VII.

Preliminary Policy Considerations

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INTRODUCTION: MATERIALS CONSERVATION OBJECTIVES

In the previous six chapters, the technical options were evaluated for their potential to conserve metal. Several promising options were identified. However, these options must also contribute in some meaningful way to the solution of current or anticipated materials problems, or to the accomplishment of some recognized materials objectives. In this chapter, the technical options are evaluated in terms of materials objectives and problems. Through the use of systems analysis, the technical options are matched with materials problems. And finally, illustrative methods of implementing the more promising options are presented and briefly discussed.

Conservation is a response to some real or imagined threat or condition, and conservation options are implemented in attempting to accomplish some objective. The primary objective of concern in this assessment has been materials availability, either short term or long term. However, there are a number of other objectives that might be relevant to materials conservation, such as conserving energy, reducing the volume of waste, stabilizing materials markets, protecting the environment, or promoting a resource-conserving society. These objectives are not independent of each other but are merely different "end points" which may be achieved through materials conservation.

Materials availability, either short term (during critical situations) or long term (with respect to resource depletions), is a vital concern to both industry and society. Without the proper materials, many industries would be forced to close unless alternative plans were made well in advance. As shown in appendix C, materials shortages have been commonplace for many years and will undoubtedly continue in the future. If these problems become severe enough, conservation is a possible response.

Likewise, energy conservation can affect the availability of materials. Since metals refining consumes about 9 percent of the energy budget and all materials 20 percent, materials conservation could be a response to the need for energy conservation. Indeed, for the foreseeable future, energy conservation will probably be more important than materials conservation because energy availability is a prerequisite for materials production and use.

MATERIALS AVAILABILITY PROBLEMS

Conservation is one appropriate strategy to deal with a large number of materials problems that threaten materials availability, such as the following conditions:

- chronic lack of capacity,
- import dependency,
- energy conservation,
- cyclical instabilities,
- environmental restrictions,
- long-term depletion, and
- technological changes.

This report does not attempt to judge which, if any, of these problems are serious enough to justify conservation measures and whether conservation is the best among available strategies.

Energy and environmental considerations are introduced here not as objectives for materials conservation but rather as factors that could and probably will affect materials availability. For example, weight reduction in vehicles to conserve energy will affect both steel and aluminum availability. Use of catalytic converters has greatly increased the demand for platinum. And installation of solar energy units in homes will most likely increase the demand for certain specialty metals.

Chronic Lack of Capacity

Chronic lack of capacity occurs when new domestic plant capacity is not built due to lack of sufficient investment incentives. As demand increases, the margin between capacity and average demand shrinks. Shortages increasingly become the "rule" rather than the exception. This shortage condition encourages customers to buy the materials from foreign sources at inflated prices, which then encourages new capacity overseas. Once installed overseas, strong incentives work to keep this capacity operational, even if it means operating at a loss. A trend towards shrinking U.S. capacity and growing foreign capacity is thereby established.

Import Dependency

import dependency is a potentially critical problem. Currently, the United States imports approximately 30 percent of its metal needs. Some nations are completely import-dependent and have learned to live with this situation. However, the United States is in a unique position as a world leader and may not find import dependency to be in the national interest. Even if import dependency can be tolerated now, it may not be acceptable in the future under changed world conditions. Some argue that the United States is import-dependent, and there is very little that can be done to change that fact. This is true to a degree. However, changes in materials usage through conservation can reduce this dependency to a minimum or eliminate the use of import-dependent materials from critical applications. If the supplier countries become less economically dependent on minerals, they may become "conservationists" and no longer encourage the exploitation of their natural resources. Furthermore, import dependency aggravates the U.S. balance of payments, and leaves us vulnerable to possible supply disruptions from political or military activity.

Energy Conservation

The current campaign for energy conservation can strongly affect the availability of materials by influencing the cost, demand, and relative use of materials. Metals refining consumes about 9 percent of the total U.S. energy budget; ail materials 20 percent. The energy intensity (1,000 Btu/$) at each stage of the materials cycle is shown in figure 30. Refining and fabricating require several times the national industrial average. Thus, materials and energy are intimately associated.

Theoretically, with unlimited energy, any material could be obtained from common rocks as low-grade ores or from nuclear chemistry. In more practical terms, the "energy materials' '—such as natural gas, oil, and coal, on which the United States has come to depend—are being depleted at rates greater than the materials from which products are made. For the foreseeable future, therefore, energy conservation will be more important than materials conservation because energy availability is a prerequisite for materials use, and energy sources are almost universally in shorter supply than materials for making products. A more detailed discussion of the energy-materials relationship is included in *Working Paper Six. (vol.* 11-F.)

