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Multiple Conditions of Urban Mining

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Abstract: This paper discusses how mines that have been adapted for the purposes of recycling carry out the business of extracting precious metals from discarded products. (1) Because industrial waste, its by-products and scrap are the major materials used by the nonferrous metal industry, the proper treatment of waste is now one of the industry's basic premises, while the setup of an adequate collection system for WEEE is an equally important condition for the recycling of such wastes. (2) For the effective usage of resources, not only the recyclers but the producers, too, will have decisive roles to play in the development of recycling technologies and strategies. (3) To bring about a low-carbon society, the reduction of CO2 by proper collection and recycling must become both the target to aim at and the indicator of whatever success may be achieved. (4) Public policy has to support the domestic recycling refinery of nonferrous metal as the keystone in the infrastructure of recycling and management of waste.
Keywords: Urban Mining; Recycling; mobile phones; WEEE; recycling; small house appliances; precious metals

1 Introduction

Since the quantity of precious metals in manufactured products is proportionately greater than in the original mines and since less energy is required to refine them than was necessary for the metals' original refinery, the late Prof. Michio Nanjyo coined the term 'Urban Mine' to specify designated sites where discarded manufactured products can be stored and where the metals in the products can be extracted: that is to say, 'mined' (Nanjyo 1988). And since the establishment of the collection system for recycling is so important, Prof. Nanjyo proposed that the sites designated for recycling ELV, packaging waste, WEEE, batteries, used paper and building scrap should therefore be classified as 'urban mines'.

This classification is more or less the same as that devised for the Japanese recycling system under the law for the establishing of a circular society (2000), whose aims are to promote a low environmental burden and to reduce material use. A further word of clarification may at this point be necessary: the term 'Urban Mining' is to be understood in two senses. In the first place, it can refer to old mines adapted for new purposes; in the second place, its extended meaning signifies that each piece of discarded equipment — each mobile phone, computer or whatever — can itself to be thought of as a mine So, bearing in mind the double meaning of the term 'urban mining', our paper focuses on the treatment of nonferrous metal by the industries that

recycle electronic wastes; at the same time, it attempts to carry out an analysis from the viewpoint of environmental engineering and concludes with suggestions for future policy.
WEEE (Waste Electronic and Electronics Equipment) and used batteries constitute a complex mixture of still valuable yet extremely hazardous materials. Such materials are the residue of products that have themselves always been important in controlling the demand for the primary metals used in their production and have thus contributed to an increase in their price, while the uneven distribution of these often rare metals and the various changing conditions responsible for their price increase have, at the same time, become global issues.
Although the potential for recycling electronics products is significant, many products are discarded without due care, and, consequently, are improperly treated. Meanwhile, since the latest global financial crisis has caused the price of precious metals to plummet, the market is in turmoil, and the recycling market is also in disarray; all this in its turn has influenced the issue of urban mining.On the basis of the data provided by companies, we analyze the concept of ‘urban mining’ in terms of their environmental and engineering significance by focusing on the question of WEEE and upon the fate of batteries, their collection and recycling, as well as environmental protection and their response to the resource price fluctuation in terms of three issues: (1) the proper treatment of waste, (2). the effective usage of resources, (3) the reduction of CO2 through the proper collection and recycling of waste.

2 Multiple Conditions for Urban Mining

According to a survey carried out by the National Institute of Material Science (released on January 11, 2008), of the quantity of metals that had by that time accumulated in Japan to be recycled (in short, the products of man-made ‘urban mining’), gold amounted to about 6,800 tonnes (16% of world’s reserves), silver came to 60,000 tonnes (22%), indium (16%), tin (11%), and tantalum (10%) (Halada 2009). Although the quantity of many of these metals exceeds by more than 10% the rest of the world’s reserves, they have, even today, not yet been ‘mined’. Instead, they are stored and some of them are shipped to other countries. The research conducted by the National Institute of Material Science has not confirmed the location of all the collections of recyclable material that have been designated as resources set aside for ‘urban mining’, and while the current available data has been estimated on the basis of governmental trade or production statistics, it is still not clear whether it is the fate of the residue metals to be scattered in the air, oxidized, or buried in a waste landfill. Nor is the grade of the urban mining at all clear. It thus remains necessary to clarify the form in which the materials at present exist.
As for electronics products, the generated amounts of WEEE are estimated to be 2,500,000 tonnes per year (19.4kg per capita): among them, the smaller items of EE amount to around 500,000 tonnes per year, while the quantity of metals included in such small amounts of

WEEE is estimated to be in the order of some 1,000 tonnes to 10,000 tonnes for base metals like copper and lead, while precious metals to the order of some 10 tonnes are scattered here and there (Shiratori and Nakamura 2007).

