TASK FIVE: UTILITY OF ORGANIC RENEWABLE RESOURCES

A. TERMS OF REFERENCE

What are the policy implications for engineers and scientists of the potentially increased availability of and new uses for renewable organic resources?

Rationale

As prime reserves of exhaustible materials are depleted, the requirements for these materials will not diminish but are likely to rise. Resort to lower grades of mineral deposits implies increased costs of both dollars and energy. The great bulk of organic renewable resources are left in the forests or fields as largely unused and even dysfunctional wastes. Their energy content is neglected. The total mass of this unused resource is substantial. Technologies are already available to convert organic materials into engineering-structural or fuel-energy materials. Other technologies are in prospect. The principal deficiencies in the further utilization of organic renewable resources are the lack of awareness of their potential and a lack of organization and management to exploit them. Uncertainties about the economic incentives, ecological impact, future land use policies, etc., are also barriers in the substitution of fossil carbon sources with renewable organic resources.

Questions

1. What are the policy implications of the rising costs of liquid and gaseous fossil fuels, and their foreseeable exhaustion, for the organic renewable resources? Can a situation be defined at which substantial substitution is likely to occur?
2. What is the relationship between the solid fossil fuels–coal, lignite, and peat—and the renewable organics? What opportunities are there for establishing a symbiotic relationship between the renewable organics and the exhaustible minerals to maximize their joint utility?
3. How quantitatively significant are the renewable organics? Is their production amenable to technological measures to increase their abundance?
4. What policy principles should govern the utilization of renewable organics? Economic value? Technological considerations? Preservation of high energy levels of organic molecules?

5. What would be the appropriate directions of research and, especially, development to exploit renewable organics of high economic promise in industry at an early date?
6. What would be the appropriate directions of basic research and exploratory development to exploit renewable organics of potentially great impact in the long-range future?
7. How will the competition for renewable organic resources and land, primarily for food production, affect the future uses of these resources for materials and fuel, and to what extent can symbiotic relationships between end uses be visualized?
8. How can natural renewable resources, especially fibers, be developed and exploited to optimize the combined use of fibers from this source with fibers made from fossil raw materials?

B. SUMMARY OF TASK FORCE REPORTS

Task Five

Group A	Group B
Points of Agreement	
In the utilization of renewable resources economlcs IS the controlling factor.	Economic value Will provide the principal driving force for utilizatlon of renewable organics Periodic economic evaluation of the potential for such utilization will be needed to capture economic benefits that may arise,
Assessments should be made of the technical and economlc feasibility of the feedstock approach of producing chemicals for polymers from renewable resources These efforts should be backed up by research on the Improvement of processes of enzymatic hydrolyses of various lignicellulosic and carbohydrate materials,	One research area should be the development of new materials based on the carbohydrate backbone polymerized with other synthetics. Specific efforts should be aimed at biodegradable polymers. high impact strength polymers and strong absorbent polymers
Comments	
Technologies for burning coal in combination with other fuels with low sulfur-content should be advanced	Coal liquefaction should become a massive source of competitlvely economic aromatics, and coal gasification should become an economic source of synthetic gas for NH_3 and methanol
A National Commission on Land Use should be established with representation and input from a I 1 affected areas	The term renewable resources should not become equated with unlimited resources.
	The extent to which wood IS available for substitution of petroleum-based, energy-intensive, or resource- llmlted materials IS not consldered extensive without significant technological Improvement in all phases of production.

SUMMARY OF TASK ONE (A)
NATIONAL MATERIALS ASSESSMENT FOR CONGRESS: STRESSES ON THE TOTAL MATERIALS CYCLE

Recognizing the complex and highly interactive nature of materials problems and responses to them, this task force was requested to identify the most important stresses on the total materials cycle and possible alternative policy responses to avert or relieve these stresses. The need for and purpose of this evaluation is detailed in the tutorial lecture, "Materials Assessments for the United States Congress," appearing earlier in these proceedings,

Identification of Stresses

Since an attempt to list all of the important stresses associated with the materials cycle would have exceeded the time available, the following stresses were identified as having greatest potential impact in the opinion of the Task Force members:

- Increase in world population;
- Increase in per capita demand for materials;
- Environmental impacts and regulations;
- Health and safety impacts and regulations;
- Actions by foreign governments;
- Internal difficulties in foreign countries;
- Other Government regulatory policies and actions;
- Decrease in rate of mineral discovery;
- Increase in energy costs;
- Long-term trend of declining materials investment, increasing capital intensity, and cyclical nature of demand and prices;
- Destabilizing factors outside materials cycle, i.e., domestic currency inflation, drop in productivity, etc.;
- Permanent changes in demand resulting from the use of new technology; and
- Shift to processing at home of raw materials in foreign countries.

Selection of "Critical Few" Stresses

To narrow the scope of the problem and to assign priorities, the Task Force singled out four principal issue areas as follows:

I. The increasing per capita demand for materials, largely attributable to rising standards of living;

II. Internal difficulties in foreign countries and actions by foreign governments affecting supplies of imported materials;

111. Environmental, occupational health and safety impacts and regulations; and

IV. The declining long-term trend in materials capital investment.

Interestingly, although not surprisingly, these stresses are closely related to those factors occurring in the materials cycle which were viewed as most directly and significantly impacting upon considerations outside the materials cycle, i.e., those materials-related stresses having ramifications or perturbations in the total economy, natural environment, or society as a whole. In all but one of the materials-related stresses having a macro or societal effect, a close correlation with the Task Force's priorities can be seen, thus providing evidence of the interacting or two-way nature of materials-related issues. Those materials cycle stresses directly impacting conditions outside of the materials cycle are summarized in the following five problem areas:

- Environmental, occupational health, and safety issues;
- The materials industries' share of energy use, as well as the materials requirements for energy production;
- The potential stresses upon national capital markets and labor pools resulting from a possible reversal in investment trends of materials industries;
- The trend of shifting mineral extraction, processing, and fabricating industries from the U.S. to foreign sites; and
- The interacting stresses affecting foreign relations and international economic policies (including supply access goals, international commodity agreements, law-of-the-sea negotiations, investment in developing nations, multi-federal trade negotiations, tariff preferences for developing countries, and export administration).

The complexity and extremely interrelated nature of materials/resources issues, the stresses themselves, and the materials cycle make clear-cut categorization of stresses difficult. Similarly, the diverse views represented within the task group frequently resulted in differing concepts of the stress topics themselves, complicating the task of definition. However, the Task Force agreed that the "critical few" selected appeared to be serious constraints to the flow of materials or susceptible to uncertainties that could cause world destabilization and stresses in the domestic economy, compounding total repercussions on the materials system.

I. Increasing per capital demand.–The increasing total and per capita demand of most materials is unavoidable as long as the increase in world population remains unchecked, and the revolution of rising expectations in the poorer and most populated regions of the world is spreading. The Task Force feels that, for all practical purposes, these stresses cannot be relieved in the intermediate time frame (5-10 years) even though new materials standards, a conservation ethic, priorities in use and some fabrication, as well as process and engineering improvements, may somewhat slow down the rate of growth.

This leads us to the prospect that for the foreseeable future, this Nation and, indeed, most of the industrialized nations, will be importing an increasing amount of materials from foreign sources that are well endowed with as yet untapped deposits, or ore bodies that have been discovered or developed, and are capable of increased production.

As long as there is no danger of denial of supplies, interruptions, or price-escalation so severe as to damage the reliability or economic justification of foreign supplies, increased imports of materials are not detrimental, especially if U.S. exports of other commodities or services will also increase as fast), It is only when excessive dependence coincides with coercion or denial of a supply essential to U.S. well being and security that other alternatives should be explored (soberly, considering feasibility and all trade-offs), These include:

- Increased supply from less desirable domestic sources,
- Alternate foreign sources of supply,
- International counter-measures, and
- More radical conservation and distribution, etc.

The Task Force finds that an early warning system of changes in the international environment or local unrest endangering the flow of imported materials should be given more detailed and specific study.

Congress and industry should be briefed (within reasonable constraint as to security and proprietary nature of the information) on the changing risks, perils, or trends as soon as they become perceived by the United States.

The international specialized and leading agencies should be informed of the dangers of irresponsible interference with the free flow of materials to world trade.

The Task Force proposed that the following policy responses be considered for relieving the stresses on the materials cycle resulting from reduced supply:

1. Expand U.S. and worldwide minerals exploration,
2. Expand systematic analysis and cataloging of the world resources (by both USA and OECD),
3. Additional assessment of R&D needed to improve all phases of the materials cycle,
4. Improve access to Federal lands, where feasible, and
5. Improve access to foreign material supplies by a cooperative promotion of international trade by Government and industry, acting as a single trading unit in foreign negotiations with underdeveloped countries. Trade with OECD and other industrialized countries should be on a looser cooperative basis.

Demand-oriented options include:

1. Encourage conservation of materials by allowing their prices to float at real market values;
2. Encourage use of abundant (e.g., renewable) materials as a substitute for scarce nonrenewable resources;
3. Encourage materials recycling by Government-supported R&D and removing institutional obstacles;
4. Encourage conservation of materials while minimizing economic and social repercussions;
5. Encourage reduction of post-consumer waste material through changes in technologies to increase the durability and decrease the scarce material content of consumer goods and packaging;
6. Tighten use of export administration statutory authority, particularly with respect to raw materials and recycled materials. Encourage through the use of bilateral and multilateral forums reciprocal supply access where possible; and
7. Consider import tariffs on products imported from countries that do not control environmental degradation in their respective mining and processing industries, as a means of reducing competitive disadvantages to U.S. industries in world markets,

11, Foreign Country actions affecting imported materials. - Unfortunately, two stresses on the materials system will be felt worldwide to a degree that may be destabilizing to world trade.

The first is the increasing number of foreign material exporting countries where internal difficulties (e.g., labor unrest, tribal conflict, insurgency, etc.) imperil or reduce production or exports from existing sources, and/or halt exploration and development of new resources. The second stress includes deliberate actions by foreign governments to nationalize, take over, interfere with, prohibit, or make prohibitive, exports from operating deposits owned or managed by foreign investors. Interference by mandate of a materials cartel (i.e., groups of materials-producing nations that include the country now exporting materials to the United States) will obviously reduce investment in or exports from such deposits.

