IV.

Identification of Technical Options for Reducing Losses From the Materials Cycle

Identification of Technical Options for Reducing Losses From the Materials Cycle

This chapter reviews each of the loss categories discussed in chapter III in order to identify techniques for reducing these losses.

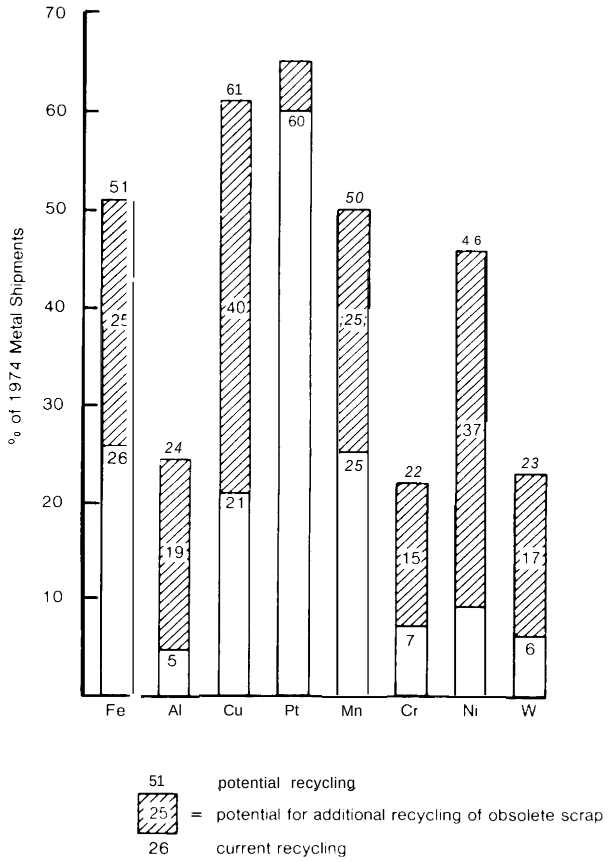
UNRECOVERED AND UNKNOWN LOSSES

As shown in the flow charts (figures 13 to 20), most industrial scrap is effectively recycled. On the other hand, estimates of unrecovered and unknown losses range from 5 to 37 percent of shipments (table 21). Regardless of estimating errors included in these figures, such losses are substantial. Figure 21 shows current levels of obsolete scrap recycling as a percentage of 1974 mill shipments. The data is from figures 13 to 20. With the exception of platinum, current recycling of obsolete scrap ranges from 5 to 26 percent. The potential for additional recycling is calculated as the sum of the unrecovered materials and postconsumer waste (from table 21), and ranges from 5 to 40 percent. However the extent to which this obsolete scrap can actually be recovered is a matter of considerable controversy.

The Institute of Scrap Iron and Steel contends that there is a large inventory of obsolete iron and steel scrap that has accumulated over the years. This view has been substantiated by two studies, the most recent of which places the inventory at over 600 million tons.[1] On the other hand, some economic studies indicate that this scrap may not be available even with much higher scrap prices.[2]

In order to gather further information on this question, the flow of obsolete products (and the metals and other materials contained in them) to their "final resting place" was evaluated for six kinds of products (buildings, lathes, office equipment, pipelines, refrigerators, and television sets) in five geographically dispersed cities of the United States. The results, which are described in detail in chapter VI, show that many of these products

Figure 21.— Recycling of Obsolete Scrap



SOURCE: OTA, based in part on data from Working Papers One and Two.

[1] Robert Nathan Associates, *Iron and Steel Scrap: Its Accumulation and Availability as of 31 December 1975,* prepared for The Metal Scrap Research and Education Foundation, August 1977.

[2] William T. Hogan and Frank T. Koelble, *Purchased Ferrous Scrap: U.S. Demand and Supply Outlook,* Industrial Economics Research Institute, Fordham University, June 1977.

rapidly find their way to landfills even though they bypass the municipal solid waste system. While not completely conclusive because of the limited range of products examined, the results do indicate that the amount of obsolete scrap available for recycling is smaller than previously calculated. However, this only reinforces the need for additional recycling to prevent materials from being lost forever.

The barriers to obsolete scrap recycling have received detailed study.[3] Obsolete scrap has a limited market and competes with higher quality virgin ore and industrial scrap that has a known consistency and presents fewer collection difficulties. Options for increasing obsolete scrap recycling include: industry goal-setting, investment tax credits, tax deductions for usage, product charges, reduction of freight rate chages, and additional research. Several of these options are included in current energy legislation and have been studied in detail in another OTA assessment.[4]

One final option is product rework and reuse. Most obsolete scrap is available in the form of a product. And as a product (with workable components), the scrap has more value than the metal alone. The main reason that products are not reused is the lack of a well-established institutional framework for collecting obsolete products and introducing them back into service in one form or another. Product rework and reuse as a recycling option are discussed in detail in chapter VI.

[3] *Economic and Technological Impediments To Recycling Obsolete Ferrous Solid Waste,* NTIS report PB-223034, October 1973.

