Assessing the Potential Value of Rare Metals in Urban Mines:
A Comparative Look at Korea and Japan

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I. The Rise of Rare Metals

Rare metals refer to metals which are scarce in the earth’s crust, or which are scarce because they are difficult to extract and process. Rare metals are also metals for which demand is high and likely to soar in the future. Included in the category of rare metals are rare earth elements. Rare metals include a group of 17 metallic elements (specifically 15 lanthanides), plus scandium and yttrium in the third elemental family of the periodic table. In Korea, 35 different types of metals, including rare earth elements, alkali metals and metalloids are designated as rare metals, while 31 and 33 types are listed as such in Japan and the US, respectively.

Since the 2000s there has been rapid growth in world demand for high-tech products, along with fast economic growth in emerging countries and expanding investment in green industries by developed countries. Strong purchasing power, coupled with increasing income among the middle class in emerging countries (notably China and India) has spurred surging demand for high-tech products. Energy reduction strategies in developed countries have also stimulated purchases of cutting-edge technology products with high energy efficiency.

At the same time, swift expansion of rare metal consumption has been accompanied by a steep increase in the number of high-tech goods which rely on rare metals for their light weight and high performance. In fact, the world’s average consumption of rare metals nearly doubled between 2003 and 2007, including a 1.7-fold increase in consumption of lithium, a 1.8-fold increase for niobium and a 1.9-fold increase for titanium.

Dwindling Supplies are Pushing up Prices

Rare metals, as implied by the name, exist in nature only in scarce amounts. Supply is complicated because they are typically dispersed, and not often found in concentrated and economically exploitable forms, making extraction difficult and costly. As of 2009, the total amount of the world’s known rare metal reserves is estimated to be about 99 million tons, while annual production volume is limited to about 124,000 tons. China alone accounts for 96.8% of the world’s output of rare metals, which entails a heavy reliance for other countries on imports from a single nation.
Korea imports more than 95% of its needs for rare metals (except for a very few elements like nickel). With continuing supply shortfalls in rare earth elements, Japan depends almost entirely on overseas imports to smooth out its rare earth demand, which had increased threefold over the past ten years.

At the same time, China’s move towards resource weaponization of its mineral resources has further raised fears of supply instability, on top of existing rarity and uneven geographical distribution. In August 2009, the Chinese government reaffirmed its determination to reinforce existing management measures in the announcement of its “Directive on Strengthening the Management of Rare Earth Resources and Promoting the Healthy Development of the Rare Earth Industry.” Two months later, the Ministry of Industry and Information Technology promulgated and issued the “Rare Earth Industry Development Plan, 2009-2015” and “Rare Earth Industry Industrial Development Policy.” With the stated reasons being to advance its rare earth industry and to enhance enterprise-level improvements, China set rare earth export quotas for 2010 at 30,259 tons, only 60.3% of the previous year’s levels, stirring up global supply jitters and leading to the start of the current price boom. There was a more than threefold increase in international prices for key rare metals from 2002 to 2007. From 2009 onwards, however, prices have skyrocketed as ever-increasing demand driven by the global economic expansion has added to the global supply woes.

**The Competition for Rare Metal Procurement Grows Fiercer**

Competition for rare metal procurement has become fiercer because a stable supply of rare metals is directly related to the survival of major producing countries, as well as demand from global manufacturing enterprises that provide high-tech goods. The light weight, high performance and energy reduction abilities of rare metals are keys to the global competitiveness of future cutting-edge products. While the strategic value of rare metals is also growing at a fast pace in the political and diplomatic fields, the acquisition of rare earth elements, which are indispensable in military applications, including use in smart bombs, is associated with national security interests whose
importance goes beyond trade issues. In particular, rare earth elements have emerged as a key factor inciting territorial disputes in Northeast Asia, as exemplified by the latest Sino-Japanese tussle in the East China Sea. Dubbed by the Wall Street Journal as the most serious dispute between China and Japan in recent years,1 Beijing imposed an unofficial embargo on rare earth shipments to Japan after it detained a Chinese fishing trawler captain.