Alternatives to closing down such operations could entail:

- Increasing royalty payments. Yielding to all demands short of all-out take over (which ultimately takes place, more often than not);
- Slow but persistent negotiations to establish an early-warning system by common agreement of all materials consuming, or multinational interests in those countries and then attempt multilateral negotiations to protect the flow of locally extracted minerals to the world markets; and
- A serious effort by the United States to make a final attempt to reach an international agreement, at least among OECD nations, the international lending agencies and the most responsible LDC materials producers to position effective and visible responses to wanton spoilation of foreign investment,

The Task Force was unable to predict the degree of effectiveness of these measures, or the likelihood that the international environment will continue to change so radically that some of these foreign sources of supply will require export royalties or taxation so heavy, or involved to such extraneous and unpredictable variables as to endanger materials flow from these countries (Cf. UNCTAD demands).

111. Environmental, health and safety impacts.–The Task Force noted that environmental as well as occupational health and safety stresses are significant from the standpoint of their two-fold or interacting nature, i.e., in terms of the adverse impact of such regulation upon producing and consuming industries within the cycle and in terms of the beneficial impact of both stress categories upon other components of the cycle or upon the quality of life as a whole.

The most direct and significant stress primarily involves the cost of compliance with environmental regulations and its effect at all stages of the cycle. Although the single greatest problem area [in the opinion of the Task Force] is control of sulfur dioxide emissions at the smelting stage for non-ferrous metals, environmental statutory requirements and regulations promulgated by the Environmental Protection Agency and its predecessor a agencies also impact upon other stages of the materials cycle ?e.g., water effluents in the electro-plating industry, water pollution in iron ore and other mining stages, the cost of reclamation in mining and the increasing problem of handling overburden, tailings, or air emissions; and the impact on coke production, foundries, and ferroalloys).

The principal concern expressed by the mining/materials industries, and by a majority of the Task Force, relates to the diversion of capital for compliance with these requirements away from cash flow that might otherwise be utilized for expansion or development of new capacity or productivity improvements in existing capacity. The capital diversion also includes diversion of research funds to develop process technology for compliance that might otherwise be, and traditionally has been, expended on innovation.

Concern must be expressed also over the implementation of environmental legislation which requires for compliance either technology that does not exist or which is not economically feasible under most commercial circumstances. The uncertainty generated by the continually changing nature of future environmental requirements, i.e., new statutes or interpretations of existing authorities, are acting as a deterrent to new capacity investment and contributing to the other investment uncertainties described below.

The Task Force made note of the need to examine land use policies and the widespread withdrawal, in recent years, of Federal lands, preventing exploration or multiple-use of such lands,

On the plus side, environmental concern has given rise to a whole variety of beneficial stresses on the materials cycle, such as resource recovery, solid waste disposal, and new incentives for increasing supplies of recycled materials. The Task Force also recognizes the many advances in technology created by the mining and materials industries which contribute to improved environmental quality, land reclamation, recovery of tailings and mine wastes, and previously non-existent supplies now part of the materials cycle,

In the occupational health and safety area, it was noted that regulation of mine safety as well as regulation of health and safety at other stages in the cycle often have a twofold effect, Improved safety and health standards, particularly those imposed voluntarily by industry, often have a favorable impact on overall productivity and efficiency. However, imposition by statute, interpretation, or promulgation of standards of health and safety regulation, without consideration of the standard level to the health/safety impact and without consideration of commercial feasibility, can seriously impact operation throughout the cycle.

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The Task Force recognized the need for understanding the unique nature of mining in conducting health and safety research and in promulgating these standards or conducting inspections for mine compliance. Beyond the mining stage, health and safety standards are generally promulgated on the basis of exposure to individual substances considered toxic, The Task Force suggests that similar consideration should be applied to the unique factors affecting conditions at all stages in the materials cycle rather than across-the-board application to all industry.

As policy, the Task Force recommends that strong consideration be given to balancing all the ramifications, positive and negative, of environmental and health/safety standards upon the materials cycle. An urgent need exists for better understanding of the interactions between these desirable social goals on the one hand and their effects upon energy use and materials productions, as well as upon international competition on the other,

Other policy responses suggested by the Task Force included:

1. Expand Government~-sponsored R&D on pollution control,
2. Encourage R&D for developing less polluting processes,
3. Reassess pollution standards regularly to balance more accurately and realistically costs and benefits,
4. Place potentially polluting processes in locations sufficiently remote to minimize environmental and health impacts,
5. Discourage consumer waste and littering of containers and packaging by allowing the full cost of control to flow through to the consumer. This might be done by special taxes, and
6. Educate the consumer by allowing the true costs of pollution control to flow through to the user.

IV, Declining trend in materials investment.– A majority of the Task Force finds that serious stresses might result from persistent and unfavorable trends in capital investment into the materials system. These are characterized by a long term decline in the flow of funds as compared with the general level of capital expenditures and by the increasing capital intensiveness of the materials industry (i.e., the increasing capital cost per ton of producing capacity; the rate of inflation in mining machinery, salaries and processing equipment appears higher than for other capital goods, etc.), Last but not least, the scarcity of capital and the high cost of money causes more severe stresses on long payoff, capital-intensive industries (as those in the materials cycle) than on quick turn-over consumer industries or short term loans. In addition, the profitability of materials industries is much less than in other sectors, so that the borrowing is not easy and internal profits are insufficient to finance improvements. It may be that to remedy this, the need to modernize our materials facilities and invest in new R&D will justify special incentives or financial guarantees to facilitate the flow of funds into the materials cycle,

The Task Force hears, loud and clear, the industry statement that, above all, the materials industry problems stem from the lack of freedom in the marketplace, and adequate profits to enable investments of the proper magnitude to maintain domestic supply and demand levels.

SUMMARY OF TASK ONE(B): MATERIALS ASSESSMENTS FOR CONGRESS: STRESSES ON THE TOTAL MATERIALS CYCLE

Introduction

The total materials cycle begins with the exploration of the earth and ends with either the recycling of the material or its return to earth by disposal. From a generalized material cycle* in the OTA report on materials information systems, the Task Force developed a series of specific stresses for each phase of the cycle. Many of the stresses were common to several phases of the cycle. These 19 specific stresses are listed and discussed below.

Since many of the specific stresses had facets in common, the 19 specific stresses were grouped into six "summary stresses" from which the policy alternatives and recommendations were generated.

Specific Stresses

1. Environmental Concerns: All active phases of the materials cycle, from exploration to disposal, generate environmental impacts, sometimes severe. Public pressure for a minimization of such effects on the environment will continue to increase.
2. Depletion of US Resources: In many materials, U.S. resources are depleted and the country is dependent solely on foreign sources.
3. Uncertainty of Foreign Supply: Swiftly changing world conditions can result in sudden embargoes of vitally needed supplies. This ever-present threat of complete shut off or severe restriction of supplies can perturb the materials cycle.
4. Capital Acquisition: The lack of investment capital in recent years, due in part to high interest rates, has deferred or even terminated proposed development of production facilities.
5. Government Controls: The increasing number of Government controls and regulations on various parts of the cycle make operations throughout the cycle more difficult and costly.

* OTA report on Materials Information Systems, figure 11-1, p. 22, US. Government Printing Office, 1976.

6, Uncertain Government Policy: In all too many instances, e.g., pollution control, safety standards, Government regulations are inconsistent or appear to fluctuate from month to month,
7. Constraints in Land Use: Government regulations, in the use of park lands for example, appear to be overly restrictive and sometimes capricious.
8. Inadequate Technology: In many technical areas of the cycle, we lack basic technology, For example, a real advance is needed in geophysical exploration techniques. New extractive methods need to be developed to process very low grade ores,
9, Health and Safety Laws (OSHA): In many areas, the application of these laws is inconsistent and variable.
10, Manpower and Training: An increase in the number of trained technical people for the early phases of the cycle (mining and milling) is needed.
11. World Financial Climate: The financial climate outside of the United States has made foreign investment attractive to the detriment of U.S. development.
12. Energy Availability: The increasing cost and limited availability of energy imposes a stress on many phases of the materials cycle.
13, Availability of Indirect Materials: Increasing constraints in the supply of “indirect materials” such as water, fer~ tilizers, etc., poses production stresses for many industries.
14. LDC Industrialization: The entrance of developing countries into the world production generates additional competition for material supplies and markets.
15. Transportation: Biasing in Government regulation toward certain modes of transportation for various commodities imposes stresses. For example, freight laws are designed to favor ore transport but not recycled materials.
16, Public Attitudes: In many areas of the materials cycle, the public attitude is negative—resulting in restrictive legislation or adverse community action.
17. Inadequate Design/Performance: Inadequate service life of many of the industrial tools results in increased production costs. Inadequate product performance results in early replacement.
18. Financial Incentive (profits): Both the Government and the public often do not understand that financial incentive must be present and sustained for successful industrial development.

19. Legal Relics: Outdated laws pose problems in conformance to various regulations.

Summary of Policy Alternatives

(Given in descending order of priority)

A. Lack of Availability of Competitive Domestic Resources–ore, energy, materials (specific stresses 2, 12, 13)
- Government aid and promotion of exploration especially through amending and expanding the Office of Minerals Exploration;
- Government aid for general replenishment of renewable resources;
- More effective utilization of domestic resources through tax incentives to industry; and
- The promotion of substitution, recycling, and product durability.

B. Uncertainty of Foreign Supply (specific stresses 3,11, 14)
- All responses of A;
- Establish a stockpiling policy (stabilizing supply situation allows for negotiation time in short term situations);
- Government should increase technical aid to foreign countries for resource development for the purpose of encouraging multiple sources of supply of critical minerals; and
- Amend and expand by means of increased funding the Overseas Private Investment Corporation to promote new development of critical materials.

C. Financing Difficulties–Poor Investment Climate (specific stresses 2, 4, 18)
- Tax credits for critical materials production.