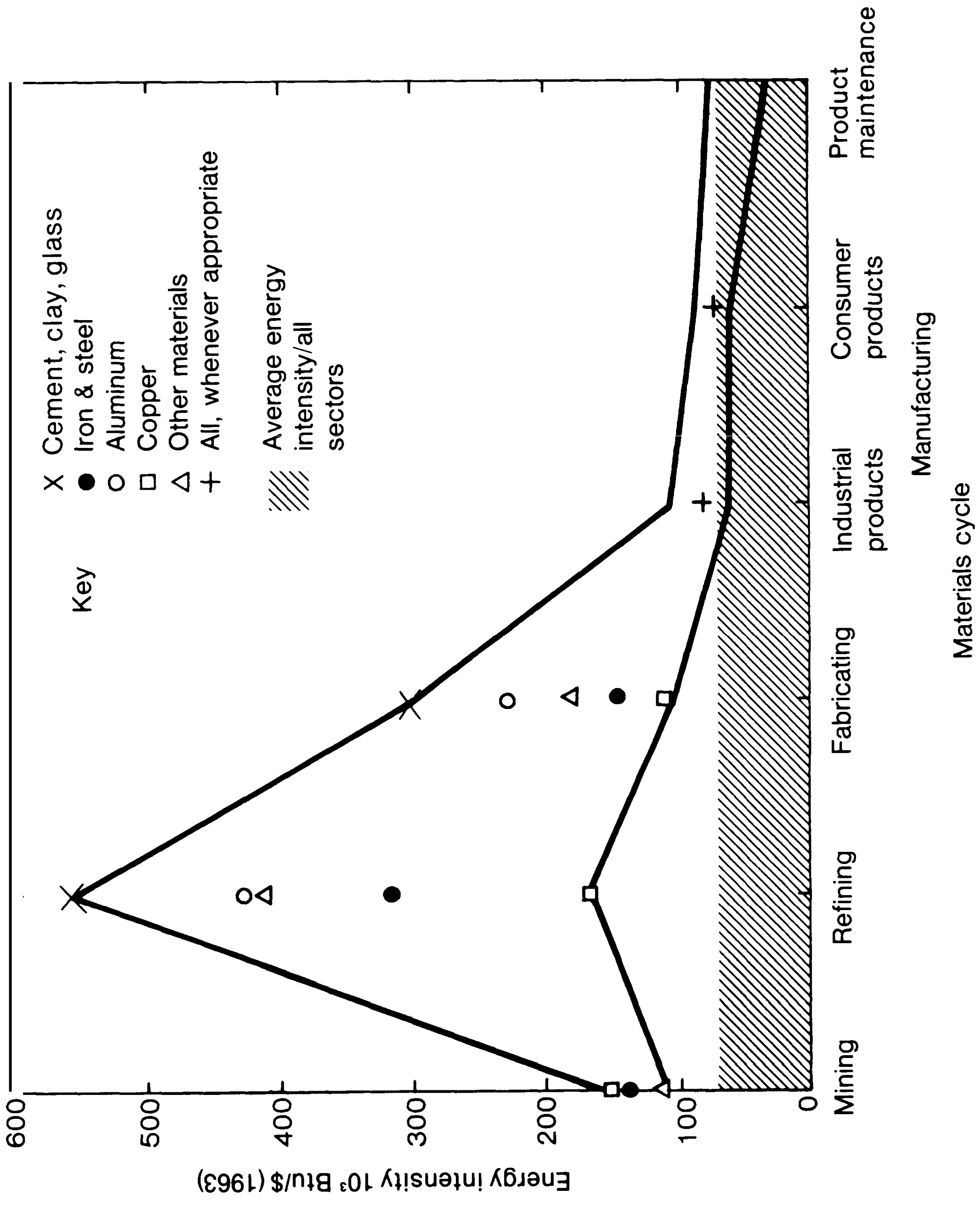
In the short run, energy conservation, as well as the effort to increase energy supplies, will lead to a greater use of materials rather than reduced demand. This will happen in spite of increasing materials prices, and will aggravate other problems such as import dependency. Further reduction of materials losses from industrial processes would in many cases be energy intensive. On the other hand, recovering materials by recycling and preventing loss of sunken energy investments in products and their components through remanufacturing promises to save large amounts of energy while simultaneously conserving materials.

Finally, the flexibility offered by materials substitutions will likely be necessary to improve overall energy efficiency and meet the changing demands for energy supply while maintaining reasonable standards of environmental quality. Materials substitution will more likely be driven by the need for energy conservation than for materials conservation or the reduction of materials "waste."

Cyclical Instabilities

Short-term availability problems occur as supply shortages and/or price fluctuations. In 1973, a

Figure 30.—Energy Intensity at Each Stage of the Materials Cycle



SOURCE: Working Paper Six.

combination of factors made cyclical shortages unusually severe. At that time, contrary to the popular notion, certain metals were not available to some customers at any price. Because of over-commitment, these suppliers would not take new orders. Since shortages can manifest themselves within relatively short periods of time, the normal market responses are not available and severe impacts can occur. Unlike the other problems, this one is less predictable and could occur at any time, with any metal.

During the period from 1946 to 1977, interruptions in supply were constantly occurring for the eight metals analyzed in this study. Factors affecting the supply of such metals include: governmental regulations, capacity limitations, raw materials shortages, strikes, transportation disruption, import limitations, unusual demand surges, and acts of nature, for example, severe weather conditions. While a tight supply situation can result solely from the general fluctuations of the business cycle, the occurrence of supply disruptions adversely affecting industry usually involves the combination of several factors, for example, unusual demand combined with capacity limitations, and/or demand surges combined with raw materials shortages.

Tight supply situations or actual disruptions in supply occurred as follows:

- aluminum was in tight/short supply in 1950-53, 1966, 1972-74, and early 1976;
- ferrochromium alloys were insufficient to meet peak steel demand in 1973-74;
- copper was in tight/short supply in 1946-48, 1954-56, 1959, 1965-68, and 1972-74;
- nickel was in short supply during 1950-57, 1966, and 1974;
- supply shortages of scrap were apparent in 1948, 1952, 1955-57, 1969, and 1973-74;
- steel was in short supply in 1947-57, 1959-60, 1969-70, 1972-74, and the first quarter of 1977; and
- the supply of tungsten was interrupted during 1972-74.

Thus, the facts indicate that tight/shortage situations in regard to these seven metals did constantly occur over the past 30 years. Since the factors that combined to cause such supply disruptions were not metal specific or time specific, the probability of shortage conditions occurring in the future in regard to such metals is quite high. (See appendix C for further discussion.)

