic: including the high initial costs of the material due to limited volume and the high capital facilities investment.

c) Management and Organization: including innate conservatism and the reluctance to assume the additional management tasks associated with the use of new materials.

d) Contractual: including procurement specifications which limit the use of new materials and the unilateral risk which must be assumed by the contractor.

There is understandably a great reluctance on the part of the producer and the customer to accept a material or process that is new, that is, that has not seen service experience. This provides the designer another ‘‘the chicken or the egg” problem. A designer is often unwilling or unable to apply a new material or process because it lacks service experience; of course, it cannot gain service experience without first being applied.

The National Materials Advisory Board made a number of specific recommendations to relieve this situation and to provide for the accelerated utilization of new materials. These included the establishment of a continuing function under the auspices of an interagency government organization to assist in providing the necessary guidance, knowledge and funding for the development of materials and processes which show potential for wide application to national problems. The applicability of such a function to materials conservation through improved ‘‘materials effectiveness” is obvious.

Conclusion

Let’s take a moment to review the points I’ve made today. I have a deep, abiding respect for the creative ability of man. I sincerely believe that the product designer can achieve whatever reasonable goals we establish for him. More to the point, I believe that potentials for materials conservation in the product design process are significant enough that their realization should be established as a national goal.

But it is necessary, in order for our designers to attain these goals, that we provide them with the necessary *tools* and *motivation.* Moreover, it is critical that as resource conservative materials and processes emerge from our laboratories, we get them into the hands of the designers as rapidly as possible.

As I’ve attempted to convey to you today, these are not trivial tasks. We must provide the designer a new means of “keeping score” in the “materials economy”-a task requiring new libraries of design data and codes. We must devise a procedure for the accelerated selection, development, introduction and utilization of promising new materials and processing techniques.

The proper execution of these tasks clearly requires the guidance and support of a dedicated national materials body which draws from all the necessary concerned groups from Government, industry and the academic world.

Whatever course we choose for our materials future, our investment will be substantial. Accordingly, we must expend the time and effort, however great, to assure that the course we choose is the fundamentally correct one.

MATERIALS AND ENERGY CONSERVATION THROUGH RECYCLING

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The Mitre Corporation

Prologue

The Henniker Conferences on materials have always been designed to be working meetings. Any attempt to prepare a tutorial approach to areas in the broad area of my assignment must try to get at the issues and alternatives rapidly. An effort must be made to describe the problems, the issues and the alternatives in order to be able to discuss and develop policy. I will attempt to do this by using an example, the conversion of municipal solid waste to energy. It is recognized that the problem is much broader than municipal waste and the treatment of this broader problem will be handled in the working sessions. However, I hope to develop, in this presentation, methodologies for approach that can be **used** in the working session. Some of the methodologies are literally borrowed from the systems analysis approach. These are designed to help view the elements of the problem in context with the broader picture.

Introduction

There is a pervasive logic that at times often borders on religious intensity that is involved in recycling and reuse. Throughout history communities which were materials limited worked out natural strategies to conserve limited sources of supply. As affluence increased, there has been a tendency for the quantities of waste to increase. We are living in a complex society where it is very difficult to recognize materials as such. We see products, buy services, and only in times of stress is it recognized that materials are the building blocks of things we use and energy we need.

We are at such a time now where we must take stock of our supplies and demands and attempt to balance these. The balancing mechanisms are complex and involve many potential strategies.

Any option for technology policy must address the public concern of benefit to the total society and also the individual’s concern of

‘ ‘what’s it worth to me?’ A problem often develops in how to present technological alternatives in a manner easily understood, in a fashion which minimizes all potential ambiguities. Various viewpoints are invariably involved and although it is desirous for these to complement each other, they are often disparate.

An area of concern in the materials field is that of resource use and recycling. Each of these has descriptive components that can be broadly characterized as technical, economic and institutional. Each of the characterizes of these components may not only have a different professional cultural background but also a different language.

Resource and waste management when properly planned should take into account all the factors involved, from the generation of waste to its utilization or destruction. One can look at the entire system to identify areas of most interest with various reference points of time, location and point of view to best place the problem in perspective.

Recycling, one option in solid waste management, has been practiced in various forms for a long time. Recycling as now practiced is oriented primarily towards the benefit of the individuals engaged in the business; that is, the rather straightforward buyer-seller relationship. Another component has been recently added to the recycling scene: community benefit. In the past we were able to work with resource recovery in a relatively simple fashion because the complex nature of the sometimes overwhelming concept of community benefit was not an integral part of the issue. The individual business response to the potential profit stimulus was the main determinant to the extent of recycling. But now a new dimension which is societal in nature must be coped with, and requires an understanding of the institutional factors.

Since community benefit requires inputs from a broad spectrum of interests, it is clear that some method of bringing these interests together is essential. A systems approach could be used and should be concerned with factors such as economics and human motivation as well as technology, and should recognize the influence of these factors on each recycling strategy. Problems which are in the national interest should be “priorozed”, and the blockage points that prevent solutions should be identified and removed by formulating relevant national policies.

In chemical reactions, the rate of reaction is dependent upon the slowest acting substance; a similar phenomenon is true in the recycling area, the rate-controlling step may involve regulation or law, technology, market, economics, or institutional arrangements, to name a representative sampling. In other chemical reactions, the mere combination of reactants may not yield a product; often a catalyst is needed. Similarly, in this system context, a catalyst such as legislative incentive or revised federal policies which initiate technology transfer or induce capital investment in recycling, may be needed to implement recycling activity. By utilizing an analysis approach that concerns itself with a broader “system”, problems, focuses on key issues, and then, hopefully, provides solutions so that the factors which currently inhibit recycling can be redirected. In this way, incremental growth in recycling can be planned, and all participants can recognize where their greatest opportunities lie in the area of technology, institutional factors, or economics.

A useful concept for the visualization of these three components (technology, institutional and economic or TIE factors) is as shown in Figure 1. This concept, borrowed from phase equilibria, uses a triangular representation. Each of the apices represents one hundred percent of that factor and a decreasing percentage going to zero as one moves away from the apex. For example the center of the shaded area shown in Figure 1 describes a problem in recycling that is 20% technology, 20% economic and 60% institutional. It is meant to be broadly quantitative and designed to give an approximate order of the barriers in the problem area using the TIE factors. The area shown represents an analysis of the factors involved in the use of municipal refuse as a fuel which is described later in this paper. The TIE factor concept is not limited to the subject being discussed in this paper, but is useful in recognizing the scope of many problem areas being faced today.

The options in solid waste management are many and the strategy used must fit the situation on hand. There is no ideal scenario to be used throughout the country but a series of options which can be tailored to the situation. Sometimes recycling makes sense, other times it doesn't. The same is true of the use of municipal waste as fuel. The example discussed in this paper is designed to show that there are a variety of choices, only one of which might fit the situation

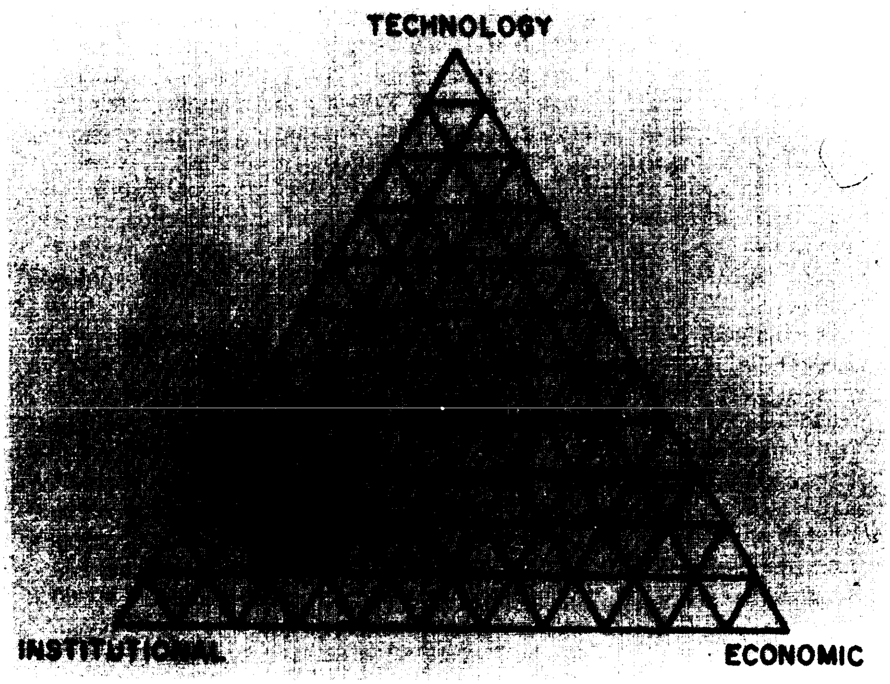


Figure 1. TIE factors.

on hand, and that its location on the TIE diagram, Figure 1, can help determine the priority of the problem area.

