A calculation of metal consumption toward 2100

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Consumption of metals is calculated toward 2100 with simple assumption. The assumption is reflected by the fact that the world average GDP per person has reached $10,000. The average level of $10,000 of GDP per person of a country means that metal consumption per person of the country also reaches the level of developed country. Many influential developing countries will reach $10,000 GDP per person by 2050, and almost all of countries in the world will reach it by the end of this century. The consumption of metal at 2100 is calculated by the assumption that all country will consume metals with the same level of current developed countries. A linear developing model toward 2100 gives accumulated consumption by 2100. The vested reserve amounts are also allocated in the linear model. The required rates of recycling are amazingly great. The prompt shift for the circular economy is required.
Several times amount of resources will be required by 2050.

It will be close to the amount of reserve by 2050: Fe, Mo, W, Co, Pt, Pd

It will require several times amount of reserve by 2050: Ni, Mn, Li, In, Ga

It will run over the amount of reserve base by 2050: Cu, Pb, Zn, Au, Ag, Sn

Accumulated consumption from 2000 to 2050

My earlier work at 2005

Already mined
A prediction of consumption was studied with use of the relation between *GDP/capita* and amount of *consumption / capita*.
Fig. 1 GDP per capita at each country predicted by Goldman Sachs
Prices have changed more drastically.

Not linear, Logarithmic scale

Maximum peak of Nd was 60 times

Co keeps nearly two times of price
We had three peaks of prices during the former century. After the peak, prices shifted to higher levels. Now, there is an oil shock.
These 15 years was turbulent fifteen years for strategic metals Co and Ti has grown to 3 times.

Li, Mn, Si, Mo, Mg, Nr, Fe nearly 2 times or more. Only Sr has decreased.

Excluding hazardous substances, it had taken 36 years for Fe to be produces double until 2000.
Fig.1 meta production index (1945base)
Change of annual consumption of metals from 1999 to 2009

Resource issue is no longer the issue of the next generation but that of our generation.

Au in cell phone has decreased into 1/3

Thickness of HDD Magnet decreased 1/5

Now, we have to design products with considering resource constraint.
What has changed?

The world average GDP / person has reached $10,000.
Almost metals consumption have developed linearly to GDP/capita until now.
There are some exceptions. They had reached independent level of consumption per person.
Fe consumption / capita v.s. GDP/ capita from 1994 to 2014

$10,000 /capita

Exporting countries

Consuming countries

Developed level
Almost of prepotent countries will north of $10,000 / capita in 2030.

We will reach 10 billions’ universal economy in this century, and we at the entrance now.
Rough forecast gets to be simpler, (population) x (developed consumption level)

Every country reaches developed level of consumption per capita

Consumption prediction with concerning only prepotent countries

<table>
<thead>
<tr>
<th>metal</th>
<th>Fe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumption/year at 10Gperson world</td>
<td>4.5Gton/year</td>
</tr>
<tr>
<td>Reserve</td>
<td>87Gton</td>
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</table>
Estimated demand up to 2100 v.s. current reserve amount
Are the reserves enough for the 10 billions’ universal economy?

<table>
<thead>
<tr>
<th>metal</th>
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<th>Cu</th>
<th>Co</th>
</tr>
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<tbody>
<tr>
<td>Consumption/year at 10Gperson world</td>
<td>4.5Gton/year</td>
<td>90Mt/year</td>
<td>224kt/year</td>
</tr>
<tr>
<td>Reserve</td>
<td>87Gton</td>
<td>700Mt</td>
<td>7.2Mt</td>
</tr>
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19 years  8 years  32 years

It is said that reserve increase when the price rises.

Prices had risen in these dozen of years.
How are reserves?
Transition of reserve and price of metals

It looks like soaring trend, but
Reserve ratio to annual consumption is decreasing
Price could not raise up the ratio of 
(resource amount) / 
(annual consumption)
What can solve it?
The circulation society must be promoted from right now.

Estimated accumulated consumptions till 2100 with simple assumption of linear growth

Accumulated consumption

Fe
257Gt

87Gt

1.34Gt

0.2Gt

2012

2100

Suppliable with natural reserve

Cu
4.84Gt

20Mt

6Mt

2012

2100

Should be supplied by recycling

Co
14.4Mt

7.2Mt

103kt

224kt

2012

2100

700Mt

73%

98%

81%

81%

98%

73%
Circular Economy is inevitable

Source: Own representation, P ten Brink, P Razzini, S. Withana and E. van Dijl (IEEP), 2014
Difference of Circular Economy (CE) from Japanese 循環型社会 (3R)

<table>
<thead>
<tr>
<th></th>
<th>3R</th>
<th>CE</th>
</tr>
</thead>
<tbody>
<tr>
<td>aim</td>
<td>Reduction of final disposal (output oriented)</td>
<td>Improvement of Resource Efficiency (input oriented)</td>
</tr>
<tr>
<td>benefit</td>
<td>Reduction of extra economic burden of the society</td>
<td>Creation for new business different from mass consumption</td>
</tr>
<tr>
<td>measure</td>
<td>Recovery of secondary raw material</td>
<td>Multiple utilization of EoF products</td>
</tr>
<tr>
<td>EoF products</td>
<td>Subjects to be recycled as raw material</td>
<td>Subjects to be used again.</td>
</tr>
<tr>
<td>Economic entity</td>
<td>Recyclers, mining company</td>
<td>Service suppliers, SME producers</td>
</tr>
<tr>
<td>motivation</td>
<td>Social responsibility</td>
<td>Add-value toward sustainability</td>
</tr>
</tbody>
</table>
Different circulation society of EU from JP

Japanese circulation society

- Produce
- Recycler

Share of roles to decrease waste

EU’s Circular Economy

- EU produce
- EU consume
- EU recycle
- EU provider

Various circulation business

Business chance in circulation from viewpoint of sustainable consumption

Arranged the outer ward of material circulation in the society

Create multiple inner route of gods circulation in the society

⇐ material tax
⇐ harmful substance free as EPR
In the ubi-culation society, circulated goods have higher add-value of sustainability, which brings new economical activity.
Urban mined Gold metal will be a symbol that recycling has higher added-value for sustainability

Thank you!