Environmental Restrictions

Concern for the environment may favor the use of certain materials and restrict the use of others. Some metal-processing techniques discharge more pollutants to the atmosphere than others. Since the damage done to the environment is often not reflected in the metal cost, conservation may be mandated. The environment is a major consideration and any conservation options should be evaluated for environmental impacts. Municipal solid waste is a special environmental and economic problem. Any options that could effectively reduce the amount of material entering the waste stream would be beneficial, both from an environmental as well as a conservation standpoint. Thus, the reduction of the amount of municipal solid waste is a strong driving force for conservation of those materials that find their way into this waste system.

Long-Term Depletion

The depletion of natural resources is an area of major materials concern. However, there is little danger of actual physical exhaustion over the next 20 to 50 years. This is not to say there are no problems. Old mineral deposits are being worked out and new ones are being discovered, But levels of ore quality are declining. If new mining technology does not increase the accessibility of low-grade ores, then prices will rise and supply shortages may develop. This will come sooner for materials such as gold, mercury, silver, tin, lead, and tungsten than for other metals such as iron, aluminum, and nickel.

Technological Change

Technological changes will require shifts in materials usages. No unusual technological changes are expected to radically alter demand over the next 25 years. However, these estimates are based primarily on historical data and expected growth in the gross national product (GNP) and population. Probably the major technological change, other than in energy, would be the widespread use of composite materials. This would reduce demand for structural metals such as steel and aluminum. Deep sea mining, if it becomes economically feasible, could increase the supply of certain metals by an order of magnitude.

MATCHING CONSERVATION OPTIONS TO MATERIALS AVAILABILITY PROBLEMS

If a specific materials problem arises (for example, a threat to the supply of nickel), then specific technical conservation options to address the problem could be selected from table 24 (reducing losses) or table 36 (reducing excess metal usage). These tables identify options with the greatest potential to save metal, but do not indicate the applicability of the options to specific materials availability problems. Given the many possible materials availability' problems, a technique or approach is needed to match conservation options to materials problems.

The approach used in this assessment was a systems analysis that classified the problems and the possible solution (options) in terms of their overall impact on the parameters that describe the behavior of the system. [n this case, the system is the materials cycle, and the parameters are efficiency, stability, and adaptability.

Thus, the systems analysis concepts of materials efficiency, stability, and adaptability were used to establish a linkage (or matching) between technical conservation options and materials problems. These concepts are summaried below and in table 37, and discussed in more depth in *Working Paper Six, (vol. II-F).*

Improved efficiency means better utilization of resources or making the best use of what one has. It means making products with a minimum expenditure of materials consistent with other accepted values of society. Efficiency does not rate materials saving as the only priority, but tries to optimize usage based on a whole spectrum of criteria. Options to improve efficiency attempt to reduce the total material usage and usually deal with losses. Efficiency is one appropriate response to resource depletion, that is, a gradual reduction in losses and usage over the remaining resource life.

Improved stability is an attempt to assure a more adequate and consistent amount of materials in the material cycle to satisfy demand. It means

Table 37.—Systems Analysis Concepts of Materials Efficiency, Stability, and Adaptability

	Efficiency	Stability	Adaptability
Goals".	*Optimize* according to recognized goals and objectives.	Make sure that all actions will *suffice* in satisfying recognized goals.	*Evaluate* appropriateness of existing goals under changing conditions; *identify* new goals or objectives.
Resource emphasis .	Reduction of wastes; make sure all resources are fully utilized (labor, equipment, energy, capital, materials).	*Protect/on* against all possible failure modes or malfunctions; build in redundancy and safeguards.	*Rapid adjustment* to change, capability to cope with variability, innovation, search for new opportunities.
Resource management	*Reduce operating margins (excess* capacity, labor, inventory, and stockpiles).	*Increase operating margins* to allow for errors or contingencies; provide standby capacity.	*Provide substitutes* and alternatives (materials, processes, facilities, sources of supply).
Resource flows (along cycle) . .	Assume predictable controlled transactions; establish minimum number of source: and markets.	Reduce variability and diversity; establish overlapping but stable sources and markets.	Provide fall-back options and decision mechanisms for rapidly redirecting flows under changing circumstances.

SOURCE Working Paper SIX

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taking actions to protect market participants against possible failure modes, to reduce the cyclical variabilities, and to remove market instabilities. Options consistent with stability are increasing standby capacity, use of multiple sourcing, economic stockpiling, and improved information on materials supply and demand.

Improved adaptability, on the other hand, means more rapidly adjusting to change and coping with problems as they arise. It means developing the capability to deal with and overcome problems, difficulties, threats, or conditions as they occur.

Unfortunately, some options can lead to conflicts among materials efficiency, stability, and adaptability. That is, all-out efforts to improve efficiency can reduce the slack in the system and lead to a destabilization of the market and reduced ability of industry to cope with materials problems as they arise. Moves by the Government to stabilize markets can reduce efficiency and adaptability. Finally, efforts to become more adaptive may compromise both efficiency and stability.

For example, options to improve efficiency will reduce the amount of material used. But as a result, there will be less slack in the system to absorb unforeseen shortages, and companies will be less able to adapt. As companies exercise the limited number of options to reduce the amount of material used in product manufacture, these options are then no longer available to stabilize supply/demand or cope with unforeseen events,

On the other hand, actions to become adaptive include developing substitutes, establishing a variety of sources, multiple ordering, having extra material on hand, and, in general, developing a pattern of usage that gives the user a variety of choices to cope with all uncertainties. All of these actions are, by nature, materials inefficient. Furthermore, this ability to adapt can be exercised at the discretion of the materials user for any reason he chooses. If he is a major user, his action and the counteractions by other stakeholders might cause a very unstable market. Materials suppliers might not be able to predict from year to year what the demand would be and plan production. They would either overproduce or underproduce. Overproduction would lead to lower prices and inefficient use. Underproduction would lead to shortages and greater instability.