[4] *Materials and Energy From Municipal Waste* (Washington, D. C.: U.S. Congress, Office of Technology Assessment, July 1 979), OTA-M-93.

LOSSES IN THE POSTCONSUMER SOLID WASTE STREAM

Postconsumer solid waste includes beverage and food containers, worn-out residential and commercial hardware, obsolete and worn-out small appliances, toys, sporting goods, automotive parts, etc. Such obsolete parts become a minor but significant part of the total refuse stream of kitchen waste, paper, glass, and plastics. As shown in table 21, large quantities of basic metals are in the postconsumer solid waste stream, representing 7 to 14 percent of domestic shipments of the metals studied. The total ferrous content of solid wastes is about 11 million tons of iron and steel (which ineludes manganese and other alloying elements). In all probability, there are substantial quantities of other metals in postconsumer solid waste, roughly in proportion to this general usage.

Options for solid waste handling and resource recovery from the postconsumer solid waste stream are the subject of another OTA assessment, and are therefore not discussed in this reports

[5] U.S. Congress, Office of Technology Assessment, *Materials and Energy From Municipal Waste: Volume II Working Papers,* July 1978.

LOSSES IN DISSIPATIVE USES

Dissipative uses involve the dispersal of metals and alloys by chemical action or physical dispersion during use. For example, aluminum pig and aluminum scrap are used in the deoxidation of steel. The aluminum is lost as an oxide in the slag. Another dissipative use of aluminum is as a powder in the manufacture of aluminum paint or in munitions. Similarly, uses of steel such as in reinforcing bars or as nails are considered dissipative.

As another example, large quantities of alloying elements are used at low levels in the production of high-strength low-alloy steels. These steels with low levels of alloy content are difficult to identify and segregate from the ferrous scrap stream. As a result, alloying elements such as chromium, nickel, and tungsten are diluted and lost in the normal recycling of iron and steel scrap.

Referring to table 21, from 4 to 23 percent of the domestic shipments of the selected metals is lost in dissipative uses. A number of technical and economic barriers make it difficult to reduce this form of waste. In cases where metals and alloys are dispersed by chemical action, performance and cost considerations dictate their use over other materials and processes. For example, aluminum is used in the deoxidation of steel because aluminum is a reactive metal at the temperature of molten steel and is more effective and lower in cost than other alternatives.

In cases where metals and alloys are physically dispersed as nails, hairpins, etc., the costs of their collection would be very high in relation to the value of the metal they contain.

If there is to be conservation here, it will be through the development of substitutes on a case by case basis. Research and development on substitute materials and processes is underway and would be accelerated by any threat to supply. However much of this work is uncoordinated and sporadic.

LOSSES IN EXPORTS

Of the metals studied, none has a large net export. On the contrary, imports of metals are a major problem for domestic producers. A large amount of material does leave the United States through exports of fabricated products. However, specific quantities are not known since data on imports and exports of fabricated products are available only in terms of dollars and number of items. A detailed analysis would have to be made to calculate the total metals contained in such products. As shown in table 21, a significant amount of aluminum and manganese is lost from the domestic materials cycle through exports of iron and steel scrap.

Losses through exports differ from other kinds of losses because of foreign policy concerns. For several years the United States has needed to increase exports in order to reduce an unfavorable balance of payments. Further increases in exports and imports are an integral part of U.S. foreign policy and relations with all countries in the free world. Any change in the pattern of exports, and particularly through overt imposition of export controls, would likely have severe political repercussions and invite counter restrictions. In addition, controls on fabricated product exports would be a high price to pay for metal, since products on the average have a value of from 2.5 to 5 times their contained metal, During an emergency, however, this approach could be and has been used as a materials conservation measure.

LOSSES IN MILLING AND CONCENTRATING OF ORES

After mining, ore is usually beneficiated before smelting. Beneficiation involves milling of the raw ore and processing to separate the desired mineral from the rock associated with it. Although large quantities may be lost in the milling and concentrating steps, the value of the material lost is low and the cost of further recovery is high.

This report has focused on losses from the domestic materials cycle. Any losses from milling and concentrating in a foreign country are outside of the domestic materials cycle and the scope of this report. The low level of milling and concentrating losses for aluminum, platinum, manganese, chromium, nickel, and tungsten reflects U.S. dependence on imported concentrates and semirefined products of these metals. In this case, much of the waste occurs overseas.

With respect to beneficiation of iron and copper ores, the level of losses is fixed by the technology and economics of processing taconite (iron ore containing about 25 percent iron) and low-grade copper ores (containing 0.4 to 0.8 percent copper). Presently available technology cannot significantly reduce the losses shown in table 21. In addition, processing of lower grade ores incurs increasing energy and environmental costs.

One obvious option is to increase imports of high-grade ore concentrate. Higher grade deposits of iron ore and many other metals are available outside the boundaries of the United States. But increasing U.S. dependence on imports raises serious questions about the amount of risk associated with dependence on foreign supplies. This must be balanced against the increased costs of energy and environmental controls that would be required in domestic processing of lower grade ores.