II. Korea’s Urban Mines

The Economic Value of Domestic Urban Mines is Worth at least 50 Trillion Won

“Urban mines” refers to the stock of metal resources in discarded electronic home appliances and industrial scrap and waste that can be recovered, hence “urban mining.” This term also includes related industries involving resource recovery and urban mining. Ferrous and non-ferrous metals as well as precious and rare metals found in collected waste are recyclable for reuse as production materials. While securing rare metals from overseas mines has become more difficult, tapping these urban mines is gaining new attention because urban mining can also reduce import dependency and contribute to environmental protection. In fact, some subsidiaries of large corporations have rushed to develop urban mines, as soaring rare metal prices after the global financial crisis make urban mining more economically viable.

Discarded metal resources in waste materials are referred to as “re-commercializable” metals through recycling. These reclaimed metals come from two sources: industrial waste generated by factories and industrial plants (scrap iron and steel, discarded machinery and equipment) and domestic waste from households (EOLed vehicles and obsolete cell phones, etc.). Based on the number of units distributed in 2010, the potential value of all discarded metal resources in Korea is estimated to be worth more than 50 trillion won. According to a press release, entitled “Measures for Discarded Metal Resource Recycling,” jointly issued by the relevant authorities, the estimated value of accumulated industrial waste amounts to about 30.4 trillion won, while industrial waste would bring in an additional 2.2 trillion won every year. The value of domestic waste as metal resources is also estimated to be approximately 20.3 trillion won, plus an annual extra 1.8 trillion won from household waste recycling. From obsolete electronic/electrical devices, the potential value of 10 different types of EPR-designated e-waste2 alone is about 3.8 trillion won. The recycling of end-of-life vehicles and scrap LCD panels is expected to generate potential value of 11.5 trillion and 32.54 billion won, respectively.

2 In Korea, the EPR (Extended Producer Responsibility) has been implemented since 2003. Essential to the EPR system is its mandate for manufacturers to take back and recycle their end-of-life products, with the imposition of substantial penalties for non-compliance.
Table 1. Economic Value of Discarded Metal Resources by Prod

<table>
<thead>
<tr>
<th>Classification</th>
<th>EPR-designated 10 Electronic/Electrical Devices</th>
<th>Automobiles</th>
<th>LCD Panels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Distributed Products (1,000 units)</td>
<td>185,627</td>
<td>18,129</td>
<td>13,890</td>
</tr>
<tr>
<td>Average Value per Unit (won)</td>
<td>20,787</td>
<td>635,982</td>
<td>2,450</td>
</tr>
<tr>
<td>Total Value (100 million won)</td>
<td>37,780</td>
<td>115,297</td>
<td>325</td>
</tr>
</tbody>
</table>


The Potential Value of Rare Metals Alone is Worth 2.8 Trillion Won

At the same time, the accumulation of rare metals in Korea’s urban mines is estimated to be at least 85,800 tons with a possible value of 2.8 trillion won. In the case of automobiles, which account for the largest portion of rare metals, the composition of rare metals recovered from cars is mostly broken down into chrome, manganese and nickel, all of which are essential inputs in the production of ordinary and special steel. Considering the current distribution of 1.813 million cars, there could be at least 82,000 tons of rare metals potentially worth 1.8 trillion won. In addition, a total of more than 38,000 tons of rare metals can be reclaimed from a dozen different types of electronic and electrical devices which contain about 20 different rare metals. Their economic value is believed to be 980.3 billion won.

These figures are drawn from indirect estimates that first examine the type and density of rare metals contained in those major products and then measure the content of rare metals per unit by total mass. For example, an LCD panel contains 344 grams of rare metals like titanium and manganese, whereas a typical mobile phone yields 11.5 grams of rare metals. As a next step, the potential value of rare metals extracted from such devices can be calculated on the basis of the average price of rare metals in 2011. A mobile phone, for example, has a high density of rare metals, but their economic value is low at 0.35 dollars because of low rare metal content per unit. When calculated as such, the total value of rare metals in the 12 types of electronic and electrical devices turns out to be 980.3 billion won. In particular, the four most widely distributed types for household use account for the largest proportion, with an estimated value of 793.2 billion won. If all electronic/electrical home appliances are included in addition to a dozen EPR-designated types, reclaimed rare metals will yield far greater value. However, such estimates are limited to those devices with accumulated statistics available.