The bulk of the materials utilized by the nonferrous metal industry consist of industrial by-products, what is termed industrial waste, and this is enough to keep the industry in operation and the quality of its products homogeneous. For example, the quantity of the materials fed into the TSL furnace at DOWA's Kosaka refinery, opened in 2007, is sufficient to keep the furnace operational and the quality of the input stable. The main materials are waste-water sludge, electronics scrap, metal plate waste solution, used mercury oxide cells, lead frames, control boards, PCs, and connector boards. Yet while, throughout Japan, the waste electronics material constitutes only 4% of the recycling material of the nonferrous metal industry (Kozan2009), in neither Umicore nor Xstrata are the percentages of the WEEE so high. We thus see that the nonferrous metal industries are carrying on their business by unifying the collection of metal and the treatment of waste, and that, within the total amount of WEEE that constitutes the mass of 'urban mining' (the scrap that is to be mined), the percentage of mobile phones is very small. Recently, whereas the electronics scrap generated in Japan has been decreasing, the industrial by-products generated in China, as well as in Taiwan, Korea and other developing countries has been increasing, and Japanese smelters have therefore been trying to gather and use the sort of byproduct that is processed by other countries.

According to a report published by the Ministry of Public Management, Home affairs, Post and Telecommunications titled "The Report on the Ecological Response in the field of Information and Telecommunication, part III" (2009), the metal price recoverable from one mobile phone is about 100JPY (in case of gold, 0.03gx2920JPY/g=87.6JPY). The collection, dismantling and recycling cost is therefore reduced, and the real price of one phone is some 1-10JPY (The Ministry of Public Management, Home affairs, Post and Telecommunications 2009, 37).

On the basis of this estimation, we can predict that if mobile phones were to be collected from each of the 120 million people living in Japan (supposing that every one of those 120 million had a phone), the amount of gold they contained would be worth about 10 billion JPY.(For comparison, we note that in 2008 DOWA's annual sales came to 350 billion JPY.)

In order to obtain a better picture of the collection and recycling of rare metals, the Japanese Ministry of Environment and the Ministry of Economy and Trade and Industry set up a research committee, and since 2009 it has been carrying out a model business in Japan.(DOWA and 3 other entities are cooperating in the project.)

The model business has already published its first results: the mobile phone has had the highest collection rate, about 14% (collection units per potential collection units), while the average collection rate of a total of 9 items (game machines, DVDs, digital cameras, etc) has reached

10.9%. Although the estimated total of the 9 items (84 million units per year) will contain 353 tonnes of rare-metal per year, this figure accounts for only 0.2% of the total quantity of imported rare metals, and since the recovery rate at the smelter is about 60%, this entails that if the collection of rare metal combined with the recovery of the base metal and precious metal is only of the order of 30%, then the B/C (Benefit per Cost) will simply become one and the same. This means that the economic conditions of the rare metal collection business are very severe, and that a high collection rate of over 30% and the development of a more sophisticated extraction technology are therefore indispensable.

When we consider the collection cost per unit, we may conclude that the methods of collection, recovery and recycling of WEEE and ELV offer a possible solution, for as well as an effective system of collection of WEEE and ELV, the research and development technology for dismantling and sorting plays a role of critical importance. For example, Shin-etsu Chemicals, one of the Japanese producers of the Nd-Fe-B permanent magnet, has developed recovery and recycling technology for extracting neodymium and dysprosium from motors in the compressors of used air conditioners. It is estimated that if 70% of the air conditioners and washing machines in use in Japan are recycled, the amounts of rare metal magnet can, by 2030, amount to 410 tonnes.

But it is necessary to further develop the dismantling and recycling technology (Arai 2010).

On the basis of these analyses, we can summarise the multiple conditions of urban mining under three headings:

The first concerns the system of collection. WEEE is both diffusely scattered and (despite its potential for bulky accumulation) movable, and the creation of an efficient collection system for WEEE is thus an important condition for enabling items to be recycled. The four items regulated and collected by Japan’s Home Appliance Recycling Law are TV sets, washing machines, refrigerators and air conditioners, while the Law for the Promoting Effective Use of Resources permits PCs to be taken back without charge. Nevertheless, the collection rate is not sufficiently high since used PCs have their own market value.

At the same time, municipalities have been collecting and disposing small electronics appliances as municipal solid waste, despite the difficulty of treating them, and this creates problems for both proper treatment of waste and resource usage. If the range of the collected objects regulated by Japan’s Home Appliances Recycling Law is extended to include the smaller items of WEEE, the consumers will have to pay the recycling cost at the time of disposal, which induces the consumers to store or dump such small pieces of WEEE illegally. Yet without a proper understanding of role sharing and cost bearing, the project for the collection of small items WEEE that is now being carried out in Japan, an experiment aimed at collection and treatment, is bound to be limited. Although the business has facilities for both the proper treatment of waste and the recovery of resources, only resource recovery is at present stressed.

