# A calculation of metal consumption toward 2100

Kohmei HALADA

NIMS

# A calculation of metal consumption toward 2100

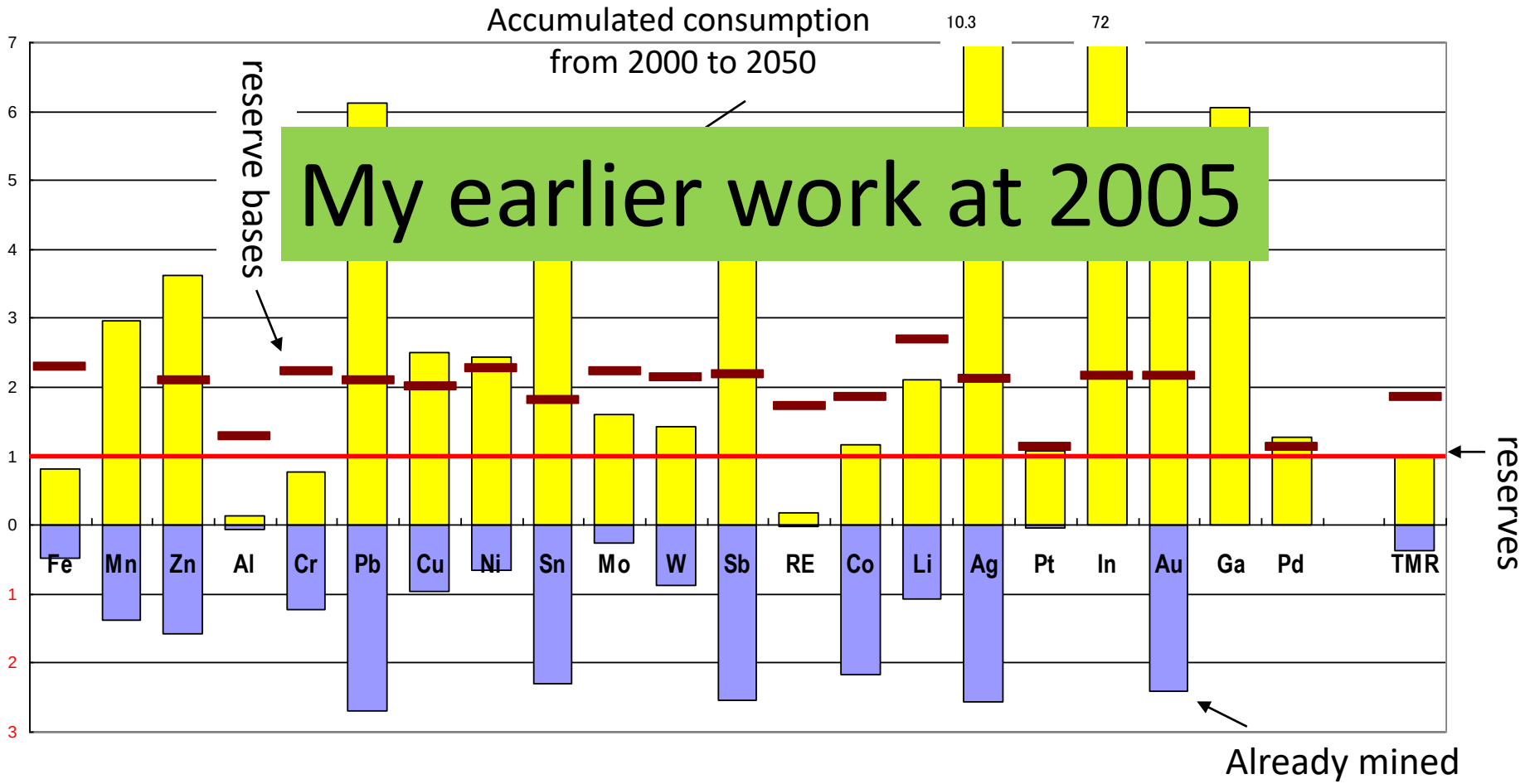
Consumption of metals is calculated toward 2100 with simple assumption. The assumption is reflected by the fact that the world average GDP per person has reached $10,000. The average level of $10,000 of GDP per person of a country means that metal consumption per person of the country also reaches the level of developed country. Many influential developing countries will reach $ 10,000 GDP per person by 2050, and Almost 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.

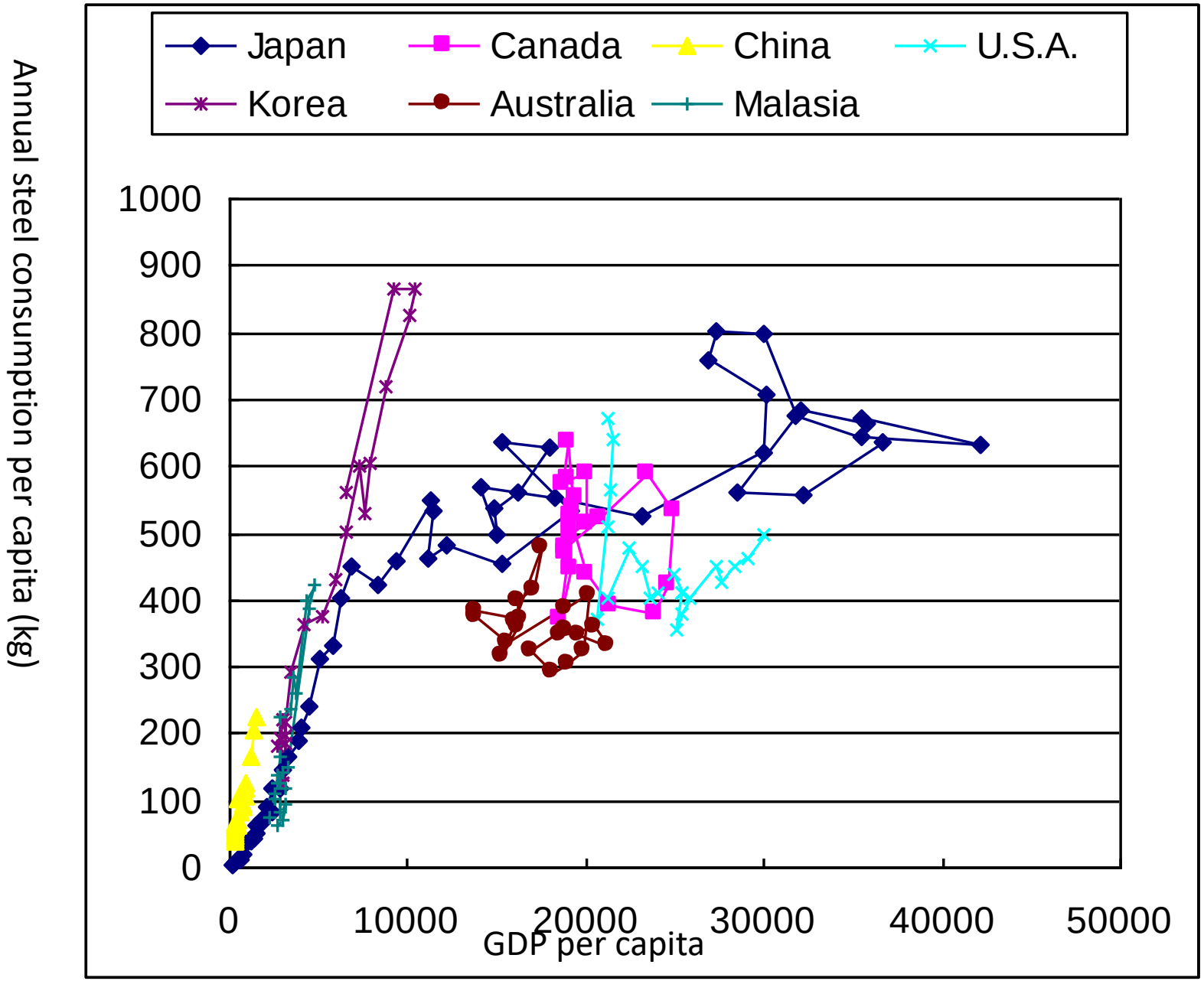
It will be close to the amount of reserve by 2050: Fe,Mo,W,Co,Pt,Pd

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



A prediction of consumption was studied with use of the relation between **GDP/capita** and amount of **consumption / capita**



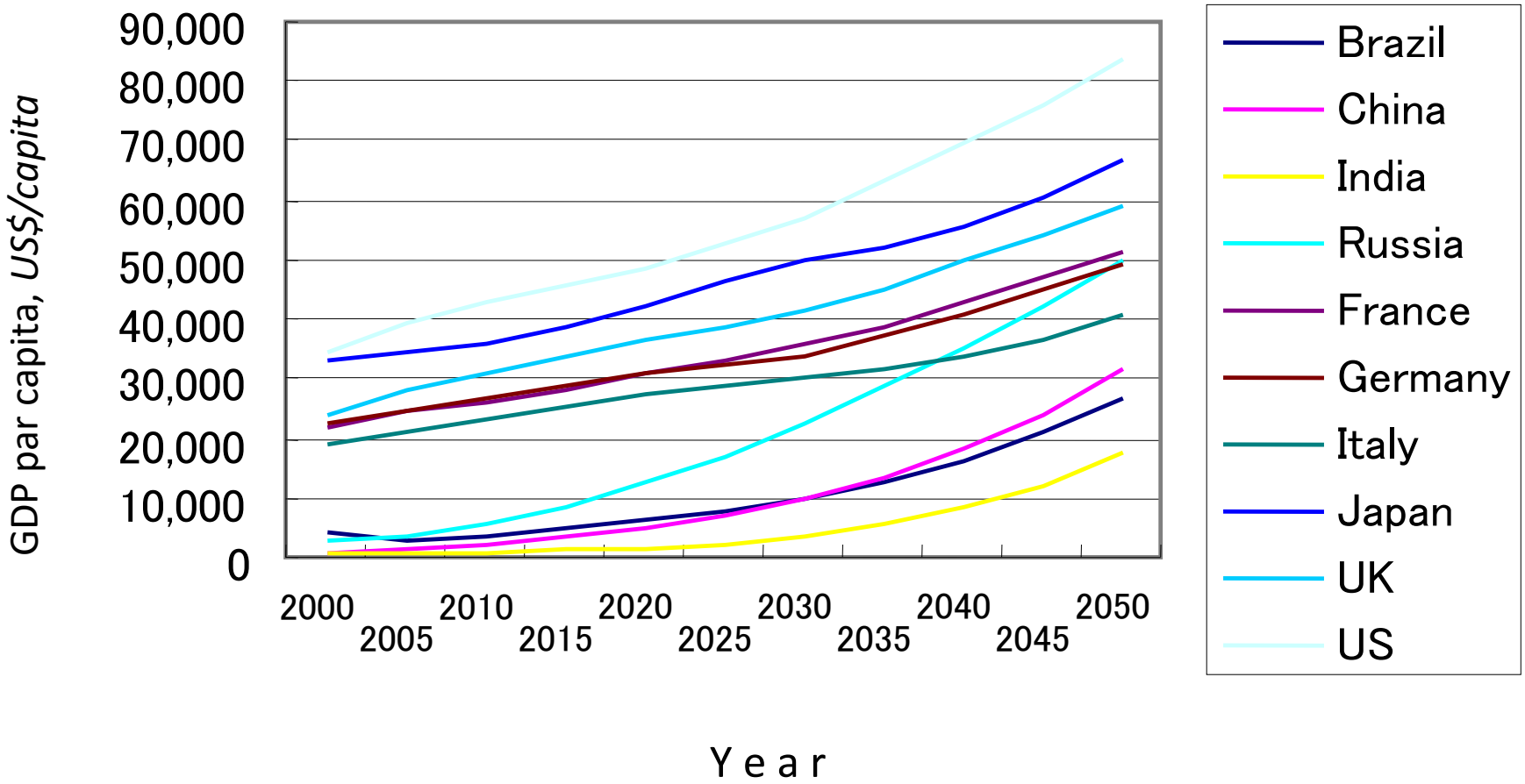
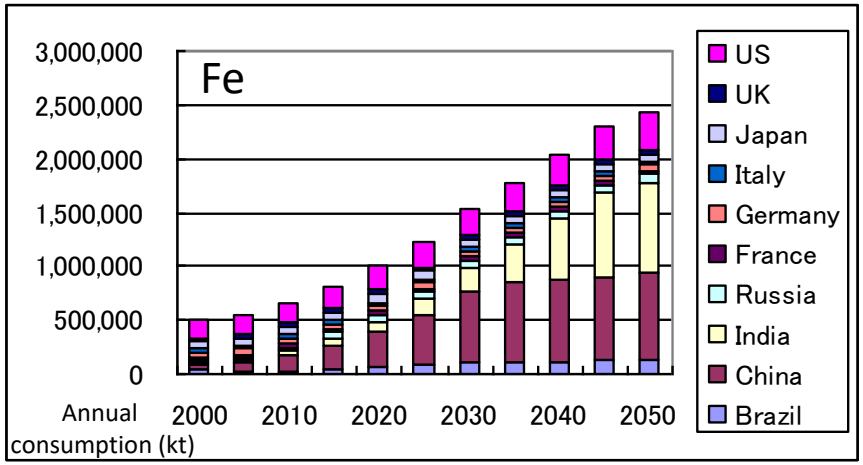
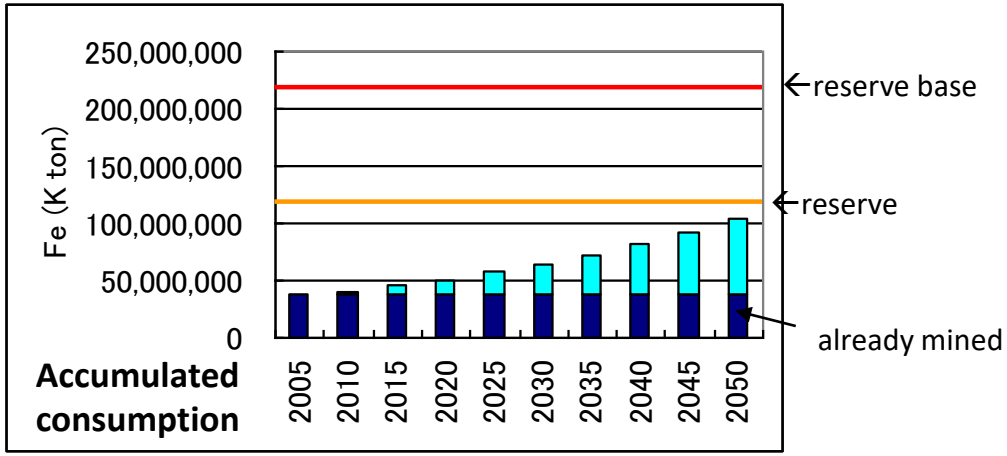
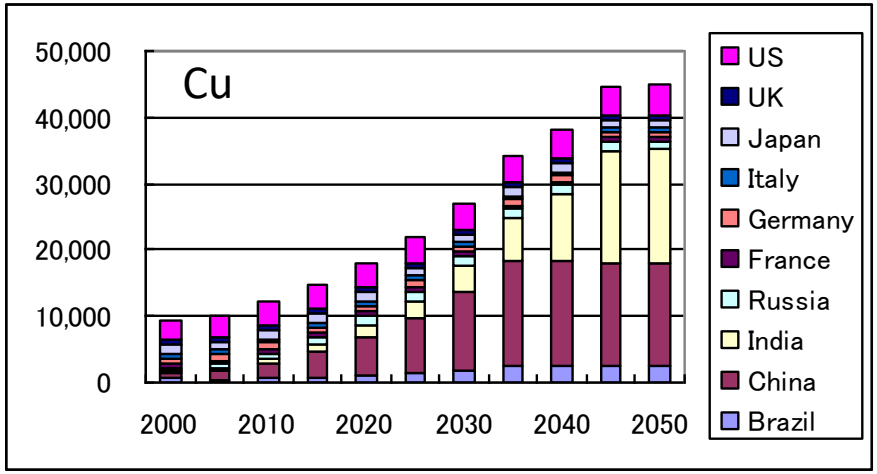
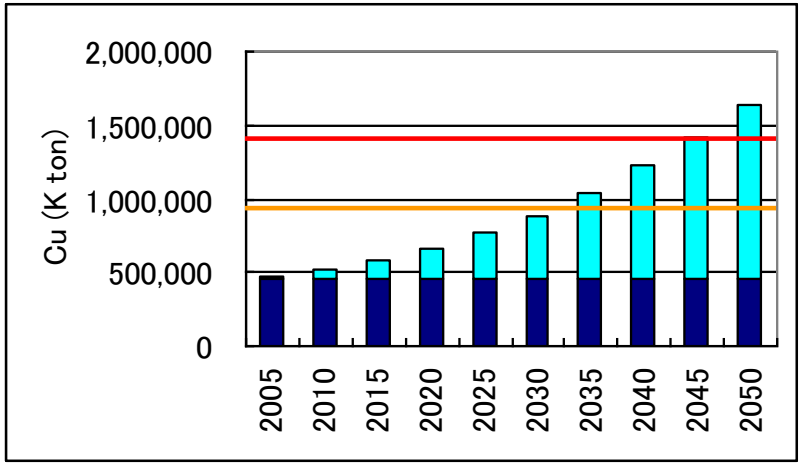