As indicated earlier, materials problems can be classified as requiring improved materials efficiency, stability, and/or adaptability. As shown in table 38, all problems cited—except for chronic lack of capacity and long-term depletion—appear amenable to options that improve adaptability. Balance of payments, energy conservation, environmental restrictions, and long-term depletion problems call for options to improve efficiency. Finally, lack of capacity and cyclical instabilities suggest options to improve stability.

Table 38.—Materials Problems Require Improved Efficiency, Stability, and/or Adaptability

Materials problems	Improved efficiency	Improved stability	Improved adaptability
Chronic lack of capacity	—	✓	—
Import dependency			
Balance of payments	✓	—	✓
Threat of disruption	—	—	✓
Energy conservation	✓	—	✓
Cyclical instabilities			
Stable prices/shortages	—	✓	✓
Unstable prices/steady demand	—	✓	✓
Environmental restrictions	✓	—	✓
Long-term depletion	✓	—	—
Technological changes	—	—	✓

SOURCE: Working Paper Six.

Thus, based on this analysis, most future materials problems seem to be more amenable to improved industrial adaptability rather than to improved efficiency or efforts to stabilize the materials markets. This does not mean that industry should become less efficient or that markets should be destabilized. It also does not mean that adaptability should be stressed to the exclusion of efficiency and stability. Rather, it does suggest that a balance between efficiency, stability, and adaptability should be maintained. And at this time conservation options that increase adaptability require primary consideration. However, at the same time, care should be taken that this increased adaptability does not sacrifice efficiency or stability to any great degree.

Thus, the analysis suggests that competition among organizations and alternative technologies will continue to produce relatively great efficiency, including materials conservation. The greater need at present is for options to better anticipate societal vulnerabilities, to devise strategies to cope with recognized uncertainties, to establish norms for orderly interactions among organizations, and to assess the need for better adaptability in the face of future contingencies. Under these conditions, private stakeholders would be able to plan for efficiency with a clear understanding of the opportunities and attendant risks.

In table 39, some of the more promising technical conservation options are classified according to their ability to improve materials efficiency, stability, and adaptability. These options—with the exception of major savings (allocation) —apply to improving efficiency and/or adaptability. Also included in table 39 are illustrative methods of implementing some of the technical options. These implementation options are discussed in the next section.

Table 39.—Ability of Conservation Options to Improve Efficiency, Stability, and Adaptability

Improved efficiency	Improved market stability	Improved adaptability
Technical Options		
Increased metal recycling	Metal savings (e.g., through allocations)	Major savings (e.g., through allocations)
Increased product remanufacturing		Metal substitution
Increased product reuse		Use of stocks
Reduced dissipative uses		Export controls
Illustrative Implementation Options		
Public data base	Public data base	Public data base
Improve product after-market	Contingency planning	Contingency planning market for contingency shares certificates
Establish scrap inventory	Market for contingency shares certificates	R&D on metal substitution.

SOURCE: OTA, based on Working Paper Six

ILLUSTRATIVE IMPLEMENTATION OPTIONS

In the previous sections, preliminary consideration was given to options with respect to their ability to solve materials problems that may arise in the future. The purpose of this section is to briefly present illustrative methods of implementation applicable to the most promising options.

However, this report does not assess in detail the impacts of the options on the economy, energy conservation, environmental quality, employment, and other important impact areas.

A more detailed discussion of the implementation options can be found in *Working Paper Six, (vol. II-F)*. The implementation options listed below are illustrative of the range of options that could be considered.

Establish a Governmental Contingency Planning Function

Periodic shortages and oversupply along with price variation have been a part of the materials supply system since the beginning of the industrial age. Industry and consumers have learned to live with this condition and in some situations to take advantage of it. In most of these shortage situations, warning has been adequate. In the materials field, suppliers and users maintain a close working relationship and the suppliers are usually aware of developing threats. [n addition, the Bureau of Mines, the State Department, the Defense Department, and the Central Intelligence Agency monitor materials supply and in most cases provide an adequate alert. Materials users whose business depends on a given material initiate their own information network independent of the suppliers and are often the first to anticipate a problem. Through trade publications and the technical literature, this information is available to those who choose to avail themselves of it.

The primary difficulty comes in responding to the threat. Each organization moves independently to cover their own position and often overreacts, which tends to make the situation worse. When the supply does become limited, the suppliers invoke an allocation system that provides for an orderly distribution to current customers. But this system locks out other customers and provides little incentive to increase capacity. In addition, certain industries are more dependent on critical materials than others and will suffer more during times of shortage, with a greater negative impact on the economy and total employment. The question is: What could the Government do now, if anything, to be ready for such a situation?

One option available to Congress is to assign a materials contingency planning function to one Government organization. This organization would be responsible for evaluating the severity of perceived threats in materials supply and to develop contingency plans to cope with these problems should they arise. Such a function could bean extension of the scope of work now provided by various existing offices and bureaus. The main advantage of this option is that it would provide, at a small additional cost, a continuous appraisal of the seriousness of the threats to be faced and the ability of current mechanisms to counter those threats.

Establish a Public Data System

Decisionmaking with regard to materials management in both the private and public sectors appears to suffer from a lack of comprehensive information and integrated analysis, insufficient R&D on generic problems, and lack of a long-range holistic view of materials problems.