The second condition is the development by individual private companies of sophisticated technology. Our examples show that because the technology for the appropriate analysis of WEEE that contains complex materials constitutes the base for the evaluation of the metals and the cost of their treatment, the nonferrous metal recycling companies need to possess high-level technological and R&D capability to unify the treatment of waste and the recovery of resources. If we consider the TMR (Total Material Requirement), we see that it makes sense to recover and recycle multiple metals at ‘Urban Mines’. DOWA’s TSL furnace and Mitsui’s lithium ion battery recycling are instances of companies that are responding within the current regulations to the development and deployment of new technologies of R&D.

We also require the recovery of precious metals in general and of special metals like mercury and cadmium in particular (Hagellueken 2009). The collection and treatment of LCDs, PVs and new type batteries offers the companies a new business chance. At the same time, we should take note that not only do the environmental technology, management systems and human development projects of Japanese companies — projects that are designed to cope with serious mining pollution—compare well with those of other countries, but they have also acquired a good social reputation and have attracted customers both within and outside Japan, while being favourably noted for strong international competitiveness.

The third condition concerns the demand-side problem of metals. In the countries that we have studied, price fluctuations for virgin resources constitute a major influence upon the recycling of the used resources. The price of virgin materials is affected by and reflects the fluctuations of foreign exchange, and excludes such external costs as environmental disruption, the need for subsidies, all in competition with the recycled materials (Yoshida 2004).

The operational economic conditions will depend on the costs incurred for the collection, decomposition and disposal of materials to be recycled, as compared with the prices of virgin resources. Consequently, it may be possible to focus on economically valuable resources and the application of appropriate technology for the disposal of complicated ores. Since 2008, when metal market prices fell sharply because of the world financial crisis, this has become more than ever necessary. It is essential that the nonferrous metal industry should succeed in stabilizing the diversity of the input material and the prices of the output product (metal). It is vitally important to raise the recovery rate of precious metals so as to cope with the dangerous fluctuations in the ultimate prices of finished goods.

3 Conclusion

To return to the three issues that we spoke of in the Introduction, we shall now try to set out the agenda for improving public regulations and for clarifying the role of the private company.

As for the first point we raised, that of ‘the proper treatment of waste’, we have stressed that environmental regulations must play a major role. The main materials used by the nonferrous metal industry are still industrial by-products and industrial waste, of which WEEE is only a small part; and in this instance effective environmental regulations regarding waste management that are applicable to the producers will be indispensable. The fee for waste treatment is a major concern for the nonferrous metal industry and affects conditions of employment.

When we turn to public policy, we argue that the regulations that forbid mixing small WEEE with municipal solid waste will contribute not only to environmental protection but also to the business opportunities and green employment. And if we hope to create an efficient collection system and raise the collection rate of the 4 specified items and PCs, we need to improve the present collection system by involving the participation of producers, retailers, consumers and waste treatment businesses, and by introducing such incentive systems as the deposit.

At the same time, the enforcement of regulations regarding the export of WEEE and the proscription against the mixing of waste with valuable goods will promote proper treatment, and will establish the waste management market. As for the regulation concerning the export of used WEEE, it is necessary at least that the customs inspect the nature and the packaging of the goods.

As for our second point, ‘the effective usage of resources’, we believe that both producers and recyclers must recognise that they have decisive roles to play in developing the best recycling technology. In particular, private enterprises have to develop their technologies and decide upon investment in response to the diversification of the recyclable material, the speeding up of technological progress and the enforcement of the regulations. Since the concept of zero emissions in the recycling process entails many problems that affect the dispersion of polluted matter that occurs in actual situations, the producer’s decisions about the quality of waste management will decide the direction in which the recycling industry develops.

Currently, used electronics parts that contain indium (liquid crystals), tantalum (oscillators), and tungsten (condensers), for which proper collection techniques have not yet been established, are saved temporarily until they can be treated. Although one proposal argues that these metals should be deposited in the previously mentioned ‘artificial ore deposits’ (which is the formal name for ‘urban mines’), it will be up to the enterprises themselves to decide how much they intend to invest after consideration of the future trends of demand.

Finally, as to our third point, if a circular economy is to function effectively within the framework of a lowcarbon society, we shall need to create a system that aims to reach specific numbered targets for the reduction of CO_2 and for an easing of the environmental load. Because the energy intensity of each semiconductor is very high, the chances of their effective reuse are relatively good, a situation that suggests the need for a re-thinking of the recycling priority system.

We must, in the end, clarify the purpose of the project that we have been discussing under the rubric of ‘Urban Mining’, which is to initiate a form of public policy that supports the domestic recycling of nonferrous metal refinery and establishes it as the vital infrastructure for the proper treatment of waste and the management of recycling resources.

It thus becomes vital for the recycling industry’s survival that it should take up its position as a major component of the mining infrastructure, and any plan designed to sustain itself in the changing global economy will require committed government support in the form of clear and cogent public policy.

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