The Problem

At the last Henniker Conference the concept of life cycle of materials was discussed, (Figure 2). The area of interest for this discussion involves Reclamation, Recycling, Disposal and Factors Affecting the Public Sector (area shaded).

This area can be further described in Figure 3, Recycle Potential System. If we start in the middle of the diagram, Total Resource Needs, it is shown that a portion of this, actually the majority, is obtained from available reserves and imports. The solid waste stream can supply some portion of our needs and is in active operation now with lead, copper, iron and paper. The Solid Waste Stream can be related to the State of the Economy and Life Style. Life Style involves factors which are a result of our way of living, such as the use of convenience foods and the resulting packaging material and throw-away components. The Economic Parameters involve costs and scarcity of materials, for example. Each of these contribute to the quantity and quality of the Solid Waste Stream. Materials move from the Solid Waste Stream to Disposal. At this stage they are either recovered or exist as Residuals (scrap piles, dumps, water pollution, air pollution, etc.).

With certain motivating factors (shortages, costs) there may be an incentive to remine the Disposal piles and the line flows to Resource Recovery. In other cases the Residuals may give rise to pollution effects (water and air) and affect the Life Style by affecting factors such

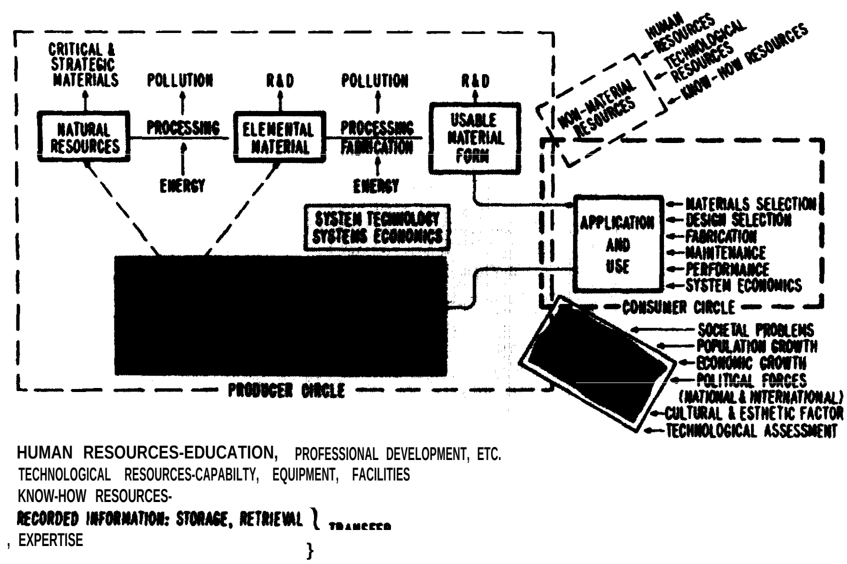


Figure 2. life cycle of materials.

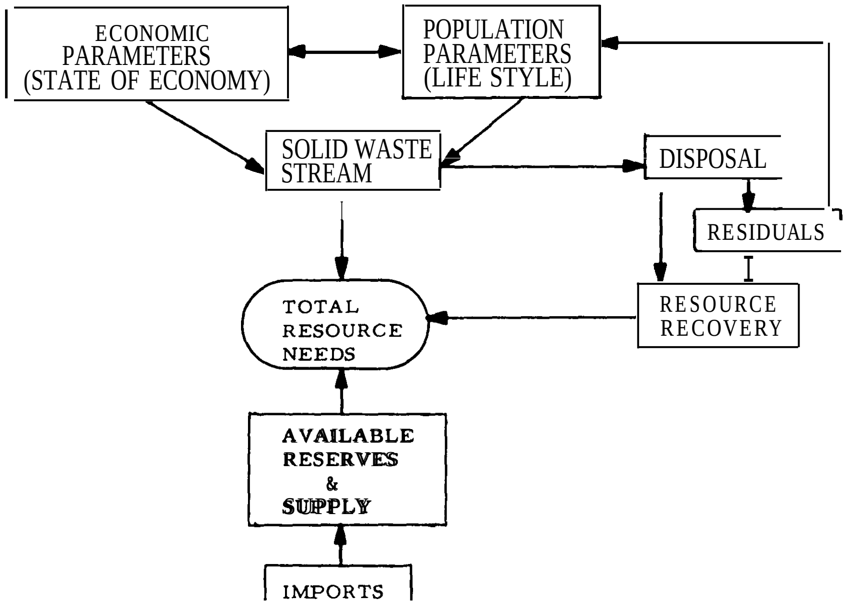


Figure 3. Recycle potential system.

as health, aesthetics and quantifiable factors such as the cost of repainting houses because of air pollution.

It may be possible to measure each of these connecting flow lines by econometric techniques to determine the magnitude of flow, to anticipate problems and to institute policies that will move the system in some desired fashion. If not easily quantifiable then they can offer an indication of magnitude and direction.

If we examine the specific problem of municipal waste, Figure 4,

- MUNICIPAL WASTE - 200M TONS PER YEAR
- INDUSTRIAL WASTE - 100M TONS PER YEAR IN URBAN AREAS
- LOCAL GOVERNMENTS SPENDING $6 BILLION/YEAR FOR COLLECTION AND DISPOSAL - COSTS RISING RAPIDLY
- 1/2 OF ALL CITIES RUNNING OUT OF CURRENT DISPOSAL CAPACITY IN 1 - 5 YEARS
- LAND FOR DISPOSAL BECOMING SCARCE - MUST USE NEW TECHNOLOGY
- FACING NEW CAPITAL COSTS, NEW TECHNOLOGY, NEW INSTITUTIONAL ARRANGEMENTS - TRADEOFFS DIFFICULT

Figure 4. The problem.

COMPOnent	COMPOS1TION (% OF DRY WEIGHT)* RANGE	NOMINAL	
METALLICS	7 TO 10	9.0	
FERROUS	6 TO 8	7.5	
NONFERROUS	1 T0 2	1.5	
GLASS	6 TO 12	9.0	MECHANICAL
PAPER	37 TO 60	55.0	RECOVERY
NEWSPRINT	7 TO 15	12.0	
CARDBOARD	4 TO 18	11.0	
OTHER	26 To 37	32.0	
FOOD	12 TO 18	14.0	CONVERSION
YARD	4 TO 10	5.0	RECOVER Y
WOOD	1 TO 4	4.0	
PLASTIC	1 To 3	1.0	
MISCELLANEOUS	5	3.0	I

* MOISTURE CONTENT: RANGE, 20 TO 40 PERCENT: NOMINAL, 30 PERCENT.

Figure S. Expected ranges in mixed municipal refuse composition.

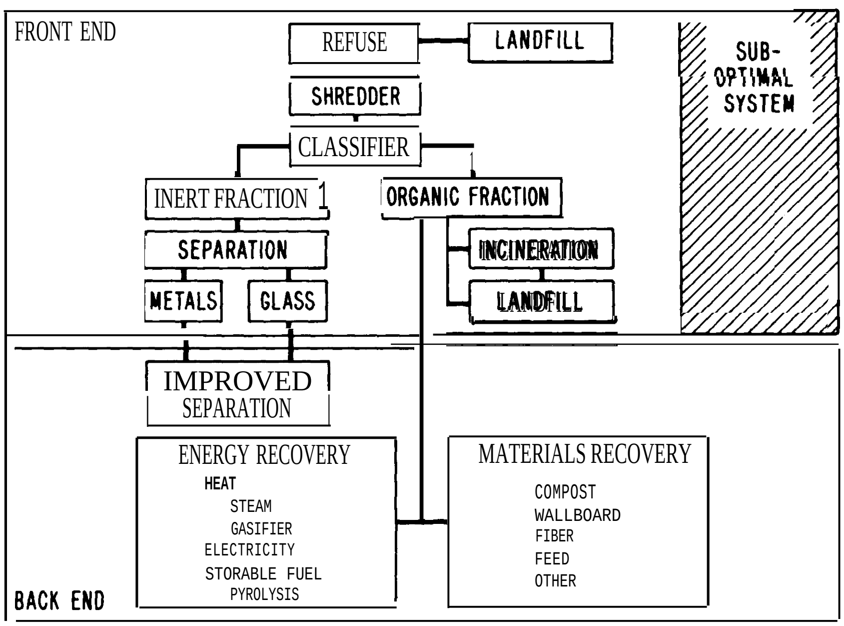


Figure 6. Modular approach to resource recovery.

we see increased quantities, an increase in disposal costs, a decrease in available land and new concern with: large capital costs, technologies not understood by the cities and new institutional problems such as setting up public utilities or combined private public utilities. In addition to discussing quantity we should also focus on quality.