3 The accumulated amount of rare metals will expand more than twofold once analysis is extended to all electronic/electrical items.
Table 2. Total Value of Rare Metals for Typical Products

<table>
<thead>
<tr>
<th>Classification</th>
<th>Electric/electronic Products Subject to EPR</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>General household electronics</td>
<td>Mobile phones</td>
<td>PCs (hard disk</td>
<td>Office equipment</td>
<td>Audio</td>
<td>Adaptors</td>
<td>LCD panels</td>
</tr>
<tr>
<td>Number of Items</td>
<td>8,929.1</td>
<td>7,249.5</td>
<td>1,384</td>
<td>645.2</td>
<td>354.9</td>
<td>9,415.5</td>
<td>1,389</td>
</tr>
<tr>
<td>Economic Value (100 million won)</td>
<td>7932.6</td>
<td>280.5</td>
<td>221.2</td>
<td>293.5</td>
<td>141</td>
<td>46.7</td>
<td>887.5</td>
</tr>
</tbody>
</table>


Expansion of the Rare Metals Market up to 33 Trillion Won by 2020

The value of rare metals, which stands now at 2.8 trillion won is likely to climb to at least 33.5 trillion won by 2020. This is because growing demand for high-tech products tends to increase the need for rare metals as an input for production. After the global financial crisis, there has actually been strong growth in demand for high-resolution visual displays, including LCD panels which contain a high concentration of rare metals with 5.3% per unit. In the automobile sector, which commands the majority of rare metal demand, a steady increase in the proportion of environmentally friendly cars has driven up the volume of rare metal consumption. Given these upward movements, the amount of rare metals used as critical input materials will likely increase more than 2.3 fold over the next ten years.

In the meantime, the objective reality of scarcity alone is sufficient to forecast a steady climb in rare metal prices. Even if the trend for the past three-years continues exactly as is, international prices for rare metals in 2020 will increase 2.6 times vis-à-vis 2011.4 Systemically, modification and reinforcement of resource recycling-related laws and regulations are most likely to help enhance national recycling rates for discarded metal resources. Accordingly, the potential value of discarded major resources can be expanded from the current estimate of 2.8 trillion won to over 33.5 trillion won in 2020.

III. Japan’s Urban Mines

Japan as a Nation of Urban Mines

Japan has a massive supply of world’s top metals in terms of reserve volume in the form of urban mines. In cash value, such urban mines amount to more than 40 trillion yen. Japan has so much it could rely on its urban mines alone to satisfy its average annual metal consumption for two or three years. In the case of base metals, Japan has large

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4 If the London Metal Exchange starts futures trading of rare metals in 2012, there is a possibility of a price surge on speculative trading in raw materials.
amounts of iron (1.2 billion tons), aluminum (600 million tons), and copper (380 million tons) in the form of urban mines. In rare metals, Japan’s reserves of indium, tantalum, and lithium are all ranked above 6th place in the world by reserve volume.

**Figure 2. Rare Metal Resources by Country**


**Government Recycling Policies and Recycling Businesses of Local Authorities and Private Companies**

In Japan, the Home Appliances Recycling Law (Law for Re-commercialization of Specific Kinds of Home Appliances) took effect in April 2001. According to this law, the recycling of key components and materials recovered from waste home appliances has taken off, and the collection of e-waste thrown away from households and offices began in full swing. With the volume of collected e-waste increasing, the re-commercialization of metals concomitantly rose from 66.5% in 2001 to 84% in 2008. Recently, through a supplementary budget for fiscal 2010, the Japanese government announced policy directions to ensure stable supplies of rare metals: recycling, development of alternative materials, reduction of usage and supply chain diversification.

In the case of urban mines, visible results have been made beyond collection to exporting through private-public cooperation between companies and local authorities which have set up a recycling system for rare metals. However, it is difficult to determine the exact scale of rare metals collected for recycling, because collection is mostly carried out by individual companies.
In the meantime, “in-company mines” where a company recovers rare metals from defective products ornew scrap generated during initial manufacturing and reuses them as production materials have become active. Yokohama Metal Co. appears to be a pioneer in recycling by extracting gold from discarded mobile phones. Shin-Etsu Chemical Co. meets 10% of its demand volume by collecting and recycling defective products and sheathing materials.