D. Federal Legislative and Regulatory Constraints (summary stresses 1, 5, 6, 7, 9, 15, 19)
- Resolve conflicting environmental and OSHA regulations, stabilize "uncertain," fluctuating, regulations;
- Promote multiple land use;
- Reappraise freight rate regulations;
- Reappraise price controls on oil and gas; and
- Government should promote a freer exchange of technical information (e.g., statistical data or supplies) between companies in the same industry by reevaluation of the present antitrust laws.

E. Inadequate Technology and Science Base (specific stresses 8, 10)

- Develop exploration, extraction, recycling, and substitution technology through Federally supported programs for basic and applied research;
- Support research for production and utilization of renewable resources through Federal funding;
- Encourage research in private industry through tax incentives; and
- Encourage educational programs in mining, milling and extraction engineering.

F. Lack of Public Understanding (specific stresses 1, 7, 16)

- Industry and Government formulation of education programs involving the public, industry, and Government concerning the environment and land use in resource development.

SUMMARY OF TASK TWO (A): GOVERNMENT, SUPPLIES AND SHORTAGES

The Task Force began its deliberation with acknowledgement of its limited resources of time and authority. Yet the fortuitous variety of its experience, expertise, and political bias provided a constructive, objective, and always colorful debate on the role of Government in response to chronic shortages and their underlying considerations.

In addressing Task No. 2, the Task Force chose to focus its attention on the first four questions and on the proposed Materials Policy Act of 1976; response to question five is implicit in the comments on the earlier issues.

On the Sources of Scarcity

The Task Force believes that the shortages observed during 1973-74 were not related to a scarcity of underlying raw material resources. Rather, those shortages were directly related to the lack of capacity of conversion and processing facilities (due in part to Federal intervention) to respond to unusual surges in demand. In this regard, we share the judgment of the staff of the Commission on Supplies and Shortages.

The adequacy of the resource base frequently is confused with the capacity of the supply system; the chain of process facilities from mine, well or field, to refinery, or sawmill, to fabricating plant; and the associated transportation systems, This confusion has led to frequent misperception of the basic problem. Adequacy of short term supply at the point of use is dependent on the capacity of the intervening extraction, process, fabrication, and transport facilities, Adequacy of long term supply depends primarily on the availability of essential technology to convert existing natural resources to man's needs.

On The Question of Self-Sufficiency

The Task Force agrees that self-sufficiency in materials is an inoperative and undesirable goal, The United States cannot, need not, and should not endeavor to be self-sufficient in all materials. It is further agreed that the issue of sufficient resources for military security is a separate matter, one of assuring that adequate divertable industrial capacity exists to provide critical military needs for the period of limited war; this capability is being examined separately and is the responsibility of the military establishment, The term "degree of self-sufficiency" is semantically misleading; one is either self-sufficient, or he is not; it is not a matter of degree, The acceptable degree of import dependence must be examined on a case-by-case basis, using an adequate set of criteria including economic dislocations, effect on employment, effect on quality of life, and strategic security. The operative institutional framework must include and feature extensive cooperation between Government, Congress, and industry. The ultimate concern is not only the adequacy of industry but the health of industry, upon which the health of the Nation depends.

On the Question of the National Materials Information System

We concur with the staff of the National Commission on Supplies and Shortages that it is neither practical nor desirable at this time, to construct a new materials information system from the "top down." However, in the longer term, experience may show that both the facility and the need may justify development of a better system. In the interim, the system, as developed, must be open-ended in design, adaptable to changing requirements and capabilities. We would refer to the well-established and rather more integrated information system in food and that evolving in energy as examples worthy of examination. Existing components of a "national materials information system" in various agencies should be maintained and upgraded, Care must be taken to avoid impairment of raw data systems by neglect as analytical capabilities are added or refined. In most instances, data collection and dissemination should be vested in the same agency. (This latter recommendation, incidentally, is not original; it appeared in the Hoover Commission Report in the 1920s.)

A "national materials information system" should not be limited to serving Government alone; its resources should be available to, and designed to serve, industry and the public as well, Industry must be a partner in, contributor to, and user of the system. To maximize its potential for service to both communities —Government and industry—the system should incorporate technical as well as economic data.

An important consideration is proprietary data–both industry and Government. Provisions must be made to assure that constructive analytical use is made of proprietary data without compromise to its source. The Task Force felt that this is an important factor in industry acceptance of the concept of a "national materials information system, " and in its cooperation with the participating agencies.

We concur with the statement in the OTA report that the information system should include "capability of interrelating many factors to generate information specifically oriented for materials decisionmaking. ” But the degree to which such analytical capabilities should extend to development of policy options is debatable; it is not the function of an information system, per se, to be sensitive to the subtleties of political considerations. An information system should provide only objective facts, without bias or coloration.

However, a primary ingredient of the information system concept should be the capability to select and effectively translate pertinent information into language suitable for the definition of Federal policy alternatives, We believe the system must provide an authoritative source of comparison between policy actions on the one hand and industry, market, and societal responses on the other.

A further essential function of the system is provision for anticipation of supply-demand disruptions. Tools for accomplishing this function—on a macro basis— exist in the present system. Expansion of these capabilities, in both scope and detail, from a coordinated national viewpoint—is necessary. The Department of Commerce Early Warning System may fulfill this need, However, we would caution that it is insufficient to consider the domestic economy in isolation; our supply-demand system is inseparable from that of the global community. We encourage expansion of the DOC EWS concept to consider and report on foreign economic, technological, and political factors affecting the flow-both import and export—of materials through the domestic cycle,

We believe that the creation of a new bureaucratic function is not necessary; the further development of a “national materials information system” can be pursued (as suggested under Approach No. 2) through more aggressive and directed effort of existing coordinating bodies, e.g., OMB. Congressional encouragement and guidance is essential, The chosen coordination agency should be charged with “bringing about improvements in the existing system” and “assuring the addition of new supplementary information services as necessary” (quoted words taken from the description of one alternative approach cited in the OTA report, Materials Information Systems, Feb. 1976).

On the Issue of Stockpiling

With reference to the extensive OTA study of economic stockpiling objectives and alternatives, the Task Force is of the opinion that there is a “prima facie” case for a carefully planned stockpile system to meet military needs, geared to the national strategy, and the weaponry requirements of the national readiness plans, Such a stockpiIe system should not be comingIed with, or used for, domestic or international economic purposes, It is our perception that our present strategic stockpile system suffers from gross imperfections, particularly when combined with or attempting to justify changes for economic objectives. It may now be necessary to substantially revise or reduce the number of materials in the strategic stockpile system, and to carefully examine the form in which such materials are stored,

The examination of scenarios and alternatives for economic stockpiles leads us to the view that an overall economic stockpile of materials for the purpose of price stabilization is not advisable, Stockpiling, as we conceive it, should be a response to an embargo on those materials, the supply of which is essential to avoid disruption of our economy. It should be an emergency stockpile, limited to short term demand for a few materials, to gain time until other normal free enterprise market forces act to limit or eliminate a perilous gap. It should not be designed to counteract swings in prices; this would imply policy decisions against a background of a less than glorious past performance.

Where such an insurance is desirable, the alternative of inventory stockpiling by the consuming industries at point of use (with some Government guidance and visible tax or other incentives to encourage prompt response) would be preferable to new and cumbersome bureaucratic management and Federal intervention.

On the Proposed "National Materials Policy Act of 1976"

Although the Task Force cannot endorse the proposed Act, the Task Force commends the interest, imagination, and concern of the authors of these bills, We encourage the articulation of a National Materials Policy, However, recognizing the inseparable relationships between energy, environment, and materials (and the necessity of integration of relevant national objectives), we believe the objective should be the expression of a National Natural Resources Policy, encompassing all these issues, rather than the more limited implications of the proposed Act.

Further, we find that the Bill does not, in its present form, define even a Materials Policy. The major function of legislation on this subject should be to state National Policy Goals(perhaps using the five elements of policy voiced by the National Commission on Materials Policy as a basis), And the responsibilities for implementation of those policy goals must be clearly defined. The proposed Act is not clear in this respect, (The structure of the Energy Resources Council appears to be a useful example for Executive Branch authority; congressional analogs also are needed; in this respect, we endorse the proposed legislation.)

The Bill focuses on materials research and development, which we recognize as an important ingredient of policy—but only one of many. Although we do not subscribe to the proposed institutional measures, we note the omission of the Administrator of the Environmental Protection Agency from the "Commission on Materials Research and Operations," and suggest that, in view of its major contributions to materials R&D, the Department of Defense should also be represented in such councils. And we would further voice some concern with the scope of the functions proposed for this Commission, which would appear, in many respects, to overlap those of existing agencies,

In summary, we heartily endorse the concise statement of a National Materials Policy, provided that it is in the context of the larger issue of National Natural Resources, and that it does not add to the burden of Federal bureaucracy. Although a useful beginning, the proposed Act does not meet these criteria.

SUMMARY OF TASK TWO (B): GOVERNMENT, SUPPLIES AND SHORTAGES

This report approaches the Task by considering each question posed in turn. Some redundancy occurs using this approach, but it serves to highlight the major concerns which are summarized in the answers to the last question.

1. (a) There are now strong indications that the shortages observed during 1973-74 had little or nothing to do with an underlying scarcity of raw materials, Was there a misperception of the basic problem ?

The direct answer to the question is yes, It would appear that the comprehensive investigation and findings of the Staff of the Commission on Supplies and Shortages is definitive. There was, in fact, no "real" scarcity of materials. The problems were essentially those of unsound Government actions and the resultant "shortage mentality, " A major concern is whether the conditions leading to these shortages will happen again. Here we first recognize that the supply and demand became imbalance for a variety of reasons but it is necessary to classify the shortages in supply as either short or long term. It is important when considering recommendations on possible Government intervention that a clear distinction be made between shortages arising from previous Government actions, unexpected machinations of the free market system or other temporary interruptions in the supply system, as opposed to long term shortages perceived as inadequate future supply because of exhausting domestic resources and increasing dependence on foreign supply.