Figure 5 describes the makeup of refuse in terms that a beneficiator would use. The greatest majority consists of paper products. Some of the components are recoverable by mechanical means, others by heating for conversion to energy.

Figure 6 shows a modular approach to recovery of metals and glass and the disposal of the organic fraction. The front end separation shown with this diagram is considered suboptimal in a total systems sense. The back end separation shown gives rise to less contaminated metals and glass and shows the organic portion converted to compost, fibers, etc., or energy.

Figure 7 depicts a detailed processing for separating materials from mixed refuse which was designed by Bureau of Mines, and is shown to give some idea of the process detail. We can describe the preparation of fuel by the diagram in Figure 8 and the firing operation in Figure 9, both of which involve the conversion of solid waste.

To this point we have described the problem facing cities with regard to solid waste and the techniques for processing the waste. These factors are important because we must examine the technology to see how adaptable it is. Several products can result from processing and include metals, glass, paper products and fuel. Figure 10 describes the relationship of various factors influencing the use of municipal refuse as a fuel for electrical energy generation. The prediction of municipal waste generation by year in tons per year (tpy) is given in column 1. The heat value, nominally figured as 5000 BTU/lb, at

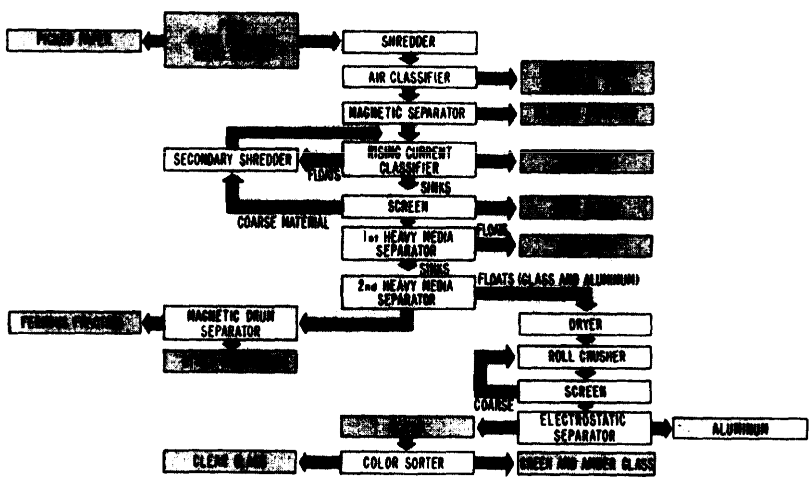


Figure 7. Processing scheme for separating materials from mixed refuse.

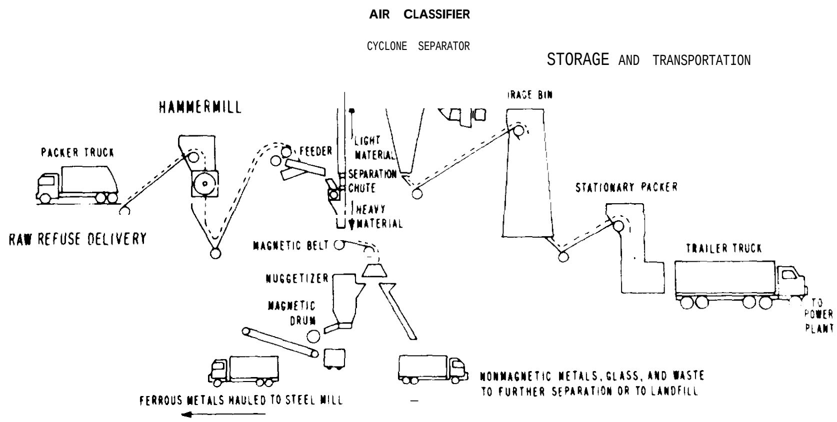


Figure 8. **Fuel preparation.**

the present time is expected to increase by about35% to 6700 BTU/lb ay materials.
These numbers are shown in column 2, Multiplication of the values in column 1 and 2 give rise to the data in column 3, the potential energy available from solid waste. This is of course a target for the maximum amount. It requires that all municipal waste be converted, which is next to impossible. The portion of the electrical energy demand to be met by oil and coal has been estimated in column 4. In this scenario we are only considering using the refuse as a fuel to be substituted for oil and coal. It has been demonstrated that coal burning boilers can be modified to burn up to 20% refuse before running into significant problems with bottom ash. However new techniques are under development which can treat the paper and plastic portion of

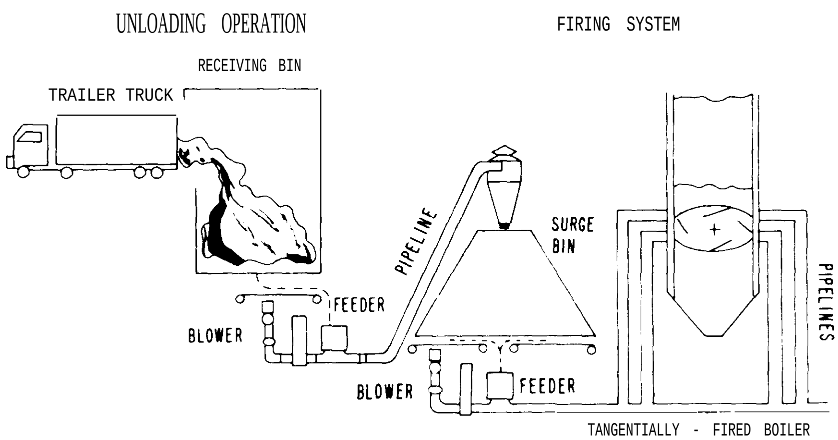


Figure 9. Firing operation.

1	2		4	5	6	7
YEAR	WASTE (1) GENERATION TPY x 10^6	(2) HEAT VALUE (BTU/TON) x 10	POTENTIAL ENERGY BTU/YR x 10^{15}	ESTIMATED U.S. ENERGY DEMAND (BTU/YR) x 10^{15} (3)	(4) %	% TOTAL ELECTRIC ENERGY
I 970	181	10.0	1.8	9.6	18. e	10.8
1980	237	10.4	2.5	15. b	16.0	6.1
1990	322	11.6	3.7	21.1	17.5	4.8
2000	422	13.0	5.5	37.4	14.7	5.9

(1) ASSUMED 12%/YEAR GROWTH IN POPULATION AND INCREASE IN WASTE GENERATION (REFERENCE 5)

(2) HEAT VALUE INCREASE DUE TO EXPECTED CHANGE IN REFUSE MIX

(3) PORTION OF ELECTRICAL ENERGY DEMAND TO BE MET BY OIL AND COAL (REFERENCES 6 & 7)

(4) POTENTL4L ENERGY CONTRIBUTION OF SOLID WASTE AS A PERCENTAGE OF TOTAL FOSSIL FUEL DEMAND; I. E., COLUMN 4 DIVIDED BY COLUMN 5 TIMES 100

Figure 10. Relationships of factors influencing use of municipal refuse as a fuel for electrical energy generation.

refuse chemically to convert it to a dry powder with minimum ash content.

The data in column 5 are the percentage of the demand for energy that can be met by refuse assuming it can all be collected, transported and burned in boilers. The actual value may be much lower than this. As far as the total electrical energy is concerned, column 6, the projected increased use of nuclear reactors, indicates potential for using all the refuse but allows for a reduced percentage of the total electrical energy by the year 2000. It is estimated that about 2% of all energy requirements (electrical plus other) can be met by the energy value in municipal refuse.

This exercise was done to simply demonstrate that we may have

	CONCEPT	STATE OF ART	BARRIERS
TECHNOLOGY	PROVEN	• USED IN EUROPE • DEMONSTRATION PLANT	• CORROSION UNKNOWN
ECONOMIC	COST BENEFIT METHODOLOGY EXIST	• USED IN MANY OTHER AREAS • DATA BEING OBTAINED IN DEMONSTRATION OPERATION	• EXTRAPOLATION OF DATA TO OTHER LOCATIONS • EXTERNALITIES NEED QUANTIFICATION • PROFIT/LOSS NO CLEAR
1NSTITUTIONAL FACTORS	• TRIED BY FEDERAL GOV. & INDUSTRY (E. G., TVA) • MUNICIPALITY UNTRIED IN PRESENT FORM	• LIMITED EXPERIENCE	

Figure 11. Use of municipal refuse as a fuel source.

