PRIMARY METAL INDUSTRY ECOPROFILE CALCULATIONS: A DISCUSSION OF ALLOCATION METHODS

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KEY WORDS: Methodology/LCI/Inventory/Ecoprofile/
Co-product allocation/Primary metal production/
Physical partitioning/Economic partitioning

ABSTRACT

Many primary metal production industries act as the sources of other compounds and elemental by-products. In many cases, very little public domain inventory data exist regarding these other materials. Many of these by-products have been treated as having zero environmental burdens, with burdens only being attributed when a specific, identifiable, processing operation has taken place. This paper discusses two separate allocation methods — physical partitioning and economic partitioning — and their effects on ecoprofile calculations.

INTRODUCTION

Besides the main product, primary metal producing industries act as the source of many other elements and compounds. Traditionally by-products of the primary zinc and copper industries, such as gold, silver, platinum, germanium etc., have largely been ignored when performing inventory analyses of the overall processes, since the quantity of these other elements is extremely small when compared to the mass of the main product. Indeed, sulphur released in roasting and sintering has also, in the past, been omitted from the allocation procedure, implying that sulphur dioxide liberated in these stages attracts zero environmental burden. Whilst this approach may have its attractions for sulphuric acid producers, it is at the expense of the primary metal inventory data, because the zinc, copper and other by-products bear all of the burdens.

Such a technique is flawed because common sense dictates that fuels and possibly other raw materials have been used in extracting the sulphur, gold, silver, platinum etc. that are contained within the ores. Subsequent ore processing and transport operations should also be attributable to each of the elements contained in the ores/concentrates, which eventually become products. Whilst the masses of most of these other elements are small when compared to the mass of zinc, lead or copper for which the ore is primarily mined, in the case of sulphur the mass is more appreciable. The main problem is how to partition the fuel and energy use, raw materials requirements and solid, liquid and gaseous emissions amongst the various co-products. Two methods that may be applied are physical partitioning and economic partitioning.

PHYSICAL PARTITIONING

Any methodology designed to determine more accurately the ecoprofile description of a primary metal industry must be uniformly applicable to all such industries, without discriminating against or being biased towards any one. Physical partitioning, specifically the technique of tracking the elemental flows within the primary metal production industries, satisfies this criterion. This technique has been applied to a pan-European study on primary zinc manufacture [1, 2] and has also been used on an international study concerning the primary copper industry [3].

To understand this technique, consider an ore mining and crushing operation, as shown in Figure 1. In the top half of the figure, the mine/crush ore operation can be regarded as a system with multiple outputs of lead, sulphur, zinc, cadmium and copper. It can therefore be regarded as a series of five parallel sub-systems, each of which is devoted to the mining and crushing of a single element within the ore: this is shown in the lower half of Figure 1.