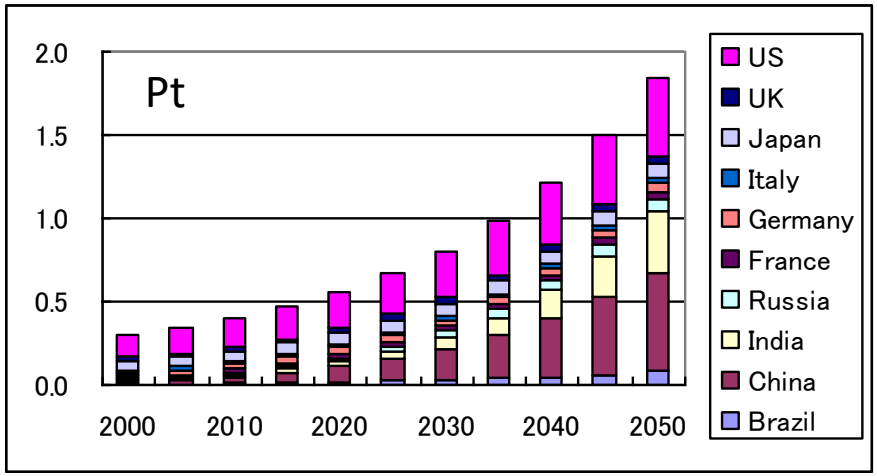

Fig. 1 GDP per capita at each country predicted by Goldman Sachs

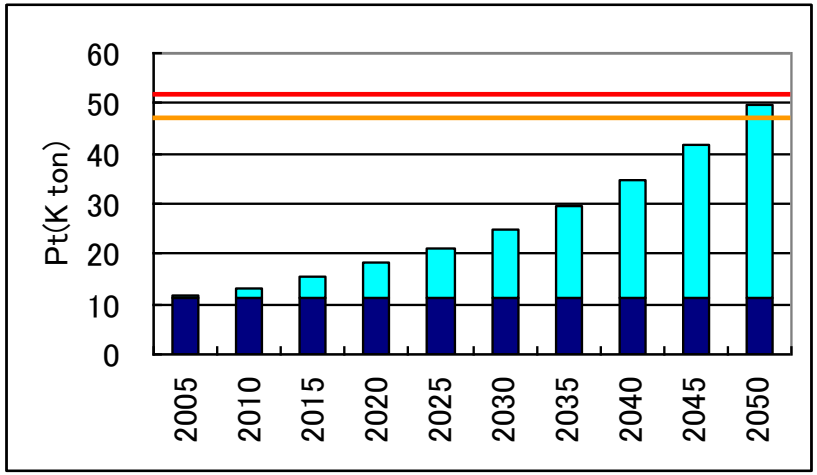

Fe
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
Annual consumption (kt)
2000
2010
2020
2030
2040
2050
US
UK
Japan
Italy
Germany
France
Russia
India
China
Brazil

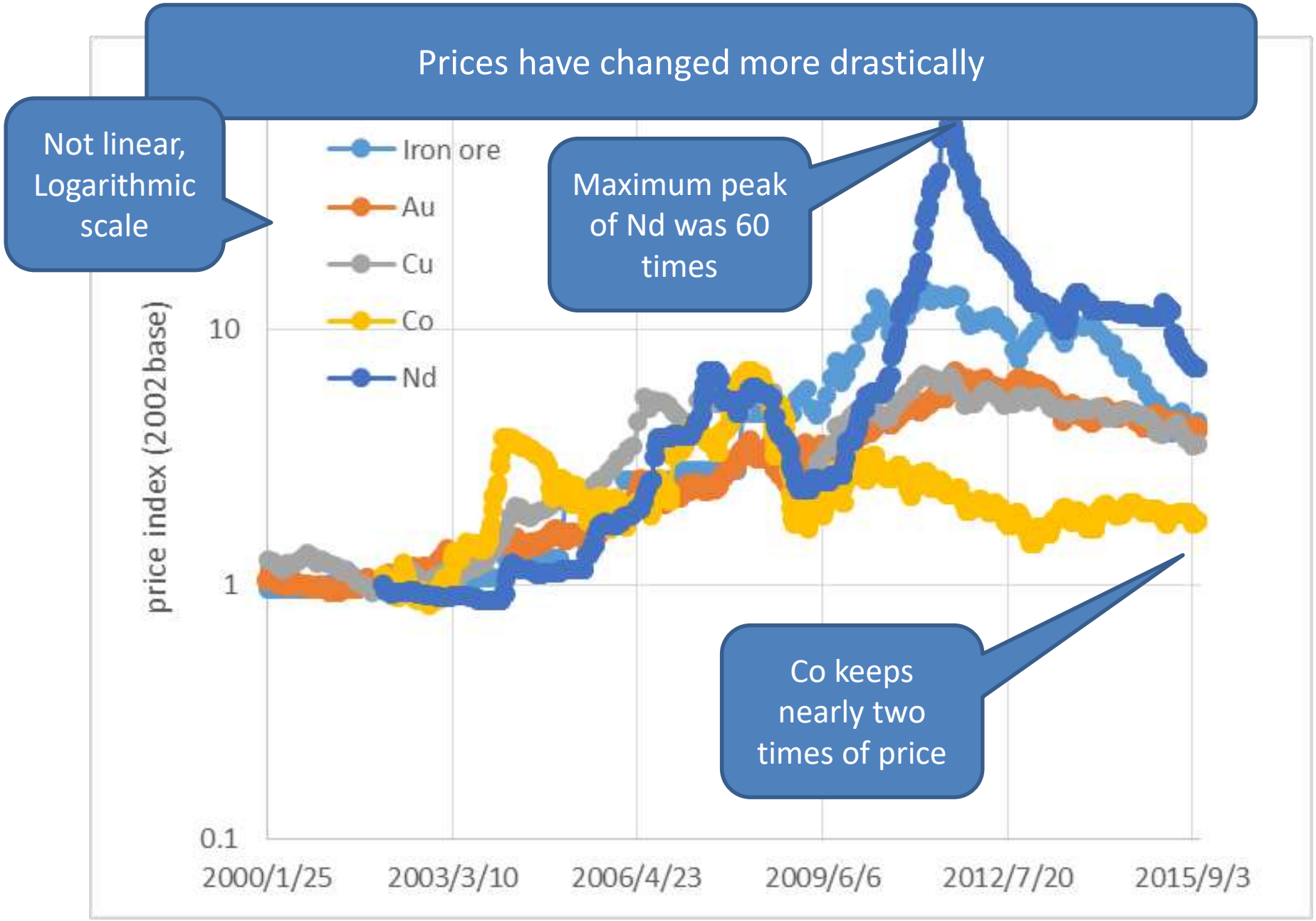

250,000,000
200,000,000
150,000,000
100,000,000
50,000,000
0
Fe (K ton)
Accumulated consumption
2005
2010
2015
2020
2025
2030
2035
2040
2045
2050
reserve base
reserve
already mined

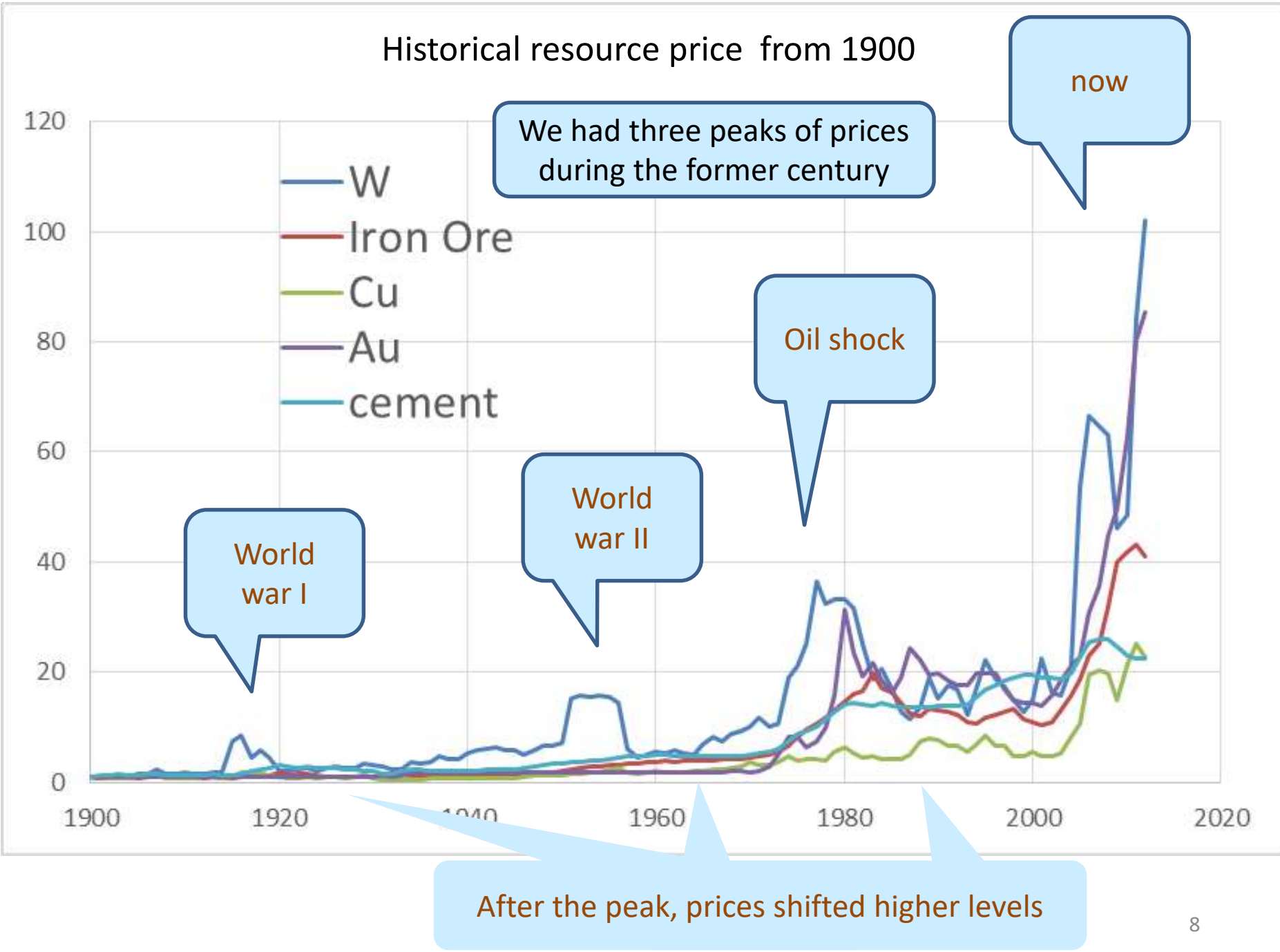

Cu
50,000
40,000
30,000
20,000
10,000
0
2000
2010
2020
2030
2040
2050
US
UK
Japan
Italy
Germany
France
Russia
India
China
Brazil