PARTICIPANTS	POTENTIAL BARRIERS	POSSIBLE REMEDIAL ACTIONS
Municipal officials	Capital expense Zoning Site selection Institutional complexity Lack of effective waste management progra	Solicit external funding Review future land resources Investigate site for co-located facilities Develop guidelines for wastes management
Utility managers	Economic risk Technological feasibility and effectiveness Limited interaction with community	Examining progress of existing systems Conduct specific technological and economic feasibility studies Promote public relations campaign
Citizens groups	Public attitudes Scenic impact (land use) Environmental impact	Educate the public Provide for citizen siting participation Develop compatible land use
Private industry	Ownership, control of refuse Conflicting interests (profit incentive	Provide incentives to private industry
State government	Incompatibility with regionalization efforts Desired uniformity of disposal methods	Develop waste management master plan
Regulatory and licensing agencies	Delay in separate siting and environmental impact approvals	Streamline approval procedures
Federal government	No direct contact with state and local governments	Provide assistance in formation of technological, economic guidelines

Figure 12. Potential barriers and remedial actions.

a reasonable goal in the conversion of refuse to fuel to meet the energy crisis (Figure 11).

What are the problems in using municipal refuse as a fuel? Earlier in this paper the concern of the three factors, technology, economics and institutional. were discussed. They are focused in the matrix in Figure 11 considering the use of the concept, the state of the art and the barriers as presently understood. The potential barriers and remedial actions are shown for demonstration purposes in Figure 12. The barriers and potential remedial actions are given for example of methodology on] y.

Many ideas have been advanced on the design of a total recovery system treating sewage and waste to generate steam and to provide recreational water. One such is shown schematically in Figure 13. The products here are considered to be secondary materials (metals, glass), heat and cooling water while getting rid of both sewage and refuse,

It might be worthwhile here prior to going further into the logic of waste to fuel that we look at our material needs in the U.S. to determine how this component, recycling of waste might fit our total material needs. Figure 14 shows the balance of trade (imports vs exports) with a deficit of six billion dollars in 1972. The detailed U.S. import dependence is shown in Figure 15. Our concern should be how to insure recycling as a viable component in material supply. I plan not to treat the area any further but to bring to attention the data in figures 14 and 15 which can be used in the working sessions.

Now going back to solid waste, what are the broad issues? I have listed four areas of importance in Figure 16 which need be treated.

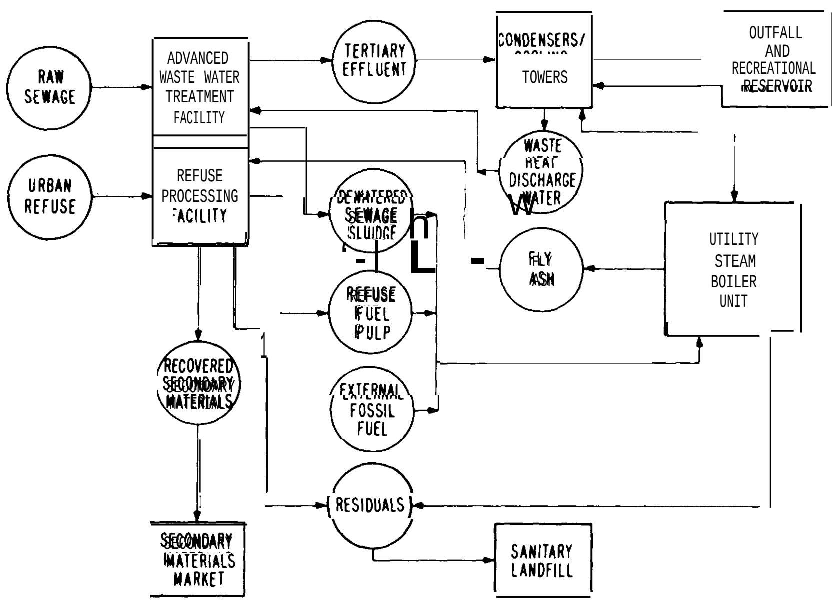
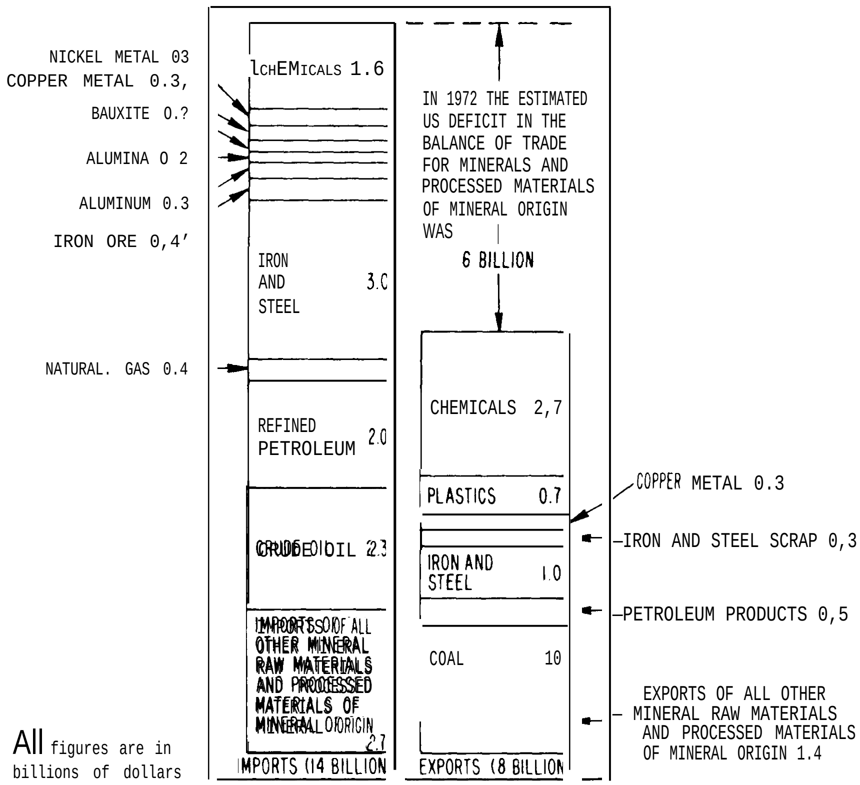


Figure 13. A joint **community utility** resource facility system diagram.



flgurc 14. BalANce of trade in materials.

National Policy is one of the most important of these issues. I don't believe that policy can be either easily established or easily instituted, but we certainly need a national direction. Without getting into the argument of the need for a national policy I have treated some inputs to such a policy in Figure 17 without much discussion. We can discourage residuals by developing product standards for increased life, use of taxes or the other factors shown. In like manner we can encourage recycling. We also have to consider the problems of conservation of resources, balance of trade, our economic health and materials security.

In the treatment of municipal refuse we have many alternatives.

FIGURE 15. U.S. IMPORT DEPENDENCE.

imports as percent of consumption, 1973

Bauxite	84%	Manganese	100%
Chromium	100	Mecury	82
Cobalt	100		92
Copper	8	Tin	100
Iron Ore	29	Tungsten	56
Lead	19	Zinc	50

FIGURE 16. BROAD ISSUES.	*FIGURE 17. NATIONAL POLICY.*

Issues in a solid waste research program (Municipal refuse)
1. National policy
2. Evaluation of alternatives
3. State of art data evaluation
4. Action for enforcement (decision support)
	Issues in a solid waste research program (Municipal refuse)
	Discourage residuals
	  Product standards for increased life
	  Residuals tax
	  Design product for recycle
	  Packaging regulation
	Encourage recycling
	  Incentive tax or bonus
	  Federal procurement thrust
	  Preference for secondary materials
	    Image
	    Shipping rates
	    Tax benefit
	Conservation of resources
	Environmental protection
	Balance of trade
	Economic health
	Security

Some of these are shown in Figure 18. Concomitant with the consideration of these alternatives is the validation of the "state of art" in order to know, in a pragmatic sense, what we can depend on. Finally once we have explored each of these previous factors the question is how do we take action. An outline of the issues is shown in Figure 19. Many of these are institutional in nature and may require new arrangements or extrapolation of existing arrangements to join the public and private sectors together in areas which will benefit and motivate both. Again, no intensive treatment is intended here, but rather the recognition of some of the issues, and some of the actions necessary for enforcement are shown in Figure 20.

Many of the issues discussed so far are interrelated. Action in one area can cause reaction in another area. Developments in technology may give use to new economic or institutional problems. In an attempt to relate these various factors I have borrowed a concept in systems analysis shown in Figure 21. This sort of diagram attempts to put many, apparently disparate factors together to help in planning and

FIGURE 18. EVALUATION OF ALTERNATIVES.	FIGURE 19. STATE OF ART DATA VALIDATION.