The Federal Government is the only participant in the process with the scope of concern and the authority to collect, integrate, and disseminate information necessary to compensate for imperfections in market mechanisms and inequalities in resources of the various actors. It may also be the only participant with the resources, capabilities, facilities, and long-range interest to fund the research necessary to solve the technical problems inherent in the transition to an economy of finite resources.

A public data base would help to improve the quality and quantity of information available to Government and to industry for better analysis and forecasting of materials supply and demand problems. It would also help identify R&D needs for solving or alleviating technical problems in the materials cycle (e.g., substitutions for temporarily or chronically scarce materials, techniques for separating and reclaiming scrap materials). Some R&D support needs were discussed in an earlier section.

New Government sponsored and operated information systems are favored by nearly all academic observers and professional societies, by labor, by Government experts (with a few exceptions, noted below), and by some industry representatives. Such actions have been opposed by the Departments of the Interior and Commerce. They maintain that existing systems, such as that of the Bureau of Mines, are adequate. Some industries oppose such systems on the grounds that they would be a step toward a "nationally planned economy" and an infringement on proprietary information rights.

A public data base would be the foundation stone for many forms of private planning, public policy review, and contingency planning. All the basic public implementation options would require specific evaluative information in the formulation, operation, and modification of standards and guidelines. The greatest need is for additional information on the end uses of materials and the total quantities of a given material used in any given product. Supplier inventories would also be valuable information to assist in assessing the need for implementing contingency plans and to assist industry in locating scarce materials.

These two implementation options, contingency planning and public data base, have been studied in detail in an earlier OTA report *Assessment of Information Systems Capabilities Required to Support U.S. Materials Policy Decisions* (December 1976). Option 3 in that study, known as the Bureau of Materials Statistics and Forecasting, encompasses these two options. Chapters VII and VIII of the *Information Systems* report provide a detailed discussion of the impacts and issues associated with implementation of such a Bureau with contingency planning and public data base capabilities.

Establish a Market for Contingency Shares Certificates

In this implementation option, a private sector market for contingency shares certificates would be established between materials suppliers and industrial customers of basic materials. This option would be a private allocation system. The Government would not be involved in-these private sector transactions. This market would be an extension of the emergency allocation scheme that the metals suppliers use now during shortages in which shares are based on the previous year's proportion of total orders. In the contingency shares market, customers would have to pay in advance for the privilege of obtaining a share of limited supply capacity during periods of shortage.

The contingency shares certificates sold in a private marketplace between suppliers and users would designate the fraction of available production capacity allocated to the certificate holder (and guaranteed by the supplier) under the contingency condition that all orders could not be met on schedule.

Furthermore, the certificates would designate a priority for the filling of the order. Those with the highest priority would have their orders filled first. But, unlike the successful wartime priority scheme, lower priority orders would automatically receive a higher priority following a specified period of delay (possibly 1 month). In this way, all orders are eventually filled because even those orders with the lowest initial priority will eventually arrive at the highest level and receive attention.

The period of incremental increasing of priorities would be calculated according to the number and size of the contingency shares sold. In this way, the fact that a fraction of capacity is allocated to each certificate holder and that those holding lower priorities eventually receive attention prevents the highest priority certificates holders from usurping the total supply by placing a large number of orders.

The major effect of using these certificates to allocate available capacity during periods of shortage would be to allow materials buyers to realistically assess their needs for an assured supply in anticipation of possible shortages. The assessment is based on a price mechanism, that is, the recognition that they will have to pay more for large capacity share and high priority.

The contingency shares arrangements allow' market participants to anticipate the relative competitive pressure for materials under shortage conditions in order to make intelligent decisions about substitutions while there is time to implement a substitute, or to reconsider whether the material is so important that their needs could not be deferred in time of shortage. Revenues from the contingency shares would enable suppliers to attract investment capital for expansion if demand were running high. Movement in the contingency shares market could give suppliers warning of shifts in demand enabling them to stockpile in advance or sell potential surplus. Also, speculators would receive much better price signals from the technically astute stakeholders and would thereby be much more likely to act to stabilize the market.

During periods of plenty, all orders would be filled as they come in with no change from business as usual. Only during shortages would the provisions and privileges of the certificates be important. The competition among various buyers would determine the specific selling price of the certificates, as in any securities or futures markets. Speculators could buy certificates and gamble on a shortage occurring to produce high profits in reselling these privileges and offering latecomers entry into the market even though it may be tight. Brokers would hold certificates and resell their privileges in smaller blocks to make it easier for small, intermittent, or new buyers to gain market entry.

Additional provisions may be necessary for very small customers so that they are not locked out of the market as happens today during shortages. The normal fraction of the market going to the many small users (probably 10 percent of the total market) could be set aside for bids during the shortage—with only the small or intermittent user or new entrants being qualified to place orders on this fraction. This provision would require oversight inspection to prevent resale and speculation. It remains to be seen whether brokers and speculators could provide this function better than the formal provision of set-aside capacity and the costly oversight to go with it.

The prices for contingency shares certificates would be a valuable indicator of "criticality" for metals under abnormal market conditions; it would also indicate beforehand which sectors would be most hard hit (those bidding highest for shares). Both public and private organizations could benefit from these price signals to improve their planning and coping strategies.

The contingency shares certificates market would virtually eliminate the cause of materials markets' imperfections during periods of shortage. Double ordering would be impossible without having paid for the privilege through the purchase of certificates; this would reestablish the rates of ordering as a useful indicator of real demand to the materials suppliers.

Increasing private stockpiles leading into and during periods of shortage would be impossible unless the purchaser had also bought sufficient certificates to gain the capacity to be able to stockpile. In either case, the certificates would be a useful indicator of real demand. The decision to buy enough shares to stockpile would help to pay for a needed expansion of productive capacity by bidding up certificate values.