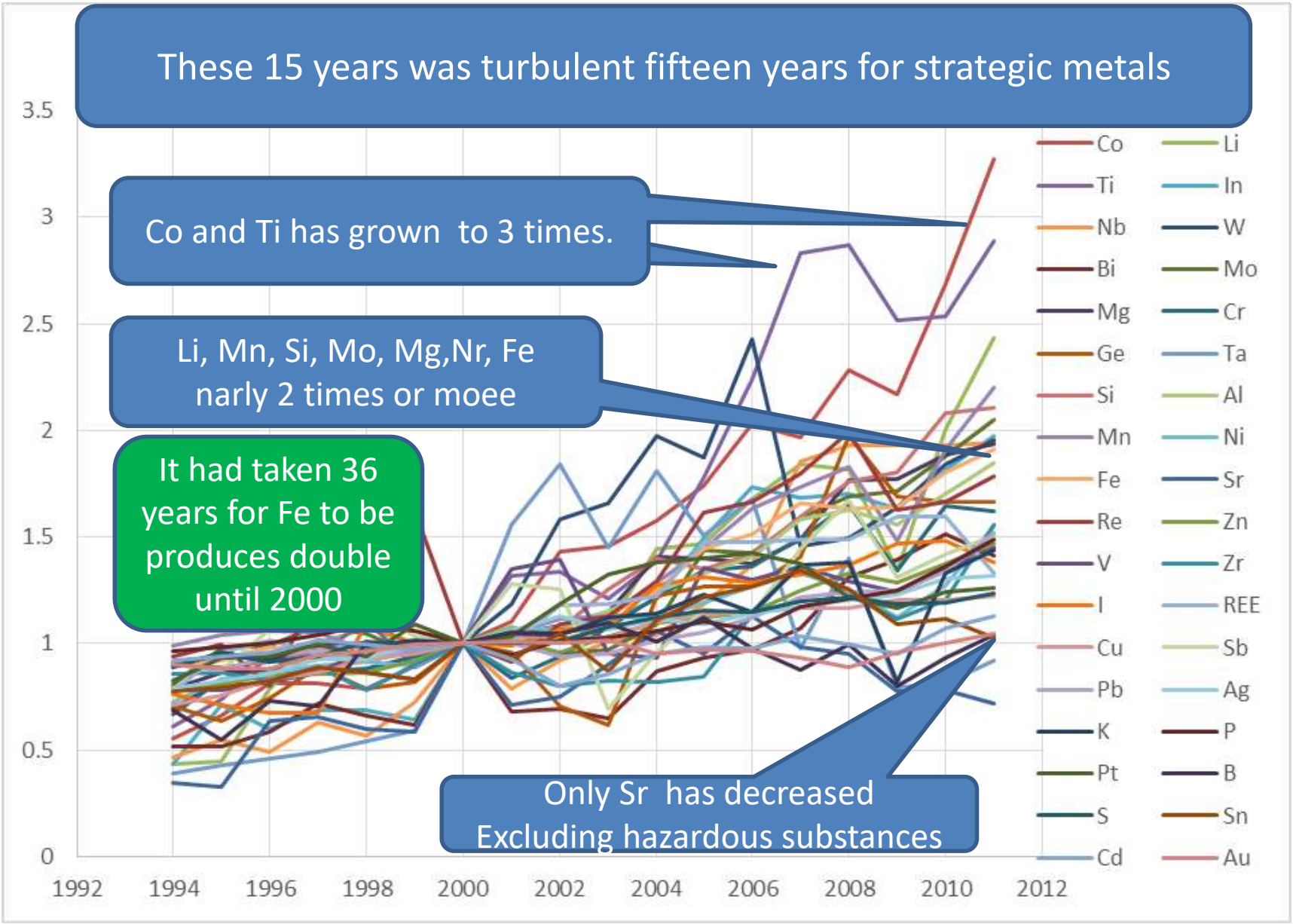

2,000,000
1,500,000
1,000,000
500,000
0
Cu (K ton)
2005
2010
2015
2020
2025
2030
2035
2040
2045
2050


Pt
2.0
1.5
1.0
0.5
0.0
2000
2010
2020
2030
2040
2050
US
UK
Japan
Italy
Germany
France
Russia
India
China
Brazil


60
50
40
30
20
10
0
Pt(K ton)
2005
2010
2015
2020
2025
2030
2035
2040
2045
2050


Prices have changed more drastically
Not linear, Logarithmic scale
Maximum peak of Nd was 60 times
Co keeps nearly two times of price
Iron ore
Au
Cu
Co
Nd
price index (2002base)
10
1
0.1
2000/1/25
2003/3/10
2006/4/23
2009/6/6
2012/7/20
2015/9/3


Historical resource price from 1900
now
We had three peaks of prices during the former century
W
Iron Ore
Cu
Au
cement
Oil shock
World war II
World war I
120
100
80
60
40
20
0
1900
1920
1960
1980
2000
2020
After the peak, prices shifted higher levels


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
narly 2 times or moee
It had taken 36
years for Fe to be
produces double
until 2000
Only Sr has decreased
Excluding hazardous substances
3.5
3
2.5
2
1.5
1
0.5
0
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
Co
Li
Ti
In
Nb
W
Bi
Mo
Mg
Cr
Ge
Ta
Si
Al
Mn
Ni
Fe
Sr
Re
Zn
V
Zr
I
REE
Cu
Sb
Pb
Ag
K
P
Pt
B
S
Sn
Cd
Au

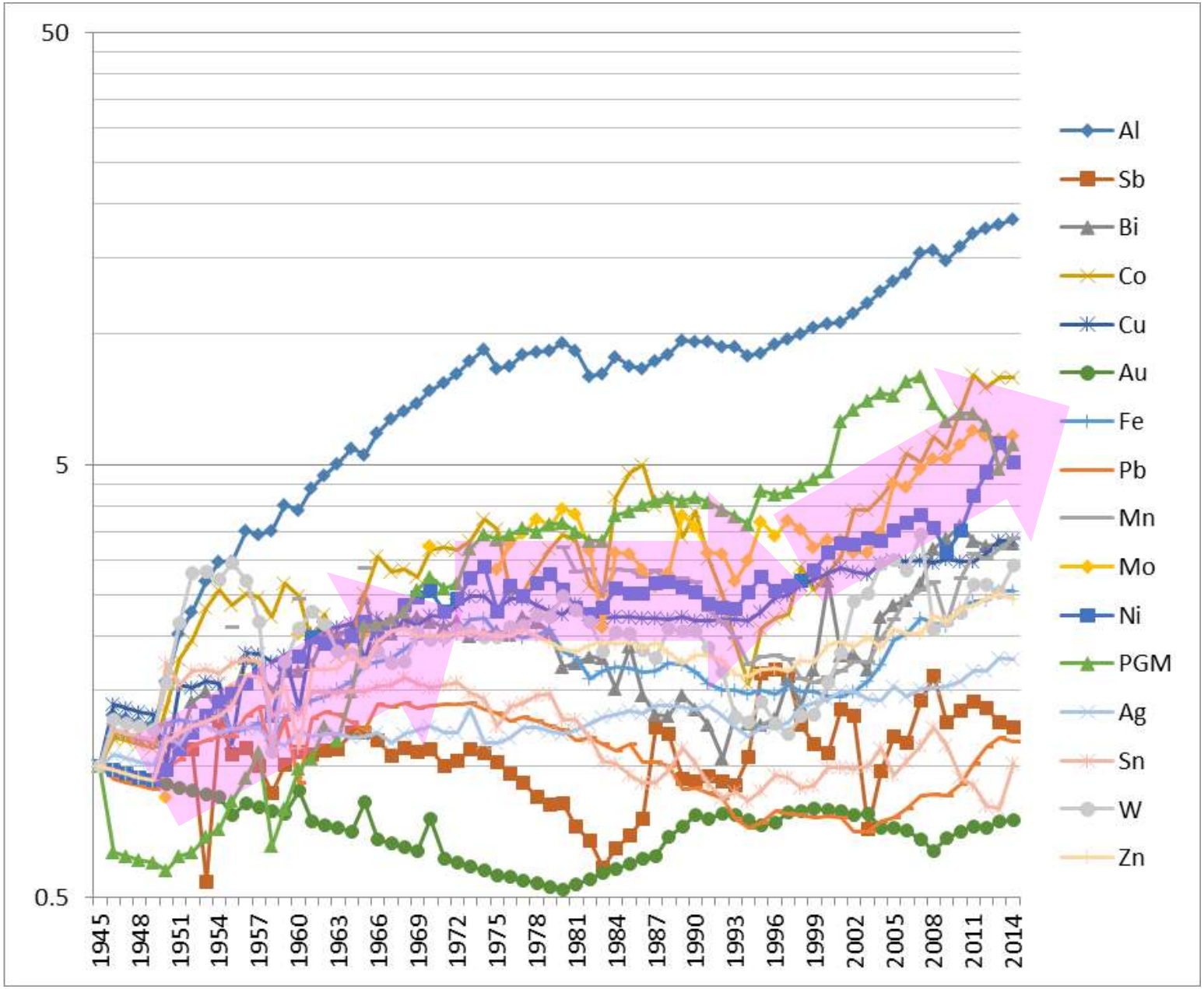
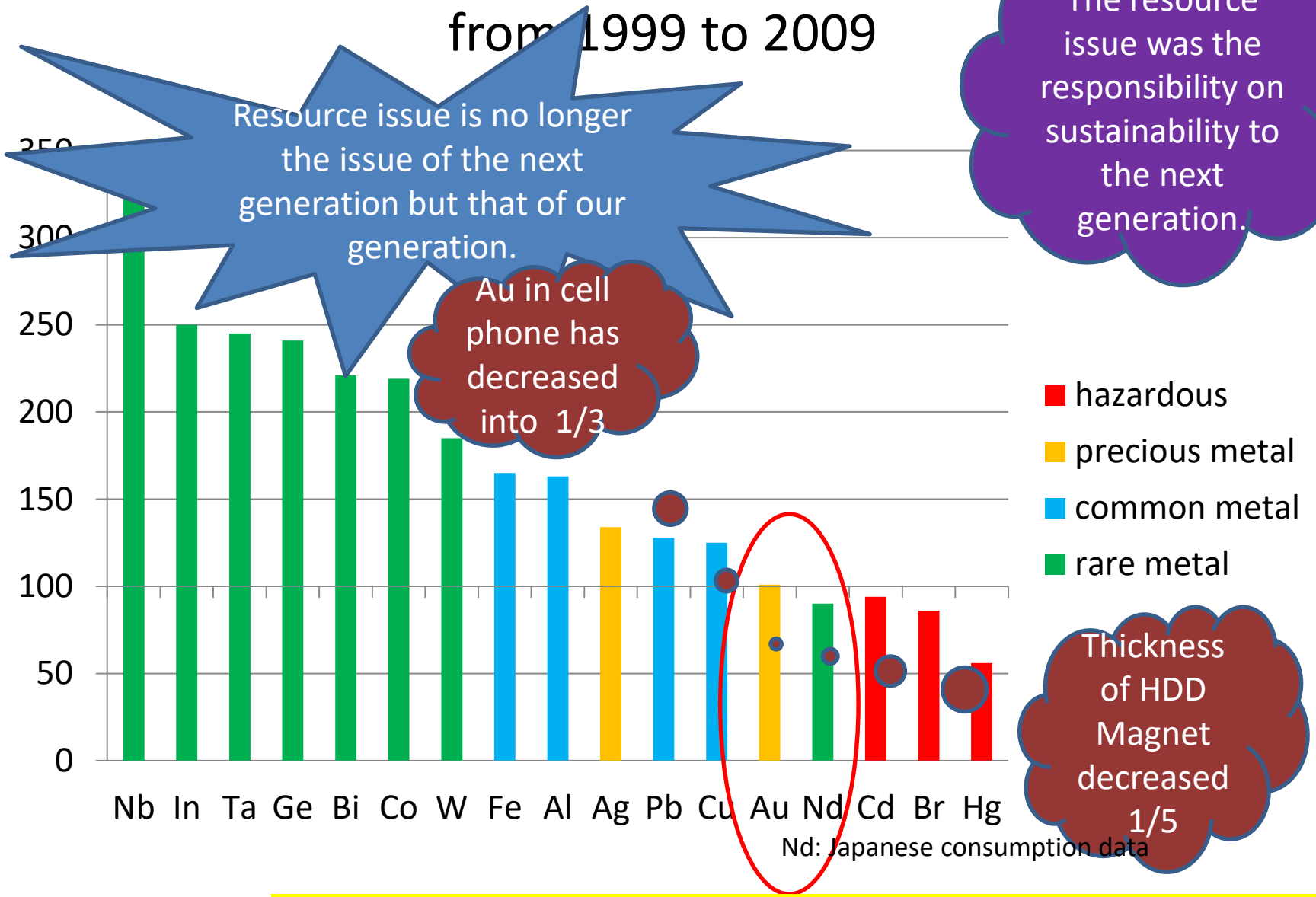