Another option for reducing losses during milling and concentrating is to invest in a major R&D program directed toward increased recovery of metal values from low-grade ores. Most experts in the field point to the need for research in fine-particle separation, since a considerable portion of the losses during milling and concentrating are in the form of fine particles and slimes. A major advance in fine-particle technology might bring about significantly increased recovery rates and reduced losses. In this way, a higher proportion of the mineral values in the ground might be economically converted to usable concentrates.

LOSSES IN METAL PROCESSING

The metal-processing stage of the materials cycle includes smelting, refining, and producing mill products. These operations are generally capital-intensive. As shown in table 21, losses in metal processing range from less than 1 to 12 percent of domestic shipments of the selected metals—except for manganese. The use of manganese in steelmaking is unique. A substantial portion of the manganese functions as a reagent in removing oxygen and in controlling sulfur in steel.

The major barriers to waste reduction in the processing of metals are technological and economic. Current technology is the average technology of all plants in operation. Average technology shows improvement only as new plants with new technology are brought online and old plants with old technology are either upgraded or dismantled. Substantial time and financing are required to turn over the capital stock in any of these basic material industries.

Besides capital replacement using new technology, few options are available for making a significant reduction in the losses associated with metal processing. One exception is the use of alternatives to manganese for controlling sulfur in steelmaking. Materials such as magnesium and calcium carbide can be used in external desulfurization processes. The economics of alternative desulfurization processes depend on many technical factors and the availability and cost of manganese. Thus far, manganese has a clear-cut cost advantage over available alternatives. Nonetheless, significant changes in availability of manganese and or costs of the alternatives could change this picture.

LOSSES IN END-PRODUCT MANUFACTURE

The losses in end-product manufacture for the selected metals range from less than 1 to 3 percent of domestic shipments of mill products. These relatively low levels of loss occur as metals are fabricated into end products, such as automobiles, appliances, electrical equipment, and buildings. The losses are associated with literally hundreds of different types of fabrication processes. Since the losses are so small, opportunities for conservation are limited to marginal improvements in management controls over the manufacturing process.

LOSSES IN CORROSION AND WEAR

As indicated in table 21, losses of material directly associated with corrosion and wear are generally small and range from essentially O to 3 percent of domestic mill shipments. These are direct losses from corrosion and wear and do not include indirect losses from the effects of corrosion and wear on product life, which are discussed in chapter V. Thus, promoting improved corrosion and wear resistance is not an efficient way to reduce material losses, but there can be substantial economic benefits through improvements in reliability, durability, and performance.[6] In addition, as is shown later, the development of improved corrosion and wear resistant treatments can be used to build a great deal of flexibility into materials usage.

[6] L. H. Bennett, *Economic Effects of Metallic Corrosion in the United States,* A Report to the Congress, National Bureau of Standards, March 1978.

LOSSES IN NONMETALLIC USES OF RAW MATERIALS

The nonmetallic use of raw materials varies substantially. Significant quantities of aluminum, chromium, and manganese raw materials are used in ceramics, abrasives, refractories, and chemicals. These are generally accepted uses of metals and would not receive separate consideration except for the fact that many of such uses are dissipative. Because of this, the same options for reducing losses would apply to nonmetallic uses as would apply to dissipative uses.

SUMMARY OF TECHNICAL OPTIONS

The technical options that have the greatest leverage in reducing each category of loss are shown in figure 22. The most highly leveraged options are scrap and metal recycling, R&D on substitute materials and/or processes, and R&D on metal recovery from low-grade ores.

Metal recycling and product remanufacturing have multiple leverage because, in addition to the direct reduction in losses of unrecovered metals in obsolete products, these options lead to an additional savings in future years. For example, if through product recycling an additional 10 percent of obsolete office equipment in a given year is remanufactured, 10 percent less metal will be required for next year's production run (assuming constant demand). This will also eliminate the losses (e.g., milling and concentrating) that would have been associated with producing that amount of metal.

Figure 22.—Technical Options for Reducing Losses in the Materials Cycle

Loss category	Range of losses"	Technical conservation option
Unrecovered metals	5-37%	Metal recycling Product remanufacturing and reuse
Dissipative uses	4-23%	R&D on substitute materials and/or processes
Milling 8 concentrating	Nil-19%	R&D on metal recovery from low-grade ores, e.g. fine particle technology
Exports of scrap& milt products	0-17%	Export controls
Postconsumer solid waste	5.14%	Productr recycling
Metal processing	0.5"12% (Mn=122%)	Capital replacement Alternative desulfurization process (for Manganese)
Nonmetallic uses of raw materials	Wrn-11 %	R&D on substitute metals & processes
End-product manufacture	Nit-3%	Improved management controls
Corrosion and wear	Nil-3%	R&D on improved corrosion and wear resistant treatments
Transportation & handling	Nil-3%	Improved management controls

• Range of losses for the eight metals in percent of 1974 domestic mill shipments
See figure 3 and tables 20 and 21 in chapter III for metal specific data
Nom = small but undetermined amount of losses.
Nil = amount of losses close t o zero.

SOURCE: OTA based in part on data from Working Papers One and Two