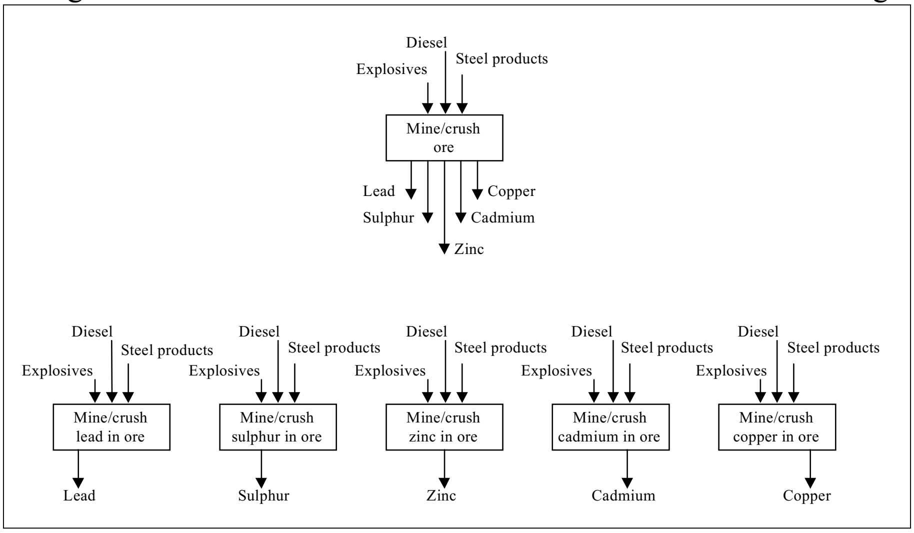

Figure 1.
The mine/crush ore operation in the upper half of this figure can be thought of as a set of parallel mine/crush operations as shown in the lower half of the figure, each of which yields a single element.

However, if the overall inputs to the system are normalised to the total mass of lead, sulphur, zinc, cadmium and copper (let us call this sum 'product') leaving the mine/crush operation, then these normalised inputs are also the normalised inputs for each of the sub-systems. Thus, the normalised inputs to mine/crush 1 kg 'product' in ore are the same as those to mine/crush 1 kg zinc in ore etc. This approach can also be applied to all subsequent downstream processing operations. By normalising each process to the (elemental) mass of materials that eventually leave the system as products, burdens are attached to the extracted products up to and including the point where they 'leave' the system as finished products. A product does not, therefore, attract any burdens due to operations that occur downstream from the point at which it left the system: it may however require further processing (i.e. enter another system), in which case any subsequent environmental burdens will be added to its existing ecoprofile.

ECONOMIC PARTITIONING

In economic partitioning, the inputs of fuels, energy and raw materials and the outputs of solid, liquid and gaseous emissions are allocated amongst the various products according to the economic values of these products. This does however raise questions regarding the treatment of intermediate products. Taking the primary zinc industry as an example, with regard to the sulphur dioxide released by the roasting and smelting furnaces, what value should be used? The values for sulphur, sulphur dioxide or even sulphuric acid could all be considered appropriate. Another point to consider is that economic figures may not even exist for some intermediate products such as purified zinc sulphate solution, or if they do then they will only really be valid for any one particular company e.g. for internal accounting purposes.

For the purposes of this paper, only monetary values for zinc, sulphur, lead and cadmium will be assigned, as they constitute over 97% (usually 99%) of the output from the primary producers studied. Study of the commodity prices for special high grade (SHG) zinc and lead [4], sulphur and cadmium [5] during this decade is interesting. Figure 2 shows how the annually-averaged prices have varied. The maximum prices occurred in 1990 and the minimum market values in this period occurred in 1993.

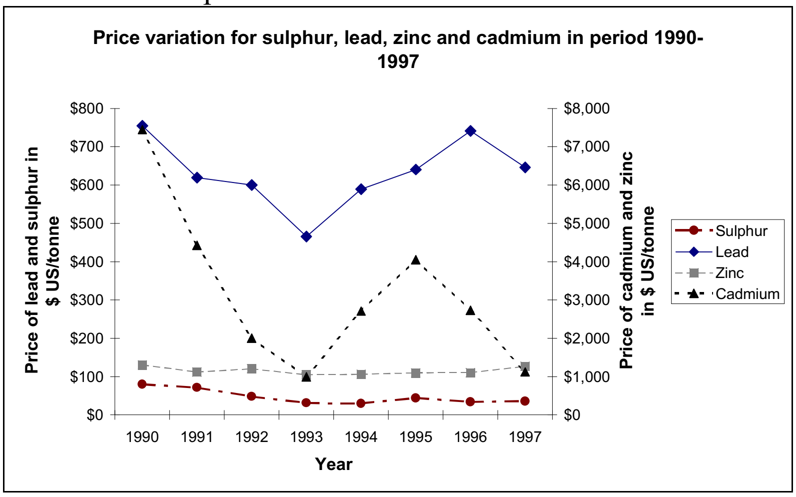

Figure 2.
Price variations for sulphur, lead, zinc and cadmium during the 1990s.