Resource recovery technology
  Front end separation
  Incineration
  Comporting
Energy recovery steam
  Oil pyrolysis
  Gas pyrolysis
  Direct firing
Disposal/technology
  Incineration
Collection procedures
Transport procedures
Storage procedures
Separation economic
	Existing resource recovery systems
	Projected resource recovery systems
	Has recycling worked?
	Over-all system
	Manufacturing practices
	Institutional factors
	  Federal
	  Municipalities
	  States
	  Regions
	  Industry

FIGURE 20. ACTION FOR ENFORCEMENT,

Laws, ordinances and standards
Manufacturing systems concepts
- Financing
- Ownership
- Long-term relationship
- Integrated utility
- Bid process
- Controls

Technology selection
- Readiness
- Environmental impact
- System costs

Markets
- Raw materials
- Products
- Energy

decision making. The diagram is not as complex as it initially appears and in general use one starts with Needs Assessment and Problem Identification. The factors involved on the left of the diagram, National Needs and Problem Identification help define the dimensions of Needs Assessment and Problem Identification. Once Goals are established they feed into helping define Policy. Since we must also examine our ability to set up attainable goals we have to factor into the process our existing Capabilities. We may then modify our Requirements and Goals to alternative Solutions. From these we can Target Program Areas and Develop a Program always being aware of Constraints. The final step is the Action Programs which might involve all of the components of Technology, Economics and Institutional factors. One

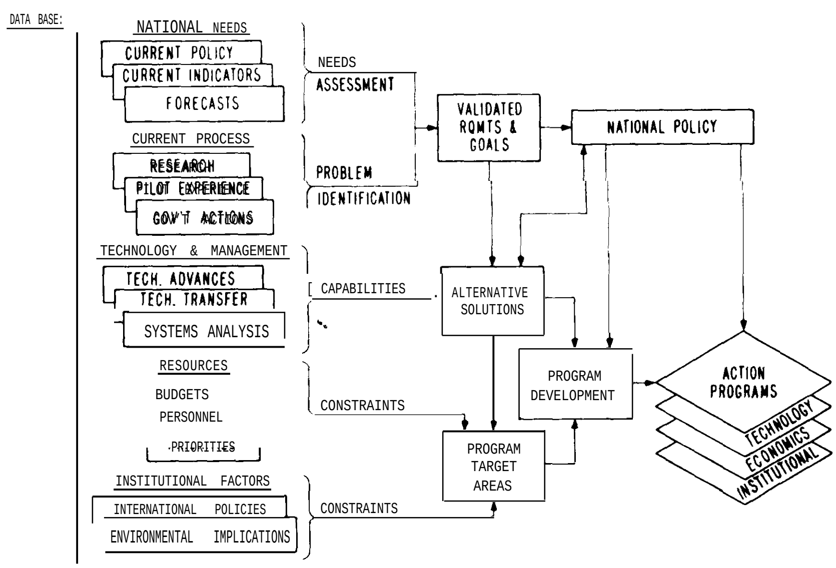


Figure 21. Recovery and reuse system.

must consider National Policy in this diagram as either a goal or an input. It can either direct the entire process or can be a resultant of the process.

This methodology of planning might be usable in our work sessions and perhaps to further imprint it I will go through an example for which I have already developed most of the data in the early part of this presentation, namely the use of municipal refuse as a fuel substitute for oil and coal in the generation of electricity.

A Needs Assessment and Problem Identification might give rise to a goal of burning refuse as a fuel substitute up to 20% of the BTU value of coal or oil in electrical generation. This scenario could come about by the forecast of energy needs, the indication that pilot trials of refuse to fuel have been made in St. Louis and the EPA has been funding some of the effort. We could from this develop validated Goals and Requirements which might indicate that energy should be generated from municipal refuse and the amount set at 20% of the BTU value of coal and oil presently being burned for the generation of electricity by utilities. However, if we look at our present capabilities, we recognize some problem with the 20% because of bottom ash and a question of whether this can be done in oil burning boilers. This might modify our goals to perhaps be: burn refuse up ‘to 2070 of coal in electrical generation. In this case we have not mentioned oil and put the 2070 as a maximum. We can then target specific program areas to determine whether oil burners can be used and examine the 20% by determining factors such as grate design, pretreating the paper to reduce ash, etc. A series of these target areas (technology, economic and institutional) are then broadly defined as Program Development in which Action Programs are to be started in these areas.

We might now question National Policy to determine what it may be. One ‘may start out broadly and describe National Policy in this area as the desire to be fuel independent (Project Independence) by 1980. Therefore the scenario we described on waste to fuel would fit in this policy. There may be other levels of policy that treat the incentives for joint government-private activity in setting up utilities (institutional) and attempt to motivate by tax treatment for example. There could be another ‘sub-policy which treats the economic portion of the waste to fuel area by setting up a stock pile of waste fuel and subsidize its sale. Other policies under consideration might include:

- Need to conserve energy
- Need to find a viable way to dispose of refuse
- Quantitative goals (time, amount) for conversion of waste to fuel
- Develop incentives for industry to work in waste to fuel area
  - Financial
  - Legal
  - Taxes

In the analysis given here we discussed Quantitative Goals for using 20% of the BTU value of coal and oil in electrical power generation. For example, if cities and states felt that construction grants to help them get started in this area was the proper way to proceed, then this could be examined as an input to Policy. It might be felt by those who are involved in policy making that construction grants might slow up the time scale for action by having cities and states wait for funding prior to taking action. Or it might give rise to the development of a policy which helps solve some of the institutional problems of raising capital and costs by developing a system of bonding or guaranteed loans. In like manner areas of a technical nature that were developing might develop a need for trial environmental relaxation for a limited time. The effect of this can be better understood by using a process of planning that would take in all the TIE factors (Technology, Institutional, Economic) and describe them in a fashion that would make the planner aware of the total system.

The need for an overview of the entire system is clear to the decision maker. However, the definition and detailing of the system is not always easy to do. In practice one starts with the specification of a desired system then a process of evaluation of the ongoing and planned programs and then the definition of an attainable system and finally a revised system specification and planned action. These modifications are real time based and require updating which tends to be event centered. In the area of recycling we are just in the process of understanding the system components and at this stage I think the problem is moderately well defined technically, the economics appear viable in some cases, but the majority of the problems are institutional in nature.

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INTERNATIONAL PROBLEMS AND OPPORTUNITIES; A ROLE FOR THE TECHNICAL SOCIETIES AND MANY OTHERS

N. E. Promisel

The petroleum embargo of 1973, aimed at a relatively small number of countries, continues to have ever-expanding, major, economic and political impact on a global scale, even on those countries on the sidelines that basically were unconcerned with the Mideast and its crisis.

This is only one dramatic example—and note that it is in the field of materials—of the unassailable fact that no country can stand aloof and avoid involvement on an international scale in many situations and problems regardless of their origin. Obviously, the degree of involvement will vary greatly, depending on the particular country and the particular problem. Obviously also, the United States, in the field of materials alone, will continue to be heavily involved internationally in most of the major issues, when we consider energy, resources, supply and demand, environment and related areas and technology, and the significant, if not controlling, role that materials play in all of these. And yet, with all these global materials problems, there is no established or recognized international organization whose major thesis, precept, or focus is founded on materials and processes. There is no such organization able to serve as a knowledgeable and adequate forum or mechanism for discussion, information exchange, mutual planning, international cooperation, integrated action, or even integrated response to materials problems and needs generated either nationally or in other international groups.

In 1972, there was formed an International Institute of Applied Systems Analysis, consisting of the U. S., U. S. S. R., U.K. and nine other Eastern and Western European countries. High on their priority list of projects were energy and materials resources, with additional proposed subjects being recycling of materials and the environment, among others. Yet—to repeat—there is no adequate international materials body to provide the necessary input to these materials-oriented projects. There is no adequate group in the U. N., nor in NATO, nor in OECD, nor in the International Council of Scientific Unions (ICSU) (which covers unions in other disciplines), nor in the World Federation of Engineering Organizations, etc., etc. At the second Henniker Conference on Materials Policy in 1972, this writer described the extant international organizations that dealt with certain facets of materials and processes and pointed out their scopes and deficiencies in terms of dealing comprehensively with this important field.

It is more regrettable that an appropriate world materials organization or union of materials science and engineering does not exist. The world can no longer afford random, incidental, casual, or limited international cooperation. There has been a need for such a major union for many years but the present climate throughout the world makes it almost imperative that action be initiated to fill this global gap. The timely reasons, as well as the ever-present ones, are quite obvious:

(1) As indicated above, the current long-range problems of energy, materials supply, and environment (for example, as it affects the economics of production and trade) are certainly global in scope and interdependency and need not be belabored here. Materials science and engineering are basic in these areas.

(2) The increasing social concern for the developing nations, with the correlative issues of economic improvement and, in most cases, industrialization, provides the more advanced countries with special opportunities for materials and processes technology transfer with obvious mutual rewards resulting therefrom. While bilateral efforts can be effective to a degree, a multilateral effort would be more effective and efficient and of great benefit—perhaps eventually essential to all concerned.

(3) Certain sectors of materials engineering require international cooperation; for example, materials exposure for corrosion study in world waters, atmospheric and oceanographic characterization data, exploitation of mineral resources in the international seabeds, etc.