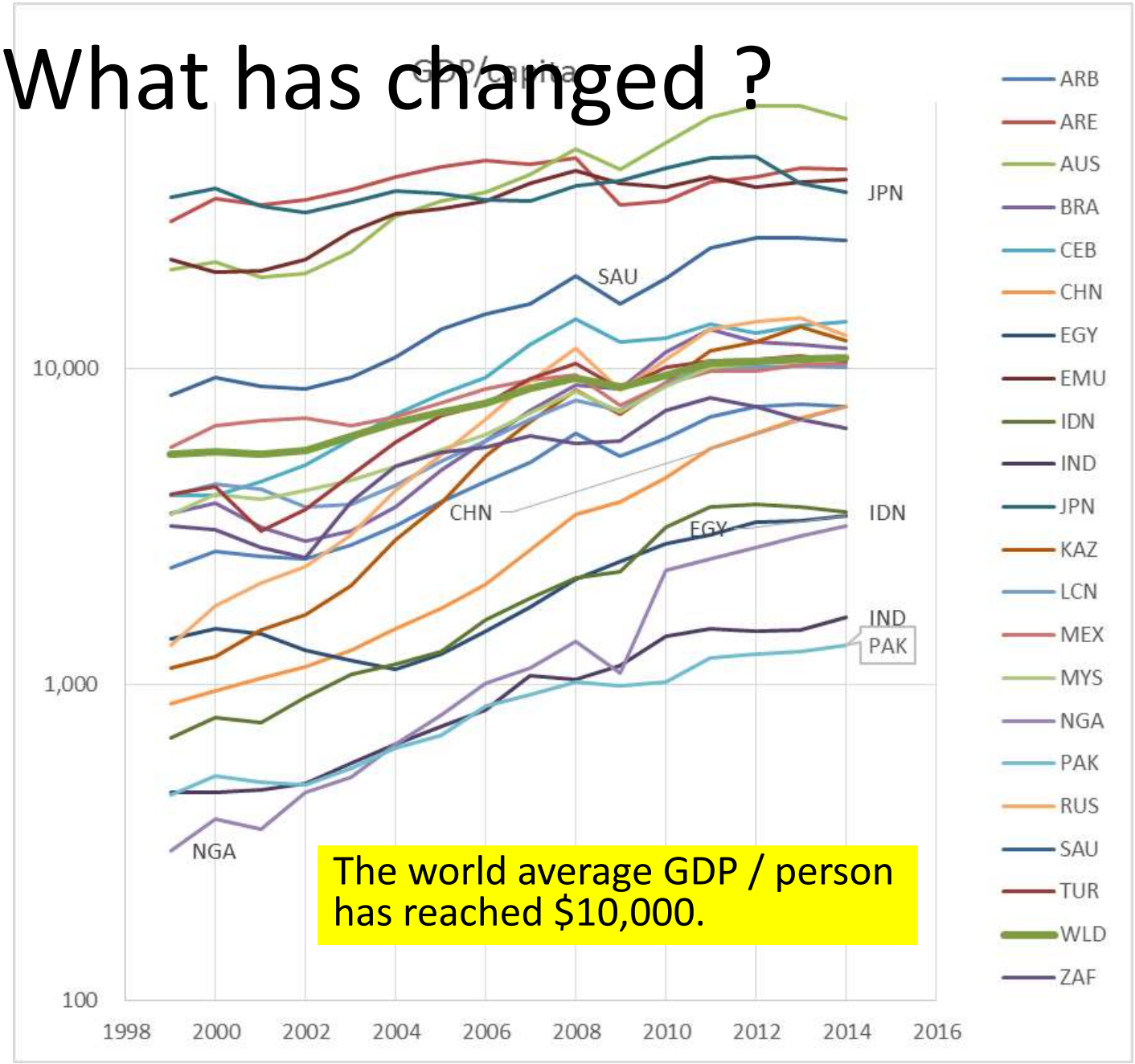

**Fig.1 meta production index (1945base)**

# Change of annual consumption of m
# from 1999 to 2009

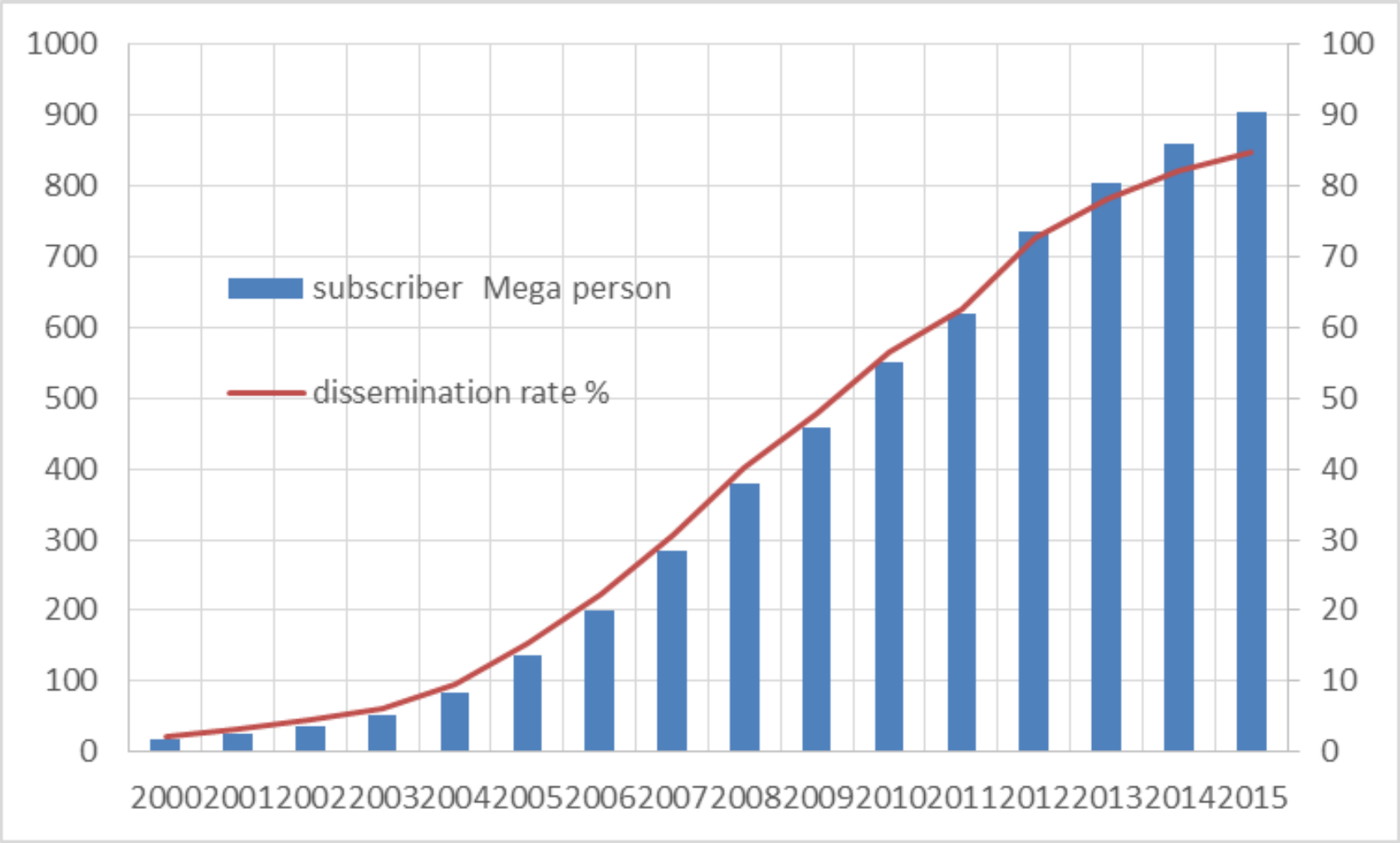



Now, we have to design products with considering resource constraint.

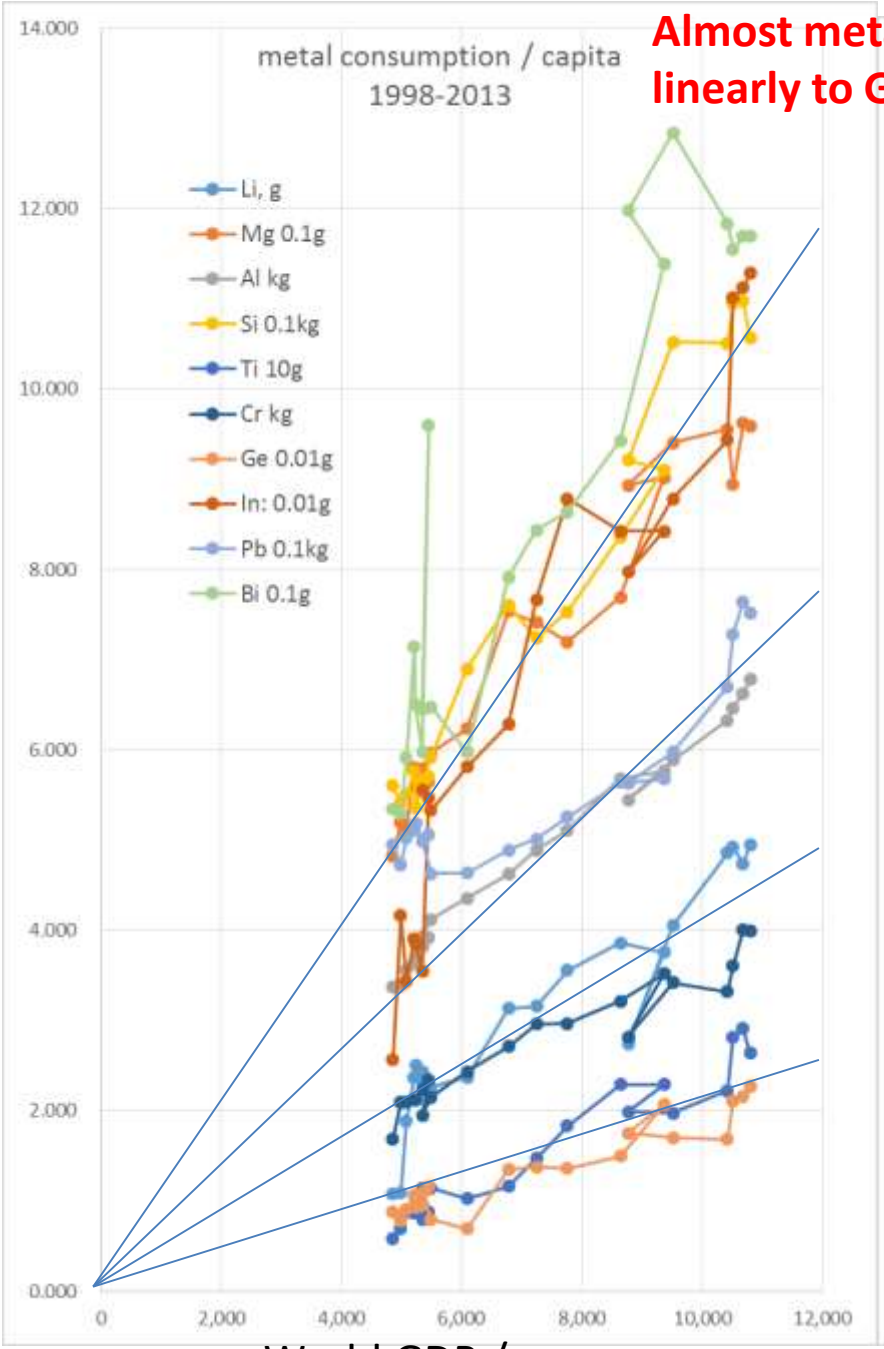
# What has changed ?

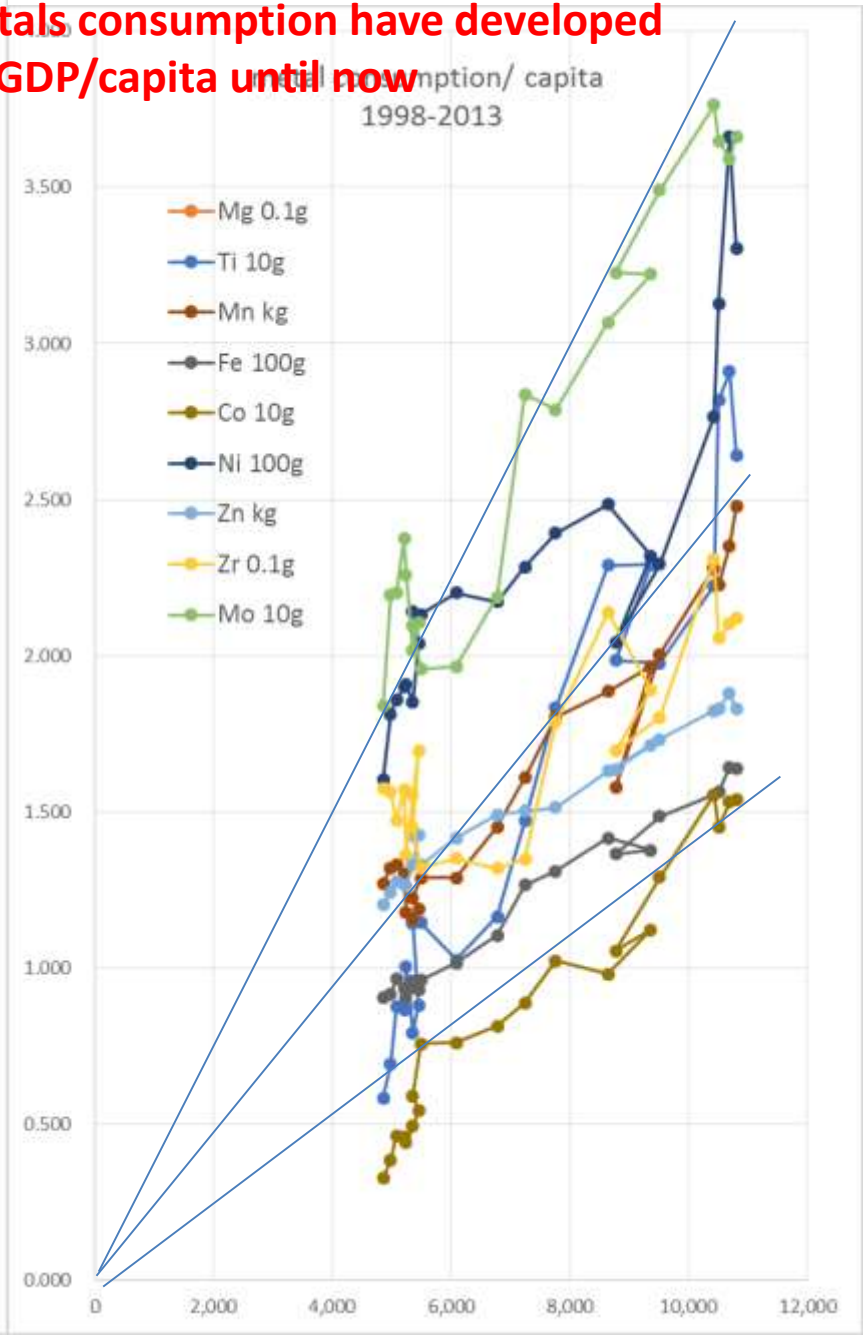



The world average GDP / person has reached $10,000.