Price signals for shortage conditions would operate in advance of shortages or true contingency events. They would thereby reduce the advantage of "quick response" by major corporations. There would be real penalties (one cost of the certificates) for using materials for less essential applications during shortage periods. By reducing hoarding and double ordering, the glut following past shortages would be moderated. In addition, increases in the certificate prices would induce compensatory actions to cope with anticipated shortages rather than increase materials prices per se.

Research and Development on Metal Substitution

Substitution promises substantial savings for specific metals. Approximately one-third of the possible substitutions would use other metals; one-third, coatings (metallic and nonmetallic); and the remaining third, nonmetals. Substitution can provide flexibility in the face of specific materials shortages. In the long run, substitution is a principal means of coping with shortages.

The Paley Commission in 1952, the National Materials Board in 1972, and others have recommended greater design efficiency and substitutability. However, Government implementation policies have been proposed only in general terms such as "tax policy" and international standards. The options available for harnessing materials substitutions as an instrument of national policy warrant further investigation.

Substitutions are a strategy selected by management to fit conditions of technical desirability, especially in product performance; efficiency of operations; and price or availability. Evidence suggests that price is usually not the most critical factor. One industry representative has noted that material costs represent only 5 percent or less of the final product cost of an aircraft, although it may be responsible for 75 percent of Iifecycle costs. Thus, Government taxing or price control can only be effective in major applications for mature industries in which small cost differences exert considerable materials selection leverage.

Some have suggested designers and manufacturers make materials choices on the basis of "true relative value" rather than cost. This "true relative value" could include disposal costs and long-term marginal costs of replacement. These policies would not lead to greater materials substitution flexibility because the true relative value is an average market price, not a reflection of the uncertainty of supply and limitations of capacity during periods of high demand.

Discovering the available substitution options is in part a product of Government-sponsored R&D. This should be done within the industries where substitutions would be desired based on high-volume usage. Congress could establish a research program to develop practical substitutes for critical materials, with particular emphasis on products with high metal use, nonmetallic coatings for corrosion and wear resistance, and dissipative uses. This would encourage additional private sector R&D.

Improve Product Aftermarket

Product remanufacturing, reuse, and repair (collectively known as product recycling) offer the greatest leverage for saving materials and energy. Improved aftermarket (the market for recycled products) would prevent the mixing of scarce materials with the landfill waste stream as well as improve the recovery of the major metals—iron, steel, aluminum, and copper. The aftermarket changes that could improve efficiency resemble vertical integration in their managerial and technological efficiency but do not necessarily lead to centralized control. For example, the following trends are toward vertical integration in the aftermarket but not by new product manufacturers: the growth of automotive jobbers and mass merchandisers in repair markets, greater leasing of products (new or used) by retail outlets, more efficient diagnostic and rework procedures in support of these integrated service groups, and greater willingness to offer guarantees on reworked products.

Improved product recycling to capture the residual value in products through a strengthened aftermarket would eventually have implications for the entire materials cycle. Table 40 systematically enumerates the functional requirements that apply to each step of the materials cycle, if recycling is to increase. The table also lists the benefits to the Nation and stakeholder groups, the corresponding disbenefits, possible Government options, and likely impacts of implementing the options.

in all, there are 20 possible Government options listed. Fifteen of these would dovetail with improved efficiency; eight directly support improvements in the aftermarket.

The results of this preliminary study of the product aftermarket indicate that four of these options should receive primary consideration.

- **Encourage product leasing through tax deductions.**—Tax deductions could be used to provide an incentive for leasing of major products, such as automobiles, appliances, and machinery. At the end of the lease period, the products would be returned to the supplier who would have product recycling capability, rather than being discarded into the waste stream.
- **Provide loans to establish aftermarket business.—Low-cost** loans could be provided to assist product recycling firms in attracting the necessary investment capital. At present, most major products are discarded rather than recycled, in large part because very few firms are in the business of product recycling.
- **Provide funding to establish a scrap inventory.**-Another likely prerequisite to effective product recycling is improved information about the amount, form, and location of residual scrap and its flow in the aftermarket. Funding could be allocated to establish a scrap inventory for this purpose. See the following section for further discussion of a scrap inventory.
- **Increase public confidence in recycled products.—Another** major barrier to product recycling is lack of consumer acceptance of used or remanufactured products. Government regulations (e. g., with regard to product testing, labeling, specifications, and procurement) could be modified so as to increase consumer confidence in the quality of recycled products.

A direct substitution of recycled products for new ones would probably have a short-term impact of reducing net jobs and replacing unskilled jobs with those requiring somewhat greater skill. However, the long-term impact would be to increase consumer buying power and generate even greater product flows and even more jobs in other nonmanufacturing sectors. Engineering skills and talent would have to shift toward the aftermarket. Following this shift, unskilled employment opportunities would likely improve.