In all probability supply/demand will never be in balance since producers will tend to produce for profitability while consumer demand might tend to the opposite direction. This occurrence may in fact be desirable since it can act as an incentive for private sector action, Hence, we may expect temporary supply/demand perturbations (or short term shortages), particularly in end products and not necessarily in raw materials. In general, market forces will adequately handle such problems, though time will be a factor. The 1973-74 shortage may well have developed from a unique set of factors which have a low probability of repetition. Even so, some rational Government/industry action will be useful.

1. (b) What lessons for future Government policy can be learned from the 1973-74 experience?

It should be recognized that Government intervention is desirable, but that there is an optimum level of Government action and industry response. This condition does not now exist and a proper balance must be sought. The major need is for accurate, timely, and reliable information to allow for proper Government policy determination and appropriate marketplace response. The latter implies that the Government should rely on the market system to correct shortages whenever this is judged appropriate. Industry must improve its efforts to supply the Government with timely and accurate reporting of the required information. There is some concern that a formal policy might be needed in this area, In addition, the Government must strive to coordinate its policies among some 67 agencies. In this regard legislative guidelines and congressional overview is desirable if not mandatory.

2. (a) Total self-sufficiency in raw materials is not a desirable goal for the United States. Accepting that statement, how should the proper degree of sel~-sufficiency be determined?

Self-sufficiency is not a goal in itself. What is required is sufficiency in "critical commodities" and "essential" industrial materials, The first ingredient is accurate information to define those "critical" commodities and "essential" industrial materials. Beyond this, the group did not attempt to quantify the degree of sufficiency.

2. (b) What policies are required to attain this level?

The Government should apply incentives to allow industry to respond with technological developments that would ensure the proper degree of supply sufficiency. Then the Government should monitor industry and apply further incentives or regulation to achieve the desired result. Here it is important to recognize the impact of the interdependence of the world's national economies (with the development of their apparent synchronized behavior) on the determination of the degree of sufficiency.

3. In light of the recent OTA study on materials information system requirements, what, if any, changes in Government materials information systems are feasible and desirable ?

The big shortfall in materials shortage problems appears to be the lack of adequate information management, Decision makers must be well informed. Policies which are uncoordinated and inconsistent can lead to uncertainty in the private sector. Basic improvements are needed in the quality of information. Uniformity of presentation for comparison in use, and better analytical tools for analysis, are also required, The Government's basic role is to accumulate needed information and provide it in a timely fashion for both its own internal use and for use publicly, These actions should operate to provide a "certainty feeling" which inspires confidence on the part of the private sector which in turn will stimulate the market to react suitably, In this regard the Government might, for example, periodically publish its interpretation of the supply/demand inventory situation. Should the Government foresee a period of shortages, it should publish its assessment of the reason for the impending shortage. In short, the Government should "sell" industry on its capabilities in this capacity. Some more detailed thoughts on implementing information needs is included as follows:

Quality, quantity and timeliness of mineral data could be improved by:

- Much closer cooperation between Government, industry, and industry associations. In particular, it might be possible to arrange for a sampling of data to be transmitted directly from the mine or plant to the final compiler.
- Encouraging the State Department to transmit more foreign mineral data more frequently from its embassies. The U.S. Bureau of Mines should continue its strengthened foreign activities program.
- Having a stated Government policy of collecting as much detailed mineral information as possible, and have industry associations endorse this goal.
- Encouraging Government and industry commodity experts to meet frequently, to standardize data definitions and format, and to minimize overlap.

It would appear feasible to make use of current information systems with evolutionary changes as required for centralized coordination. Note here that industry information systems for reciprocal inputs are equally important, with the Government/industry interface being of major concern.

4. (a) A recent OTA study of economic stockpiling suggests objectives for stockpiling and estimates benefits and costs for alternative policies. In your opinion, is stockpiling for any of the suggested purposes both feasible and desirable?

Economic stockpiling, per se, while feasible, is undesirable and, in fact, should be an action of last resort. In general, it can be expected that all the heretofore identified risks will be realized, and hence such policy will be more disruptive than useful, There does, however, appear to be a justifiable need to assure the supply of "critical" commodities and selected "essential" industrial materials.

4. (b) How are materials selected for stockpiling?

Critical commodities are readily identifiable, and strategic stockpiling has been an accomplished fact. Essential industrial materials can best be selected by analytical models and historical perspective that show a relatively high probability of shortages. These materials might best be stockpiled by extending the concept of the strategic stockpile and incorporating in it the concept of an economic stockpile.

4. (c) Might stockpiling have other benefits and aggregate a variety of objectives?

An interim economic stockpile or a stockpile as defined above might come about as the result of a sound, long-range Government plan based on the accumulation and analysis of reliable, high-quality information. For example, the policy statement might be that free and open trade on a worldwide scale is to be sought as the soundest way to solve supply problems, and some form of economic stockpile is desirable while this goal is being achieved. There are a variety of desirable objectives obvious in such an exercise. One opinion has also been advanced that stockpiling of critical materials might act as a deterrent to disaster.

4. (d) What about international buffer stock programs?

Seven such programs in the minerals area are now operative, Experience with them would indicate that they are a poor or unsatisfactory mechanism for achieving any of the economic stockpiling objectives. Participation in these schemes is not recommended.

5. (a) How active a role must the Government take to assure the long run availability of raw materials?

Again, the major Government role is to supply accurate and timely information sufficiently in advance to ensure that the market will give the proper response, e.g., R&D programs, substitution and recycling studies, etc. If shortages are short term, action by the Government should be exercised with extreme caution, The Government should monitor the market to see that long-range policy objectives are really being attained. If the condition is unsatisfactory, the Government should have available the proper incentives for rational market response. One proper Government role is the support of R&D which is appropriate to observed needs but for which industry has no incentive. Three such projects which might be found suitable upon assessment are (a) **design** of products for longer life, (b) design for recycling, and (c) design for material substitutability.

5. (b) Is there a need for increased monitoring of supply/demand trends ?

Yes, as a basic part of reliable, quality information for decision-making.

5. (c) Is increased financing of R&D on materials substitution required ?

Implicit in the recognition of “essential” industrial materials is the concomitant need for long range R&D on substitution. It should be recognized that substitution encompasses physical, functional, and social aspects, e.g., substituting one element for another in an alloy or changing the mode of transport between stations in an operation or moving from a suburban to an urban living environment all for one or more reasons involving scarcity.

5. (d) Does the situation dictate that the Government undertake something approaching long term planning?

Yes, to the extent that the following four items are recognized and implemented: (1) obtaining and communicating reliable information in a timely manner to inspire private sector confidence, (2) monitoring results of actions on stated policies to see that results are being achieved, (3) intervention only as required and whenever possible the use of incentives to allow free market response, and (4) coordination of policies and actions within and by the Government aimed at guiding the market system rather than disrupting the same. This should come as a result of guidelines prepared and monitored by the legislative branch.

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SUMMARY OF TASK THREE (A): CONSERVATION OF ENERGY IN MATERIALS PROCESSING*

1. Conservation is the wise (labor, capital, materials) and efficient (strategic, economic, political, environment use —not curtailment of use) of fuels and materials; its means is through substitution, selectivity of mix, efficiency of materials use, and minimizing waste. Measurement units include Btu/unit of output (preferred), Btu/capita, Btu/GNP, energy dependence ratios,

2, National policy should encourage high load factor use of electricity. Price should be based on cost.

3. Theoretical energy efficiency data are controversial. Practical efficiencies range from 20-90 percent (Battelle report). Short term improvement could average 10-16 percent by 1985, using currently available technology. Long term efficiency should increase substantially but will depend on the specifics of the material and technology yet to be applied.

4. Price controls diffuse proper signals from energy costs to motivate industrial energy conservation. Voluntary guidelines should be adequate.

There is no parallelism between environmental protection and energy conservation. They are trade-offs.

5. Generally, industrial energy self-generation is not necessarily efficient (size effect). To achieve utility/industry dual cycle, dual incentives are required, Match between available thermal mix and industrial needs must be designed, Reliability is essential. Siting regulations and tax credits are possible regulatory changes.

6. Federal R&D funding for industrial energy conservation should be related to needs not now fulfilled by industry. For example, the chemical industry generally does its own R&D. More R&D is needed in mining, blasting, movement of ore and comminution, etc., by the minerals-producing industry. Loan guaran-

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'Task Force Chairman's comment: This report hardly reflects the lively and fruitful discussions of the Task Force. The final approved report has been hedged and generalized and several statements cited below were deleted to avoid specificity and controversial items:

3. Battelle analysis of thermal efficiencies was considered inaccurate by some. Long-time efficiency was estimated at 20-30 percent but then removed because it is a guess.
4. Market forces internalize costs and prices reflect this addition in domestic markets but not where price is determined in an international market.
8. Recycling incentives were considered inadequate by some to recapture old scrap (except autos).
9. Import high-grade ore in place of oil difference needed to mine equivalent low-grade ore and thereby conserve energy. Concept discussed and eliminated as too detrimental and controversial.

tees are helpful for industry where capital formation is otherwise impossible, i.e., small businesses, but tends to encourage lower management efficiency, Obsolete facilities should be replaced, not retrofitted.

7, Capital formation is the primary role of tax policy to encourage conservation investment or facilities replacement. Tax credits, tax exempt energy bonds, and quick write-offs are possible actions,

8. Sufficient market forces exist to encourage recycle for energy conservation

SUMMARY OF TASK THREE (B): CONSERVATION OF ENERGY IN MATERIALS PROCESSING

Assumptions

Industry (materials-producing plus materials-application) uses approximately 40 percent of the total energy consumed each year in the United States, This Task Force addressed the role that conservation of energy could play to reduce this large consumption rate and the proper emphasis that should be given this role by both industry and Government.

The energy content of final products is made up of two parts: (1) the direct energy content contributed by the firm manufacturing the product and (2) the indirect energy content contributed by the primary materials producer. The ratios of direct to indirect energy vary widely between industry groups and even within an industry group, depending on a large number of factors such as the maturity of the industry, size of capital investments in operational but technically obsolete equipment, and whether the materials and final product are produced in a continuous or intermittent operation.