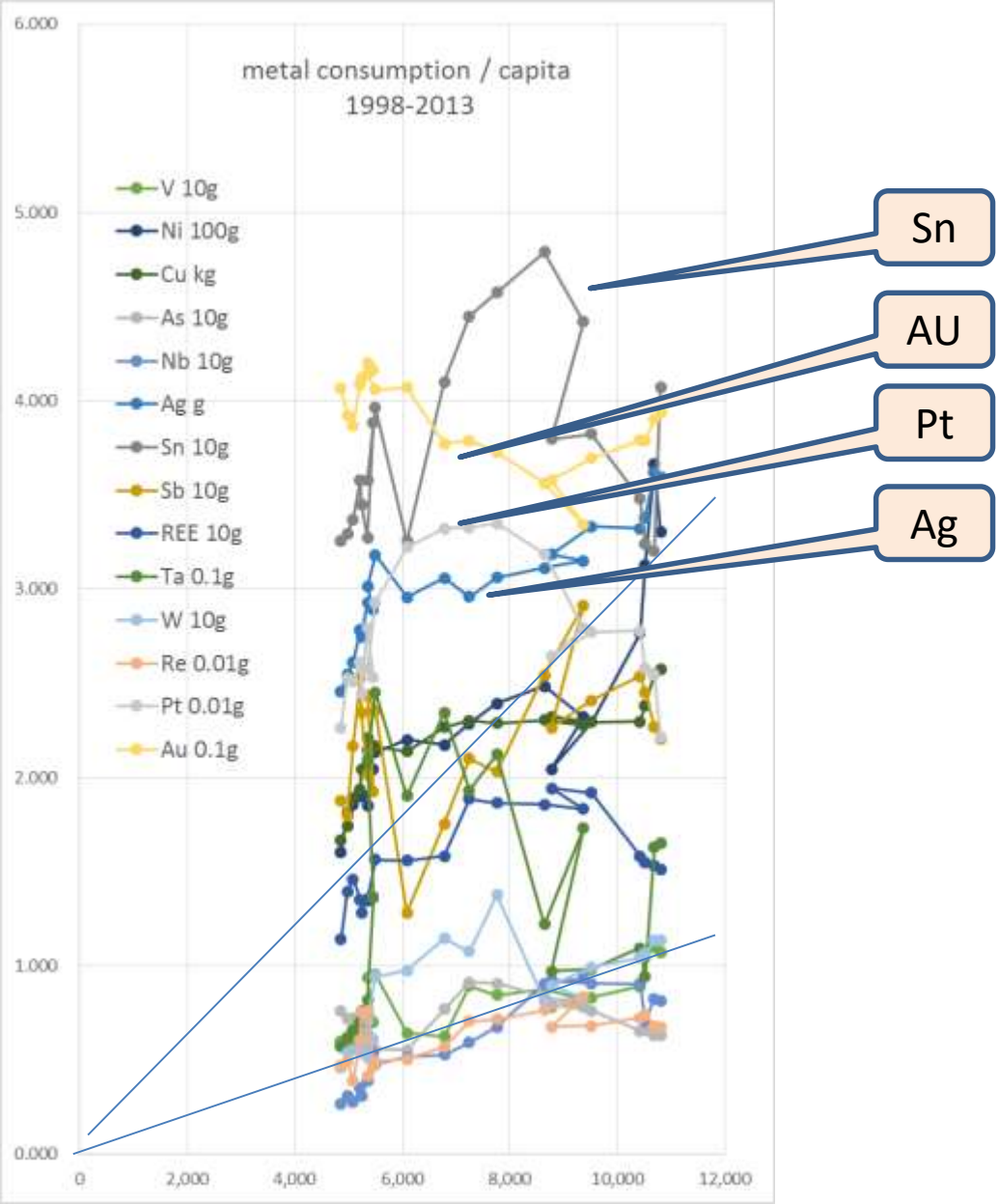

1000
900
800
700
600
500
400
300
200
100
0
100
90
80
70
60
50
40
30
20
10
0
subscriber Mega person
dissemination rate %
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015

**Almost metals consumption have developed linearly to GDP/capita until now**



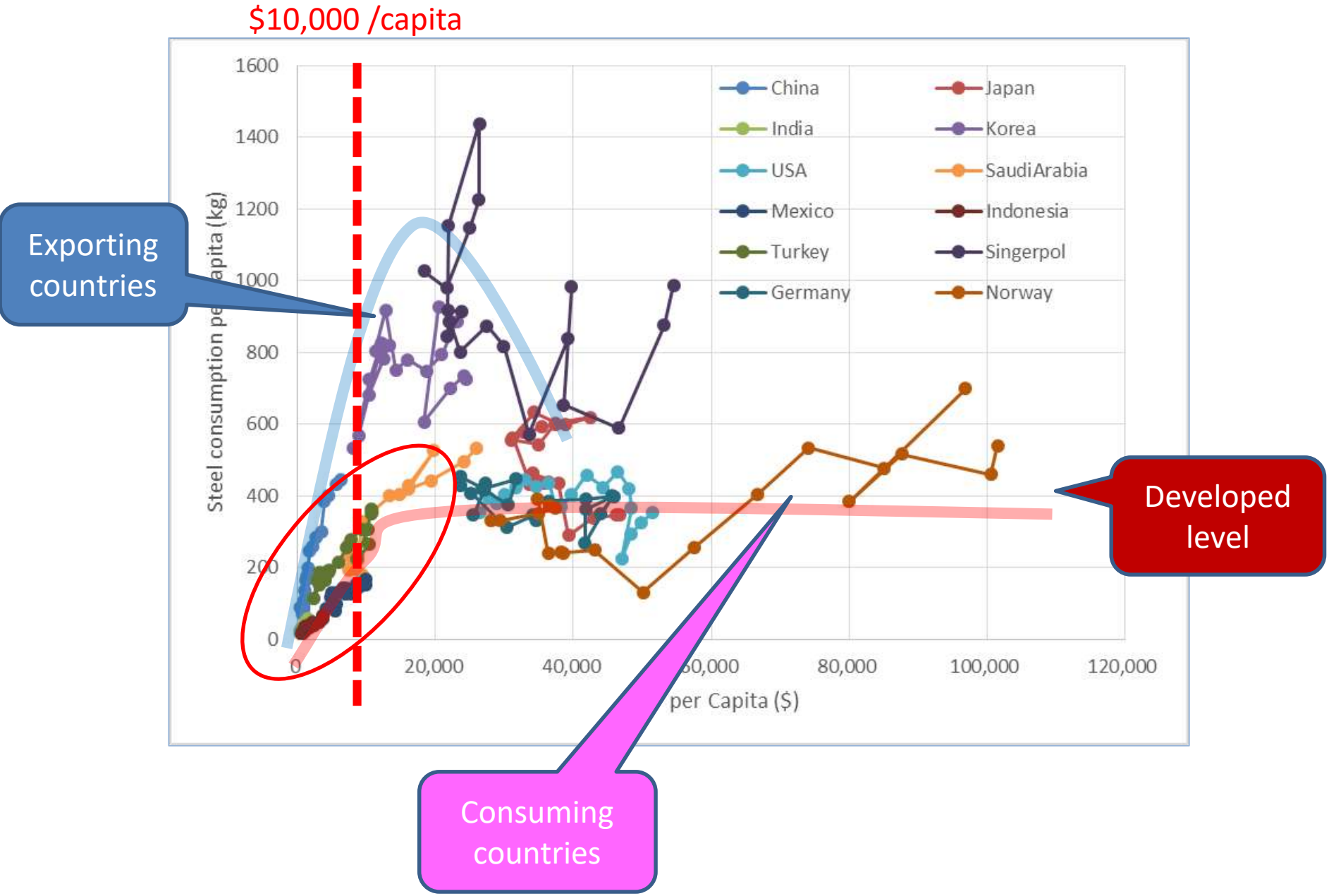



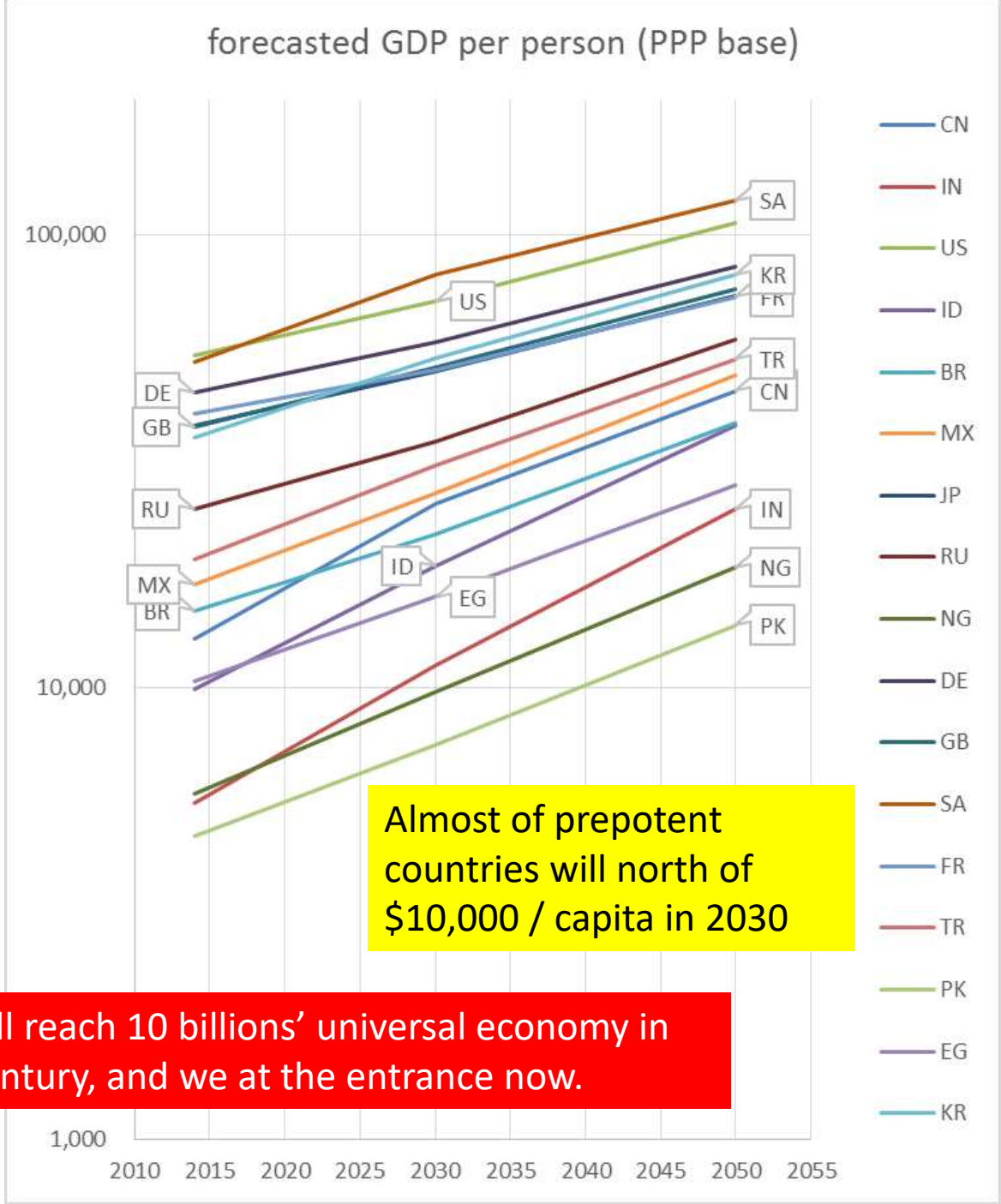

World GDP / person




There are some exceptions.
They had reached independent level of consumption per person

Fe consumption / capita v.s. GDP/ capita from 1994 to 2014





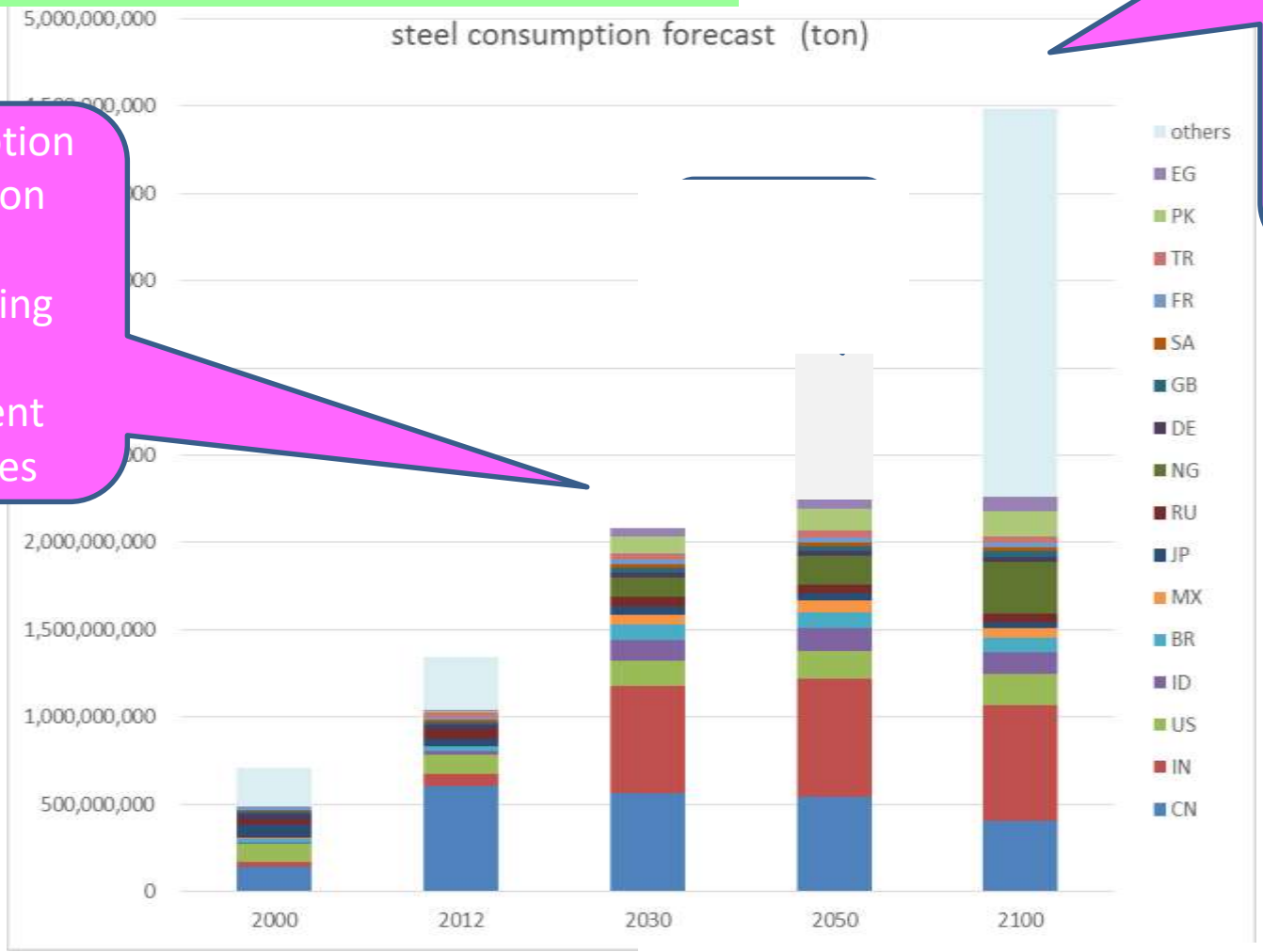

Almost of prepotent countries will north of $10,000 / capita in 2030

We will reach 10 billions' universal economy in this century, and we at the entrance now.