Table 3. Current Status of Recycling of Main Rare Metals

<table>
<thead>
<tr>
<th>Classification</th>
<th>Use (related prods)</th>
<th>Recycling Business</th>
<th>Amount Processed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nickel</td>
<td>Plating, catalysts (magnets, alloys)</td>
<td>Japan Recycling Center</td>
<td>300 tons a month</td>
</tr>
<tr>
<td>Chromium</td>
<td>Plating, special steel (aircraft, engines)</td>
<td>Nippon Denko, Nippon Chemical</td>
<td>Insignificant</td>
</tr>
<tr>
<td>Manganese</td>
<td>Deoxidants (vehicles, ships)</td>
<td>Toho Zinc, Mitsui Mining and Smelting</td>
<td>Insignificant</td>
</tr>
<tr>
<td>Cobalt</td>
<td>Polarizer, magnets (secondary batteries)</td>
<td>Metal Do</td>
<td>Scrap exports</td>
</tr>
<tr>
<td>Tungsten</td>
<td>Highways, superalloys (tools)</td>
<td>Yano Metals</td>
<td>1,000 tons a year</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>Catalysts, special steel (lighting)</td>
<td>Taiyo Koko, JFE Mineral</td>
<td>830 tons (2005)</td>
</tr>
<tr>
<td>Vanadium</td>
<td>Metal additives (ships, buildings)</td>
<td>Taiyo Koko, Sumitomo Metals</td>
<td>1,000 tons a year</td>
</tr>
</tbody>
</table>


IV. Implications

Most carmakers and electronic/electrical equipment manufacturers in Korea tend to use imported components and materials which contain rare metals rather than using rare metals as input materials in production of their finished goods. Hence, damage to the Korean economy caused by dwindling supplies has been limited. Since expansion of rare metal demand is inevitable however, the moves of supplying countries (particularly China, toward export restrictions and resource weaponization are likely to negatively affect the Korean economy. When Japanese companies, as major component suppliers, reflect increased rare metal prices in their parts prices, import price growth in components and materials will put pressure on profits for Korean companies.

Preparing for Supply Instability through Urban Mines

At present, 95% of Korea’s demand for rare metals is dependent on imports and the value of its total imports has shown an upward trend, with an average annual increase of 25%. In contrast, the entire amount of rare metals which can be extracted from Korea’s urban mines is equivalent to 12.3 times its total import volume in 2010. In view of current recycling rates for rare metals, however, stable supplies through urban mines do not look particularly promising. Nevertheless, a system of urban mines is expected to act as a cushion against abrupt supply disruptions that could occur in times of natural disasters or geopolitical conflicts.
To maximize the potential value of rare metals with an estimated worth of about 33 trillion won, priority should be given to the investigation and removal of obstacles standing in the way of industry development. The government should also secure Korea’s urban mine stock of discarded resources by modifying recycling-related laws and reinforcing export restrictions on discarded resources. In the case of industrial waste, metals (excluding ferrous and non-ferrous metals) end up overseas or in landfills due to the lack of recycling technologies. The number of exported used cars, for instance, rose from 123,000 to 239,000 during the period 2003 to 2010. In this regard, it is necessary to impose restrictions on the indiscriminate export of discarded resources shipped overseas. Consideration needs to be made for measures to selectively reserve discarded resources if extraction of rare metals, which is not possible with current recycling technologies, becomes possible in the near future.

**Private-Public Cooperation and Selection and Concentration**

As an advanced technology business, urban mining needs a system of role sharing and mutual cooperation between the government and companies in core technologies and types of rare metals. The government should concentrate its R&D investment in metals which have no accumulated technology at all, or for which commercialization is difficult, as technology development has not yet started. On the part of companies, efforts should be focused on rare metals for which development of commercialization technology has been completed up to a certain level, in order to enhance purity and develop substitution technologies. Companies should cooperate on technology development and innovation as well as on building a collection infrastructure, with the perspective of investing in promising future industries on terms other than immediate economic feasibility.5

In the future, the expansion of rare metal recycling is likely to be led by automobiles, LEDs, small household electronics and general home appliances, due to their huge volumes and easy extraction of metals in the context of urban mines. By component, secondary batteries and circuit boards contained in small household electronics are known to have high recycling efficiency rates in terms of volume and difficulty of extraction. Selection and concentration, therefore, should make the best use of these resources.

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5 In particular, those companies manufacturing new growth industry products should also consider vertical integration through internalization of the related materials sector.