Our Task Force represented a wide variety of materials-application companies and Federal agencies. It was unfortunate that only one basic materials producer was represented since the highest percentage of energy involved in the manufacture of most products is the indirect portion attributable to the highly energy-intensive production of the primary materials.

1. Definition of "conservation of energy" as applicable to materials processing.

The Task Force agreed that there was no across-the-board, single common denominator for defining or comparing conservation of energy, Total energy consumption expressed in terms of dollars, tons of fuel (or barrels of oil equivalents), Btu's or kWh's are misleading since population growth and expansion of the economic base will cause consumption to grow even though sizable conservation efforts are made, Consumption of energy rates per capita, per unit of GNP, per ton or volume of material types are also misleading (i.e., one class of steel may require much higher energy to process than another). Life-cycle energy costs of products may be the best way to compare product families such as automobiles, air conditioners, etc. All consumer (and capital goods) equipment have energy consumption contents in three stages:

1) Direct/indirect energy for generation of manufactured products,

2) Consumption of energy during life of product including energy input into maintenance, and
3) Energy consumed in disposal of product after its useful life is-exhausted,

As an example, an average American automobile (3545 pounds) requires only approximately 100 X 10' Btu of energy in Stage 1 but 1500X 10^6 Btu of energy during Stage 2.

Process vs. alternate process energy comparisons are valid only when studying a single industry and a single family of materials, Consequently, the Task Force cautioned against the imposition of arbitrary energy reduction quotas, The real-world experiences of our group led us to conclude that such a simplistic approach to energy conservation would fail.

Process analysis using material/energy balance equations familiar to the chemical engineer can point out the most energy-intensive steps that R&D efforts may minimize. Moreover, product mix considerations by the materiaIs producers and design changes by the materials application industries have a great potential for reducing energy content and maximizing materials effectiveness. What we really need to emphasize is the wisest use of available energy rather than arbitrary reduction quotas,

2. Encouragement of use of electrical energy for materials processing.

Question 2 asks whether national policy should encourage the use of high-voltage, high-load factor electricity. While it is true that electricity is the most convenient form of energy for many applications (especially in the non-thermal manufacturing processes), it is certainly not the most efficient energy form for most thermal applications and particularly in the materials-producing fields. Many of the necessary processes require thermal inputs inefficiently supplied by electrical power. Hence, the response is negative for most material processing or extractive applications.

The Task Force recognizes that it may be necessary or mandatory to switch from such energy sources as natural gas and fuel oil to less efficient electrical power in the near future. When this occurs, there are real advantages and savings in fuel consumption by the electrical power utilities in maintaining a high-load power factor to meet these industrial demands.

3. Potential for reduction in energy consumption.

Both the short term and long term potentials for reduction of energy consumption in materials processing are widely variant from material to material. The chemical and chemical by-products industry has demonstrated the ability to incorporate process changes (that may or may not conserve energy) more rapidly than mature industries such as steel. Here again, the high cost of capital expenditures to change basic processes in mature industries must be emphasized and understood. All materials-producing and materials-application industries know how to reduce energy consumption and/or to increase productivity, but capitalization and high interest rate (plus recent mandatory expenditures to conform to OSHA and EPA edicts) preclude such massive expenditures on a short term basis (1977-85). On a long-term basis (1985-2010), new facilities necessary to replace such energy-intensive processing as open hearth furnaces will require **30 to 50** percent less energy.

4. Will energy costs motivate conservation efforts or are mandatory requirements a better way?

Recent experiences of governmental agencies imposing on industries rather arbitrary quotas, allocations, or percentages lead the Task Force to oppose mandatory energy reduction requirements, The profit and competition (or dollar) incentive are considered the best at this time. When energy and material costs increase to a point at which profits are seriously jeopardized or until industry cannot compete with foreign or domestic firms, management will find technical ways and necessary capital to introduce energy-saving processes. Government aid in forms of tax incentives and short equipment writeoffs would be in order if and when this occurs. (See comments on question **6** for other ways that both Government and industry can expedite energy conservation.) Some members of the Task Force pointed out that energy cost increases have not become so out of line with other cost increases as to be the controlling factor in the motivation to introduce less energy-intensive processes.

Some concern was expressed that actual shortages of available energy fuels for processing (such as natural gas and fuel oil) would make allocations of priorities for energy by industries necessary. In such a situation, small firms without auxiliary fuel supplies and technical know-how could be mortally hurt. Moreover, public and social concerns make it mandatory that a governmental agency (rather than the local power company) determine the priorities for available energy.

5, How to encourage industrial electricity self-generation in dual-cycle mode for materials processing.

While some materials producers and application industries have generated their thermal energy requirements for basic processing steps, it was generally agreed by the Task Force that electrical generation can best be supplied by large utilities. There is a strong move towards load-level management by both the electrical utilities and the major industrial users, and this effort should be encouraged and rewarded. One member cited a survey that showed that effective load Ievelling alone by industry and utilities could save 1.8 X $1O^{Y}$ barrels of oil per year out of 16 X 10” barrels. Time/demand clocks, microcomputer control of processes, adaptive control for optimizing energy of manufacturing processes, use of available waste heat for preheating precursor material, DC power generation from thermal furnaces—all have their place in energy conservation and should be encouraged. Converting to low efficiency self-generation of AC electricity (or switching to all electrical energy for furnaces) could result in a paradox of higher thermal efficiency at the plant site but increased overall fuel consumption.

6. Role of Federal funding in energy conservation as related to materiaJs processing,

The Task Force agreed that experts in devising ways to conserve energy are needed in the specific industries that process material or manufacture final product. For example, even large companies that know their sub-contractors or vendors very well lack the “degree of technical knowledge and judgement” to advise them on energy-saving methods except in a general sense. We feel even stronger that Federal agencies lack this necessary knowledge and judgement. Tax credits for energy-saving R&D and/or expedited writeoff of energy-saving processing equipment should be considered as state governmental and Federal roles or options. Publicizing successful energy-saving methods (where proprietary information is not compromised) for smaller concerns lacking R&D capabilities should also be considered as governmental roles or options. The Task Force felt that industry in general is confused as to what the Federal policy actually is towards encouraging conservation of energy. Moreover, regardless of the policy, we see no evidence of real, across-the-board, governmental-originated incentives for energy conservation at this time,

7. Tax policy for energy conservation in materials processing.

The answers to Question **6** apply to this tax policy query. The Task Force repeats that most industry is not using all known processes that conserve energy today for the following important reasons:

- Profits generate capital too slowly to incur major expenditures for capital equipment. We can always turn off lights, but real energy savings will incur high capital outlays (with their own energy content);
- High cost of replacing capital equipment plus high interest rates on borrowed money would cause slow replacement even if profits could provide capital;
- Expedited capital equipment writeoffs based on energy saving are not available to encourage their early incorporation;

- Major capital investments to meet local, State, and Federal mandatory edicts by OSHA/EPA/FEA have taken priority over energy-conserving expenditures; and
- Energy saving alone has not had sufficient dollar impact to incorporate known processing improvements.

To the extent that governmental relief via tax policy changes can change the above basic factors, the Task Force encourages their incorporation.

TASK FOUR (A): THE ROLE OF MATERIALS IN DEFENSE

Questions 1 & 3

I, How can materials research and development be made more productive in a world of declining real dollar funding?

3. What is the best way to expedite the development of materials and technologies that limit the development of new systems and weapons?

The needs of the DOD in the areas of materials and structures technology have expanded because of increased demands on improved performance of DOD weapon systems, coupled with increasing demands of structural integrity, minimum life cycle costs, and enhanced safety. In many instances, systems requirements make it necessary to choose materials that are not completely characterized. Moreover, the data base in many cases is not adequate for detailed design, and the constraints on the system do not allow the necessary data base to be developed under the basic and applied materials research programs of the DOD.

One important and necessary method to expedite the development of materials and technologies that limit the development of new systems and weapons would be in the creation and operation of a materials properties data bank between Government and industry organizations involved in materials R&D and materials properties characterization. Such a materials properties data base would be most important to the development of materials and processes specifications and standards, and in the accomplishment of engineering design.

Much of these data are generated during the engineering development phase of major weapons system design and in the production of materials and mill-product forms relevant to that application. It is accomplished on a large number of mill products and heats at great cost. Because of costs for this type of data, it is not economically possible to generate them in the applied research phase of the materials investigation. Therefore, what is needed by the DOD is:

- a means of generating information about materials properties for the data base,
- a means of analyzing the data for the best statistical analysis,
- a means of formatting the data so that they are readily available in a meaningful manner, and

- a means of retrieving these data by potential users in an expeditious manner and useful form.

The materials properties data base can serve to direct support to basic and applied materials research so that the necessary engineering materials properties will be available for use in systems development.

As concerns making materials research and development more productive in a world of declining resources in the face of an inadequate technology base, selectivity in R&D programs in certain areas is mandatory. With this selectivity should be the assured financial support of basic and applied research as a fixed percentage of the materials R&D budget to insure that new ideas and technology will be developed, and to insure that creativity and innovative ideas are supported to supply the basis for the needed technology.

Question 2

2. Can implementing the design team approach (designer, materials engineer, nondestructive evaluation, process planning and manufacturing, and maintenance and repair) from the time of the conceptual stage provide a significant increase in cost effectiveness?

The consensus of the Task Force is that the DOD should adopt the design team approach, with the materials systems rationale in DOD management in cases where materials area critical element of a system. Matters like acquisition cost, life cycle cost, methods of nondestructive evaluation, and general materials evaluation must be considered as early as possible in the design program,

Question 4

4. Would permitting the allocation of DOD funds to basic science ‘not directly tied to specific missions be more effective in furthering the long-range, materials-associated needs of DOD than continuing the present restriction largely to National Science Foundation funding?