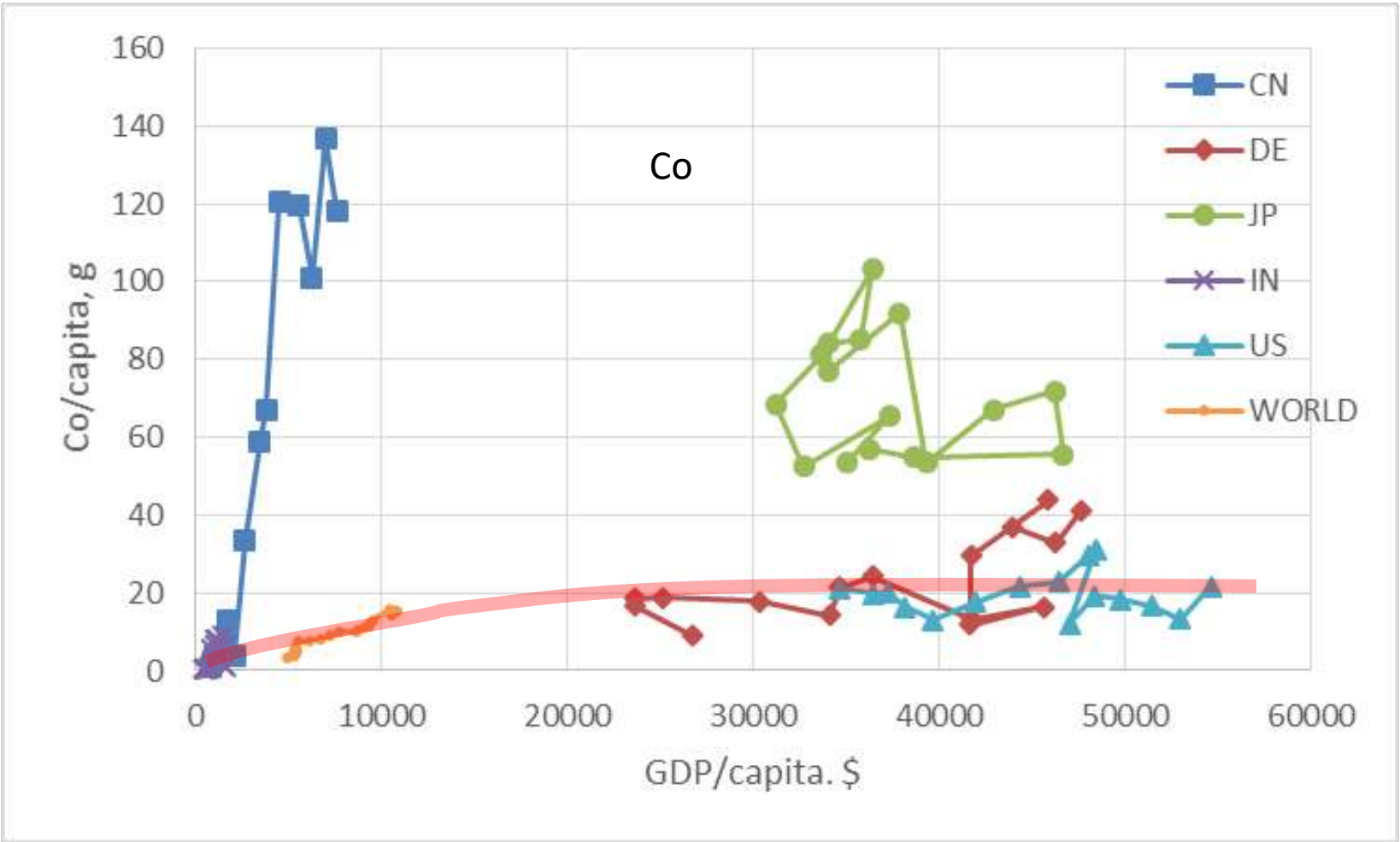
Rough forecast gets to be simpler,
(population) x (developed consumption level)

Every country reaches developed level of consumption per capita

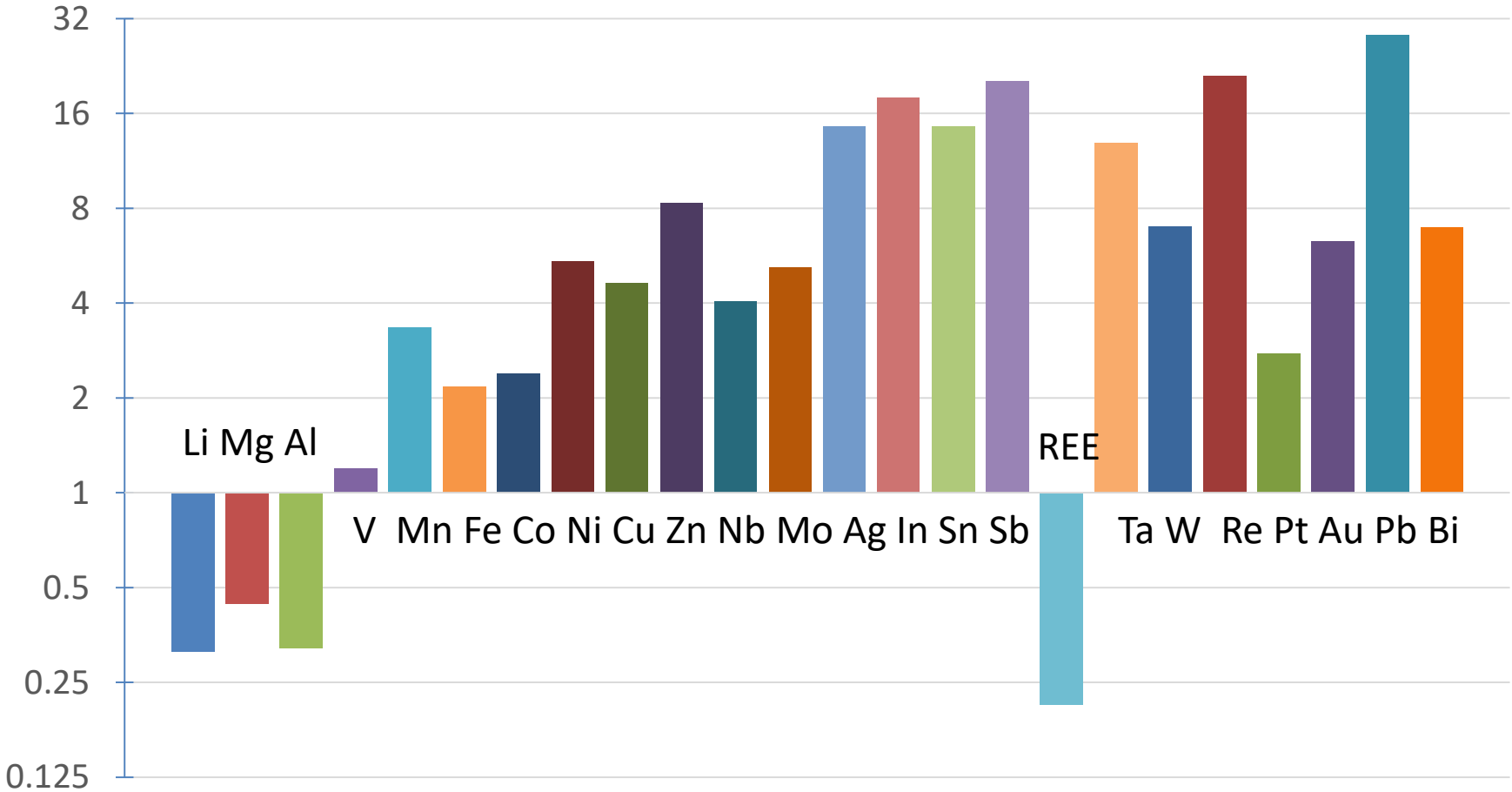
Consumption prediction with concerning only prepotent countries




| metal | Fe |
|---|---|
| Consumption/year at 10Gperson world | 4.5Gton/year |
| Reserve | 87Gton |


Co
Co/capita, g
GDP/capita. $
0
20
40
60
80
100
120
140
160
0
10000
20000
30000
40000
50000
60000
CN
DE
JP
IN
US
WORLD

# Estimated demand up to 2100 v.s. current reserve amount

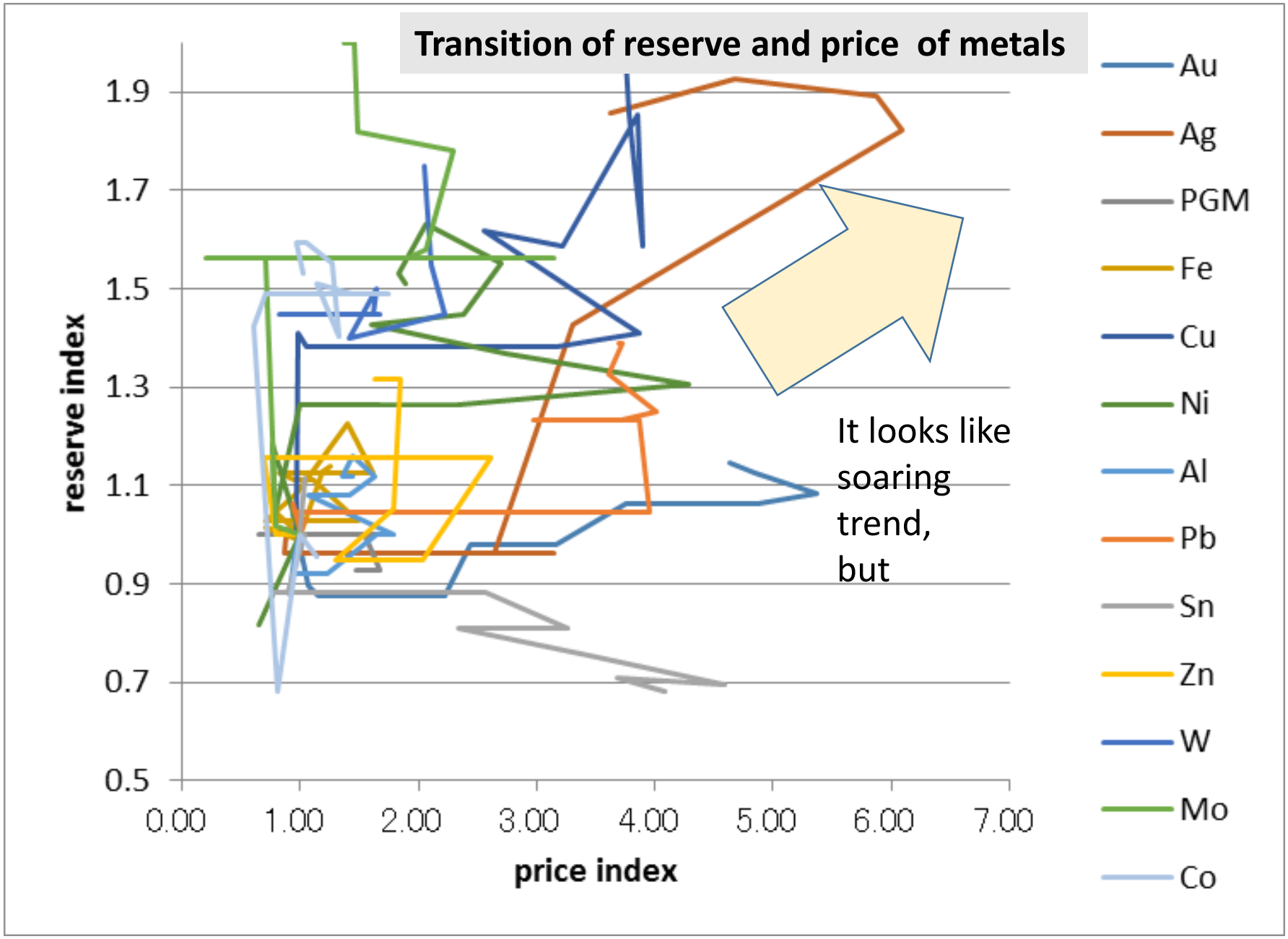


# Are the reserves enough for the 10 billions' universal economy?

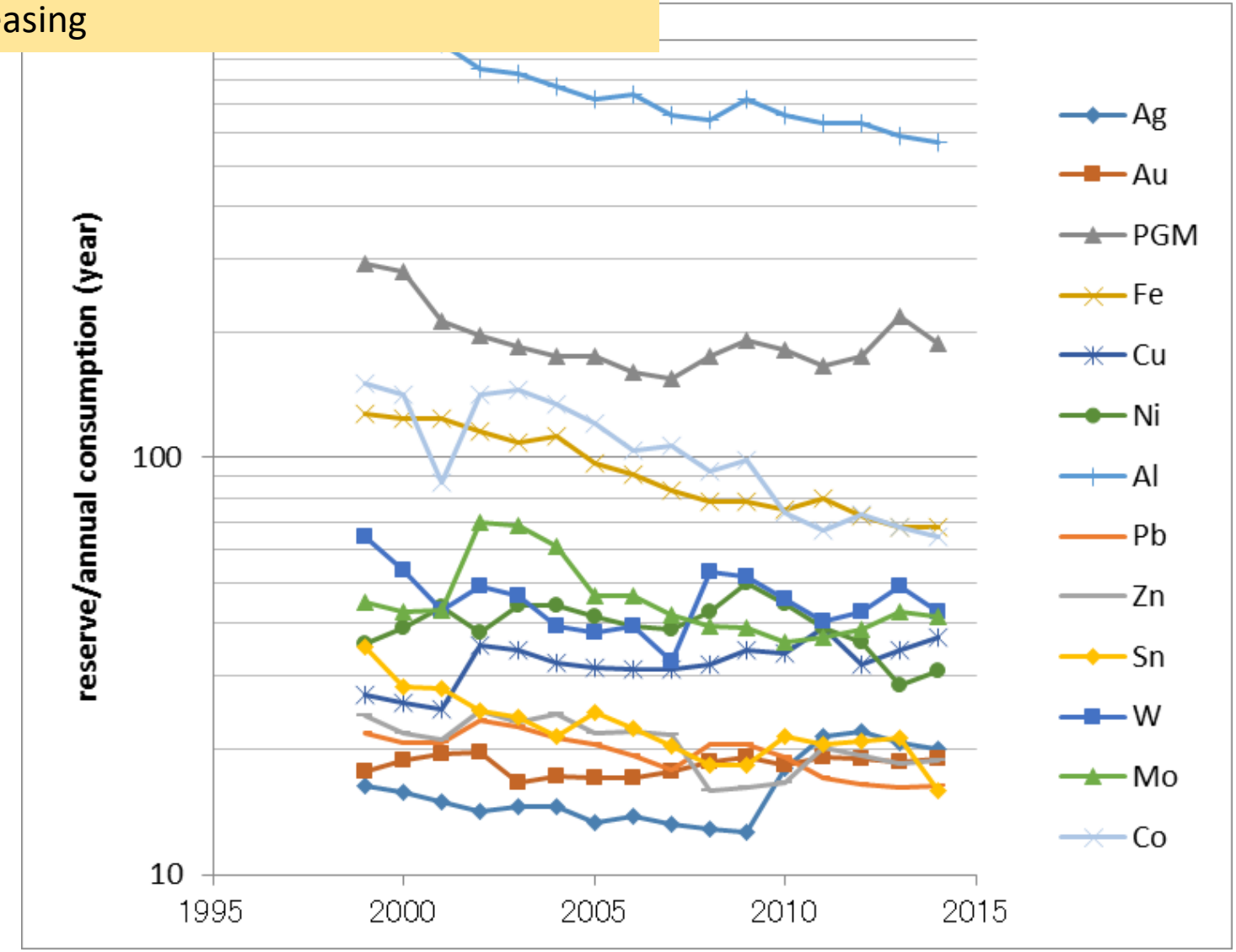
| metal | Fe | Cu | Co |
|---|---|---|---|
| Consumption/year at 10Gperson world | 4.5Gton/year | 90Mt/year | 224kt/year |
| Reserve | 87Gton | 700Mt | 7.2Mt |
| | 19 years | 8 years | 32 years |