RESULTS

Figure 3 shows the effect of partitioning on the gross energy required to produce 1 kg of the stated materials. The first bar shows the results for physical partitioning and the second and third bars show the results of economic partitioning using the minimum and maximum commodity prices respectively.

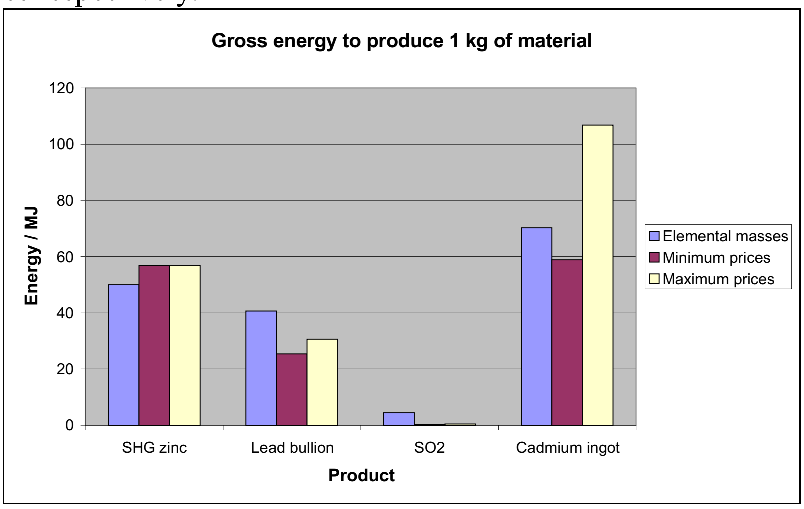

Figure 3.
Effect of co-product allocation method used on gross energy values. See text for explanation.

CONCLUSIONS

The traditional method of partitioning the outputs from primary metal industries has the drawback that by-products, such as sulphur dioxide, residues rich in gold, silver etc., can attract no environmental burdens. This is clearly not the case in practice, as energy and other resources have been expended to extract and deliver them to the primary metal smelters.

Choosing the elemental masses of the products as the normalising parameter is one way of treating co-product allocation in the primary metal production industries. This particular allocation technique has the virtue that whenever a by-product leaves the main production sequence, only the environmental burdens associated with processing it up to and including the point at which it leaves are included in its inventory data. In this regard, the methodology employed here can be regarded as being intuitively logical.

With this physical partitioning, the overall effect on the ecoprofile data for primary SHG zinc has been demonstrated to be small, being of the order of 1% with regard to the gross energy [2]. The effect on the ecoprofile data for sulphur dioxide, and hence sulphuric acid, and the other by-products is relatively more pronounced, but this method of partitioning reflects more accurately the characteristics of the system. As a consequence of this method of handling data, all by-products can be given an environmental 'history', i.e. ecoprofile data can be determined: this is of particular importance when the by-product is further processed off-site.

With economic partitioning, not only are the ecoprofile results different compared to those obtained via the mass partitioning method described above, they are also highly dependent on the economic values chosen. For both the 1990 and 1993 commodities prices, the gross energy required to produce 1 kg of SHG zinc has risen by about 14% compared to the physical partitioning case (see Figure 3.). In contrast, the economic partitioning figures for lead bullion have dropped to 51% (1993) and 61% (1990) compared to physical partitioning. The gross energy required to produce 1 kg of sulphur dioxide is almost zero implying that sulphur dioxide is again virtually ignored in the analysis. Cadmium shows the most pronounced effect, and this is due entirely to the drop in price from around $7445/tonne in 1990 to $991/tonne in 1993. In all cases the only thing that has changed is the values of the products: the physical process has not changed at all. It would therefore seem more sensible to avoid economic partitioning and use the more stable elemental mass partitioning.

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