There are often difficulties in defining the role of basic research applicable to DOD needs. The spectrum of research runs from basic to applied areas, and all are needed, as long as they comply to the concern of relevance to broad mission areas, It was the view of the Task Force that the entire spectrum of research is needed by DOD and that it would be unwise to relegate the basic research component to another Government agency that might not be in a position to recognize DOD’s needs. Since the economic health of the Nation depends, among other things, on the technical community's ability to innovate, the role of basic research takes on added meaning to the innovation process when it helps to accomplish added missions at minimum costs. The process is not limited to the DOD, but involves industry and academic participation in the needs of the DOD.

It is not within the province of this Task Force to suggest how research is to be funded, but rather to urge that DOD have a strong "role in choosing its basic research and relating it to its missions, because it can best judge its overall needs.

Question 5

5. Can centers of excellence for areas, such as casting and welding, that would involve individuals from industry, academia, and government and multidisciplines be effective in advancing and disseminating technology? How should it be structured—Government owned? Consortium of interested parties? Permanent or rotating personnel?

The Task Force agrees that there is value in identifying centers of excellence for specific technology areas which impact significantly on the missions of the Department of Defense. The Task Force believes that, except in unusual instances, acknowledged, rather than Government-created, centers of excellence are more likely to be effective and competent, and to have long-term durability and real acceptance.

In addition to identifying centers of excellence, an analysis should be made of gaps in technical competence which should be corrected, for strategic and technological planning reasons.

More specifically, the Task Force recommends that:

1. Minimum 'criteria for designation as a center of excellence should be established but without any minimum size limitation.
2. Centers of excellence which are important to the Department of Defense mission should be identified and evaluated.
3. Evaluation should be made by a group of (e.g., 3-5) peer authorities in the identified field (not necessarily a part of the Defense establishment).
4, Designation of centers of excellence should be reviewed and considered for renewal after an appropriate time period (e.g., 3-5 years). This action should include recommendations for adjustments in manpower and funding levels, in accordance with evolving Defense Department priorities.

The Task Force does not believe that there is one best structure or institutional format for the centers of excellence, What is most important is that the contribution from the Centers are effectively coupled to the relevant mission-oriented Defense Department programs.

Question 6

6. Is the trend toward reduction in DOD's manpower and resources in its materials and structures divisions severely reducing its effectiveness? Concomitantly, do reductions of staff and effort in other agencies such as the Bureau of Mines contribute measurably to the decline of materials development and technology? How can policy level officials be made more aware of the importance of materials to defense?

The Task Force expressed concern over the asserted reduction in materials technology manpower as related to defense. This reduction is taking place at a time when demand on materials performance, reliability and cost effectiveness are complicated by materials availability problems.

For years, Congress and DOD officials have not seen the need for a comprehensive materials policy, and have not appreciated the importance of and limitations of materials. The downward trend in manpower and resources in the DOD and other agencies devoted to materials and structures is further evidence that experience in recent years has not brought home the message,

This Task Force recommends that increased effort be devoted to bringing to the attention of all executives in Government and business the critical dimensions of materials problems and appropriate actions, Although efforts have been put forth by many in the past, much more needs to be done, such as:

1. Increased support and awareness of the National Academy of Science/National Academy of Engineering efforts to make officials aware of materials problems and options;
2. More effective coordination and participation by the DOD with standards-setting committees of such societies as ASTM and ASME;
3. Increased activity of the individual technical societies and the Federation of Materials Societies to bring the message not only to their individual members but also to the executive level groups in Congress, Government agencies, and business;
4, Encouragement to the DOD and its contractors to predict materials performance needs; and

5. Encouragement to the continuing and improved analysis of materials research now supported by the Federal Government, and the adequacy of the current programs in relation to a continuing assessment of needs.

Question 7

7. How could the research and development programs of Defense Services be coordinated better to more effectively develop new materials and technology? How could Government-civilian agencies interact in such a system? What international measures concerning materials would be most effective in promoting and strengthening the NATO alliance?

The Task Force understands that through periodic summary reviews (e.g., technical coordination papers) of-ongoing materials technology programs, the DOD adequately disseminates information among its own research organizations, While coordination with other departments and Federal agencies concerning its research programs is useful, we concur in the proposal that meetings be held to review these programs in concert with officials responsible for other Government R&D materials research.

The Task Force is concerned that unclassified information from DOD's periodic summary reports is not shared with the private sector. We believe it would be useful to make available information on research areas which are of mutual interest and recommend that (I) briefing sessions be held for this purpose with industry representatives, and (2) unclassified versions of its research summary reports be prepared and distributed. Responsible officials and organizations in the international community likewise could be briefed and kept informed of unclassified research activities in the DOD.

The recommendations offered here, if implemented, could yield as much, or more, information to DOD than it makes available to the private sector.

TASK FOUR (B): THE ROLE OF MATERIALS* IN DEFENSE

Rationale

The primary goal of the Department of Defense is to provide adequate and sustained U.S. security. To achieve this goal, the United States must develop and maintain modern defense systems. Increasingly, such systems are constructed from improved and advanced materials designed to meet high levels of performance under the extreme conditions encountered in actual service. Indeed, the materials required to carry out the 14 missions established by the Joint Chiefs of Staff are all materials-limited. Thus, continuing preparedness requires adequate supplies of strategic materials, a strong base of materials research and development, and rapid exploitation of new technological developments.

Though providing security is a primary national goal, pressures to achieve such other national goals as a benign environment and an adequate energy supply have led to a shift in the available Federal R&D resources toward more civilian-oriented technologies. As a result, an increasing proportion of military-related R&D is devoted to attaining short term objectives. Thus, the basic research to meet future defense needs is not being carried out at an adequate level, In addition, the growing U.S., dependence on imported raw materials, coupled with the advent of resource diplomacy as a feature of international relations, has increased the vulnerability of the United States in the longer term. To ensure national security, while at the same time meeting other national goals, the United States must efficiently allocate R&D resources not only among the several national goals but also between short and long term objectives. Obviously, to achieve this balance, U.S. materials policy must establish efficient systems for managing defense-related R&D, for coordinating this R&D with other agencies, and for transferring technology.

1. Materials R&D Management

POLICY: To develop, improve, and advance the technologies to support future military systems and weapons, the Department of Defense should adopt a more expansive materials R&D policy, Its policy should encompass the efficient management of both fun-

● The term "materials"' as used in this report is intended to include processes and structures.

damental and applied research necessary to maintain maximum national security in the present and in the future.

Therefore, it is recommended that:

1, DOD strengthen its use of MBO (management by objectives) in the management of its programs by requiring that the following steps be followed in each program?

a) Defining problems in greater detail.
All DOD Pacing Materials Problems (PMP) need to be phrased in sufficient quantitative detail so that the technical objectives are clear both to the scientist/engineer who responds with a research proposal and to the DOD personnel who review the proposal and manage the subsequent research program,

b) The PMP should be updated from the 1972 edition with quantitative objectives and kept current on an annual basis.
The PMP was the title chosen for a statement of materials limitations in various Army and Navy mission areas identified at a DOD materials conference held in May 1972. (The Air Force should be encouraged to publish their materials problems in a similar format so as to make the approach of all three services consistent.) The Joint Chiefs of Staff have established 14 mission areas to be covered by the Army, Navy, and Air Force in compliance with the Mansfield Amendment. In support of these mission areas, which are intended to provide DOD with the elements to attain its national security goal, a series of technology coordinating papers (TCPS), including one on materials technology, have been developed. These papers identify the materials barriers or problems which, if not adequately solved, will result in below-acceptable performance. These barriers define much of the needed R&D program.

c) Mandatory reviews should be made of all service needs to identify common materials problems, and make the findings public (unclassified) as far as possible.
The grouping of common problems should make the setting of priorities easier as the major materials problems should then be more apparent. Focusing on the major problems should provide some of the increased productivity and expediting sought by DOD. By making the documents unclassified, their usefulness to

the materials community and, therefore, to DOD itself, should be greatly enhanced.

d) Prioritizing the PMPs and subsequent R&D programs. Publish an unclassified document containing pacing materials problems (with a classified supplement if needed) in a prioritized way so that the more critical and important materials problems will be defined for the technical community. For each PMP, a DOD lead laboratory should be designated, and a technical contact listed from the lead laboratory staff. It is suggested that resources be emphasized on a relatively few Pacing Materials Problems where good solution ideas have been proposed, rather than arbitrarily spread over all problems.

e) Make a mandatory annual assessment of R&D program progress.
Each DOD lead laboratory should be required to conduct and publish an annual assessment, of progress toward program objectives on each of its assigned PMP. The assessment needs to be critical and quantitative with respect to technical progress, in order to provide a rational basis for the reprogramming recommendations which are the primary goal of the progress assessments.

f) Reprogram materials R&D activities as required.
The reprogramming action is essential in order to terminate unproductive research and development projects, to increase effort on productive work if warranted, and to initiate innovative new projects.

2. The design team approach should be followed with emphasis on recognition of an adherence to common standards and specifications.
Design, materials engineering, nondestructive evaluation, process planning, manufacturing, maintenance, and repair should all be brought in at the conceptual stage to save time and expense due to reworking as a result of omissions of these factors, thereby providing a cost reduction. This concept could be tested by trying a few experimental cases.

3, Some larger, significant percentage of total military materials funding should be dedicated to basic knowledge seeking research in areas identified by DOD as relevant to future systems needs. A method for accomplishing this could be via the “earmarking” of a certain percentage of the RDT&E costs already incorporated into the billing for foreign military sales (FMS) for fundamental research, The present NSF-funded program in basic research is not providing enough new materials ideas to adequately support future DOD hardware requirements. Hence, it is recommended that the DOD expand its dialogue with NSF with the objective of correcting this deficiency. The earmarking clause in FMS for fundamental research needs could be accomplished with minimal changes in present accounting procedures. It is suggested that the receipts from this procedure could be placed in a revolving fund administered either by the DOD, or by the NSF with performance input from the DOD.

4, "Centers of Excellence" or Process Centers for Innovation and Development, should be identified or created for specific areas of materials, process, and structure expertise which would serve as a resource and training ground for well qualified personnel to staff Government and industry.

   (The reasoning for the establishment of these Centers is presented in section II under recommendation 4.)

5. The effective coordination of materials R&D programs and results should be improved further through formalized inservice technology exchanges, In addition, interagency inputs, as well as those from industry and academia, should be more fully utilized.