Product recycling would also save energy. As shown earlier in figure 30, metal refining and fabricating are several times above the national average

Table 40.—Implications and Impacts of Recycling on the Materials Cycle

Functional requirements if recycling is to be increased	Application to national goals; benefits to stakeholder groups	Disbenefits to stakeholders and Nation	Government options, role, and implemental ion strategies	Impacts of implementing Government options
		1. EXTRACTION		
Constant and rapid feedback of information between extraction of primary materials and recycling to assess scarcity and value of materials in order to adjust and balance rate of depletion and rigor of recycling. Toxicity or other dangers from primary materials, which will eventually enter recycling process, must be understood and tracked to avoid hazards during reprocessing, reuse, or disposal. Rare materials which are byproducts from extraction of other materials must be preserved for future use regardless of current value (e. g., helium).	Future needs and uses protected, balanced against today's needs and likelihood of future technological development, substitutions, or changes in usage/demand, Occupational safety of recycling, reprocessing labor force and consumers; reduced landfill requirements, reduced environmental degradation. Avoidance of irreversible losses of materials valuable in the future	Errors in forecasting supplies and shortages have economic and security risks Extraction industry bears costs.	Establish commission to continually assess scarcity, provide feedback between recycling and extraction. EPA research and standards development for problem materials, tracking through cycle.	Competition between recycled and raw materials may destabilize either or both: who absorbs costs of market variability? Basic materials markets become more sensitive to Government policy decisions regarding safety, forecasting needs. and recycling.
		II. PROCESSING, FABRICATION		
Assure energy conservation benefits from using recycled metal instead of primary raw materials, Trace element contamination of recycled materials may require modification of processing equipment, new equipment, and/or higher costs in processing. Some modification in fabrication.	Reduced energy costs in production, reduced energy sensitivity. Better understanding of true costs of small alloy contamination in recycled materials, Greater flexibility in meeting materials demands, reduced fluctuation in supply cycle	Coupling of materials industry energy needs to availability of recyclable materials. Either reduced certainty about materials quality or Increased materials testing. Could lead to lower quality primary materials and higher production/ manufacturing costs because some forming/ bonding applications now require higher quality.	Tax credit or other subsidy of differential costs of processing equipment for handling contaminated/mixed recycled materials (investment tax incentive?), Joint sponsorship of R&D for processes to handle mixed/contaminated materials or to extract valuable trace elements, Procurement Incentives for use of scrap, Establish standard of metal quality for recycle.	Increased capital requirement by industry. Standards may restrain materials development and innovation.

= Indirectly Improved efficiency of reworking, repair, and resale of products in the aftermarket
● = Directly supports improvements in the aftermarket activities

SOURCE Working Paper Six.

Table 40.implications and Impacts of Recycling on the Materials Cycle—continued.

Functional requirements if recycling is to be Increased	Application to national goals; benefits to stakeholder groups	Disbenefits to stakeholders and Nation	'Government options, role, and implementation strategies	Impacts of implementing Government options
		III. MANUFACTURING		
Modularize designs so that components can be replaced, refurbished, or Interchanged. Design for ease of repair, diagnostic evaluation, and recycling. Build in diagnostic checks and/or electronic monitoring. Develop production-line compatibility with used components. Market research on reasons for discard/replacement of nonobsolescent products.	Reduced costs for product/component repair or replacement (consumer satisfaction). Easier/less expensive diagnostics, facilitate do-it-yourself repair Easier to meet specific consumer/user needs through modularization. Economies of scale in reliability studies.	Without vertically integrated companies (or sophisticated purchasers), additional design costs are borne by manufacturers for good of the repair industry. Higher priced new products due to higher resale value compensates manufacturer *but* new and used products compete and tend to destabilize the market for both. Greater volatility in demand for new products if buyer choice between new/used products is dependent on fluctuations in disposable income. Some additional constraints on design/marketing decisions; some reduction in consumer choice and convenience.	I Government procurement standards favoring reuse/rehabilitation of products, components. • Establishment of standards for design and repairability through officially designated evaluation laboratories.	Repair industry is largely captive of manufacturers; creation of new conflicts of interest. Constraints on product design may compromise optimality of design in terms of energy efficiency, substitution of materials, rates of innovation.
		IV. DISTRIBUTION		
Share new product distribution system and outlets with recycled products, or devise new distribution systems/outlets. Use distribution system for consumer in formation/education and for collecting data on product failure/obsolescence etc. Equitable transportation costs for recycled trade-In products from dealers.	Create new small business opportunities. Reduce costs of collection, transportation—principal barriers to recycling. Improved relationships between manufacturer, seller, buyer, repair industry. New customers for railroads, truckers.	Distributor may be caught in conflict of interest: higher profits on new goods than on rehabilitated goods. Better informed buyers may gain advantages over poorly educated or poorly informed. Buyers may be victimized by misrepresentat ion of recycled products, components.	[Review/revise ICC regulations on transportation rates; end discrimination or subsidize recycling. • Encourage leasing rather than sale of products[a] through tax advantages and insurance protect ion ● Government procurement through leasing rather than purchase. ☐ Assistance to small business to build distribution system and outlets: guaranteed loans, training, etc.	Consumer's control, independence, autonomy reduced by leasing. Prolonged product life through better maintenance from leasing, or reduced user care of leased devices/vehicles. Government leasing. Issues of financial/legal liability resulting from leasing.

[a]Leasing of vehicles large appliances, and equipment usually provides more systematic maintenance, greater intensity of utlization aggregated collection for eventual recycling, and greater motlvation for recycling
= Indirectly Improved efficiency of reworking, repair, and resale of products in the aftermarket
• = Directly supports improvements in the aftermarket activities

SOURCE Working Paper SIX

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Table 40.—Implications and Impacts of Recycling on the Materials Cycle—continued.