(4) Since no country has a monopoly on talent and unique equipment, and with research and development becoming increasingly costly, it is important that there be a good mechanism for exchange of scientific and technical information, and for cooperative programs.

(5) Related to the preceding item is the opportunity to exchange scientific and technical personnel, with the evident benefits of such exchanges. These benefits are in addition to the opportunity for promoting familiarity and friendships among scientists and engineers on a broad international scale and the mutual education that such exchanges provide.

(6) Just as national materials policy is evolving in the United States through intensive studies and through symposia such as the Henniker series, so other countries are interested in or engaged in generating their own national policies. It is of value to be able to exchange such information and, perhaps to make policies with international implications internationally compatible. Similarly, it is useful to understand the organization and administration of research and development and other aspects of materials science and engineering in many countries. The last time this was done was in 1961 through the limited medium of a NATO symposium.

(7) There is need for a *mechanism* for optimizing the exchange of information on an international basis, for optimizing cross-fertilization in the many fields of materials science and engineering, and for generating global data necessary for intelligent national decisions and planning (as with resources). Among other results, there could ensue a rational basis for selective international conferences and symposia on critical, timely topics, as well as the generation of valuable, cooperative research and development programs that now are practical mainly on a bilateral basis (except in the field of aerospace in NATO).

(8) There is a need for a mechanism to define important world problems to which materials science and engineering can make significant contributions for their solution and easement.

(9) There is an opportunity to focus the world materials community and apply its collective talents to the betterment of mankind, especially those less fortunate.

Undoubtedly, there are additional good reasons for establishing an international organization for materials and processes but the above are sufficient for the time being. From these, the functions of such an organization derive easily; some important ones may be summarized as follows:

(1) To provide a forum for international discussion and debate of critical issues, followed by joint planning for action.

(2) To provide a recognized mechanism for cooperative programs in research and development and other sectors of materials and processes technology.

(3) To provide an adequate and rapid means for information and technology transfer, for mutual education, and for exchange of materials scientists and engineers. Included would be international publications and jointly planned conferences and symposia.

(4) To stimulate the advancement of materials science and engineering on a global basis and promote professional growth in this field.

(5) To promote a better understanding and appreciation of materials science and engineering and its importance by key executives and administrators in many countries.

(6) To insure a mechanism for proper inputs and response to the many other international bodies in other fields and thus to insure adequate consideration (now mostly lacking) of materials science and engineering in many global, critical issues.

(7) The organization would not deal with proprietary industrial technology or the market place per se although the impact of materials science and engineering on economics would be included.

The scope of an appropriate organization must embrace three basic tenets, even though, from a practical point of view, only selective portions of these could be encompassed and implemented at the beginning:

(1) The whole spectrum of materials and related processes and techniques must be included.

(2) Science and engineering and the whole life cycle of materials must be included.

(3) The organization must be worldwide.

The establishment of needs, potential achievements, scope, etc. is relatively simple but the best approach (simplest, fastest, most practical) is open to considerable discussion. As stated above, the author discussed existing institutions that might serve as nuclei, and their limitations, at the 1972 Henniker Conference and some (NATO, OECD, U. N.) have been mentioned again above. None of these are truly worldwide although the U.N. could conceivably be. It is suspected, however, that it would be extremely cumbersome and complex to set up the desired organization within the U.N. All of these groups could, however, be of value and assistance. It should be noted that other existing international groups, more closely related to materials science and engineering, could also be helpful, such as the International Welding Institute. ICSU conceivably could be prevailed upon to serve as a starting point but is quite scientifically oriented and therefore unlikely to be enthusiastic about the engineering and application functions of a group. In short, it appears to this writer that the best approach to forming a materials union of some kind is to build anew, building, in other words, our own umbrella, using existing international groups in other areas for guidance and assistance.

The successful establishment and operation of the Federation of Materials Societies (FMS) (which itself has an international Constitution) offers good encouragement that expansion of this concept on a global basis may be a promising route to explore; that is, enlisting selected materials societies and materials-oriented societies, wherever they exist in the world, to create a strong nucleus for further expansion. U.K. is considering establishing its own Materials Advisory Group (consisting of a number of internal institutions) to deal with many aspects of materials including, in addition to energy and shortages, better design practice, fabrication, standardization, and recycling. Representatives of several other countries, approached by the writer over the past few years, have indicated a receptiveness to cooperation—if someone else begins the action. The Planning Committee for the 2nd International Conference on the Mechanical Behavior of Materials—to be held in the U.S. in 1976—discussed formation of an international group and announcement and observance of its formation at this Conference, with an expected attendance of 600-1000 from all parts of the world. This Conference is under the general cooperation of FMS. The recurring suggestion over the past 15 years of an International Materials Year—independently and strongly suggested and endorsed at this Henniker Conference—would be another significant aid in launching an enduring international materials organization. From these, admittedly somewhat random, thoughts, this writer derives and proposes the following approach and sequence:

(1) Establish a U.S. Planning and Steering Committee for the establishment of an International Materials Union (IMU) or equivalent.

(2) Develop a tentative but specific plan, based on using existing technical and professional societies throughout the world as sources or catalysts for forming the hard core of this Union.

(3) Establish contacts in other countries, whenever possible with existing societies, for the purpose of forming an International Planning and Steering Committee, under this Committee, prepare a Constitution and Rules for Operation and proceed to specific first steps.

(4) Simultaneously, move toward the initiation of an International Materials Year, both for its own sake and as an aid to promoting and forming the Union.

(5) Set a target of mid-1976 for the announcement of the establishment of the Union, with specific activity to begin, probably, in 1977.

(6) At some stage in this sequence, acquire some financial assistance, direct or indirect.

Summary and Conclusions

(1) A number of reasons, particularly current global problems and the climate of the times, indicate the need for an International Materials Union or organization of some type. No equivalent materials organization exists.

(2) The functions follow logically from the dictating needs.

(3) The scope would be broad technically and worldwide in membership.

(4) Attempting to organize within an existing international group does not appear promising. The alternative of organizing independently, possibly with the aid of other international groups, appears more practical.

(5) The technical and professional *societies*, including groups such as the Federation of Materials Societies, could play important roles in developing the new organization, along lines proposed above.

(6) The thoughts expressed herein will be tested for receptiveness

and, if so indicated, some action will be initiated, probably Step 1 in the above sequence.

SHORT STATEMENTS

Explanatory Note: Because *of* the unavoidable *absence of Mr. Promisel, who had been scheduled to deliver the tutorial paper on the national and international roles of the technical societies, a symposium of speakers was organized at the conference by Dr. Wachtrnan to cover the topic. They spoke ad lib without advance preparation. Subsequently they were limited to commit their thoughts to paper as a part of the proceedings. Their submitted papers follow.*

Statement by Dr. Edmundo de Alba, Scientific Counselor, Mexican Embassy

No country in the complex technological world of the present day is completely self-sufficient in the raw materials consumed by its people. Even the so-called "supplier countries" in their turn need materials from other countries. This interlinking of availabilities and necessities is the most profound reason to mount an effort to resolve the problem of world materials supply by interdependence within international justice.

The interchange of materials, capital, and technology is an increasing feature of the present time. A just order to assure an adequate share of wealth and commodities at the international level is the main goal. This calls for the creation of mechanisms among nations to promote the well-being of their people by sharing commodities and technology at a just international price.

The efforts for increased international cooperation in the field of technology related to materials can enhance the achievement of the foregoing goals, Some of the proposals for an international materials year produced at this Henniker Conference will help to provide an adequate basis for better understanding. Enhanced communications among the scientific and technological societies of our countries can help to realize the possibilities of global interdependence in justice.

Statement by Jean-Pierre Hugon Ministere De L'Industrie Et De La Recherche Republic of France

Problems of supply area main concern for all of us developed nations. We are all thinking about the same kinds of remedies: developing our own resources, improving diversification of our foreign resources, improving our control on domestic consumption and especially improving recycling and control of materials life-cycles.

All of that must be done by each of us: that is necessary to strengthen our national positions, but, above all, the most important fact is that we are now entering a new era of worldwide interdependence.

There is not any estimation to be done: we are condemned to interdependence.

Inferences must be drawn from that new state of things, all over the world.

Particularly, some of you know that for the last few years we, in France, are supporting the idea of building international agreements by commodities: bringing together consumers and producers. That kind of confrontation appears now necessary, even when discussions are difficult and especially with developing countries.

By the way, we know that until now most of the U.S. delegations in international discussions are looking somewhat reticent, We hope that, all together, we shall be able to talk about, in the near future.

MATERIALS POLICY IN THE UNITED KINGDOM

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Introduction

The United Kingdom position on raw materials is very different from that of the United States. We rely on imports very heavily for many of the essential minerals for our industry, and the same is true for energy.