   Implementation of the policies outlined in the above 'will improve tri-service coordination, and should lead to the development of new improved materials and materials technology. Interaction of Government and civilian activities will be improved by dissemination of the prioritized Pacing Materials Problem document. A series of briefings may be useful in dissemination of these materials needs; and distribution of the document to industry, universities, and professional/technical societies may also be usefuI. In this respect, removal of security classifications to the maximum extent possible would be very helpful.

   With regard to the NATO alliance, the Advisory Group for Aerospace Research and Development (AGARD) is functioning and could be improved by increasing technical activity within its charter. In addition, it may be useful to broaden the tri-partite technical coordination program (TTCP) activity to other NATO countries,

6. A continuous evaluation of DOD materials research programs should be carried out in order to isolate projects suitable for application in commercial markets, The efficiency of a research effort is to some extent dependent on

87-315 0 -77 - 18

the ability to utilize research results in any application regardless of the primary goals. In situations where research results indicate possible application outside the general objectives of the organization it is desirable to provide license-free rights to private industries that may be interested in further developing or marketing the process or product. The benefits of such endeavors may include the following: (a) DOD research may accomplish improved contact with materials research and process technology, (b) DOD scientists and engineers will have the opportunity to follow the idea from conception to implementation, (c) DOD scientists and engineers will be, to a greater extent, exposed to limitations and possibilities in the production of materials, (d) in general, successful research projects will create a more innovative research atmosphere which in turn will attract creative scientists.

H. Technology Transfer and Coordination

POLICY: To expedite development and improvement of new military systems and weapons, the Department of Defense should adopt a policy to facilitate the flow of information relating to the promotion and development of advanced and improved materials and process technology within the Government, private industry, and academia. This effort should provide broad support for early implementation of research results both in areas for which the work was originally undertaken and in other areas where new knowledge may be applied.

Therefore, it is recommended that:

1. DOD should continue to support materials information systems and weigh the subsidization, if any, needed to better disseminate the available data pertinent to specific areas. Technical data and information are the foundations on which materials technology and processing are built. Information systems still are in early stages of development regarding the best methods for collection, retrieval, and dissemination at minimal costs. Continued innovation and support are necessary to develop the most flexible system to utilize the voluminous data that are generated continuously.

2. The DOD should improve its technology transfer and information exchange mechanisms by initiating a variety of programs such as: (a) a more extensive visiting scientist program at its service laboratories, (b) promotion of con-

tact with researchers involved in apparently unrelated technologies, (c) expansion of the existing Executive Exchange program between DOD and industry. to include non-executive level scientists and engineers, (d) expansion of contacts with the private sector to encourage the use of the civilian sector of new technologies developed by DOD research, and (e) educational programs for the DOD research management structure in order to inform them of materials problems.

Technology and information transfer are the cross fertilization of principles and information between disciplines and people and may be affected by methods such as (a) the implementation of research and development into the applied research and production areas, and (b) the innovative transfer of research results into areas and disciplines not contemplated when the program was planned originally. Generally, it is believed that such transfer is effected best through personal contacts by individuals in discussions during informal meetings, seminars, or conferences.

3. DOD should use contract provisions to require that data (such as mechanical and physical properties of materials and structures, including processing where applicable) developed under Government contract be submitted in an orderly fashion to designated Government information systems for storage and retrieval.

   Considerable data (mechanical and physical properties, and material characterization) and processing information have been developed by various DOD contractors. Such data are not required to be assembled or submitted by the contractors in any orderly manner and generally are lost to the Government or are redeveloped by subsequent programs. To utilize and disseminate these data, DOD must establish appropriate contractual requirements and insist on compliance,

4. The Government should fund on a continuing basis "centers of excellence" of process centers for innovation and development, on Government owned property to develop the expertise and manpower as needed for emerging DOD goals. It is believed that these centers should be operated by a relatively permanent, innovative managerial staff with possibly one relatively permanent resident scientist in each discipline, The remaining personnel should be recruited from industry, academia, and Government on a rotating basis in order to promote the introduction of new ideas.

High productivity in the development of new knowledge is dependent on programs which will fund efforts of individuals who have developed after many years within a stable, invigorating, and innovative leadership and atmosphere. If many disciplines are involved in this effort, increased creativity may result. To achieve and maintain such excellence, particularly in areas where the commercial payoff is distant or jeopardized by the vicissitudes of the business cycles, "centers of excellence" appear desirable, "Centers of excellence" are defined as Government-owned establishments devoted to (a) using applied research in materials and processing in solving DOD roadblocks in specific military systems, (b) developing needed manpower in particular areas, (c) establishing the engineering criteria upon which to base standards and specifications. These centers should be on Government property and could be directed to processes such as melting, casting, joining, powder, metals, and polymer chemistry.

5. DOD and non-Government standards-writing organizations should coordinate and integrate a national effort on specifications and standards.

   The manufacture of materials and products of uniformly high quality require specification and standards that characterize materials properly and clearly state the requirements— function, minimum life, inspectability, and maintainability as appropriate, These specifications and standards should be up-to-date and responsive to the needs of Government and industry. To develop the engineering data upon which to base such specs and standards, it is believed that there should be a coordinated and integrated national effort involving Government and industry.

TASK FIVE (A): UTILITY OF ORGANIC RENEWABLE RESOURCES

Organic renewable resources provide a significant reserve of potential energy supplies, This reserve ameliorates, to a limited degree, the threat of rising costs of liquid and gaseous fossil fuels. According to the report of the Committee on Renewable Resources for Industrial Materials of the National Academy of Sciences (CORRIM Report), the total residues from agricultural and forest crops at 1970 levels of production and use efficiency could provide energy equivalent to 11 percent of U.S. energy requirements.

In projecting the use of renewable resources for fuel, other points, in addition to potential contribution to total energy needs must be considered. These points include ecological impact, cost of collection, cost balance between fossil fuels and organic renewable resource fuels, and available technology.

It is the conclusion of the CORRIM study that, in general, the environmental impacts associated with the production and use of biomass for fuel are much less severe than are those resulting from the use of fossil fuels and nuclear power in terms of duration of impact or effect upon human health or welfare. Nonetheless, the Task Force concludes that more information on the effects of total or near total removal of biomass from land is needed.

Costs of agricultural and forestry residues in place in a dry condition at conversion plants or power generating plants are estimated to vary from $15 to $34 per ton. A likely cost for a dependable supply in significant quantities (1,500 tons per day) over the long term might cost $30 per ton. For use as fuel, this would be equivalent to about $1.75 per million Btu's. Oil costs are at this level now and are projected to increase in constant dollar values through 1985.

With this situation it is indicated that industries located close to such residue sources as pulp mills would soon be in a favorable position to switch from the use of liquid and gaseous fuels to the use of more fuels from residues.

More rapid change in sources of fuel for pulp and paper mills could be encouraged by greater efforts in development of machines and processes for harvesting, processing, transporting, and using residues. This would be a beginning step toward conserving the fossil fuel supply and decreasing our dependency on imports.

Recovery boilers in pulp and paper mills are an effective means of using isolated lignin and making it available for process fuel. There is an added bonus in burning lignin since it has a significantly greater fuel value than other wood components. By the same token, there is a good potential for using lignin in higher value applications than for fuel.

According to the CORRIM report, if all U.S, energy needs were to be filled by using coal as the fuel source, we could obtain about 148 years of our requirements based on 1970 consumption rates.

Much of our coal has a significant sulfur content which causes problems in emission control when the material is burned as a fuel, If coal is burned in combination with low sulfur fuels such as agricultural and forest residues, the emission control problem is significantly reduced.

Technologies for burning coal in combination with other fuels with low sulfur content should be advanced. There should also be increased efforts in planning land restoration after strip mining and erosion control after other land disturbances to establish biomass for economic as well as aesthetic purposes.

Recently, there have been recurring suggestions for growing trees and annual crops, such as grasses, for fuel, Conceivably, fuel from such plantations would be used in boilers to power electrical generating plants. There is no question that production of agricultural and forestry biomass could be increased with the application of more intensive cultural practices.

However, we believe that only in comparatively few locations should biomass be grown exclusively for fuel. Generally, there are more important uses than fuel for most biomass crops. Fuel can often be a secondary use for portions of the crop or tree harvest. In considering biomass crops for fuel, fresh and salt water plants should not be overlooked. The possibility of using solar energy to dry biomass fuels, especially those from water plants, should be explored.

We believe more attention should be given to cultivation of grasses in place of feed grains for animals in production of red meat.

In the utilization of renewable resources, we believe that economics is the controlling factor. Technology for using biomass residues for fuel and chemical feed stocks can be improved, but generally it is not limiting.

We agree with the tutorial lecturer, Dr. Falkehag, that it is desirable to attempt to use agricultural and forest crops at their highest enthalpic value, We should not increase entropy and destroy a composite material when we do not have to in order to meet our need,

We recommend that past research results on biomass for fuel and chemical feedstocks be reviewed and that possibilities for their application in today’s economy be analyzed.

We have defined the following objectives for research in renewable organic materials:

a. Control the biosynthetic process in order to improve the yield of fibers suitable for paper production, to improve the yield of wood polymers for fuel or other purposes, and to improve the yield of chemical byproducts from pulp and paper manufacture;
b. Develop new enzymatic and fungal systems to manufacture chemicals or feedstocks from organic materials;
c. Develop new materials based on the carbohydrate backbone polymerized with other synthetics. Specific efforts should be aimed at biodegradable polymers, high impact strength polymers and strong absorbent polymers;
d. Conduct research in the areas of fiber and cellulose morphology, biosynthesis of natural polymers, enzymatic systems in growing plants, rheology and physics of crystalline materials and physical chemistry of wood-based polymers;
e. Increase research on the potential for lignin for applications other than fuel;
f, Develop new techniques for reducing energy consumption and materials savings in the pulp and paper industry including improved efficiency of the recovery boiler, reduced energy consumption in mechanical pulping, increased dryness after wet pressing, improved control and process knowledge to obtain a functionally-oriented product and increased strength potential of recycled paper; and
g. Increase efforts to apply intensive culture in forestry and thereby increase forest productivity.