Functional requirements if recycling is to be increased	Application to national goals; benefits to stakeholder groups	Disbenefits to stakeholders and Nation	Government options, role, and implemental ion strategies	Impacts of Implementing Government options
		V. USE AND REUSE		
Better information about patterns of obsolescence, discard, etc. Better knowledge of durability, safety of rehabilitated, resold items. Building of consumer confidence through standards, warranties, labeling, etc.	Extended use, avoidance of premature obsolescence. Improved customer confidence in buying decisions. Improved discretionary income. Less pressure on individuals and households for excess consumption.	More labor requirements, lower profits for retailers. Possibly lower GNP due to reduced markup between purchase of used product and sale of reworked product; i.e., less value added which mostly goes to wages. Possibly reduced customer choice and satisfaction.	I R&D on durability, safety. [Public education and persuasion. • Manpower training for rebuild ing/rehabilitation. • Development of diagnostic/repair techniques. • Development of insurance warranty systems.	Resistance from manufacturers/distributors, wholesalers/retailers because of competition New product manufacturers may move into the aftermarket in competition with existing repair/rework companies or new part manufacturers; conversely aftermarket firms could develop more sophisticated units and encroach on new product manufacturing.
		VI. DISPOSAL		
Collection systems for materials, products, components. Sorting/evaluating systems for products and components. Residual disposal system. Product design for easier recycle. Knowledge of availability and locational access to obsolete discarded material items.	Reduced municipal solid waste disposal problem: land and environmental degradation, costs. Preservation of items of value Enhanced international image. General encouragement of prudence, conserving society. Establish learning curve for recovery of additional material under increased scarcity. Reduced costs of retrieval through better information.	Esthetic/environmental insults from collection, sorting, transportation, stockpiling (local). Inhibit substitution of composite material, special alloys, and complex designs because it makes recycle more difficult.	Encouragement of MSW[b] resource recovery centers (technical aid). Disposal deposits based on testing, lab evaluation of recyclability. • Inventory of obsolete, abandoned, discarded materials (in large or concentrated deposits) available for recovery. • Requirement for manufacturers/distributors to buy back. Disposal charges.	(MSW centers) requires changes in State laws/ constitutions; may undercut present secondary suppliers and destabilize prices; requires heavy State/ local investment in rapidly evolving high technology; requires steady flow of waste, may undercut longer range conservation in initiatives; centers also produce energy. Disposal charges promote roadside dumping Deposits add to consumer prices, reduce sales volume, high administrative costs. Inventory may undercut scrap dealers basis for business (knowledge of location and accessibility y of material for recycle).

[b]Municipal solid waste
= Indirectly improved efficiency of reworking, repair, and resale of products in the aftermarket
. = **Directly** supports improvements in the aftermarket activities.

SOURCE: Working Paper Six.

in energy intensity. Therefore, recycling of metal products and components—which involves the maintenance and manufacturing stages of the materials cycle—is more energy-efficient than building products from scratch with newly mined, refined, and fabricated metal parts.

In sum, improvement of the product aftermarket would provide the institutional mechanism to achieve many other important objectives such as energy conservation and environmental protection, as well as contribute to materials conservation.

Establish Scrap Inventory

A complementary approach to recycling would be to inventory the unused products or abandoned materials available for recycling when needed. Discarded products form a large reservoir of materials that has never been accounted for in detail. Estimates of the magnitude of this resource have been made, but to support recycling, the types of metal and their location, physical accessibility, and unit sites would be needed. A periodically updated inventory might provide an ongoing assessment of available resources sufficient to reduce the need for direct Government action. The inventory would also provide accurate estimates of true product life and reuse patterns. Many "obsolete" products are in fact acting as backup units or serving as second systems (refrigerators and machine shop lathes are clear examples of this).

The most valuable metals (other than common steels) are found in specialized applications and may or may not be accessible. By balancing the books on obsolete products, one could: 1) determine the amount of accessible scrap (scrap that is not corroded and within a reasonable distance of a recycling center), 2) the flows of material products in the aftermarket, 3) the reserves the Nation has to fall back on in case of shortage, and 4) products performing nonessential functions or materials that could be removed from working products and replaced with substitutes in the event of an emergency.

One objection to such an inventory of unused products would be the high administrative cost of the inventory, especially for materials not owned by organizations with readily available inventory records. Some form of sampling procedure would be needed to obtain estimates and focus further study to keep administrative cost down. Existing scrap dealers might object to losing the proprietary information needed to match sellers and their customers. New metal industries may feel their market would be undercut in the short-term, reducing their capacity, but when the scrap ran out there would not be enough capacity. Such instabilities or overreaction would have to be eliminated.

Owners of the scrap might fear that proprietary information would be released to competitors by revealing the amount of material or equipment in current inventory. The data base would need some security protection; this would raise costs. If owners of products lost some control over these products—as in a recall during a materials shortage—this would complicate the present owners' planning for future needs.

Summary

The illustrative implementation options presented were selected so as to avoid Government intervention in private decision processes to the greatest extent possible. Instead, they enable the private sector to more efficiently deal with their own needs while reducing the uncertainties and vulnerabilities for all parties. These means of implementation are to a great extent self-correcting. They do not require constant Government adjustment of standards or regulations in order to achieve a balance of interests.

These options were also selected so as to maximize the potential for reducing materials losses, and to increase the adaptability, stability, and efficiency of the materials cycle.

The set of illustrative options discussed are mutually reinforcing. The public data base supports all the other options. Contingency planning primarily strengthens adaptability and stability. The contingency shares certificate market would moderate the extremes of tight materials markets and diminish the frequently self-defeating responses of stakeholders during short-term crises. Substitution is very much the result of a private decision process, but it also can be an important instrument of national materials and energy policy. Improvements in the aftermarket will contribute to greater efficiency but will also provide the institutional mechanism to achieve many other goals such as energy conservation and environmental protection.

These options if implemented would depend on cooperative action by the private and public sectors. By initiating a private/public sector partnership now, when crisis conditions do not yet exist, all parties could fully assess these and other options without the overriding pressure of emergency situations obscuring their underlying and long-term needs. Through such a partnership, options like those illustrated in this section could strengthen the ability of the United States to avoid crisis conditions in materials such as now exist with regard to energy resources.