Britain took 10.4% by value of the world's exports of primary products in 1973, and provided 10.170 of the world's exports of manufactured goods: manufacturing industry accounts for a third of the national output; but it is one of those sectors which are heavily dependent on imported commodities. The agricultural industry in Britain has a very high level of productivity, but we are able to grow only half of what we need and nearly half of the food we do produce is import dependent. We have to import 46% of all the energy we use.

A key factor in any national policy for materials is their supply; and a second aspect is the recovery and reuse of resources when possible. A third element of materials policy is product use and design, and the substitution and conservation of resources.

Supply of Materials

In 1973, 57% of imports to Britain were in the form of finished goods or semi-manufactures for further processing. Another 20% comprised food, drink and tobacco; and the remaining 2370 can be split roughly equally into raw materials and fuel. The cost of these imports was more than £10,000 million, of which as much as £800 million was spent on non-ferrous metals and £300 million was for copper alone. The only non-ferrous metal mined in Britain in significant quantities is tin, but even that accounted for only 20% (£7 million) of consumption in 1973. In addition, oil imports in 1973 cost £1680 million, wood pulp cost £201 million, and iron ore f 152 million.

For such reasons, we have been examining the supply of those minerals which we must import; no two are alike. Some, like iron ore, are widely distributed; others, like chromium and platinum, are concentrated in a few areas of the world. Some vital materials, such as nickel, are produced mainly by developed countries; others, like tin, come from developing countries and make a significant contribution to their economies.

In the past it has been United Kingdom policy to seek supplies of raw materials in the cheapest markets, and with current balance of payments problems this remains our objective. We have largely left it to consumers to make their own arrangements to obtain supplies, but have participated in international organisations like the International Tin Council (1) where appropriate. We have, however, encouraged major consumers to examine their supply policies and to work at the possibility of diversifying sources of supply, entering into long term contracts and participating in mining ventures in third countries.

There are conflicting interests in the raw materials field and in considering measures which might be adopted to reduce dependence on overseas sources we have to bear in mind that changes in technology or social patterns are likely to change patterns of use, and hence the future values of minerals.

We do not consider that the recent world-wide rises in commodity prices represent a chain reaction caused by steps taken in 1973 by the Oil Producing and Exporting Countries (OPEC), apart from oil itself, of course. The very large recent increases in prices are largely the result of a combination of market pressures, originating in the consumer countries. In the short term, commodity prices are expected to fall somewhat from the peak levels reached in the spring of 1974. Price movements can be expected to vary from commodity to commodity, but average prices will still remain above the 1973 level. Some further decline in real terms is likely in 1975; but the critical factor affecting commodity price trends is the level of demand in the industrialised consumer countries, and this is difficult to forecast.

Like most other industrialised countries we have however been reviewing our policies in the light of the recent action of the OPEC countries. It seems unlikely that other producer groupings (e.g. copper, bauxite, mercury, iron ore) will be able to cooperate as effectively as the OPEC countries. Some of the factors which are different are that in general:

- Reserves of many other materials are more widely distributed;
- Substitutes are more readily available;
- Recycling is possible, whereas oil can only be used once,
- Many developing countries are very dependent on their income from raw materials exports and could not afford to cut back on production, particularly if the recent fall in prices is maintained.

In spite of this, the possibility cannot be ruled out for the future. We can expect to see all producers of raw materials looking for an improved return on their exports. For our part, we recognise the need for pricing structures which are remunerative to efficient producers and equitable to consumers, but there is no single method which would suit the circumstances of every mineral.

The United Kingdom is participating in the work of a number of international organisations on raw materials. Various committees of the United Nations are actively discussing raw materials issues, and we are represented on international groups on specific minerals: the International Tin Council has already been mentioned; other bodies include the Lead and Zinc Study Group and the UNCTAD Tungsten Committee. The European Economic Community is currently undertaking studies of the supply position of important raw materials with a view to putting policy proposals to the Council of Ministers, but no firm proposals are expected in the immediate future; the EEC Scientific and Technical Research Committee (CREST) is considering research programmed in the raw materials field and their coordination. In the OECD, materials are under consideration in the Science and Technological Policy Committee, Trade Committee, Industry Committee, etc.

Our approach to the methods which might be adopted to minimize future supply problems is similar to that of other countries, though we have tended to encourage industry to take action rather than offering direct financial support. Our strategy has been to:

Commission a programme to provide basic geological information on areas of potential mineralisation;

Provide financial assistance for exploration (in the UK) by companies under the Mineral Exploration and Investment Grants Act 1972. Assistance of 35% of the cost of approved programmed of exploration for non-ferrous metals, fluorspar, barium minerals and potash may be provided, and is repayable if commercial production results;

Support research and development on minerals processing and metal extraction;

Create a regime in which commercial exploration may flourish: and at the same time promote the recovery and conservation of materials.

Mining ventures within the UK may also make use of the assistance that is available to industry in general under the Industry Act 1972.

Whatever we do to promote the development of indigenous resources, we shall still have to rely on overseas for the majority of our supplies. We do not provide any special assistance for this purpose, although United Kingdom companies may benefit from the general assistance available for overseas investment through, for example, the Export Credits Guarantee Department non-commercial risks investment insurance scheme, and under the aid programme.

We are naturally anxious to make the best use of our own sources of raw materials, both for the security of future supplies and to make savings on the balance of payments. The reclamation industry is one of our most valuable indigenous resources: 62% of the lead, 5870 of the platinum, rather more than half of the steel, about 40% of the copper, paper and board, 26% of aluminium and 2170 of the zinc consumed in the United Kingdom are derived from reclaimed and recycled materials.

Recovery is closely bound up with methods of waste disposal (2);

also there are immense problems of coordinating the wide range of organisations, materials and industries. Much of what can be recovered economically already finds its way back into the production system, especially at current high prices, and there are no vast stocks of waste materials which could be easily reclaimed. Also, there are considerable problems of markets, economics and technology to be overcome if significant increases in recycling are to be achieved.

The government's recent consultative paper "War on Waste: A Policy for Reclamation" (3) urges a new national drive to cut down waste and to promote ways of recovering materials, The Control of Pollution Act, passed in 1974, requires local authorities for the first time to examine ways of promoting the reclamation of waste (not just to collect and dispose of it) and gives them new powers for this purpose.

During the past two years, there have been three major studies by industry-led working parties on the special problems which arise in recovering metal containers, bottles, and plastics (4). An official interdepartmental Working Group on Recycling, Reclamation and Re-use of Materials already exists to coordinate government activity and to decide on priorities for action and research in the interest of efficient and economic waste management, in particular the encouragement of reclamation and recycling.

A Waste Management Advisory Council is being established to bring together those involved in the production, collecting, disposal and recovery of waste materials of all kinds. An Advisory Group on Waste Paper Recycling has already been set up, and an Advisory Council on Energy Conservation was established in 1974.

It will be for bodies such as these to make the economic and technical assessment, to advise on the role of government and whether more should be done to encourage reclamation and conservation of resources. The environmental costs of disposing of waste and of obtaining new raw materials have also to be borne in mind. The main issues are to establish what is technically possible now, what is economically worthwhile and what technical developments it would be worth promoting.

Research and development programmed on reclamation are being reviewed and expanded. Such work is carried out principally by the Department of Industry, the UK Atomic Energy Establishment, by the National Coal Board, and in universities and in industry. The present programme of the Department of Industry's Warren Spring Laboratory concentrates on two programmed: scrap and waste processes including pyrolysis and domestic refuse sorting, and the recovery of metals from effluents and sludges.

The Warren Spring Laboratory has been working with industry for some time on the more difficult problems associated with reclamation and recycling of materials, especially the processing of complex materials and residues. Included in this work is the recovery of valuable materials from slags produced by metal processing, from electroplating residues and from effluent treatment plants. Various projects in such fields as pulp, waste paper, rubber and plastic are also being examined. The Laboratory has recently received approval for a Waste Recovery

Service, to provide consultancy and information for producers and processors of waste material.

Substitution, Design, and Conservation

Other approaches to materials problems concentrate onuses rather than supply or recovery; they include research and development aimed at conserving materials and finding substitutes for the most vulnerable ones. The problem in this area is to know where to begin: substitution is a process which is occurring all the time, but whether and at what rate it occurs depends on both technical and economic factors. As far as we know there has been very little investigation of this area but we doubt whether it is feasible to carry out detailed end-use studies of the important materials, or indeed whether it is possible to identify with any degree of certainty the materials for which the risk of supply is greatest.

In the past, manufacturing industry has devoted considerable attention to designing and making machines and tooling to reduce direct labour costs. This approach may change if materials costs account for a bigger proportion of finished goods. But we must also recognise that these are not simply questions of technology or economics: changes in social outlook may also be required, and these may not be desirable for other reasons.

More efficient use of materials could be achieved, without sacrificing living standards, by better design to increase product life and reduce manufacturing waste. Material costs can represent 30 to 40% of the factory cost of consumer goods, and the proportion of the gross material purchased and converted into net saleable goods is seldom greater than 70% and frequently less than 30%.