We recommend that international seminars on the subjects of controlled synthesis of polymers in plants and plants as sources of chemical feedstocks be established. We recommend that exchange of scientists between national and international locations be encouraged. We encourage universities to build up programs in physics of wood-related polymers.

The Task Force does not feel competent to recommend policies for regulating use of land for competing purposes in the future. In like manner we have no recommendations with regard to multiple use, dominant use, or restricted use policies. However, we feel that land use considerations are important enough to warrant the establishment of a National Commission on Land Use. This National Commission should develop land use plans for regional implementation, but it should have representation and input from all affected areas.

We believe that the combined use of natural fibers and fibers made from hydrocarbons other than plants will progress only as economic conditions favor this development,

TASK FIVE (B): UTILITY OF ORGANIC RENEWABLE RESOURCES

Renewable resources in the foIlowing discussion means: wood and wood-based materials; agricultural sources such as nonfood oils, fats, cereal products, natural fibers, crop and animal residues; and biomass in general not used for food.

In order to examine and derive policy implications of importance to engineers and scientists of the potential increased availability and use of renewable organic resources, questions posed to the Conference were considered in some detail. Some of the points, issues and rationale developed in these considerations are listed in association with each question.

1. Policy Implications of Rising Costs of Liquid and Gaseous Fossil Fuels.

It seems most likely that rising costs of liquid and gaseous fossil fuels will restrict their use, the degree of restriction depending on the extent to which such costs will relate to those of feasible alternative fuels. Restriction of use of fossil fuels will have the three major impacts of (1) reducing the rate at which they approach possible exhaustion at present recovery levels, (2) increasing the incentive to extend recovery technology to lower recovery levels, and (3) hastening the time at which alternative materials become competitive. Deregulation of oil and gas prices in the United States will tend to accelerate these indicated movements. Other efforts to meet the stated national goal of reducing dependence on oil imports will also encourage development and feasible substitution of alternative fuels,

It seems likely that coal resources will be developed and substituted first for liquid and gaseous fuels, before extensive development and substitution by renewable resources. However, development technology for renewable resources for alternative fuels should be encouraged and will be accelerated by rising prices of currently-used liquid and gaseous fuels. In this connection, it will be important to conduct periodic economic analyses of the relative feasibility of fuel supplies from coal and from renewable resource materials.

Since we are dealing here with a shifting economic base, it seems unwise to attempt to focus on one option for alternative fuel supplies. Rather, multiple R&D approaches are needed. These would include, but not be limited to, research and development aimed at improving the substitutability of renewable natural resource materials. Particular attention should be given to exploring the feasibility of alternative fuel use of forest and agricultural residues that do not now enter the production stream.

We see opportunities for substantial substitution in some areas. Examples are the substitution of Iignin and starch derivatives for carbon black, and the adhesives derived from wood processing for phenolics derived from petrochemicals. For fuels substitutions we would see these first occurring on farm, and near locations where they are generated. Rural residential heating, drying of crops, and processing of wood products are applications which come to mind,

2. Relationship between the soJid fossil fuels and the renewable organics and opportunities for a symbiotic relationship between the renewable organics and exhaustible minerals to maximize utility.

Prior to development of low cost, petrochemical building blocks, wood and grain by-products were major sources of organic chemical intermediates such as acetone, methanol, dienes, and ethanol, With the expansion of the petrochemical industry after World War II, basic petrochemical building blocks were produced economically on a very large scale, and biomass sources became generally uneconomic except for special uses (e.g., potable grain alcohol). During this period aromatics (benzene, toluene, and xylene) were extracted from refined gasoline components, and olefins were produced by cracking natural gas liquids (ethane, propane and butane). Rapid growth in the 1960's (12 percent/yr) of building block production continued into the early 1970's and by 1973 consumed about 7 percent of petroleum supplies as fuel and feedstocks. Natural gas was the principal source of fertilizer (NH3) and methanol. Over 75 percent of olefins and aromatics are used to manufacture materials (plastics, fibers, and synthetic rubber).

Liquid petroleum fractions will be the principal source of basic building blocks through 1985 or 1990, after which coal-source chemicals and OPEC imports will extend domestically manufactured petroleum source material, It does not appear likely that renewable sources can develop new product technologies for substitution by 1995. It is possible that in the 1995 timeframe, technology could be developed to produce olefins and carbon black substitutes. The key idea is that utilization of renewable resources in selective situations over the timespan considered will be possible, Coal liquefaction should become a massive source of competitively economic aromatics, and coal gasification should become an economic source of synthetic gas for ammonia and methanol. Olefins and carbon black substitutes appear to be the most fertile area for post 1995 development to extend plastic, fiber, and rubber supplies from renewable resources without development of complex downstream technologies.

3. Significance of quantities of renewable organics and amenability of production to technological measures to increase abundance.

Potential increase in yield of products from commercial forest lands is estimated as two to three times current levels and can be attained through improved management practices, on forest holdings in all ownership classes, and enhanced utilization based on broad application of the best techniques, A continuation and strengthening of current incentives to encourage better management should receive continued attention as a necessary element in attaining these increases.

These increases are. sufficient to meet increasing demand in traditional uses without the necessity of increased imports, The extent to which wood is available for substitution of petroleum-based, energy-intensive, or resource-limited materials is not known, but is not considered extensive without significant technological improvement in all phases of production,

A significant and abundant source of underutilized biomass is that of agricultural residues. Agricultural residues left in the field annually amount to almost one-half the heating value of coal produced annually. Two-thirds of these residues can probably be safely removed from the soil and used for energy or materials purposes. The use of agricultural residues is environmentally favorable, would encourage the production of more food, and can begin within a crop year.

The energy farm concept, in which plants selected for rapid and efficient capture and storage of solar energy are grown and harvested to be substituted for fossil fuels, may also have potential for materials applications.

Abundance ,of agricultural products from cereal grains, oil seeds, animal fats and hides suitable for use as engineering and other materials is such that some replacement of other materials is possible.

4. Policy principles governing the utilization of renewable organics.

It seems likely that economic value will provide the principal driving force for utilization of renewable organics. Periodic economic evaluation of the potential for such utilization will be needed to capture economic benefits that may arise.

However, such economic utilization will be dependent on establishing a strong base of science and technology, as is treated under items 5 and 6 of this task. A general principle for such technological development should be that of retaining the highest possible energy levels of organic molecules. This governing principle will both guide the technology along lines that are likely to be most productive of practical utilization options and enhance economic feasibility.

There may be merit to considering resource values in terms of highest, long range public benefit, rather than leaving development and use of increasingly scarce materials entirely to the influence of the market. Development of materials policy regarding alternative use of renewable organics should include consideration of the degree to which such a principle could be applied to that case and of mechanics for its implementation.

5/6. Research and development needs and directions.

As a matter of science and technology policy, the materials foundation of science of renewable resources should be strengthened and extended. The structure/property /performance/requirement relationships for renewable resources alone and as composites should be the subject of an extensive basic research program. For this "research the methods of material science and materials engineering should be applied to wood and its components and materials of agricultural origin. Wood and plant components should be viewed as members of the family of materials. Wood science groups should be brought into centers of material science and engineering. This approach should also be extended to education.

The incorporation of wood and wood-related materials (materials derived from the biomass) in the domain of materials science and engineering (MSE) would hold substantial potential benefits for wood science. At the same time, for MSE it would represent the addition of a major new component with a consequent strengthening of this still-developing, multidisciplinary field.

Materials research laboratories, polymer and material science departments of universities, and existing concerned Government laboratories should be given incentives for the development of strong and imaginative programs on the material science and engineering of renewable materials. The roles of various Federal agencies in relation to the materials science and engineering research effort should be defined. There are some immediately applicable research areas such as ligin and starch substituting for carbon black in rubber reinforcement or as an adhesive in reconstituted wood products. There should be new emphasis on long-range research leading to substitution of natural macromolecules and structures for petrochemically -derived materials and the development of new synergistic combinations of natural and synthetic materials.

Multidisciplinary studies and joint programs between forestry- and agriculture-related research groups should also be encouraged, A quantitative and qualitative survey of all types of potentially available biomass is essential to selective development of applications. The potential for major improvement of bioproductivity, the extended use of biological nitrogen fixation, and the selective production of high value chemicals from plants and other photosynthesizing systems should be the subject of major cooperative basic and applied research programs.

An assessment should be made of the technical and economic feasibility of the feedstock approach of producing chemicals for polymers from renewable resources, Specifically, a demonstration program on an integrated ethanol —furfural —phenol production from hardwoods should be evaluated. These applied efforts should be backed up by research on the improvement of processes of enzymatic hydrolysis of various Iignicellulosic and carbohydrate materials. Basic research on a "biological feedstock" approach for production of small molecules by organisms of microbes should be encouraged as well as work on photolysis for hydrogen production.

7. Competition for land resources

Complex interactions are involved in the use of land for production of renewable resources, production of food, production of energy, and for social uses. In some cases, increased emphasis on one may increase the production of another, while in other cases direct competition will occur as pressures on these resources are intensified.

Land policy at Federal, State, and local levels needs to be examined and tailored to national resource development in satisfying needs for energy, materials, food and social purposes. In particular, this policy is important in resolving conflicting priorities among critical and sensitive needs.

Question 8 was considered to address a technical matter beyond the expertise and resources of the task force.

The Task Force considered it very important that both the public and the scientific and engineering communities be aware of the factors limiting the use of renewable resources. In particular, the term "renewable resources" should not become equated with unlimited resources, Renewable resources are dependent on land, plant nutrient availability, and ultimately on genetic limitations and the photosynthetic process.

Other limitations arise through the vulnerability of plant materials to fire, vagaries of weather and climate, disease and pests, all of which create an element of unpredictability in yields. This is not to suggest a pessimistic view of the utility of renewable resources, but rather to avoid creating an oversimplified and unbridled enthusiasm for renewable resources as a major and an immediately available solution to all materials needs which might divert attention from other alternatives.