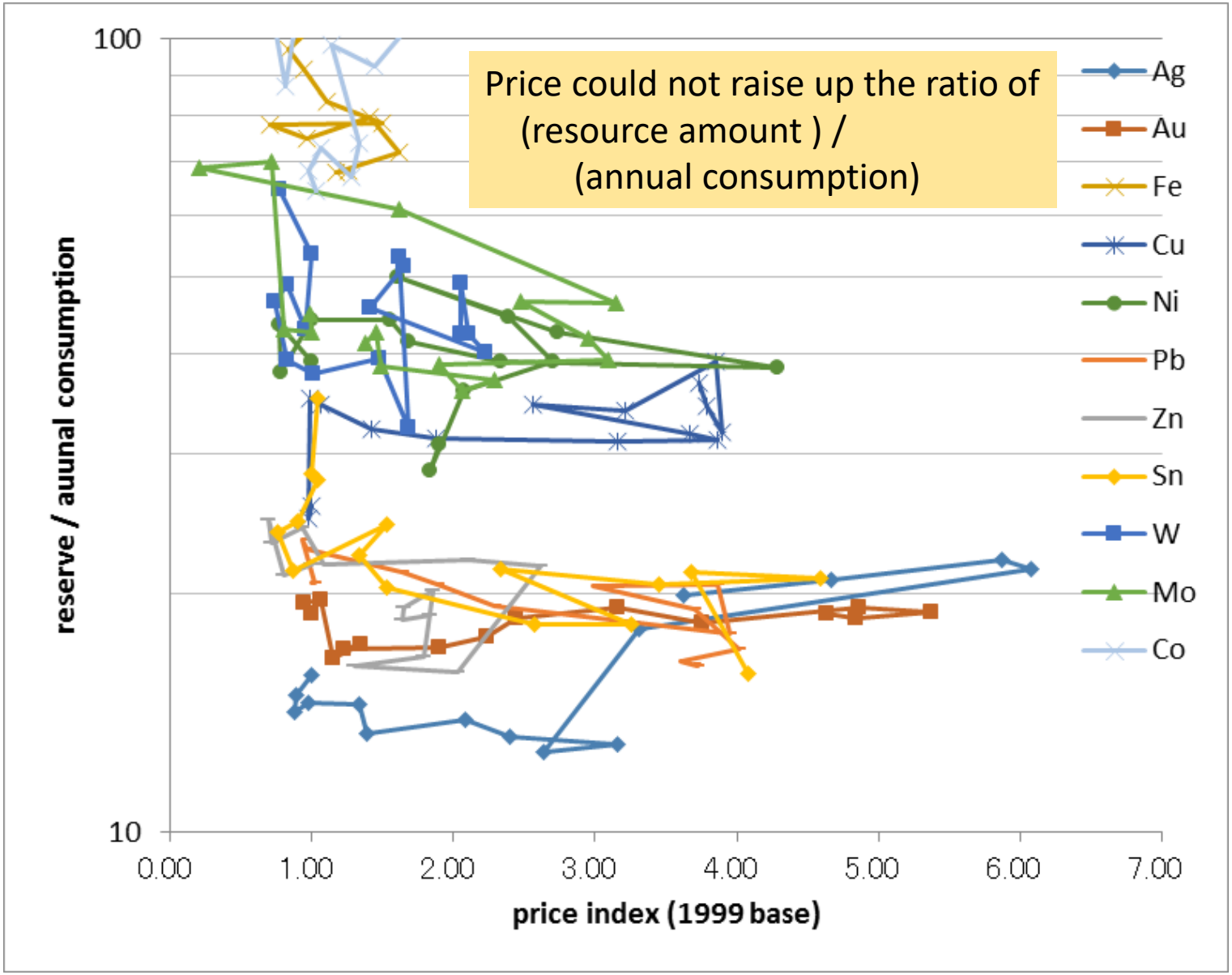
It is said that reserve increase when the price rises.

Prices had risen in these dozen of years.
How are reserves?

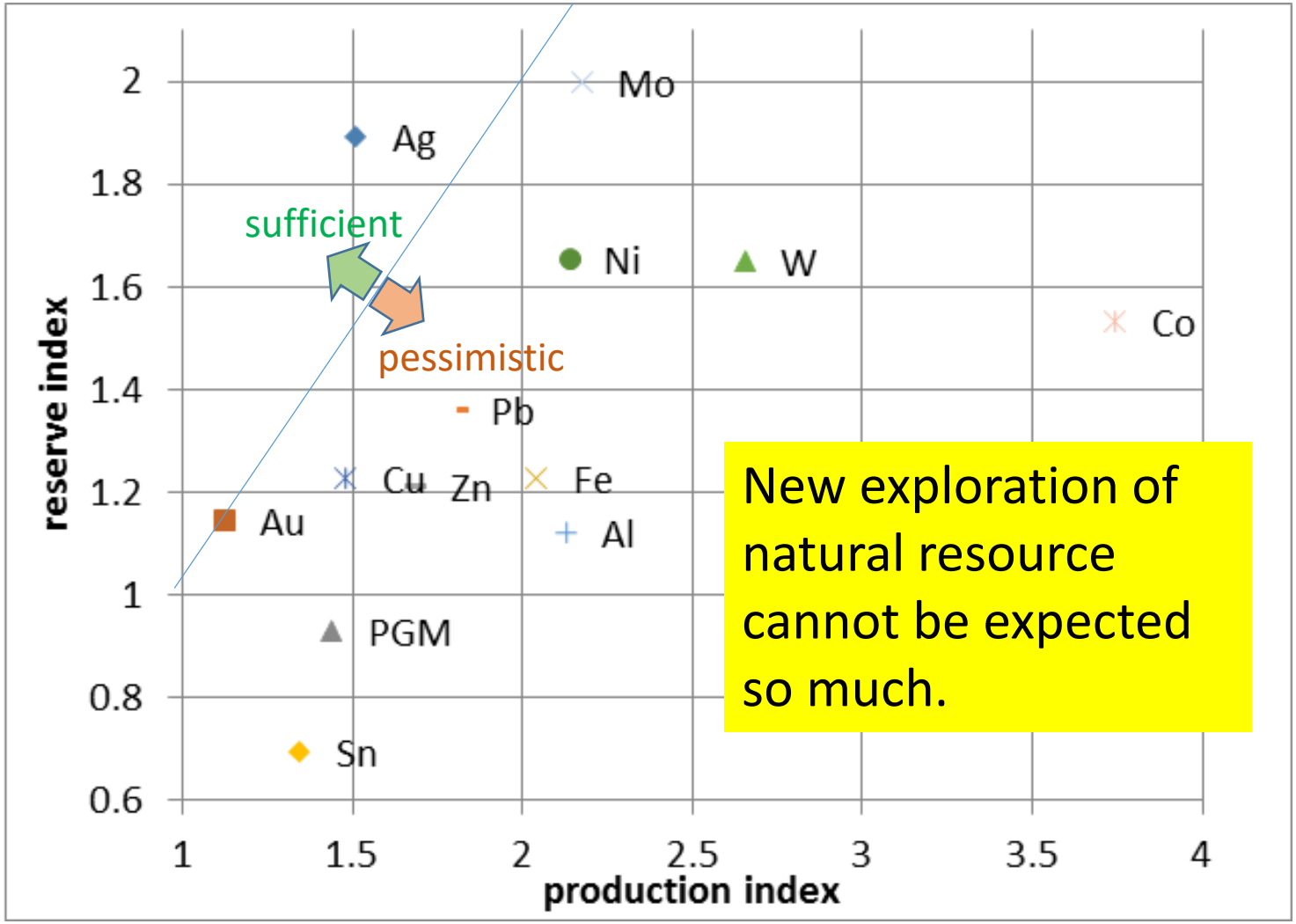

Transition of reserve and price of metals
reserve index
1.9
1.7
1.5
1.3
1.1
0.9
0.7
0.5
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
price index
It looks like soaring trend, but
Au
Ag
PGM
Fe
Cu
Ni
Al
Pb
Sn
Zn
W
Mo
Co

Reserve ratio to annual consumption is decreasing




Price could not raise up the ratio of
(resource amount ) /
(annual consumption)
100
10
reserve / auunal consumption
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
price index (1999 base)
Ag
Au
Fe
Cu
Ni
Pb
Zn
Sn
W
Mo
Co