There are numerous ways in which improved design considerations can assist materials conservation. Standardisation and variety reduction of materials and components can contribute to the simplification of design, and so can reduction in the size of a product or in number of its parts. Extended product life is related not only to design considerations but also to improved selection of available materials for the conditions of service. Reduction in the number of production operations and process waste, and quality control to detect defects at the earliest possible stage all help to save materials and money.

The introduction of improvements along these lines depends greatly on the response of society in developed countries. Although more positive attitudes are developing on the recovery and recycling of waste, the “man in the street” is probably reluctant to accept extended product life (or reduced lifetime cost) if this entails an increased initial outlay; but this attitude may change with time.

At present, responsibility falls mainly on engineering industry to improve the efficiency of materials utilisation. The government has long encouraged the more efficient use of materials mainly but not entirely by supporting research and development; the basic justification for government involvement is to improve the technological and commercial competitiveness of UK industry. Under the customer-contractor concept proposed by Lord Rothschild (5) requirements boards for research and development have been set up by government departments. In the Department of Industry for example these boards function as proxy-customers who are responsible on behalf of industry for identifying research and development needs and for the placing of contracts to meet those needs with contractors both inside and outside government. The most relevant of these boards in the Department of Industry is the Engineering Materials Requirements Board; its general objective is to increase the efficient utilisation of materials, by extending their characterisation and by developing design techniques and criteria,

These are all aspects of materials conservation. The use of fuels may also be regarded as a component of a national materials policy. Energy conservation ranges over such diverse subjects as domestic insulation and the use of smaller motor cars, and is not something which can be achieved overnight; nevertheless action now will yield substantial economies later. In a recent Cabinet Office study (6), recommendations for energy conservation in Britain are made under these headings:

Transport:

fiscal measures; aerodynamically more efficient car bodies; improved fuel use by internal combustion engines; hybrid and electric vehicles and advanced batteries, including sodium sulphur batteries;

Electricity generation:

technical and economic appraisal of harnessing wave power;

Energy in the home and industry:

pricing and fiscal policies for energy supplies; higher insulation standards for new buildings and improvement grants for insulating existing dwellings; combined district heating and electricity schemes; more efficient light fittings; promotion of hydraulic systems in place of electric motors; information campaigns and services for fuel and energy conservation.

Conclusion

It might be misleading to claim that Britain has a comprehensive national policy as such for materials; but some components of the policy exist and are in place. As a country which is highly dependent on trade and on imported basic materials in order to survive, we are conscious of how vulnerable we are to any force which threatens our supplies of food, fuels, and minerals. As a country which is very conscious of the balance of payments between imports and exports, we are concerned to conserve and make good use of those resources we already possess, and of those we are obliged to import.

We are willing to share what we have learned with other countries. Unilateral action by individual nations to protect their own position may only worsen the situation, for in the long run—as in the short term—producers and consumers depend on each other. We must work to conserve resources as best we can—within existing institutions for preference—and to ensure the orderly exploitation of these resources.

I am greatly indebted to colleagues in Britain for the help on which this note is based, but its contents are my personal responsibility.

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REPORT ON UK CONFERENCE ON CONSERVATION OF MATERIALS

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I had the privilege of participating in a Conference on Conservation of Materials held at the Atomic Energy Research Establishment in Harwell. England, last March and have been asked to comment on the results of the Conference to this Henniker audience. The Conference was organized by the British National Committee on Materials and was co-sponsored by the Institution of Chemical Engineers. Since this was the first materials conservation conference in the United Kingdom, attendance exceeded the hall capacity (250 persons) and spilled over into a lobby where remote loudspeakers were available. Strong press coverage was evidenced by the presence of nine editors and reporters of major UK publications.

The UK attendees and lecturers represented the highest levels of industrial, governmental and academia groups. For example, Sir Alan

Cottrell, Chief Scientific Adviser to Her Majesty's Government and Sir Kingsley Dunham, Director of the Institute of Geological Sciences, gave papers at the opening Keynote session. Dr. Nathan E. Promisel, at that time Executive Director of the US National Materials Advisory Board and President of the Federation of Materials Societies, had been requested to participate in the Keynote session. Dr. Promisel was asked to discuss the results of an extensive USA study on materials conservation as part of an overall materials policy review of the NCMP.

Dr. Promisel broke his hip on a visit to USSR and asked me to prepare and deliver the requested keynote paper since I had chaired the ad hoc committee of the FMS that provided the conservation of materials input to NCMP. My comments were well received and evoked many useful discussions during the Conference. There was a tremendous interest in both the NCMP study and the FMS input report entitled ● 'Conservation in Materials Utilization", copies of which were given to the attendees after my presentation.

Some personal observations which I feel will be of interest to this audience were the following:

1. Our potential materials shortages in the USA are significantly less than the outlook for the UK. A program for internal self-sufficiency in energy fuels as President Nixon initiated in the USA would be impossible in the UK. The same comment would be applicable to many of the other critical industrial materials.

2. A conservation ethic has been in effect in the UK of necessity for a number of years, Nevertheless, all persons agreed that what they have been doing in the recycling and more efficient materials utilization must be intensified as soon as possible. It was quite apparent that they considered our "throw-away" habits and ● 'cosmetic obsolescence" practices in the USA as a major burden on the rest of the industrialized world as well as the emerging nations.

3. A strong concern and anxiety was expressed as to the possibilities of "materials blackmail" practices by the nations with major raw materials sources. It was evident that the success of the Arab "oil blackmail" had triggered this concern.

4. During the final session, recommendations were made that the United Kingdom make a materials policy study similar to our NCMP one, using as much of the NCMP recommendations as deemed applicable to the UK. The wrap-up speaker, Dr. J. Pick of the University of Aston, felt a strong message to Her Majesty's Government should be sent from the Conference pointing out the urgency of maximizing materials conservation practices,

5. Follow-on conferences on various aspects of this subject are planned. These will probably be directed towards specific materials and/or industries in the UK. Several feature articles on conservation methods are planned in technical journals and a new publication, "Resources Policy", is to be launched in September, 1974, by IPC Science and Technology, Press, Ltd. The entire proceedings of the Conference are being published together with the question and answer

sessions and should provide a valuable reference for many of the attendees at this conference.

Statement by C. M. Cosman, Consultant, United Nations

The crisis in raw materials which was brought on by the Arab oil boycott and the subsequent price jump by the OPEC nations, is spreading to other minerals and threatens the pattern of trade and the high standard of life in the world. This situation is ameliorated only where economic or technical alternatives provide relief.

This situation is further accentuated by the fact that the largest oil producers for lack of population and for socio-religious reasons cannot take back from the industrial world products that even faintly measure up to the funds received by these oil exporters. Investment in plant—petrochemical, steel or aluminum production—only further tilts the adverse balance of payments, since the market for these products is largely in the industrial world.

There is a deep sense of malaise on the industrial world as a result of this situation: the flow of funds to the oil producers amounts to a hemorrhage, and must either result in a reduction in the standard of living—with the likely consequence of unemployment and social unrest—or in ever-accelerating inflation—with similar social consequences.

Third World countries that have no oil or exportable mineral resources are now required to pay so much for oil imports and for industrial supplies as to beggar themselves also. This has particularly serious consequences for agriculture, since these countries can no longer afford to provide needed fertilizers.

The industrial world is being blamed for the turmoil that has been created. Conversely, the industrial countries bend every effort to attain energy ‘‘independence’. Enormous research programs are being launched to reduce reliance on imported oil. Work is also being done to lower dependence on bauxite and other imported raw materials.

The pattern of world trade, the pattern of an orderly draw-down of resources—the most economical first, the more expensive later—has been upset. This development arises not only from the events of the last year, but from political actions taken by some Third World countries which make investment in raw material development extremely hazardous. Expropriations and nationalizations do not sit well with investors. And the entire burden of development cannot be shouldered by the World Bank and similar organizations.

Consequently the pattern of commerce which has served the entire world well during the past quarter century seems to be on the verge of collapse. A return to economic nationalism, to autarchic modes of thought, may bring disaster to many nations—especially the dependent ones—a lowering of the standard of living, and the frustration of hopes.

At the United Nations I am associated with a great effort to help Third World countries toward economic growth by finding and developing their raw material resources. With this perceived trend toward economic dislocation—admittedly caused to a considerable extent by actions taken in the developing countries—such efforts are being vitiated.

Before positions become frozen, before decisions are made that set the world irreversibly on the course of economic nationalism, the nations should give pause and get together and evaluate these trends, and see whether there is no possibility of composing these differences, of saving the world-wide exchange of goods and services that has led the world to unprecedented prosperity and stability in the last twenty-five years. It will be necessary, however, to respond more extensively to the aspirations of the Third World.