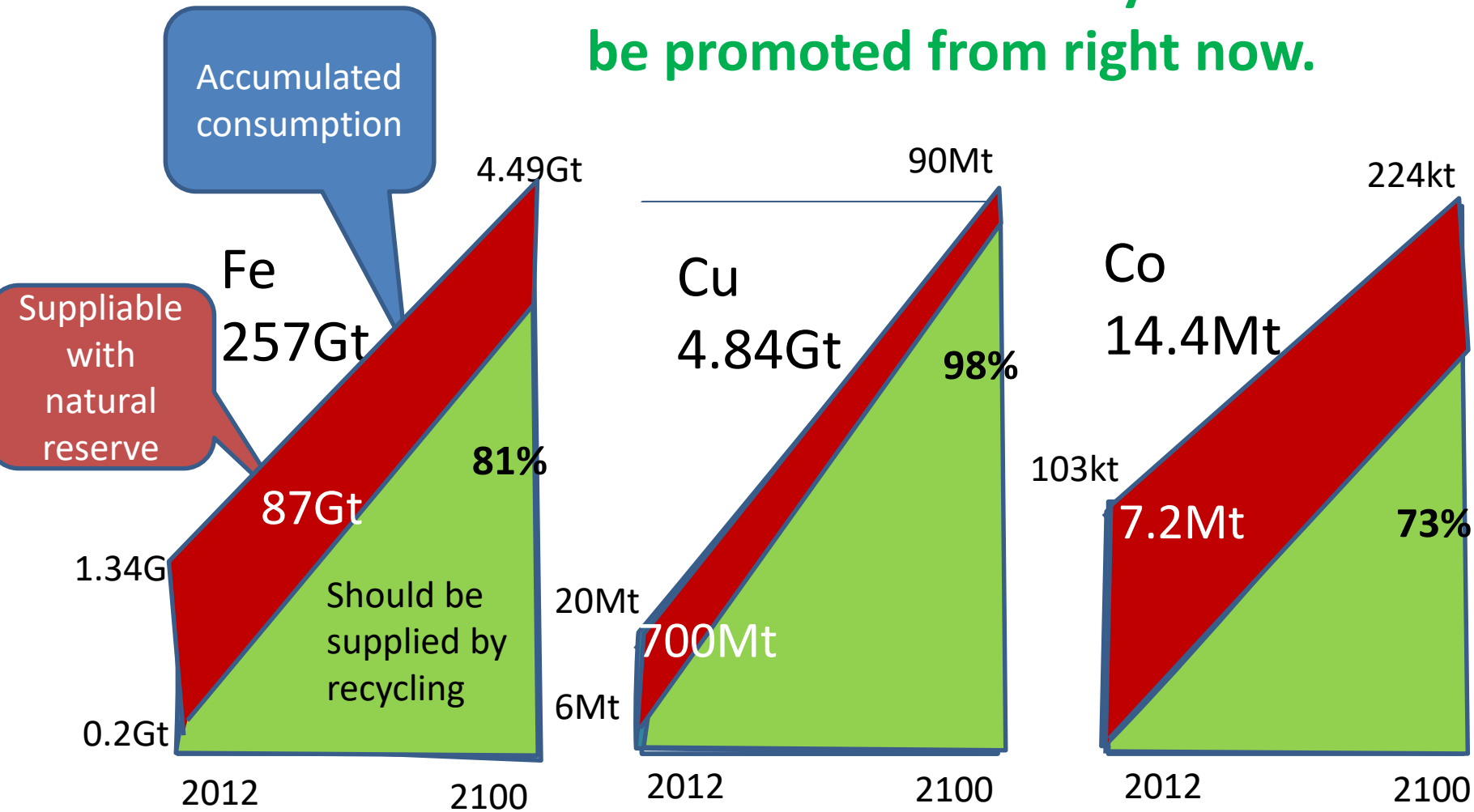
Sustainable reserve development line



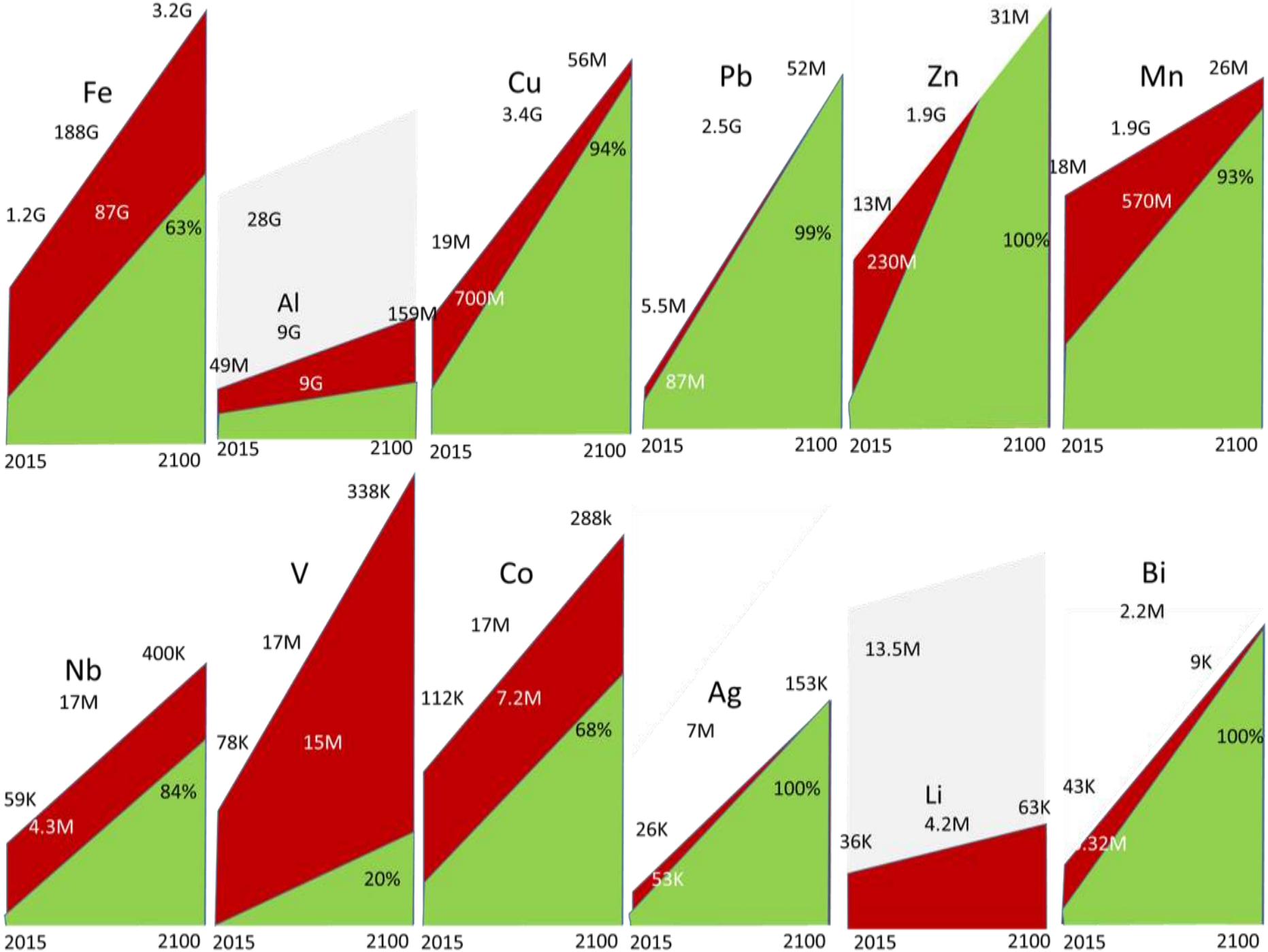

New exploration of natural resource cannot be expected so much.

What can solve it?

# The circulation society must be promoted from right now.




Estimated accumulated consumptions till 2100 with simple assumption of linear growth


Fe
3.2G
188G
1.2G
87G
63%
2015
2100
Al
28G
9G
49M
9G
159M
2015
2100
Cu
56M
3.4G
94%
19M
700M
2015
2100
Pb
52M
2.5G
99%
5.5M
87M
2015
2100
Zn
31M
1.9G
13M
230M
100%
2015
2100
Mn
26M
1.9G
18M
570M
93%
2015
2100
Nb
400K
17M
59K
4.3M
84%
2015
2100
V
338K
17M
78K
15M
20%
2015
2100
Co
288k
17M
112K
7.2M
68%
2015
2100
Ag
153K
7M
26K
53K
100%
2015
2100
Li
13.5M
4.2M
36K
63K
2015
2100
Bi
2.2M
9K
43K
.32M
100%
2015
2100

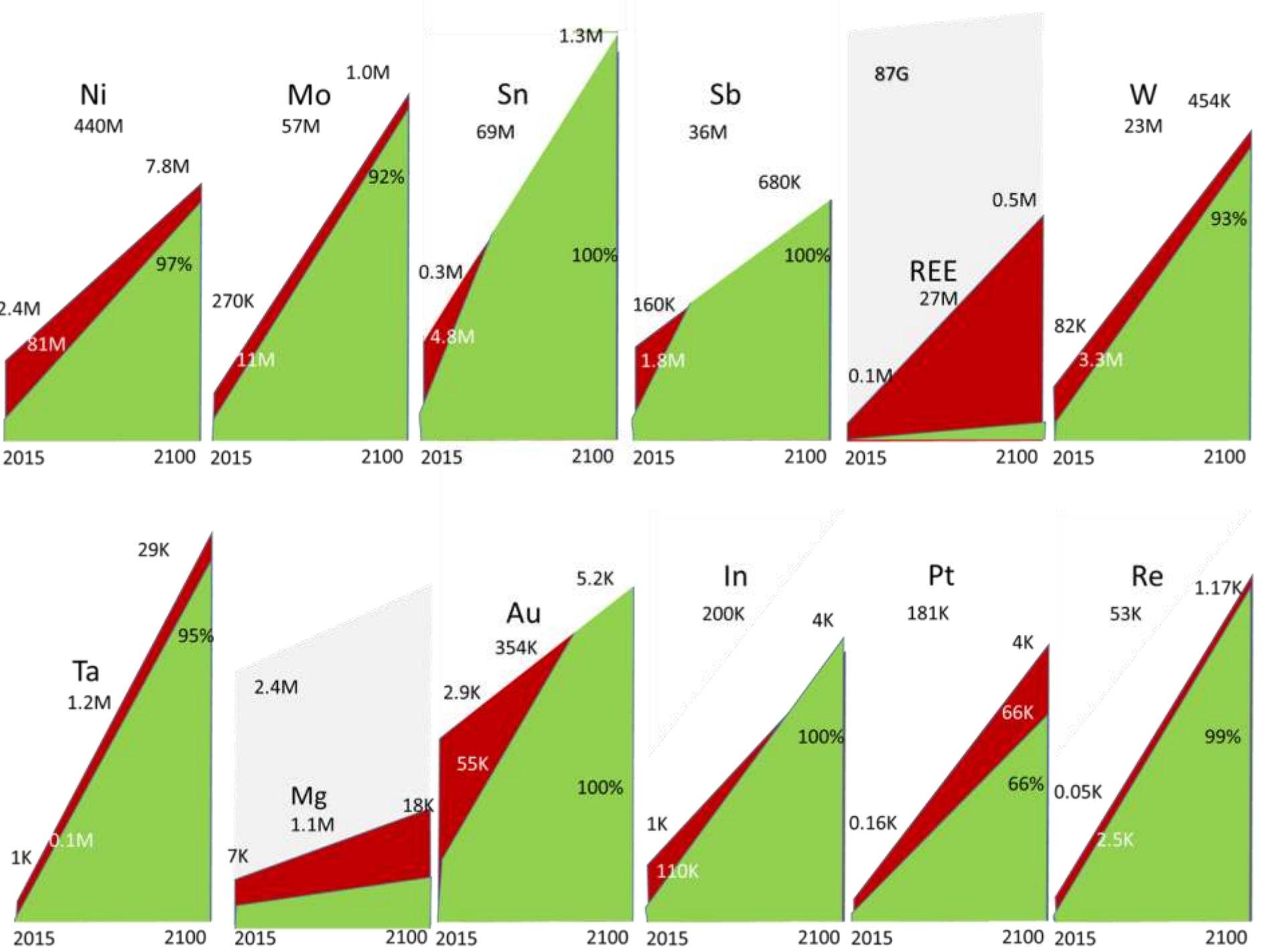
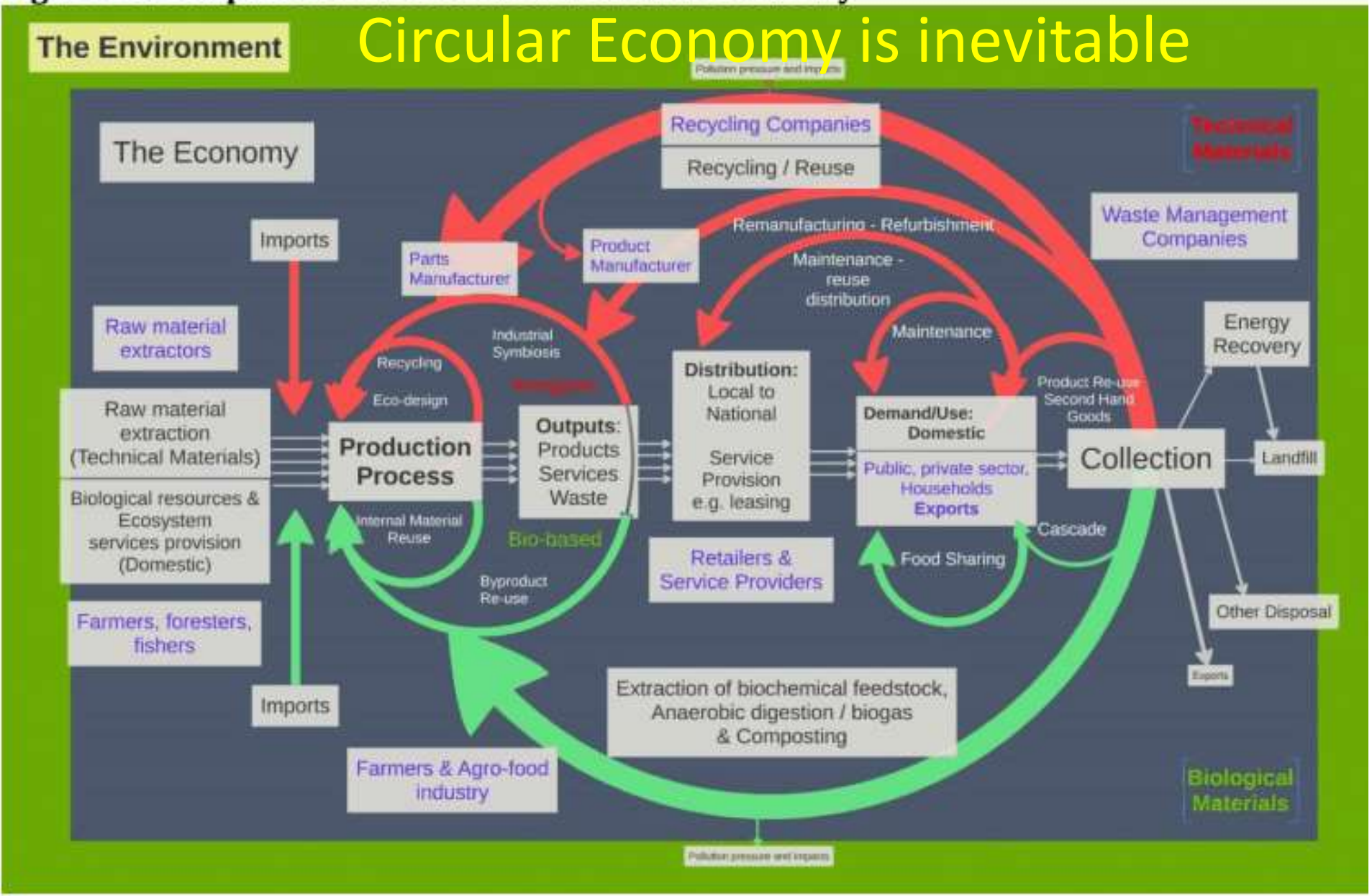

Ni
440M
7.8M
97%
2.4M
81M
2015
2100
Mo
57M
1.0M
92%
270K
11M
2015
2100
Sn
69M
1.3M
100%
0.3M
4.8M
2015
2100
Sb
36M
680K
100%
160K
1.8M
2015
2100
87G
REE
27M
0.5M
0.1M
2015
2100
W
23M
454K
93%
82K
3.3M
2015
2100
Ta
1.2M
29K
95%
1K
0.1M
2015
2100
Mg
1.1M
2.4M
18K
7K
2015
2100
Au
354K
5.2K
2.9K
55K
100%
2015
2100
In
200K
4K
100%
1K
110K
2015
2100
Pt
181K
4K
66K
66%
0.16K
2015
2100
Re
53K
1.17K
99%
0.05K
2.5K
2015
2100

**Figure E2: Simplified illustration of a circular economy**

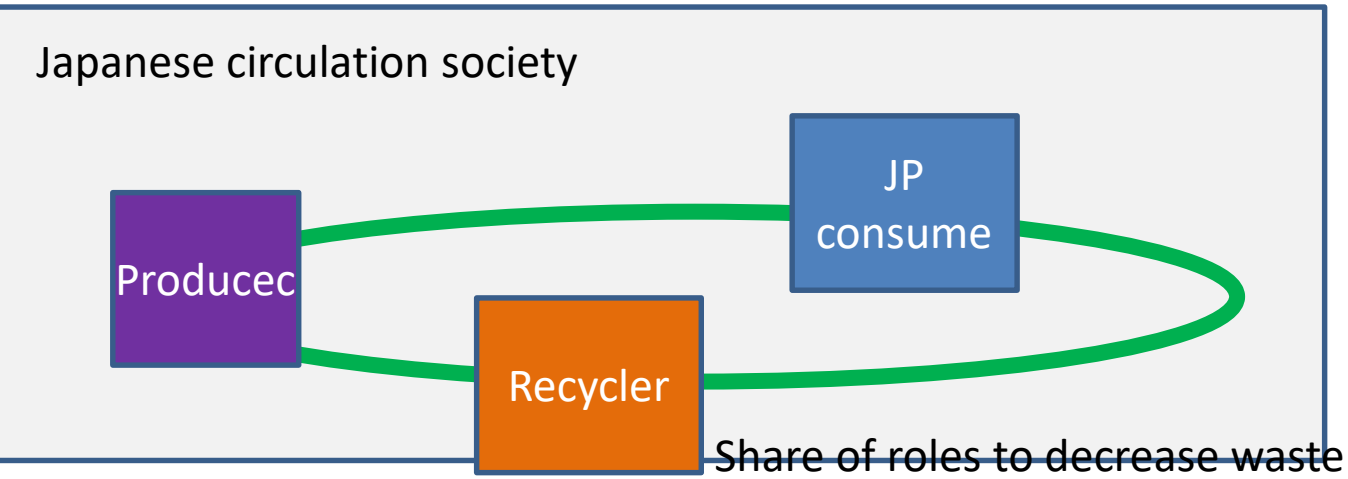



**Source:** Own representation, P ten Brink, P Razzini, S. Withana and E. van Dijl (IEEP), 2014

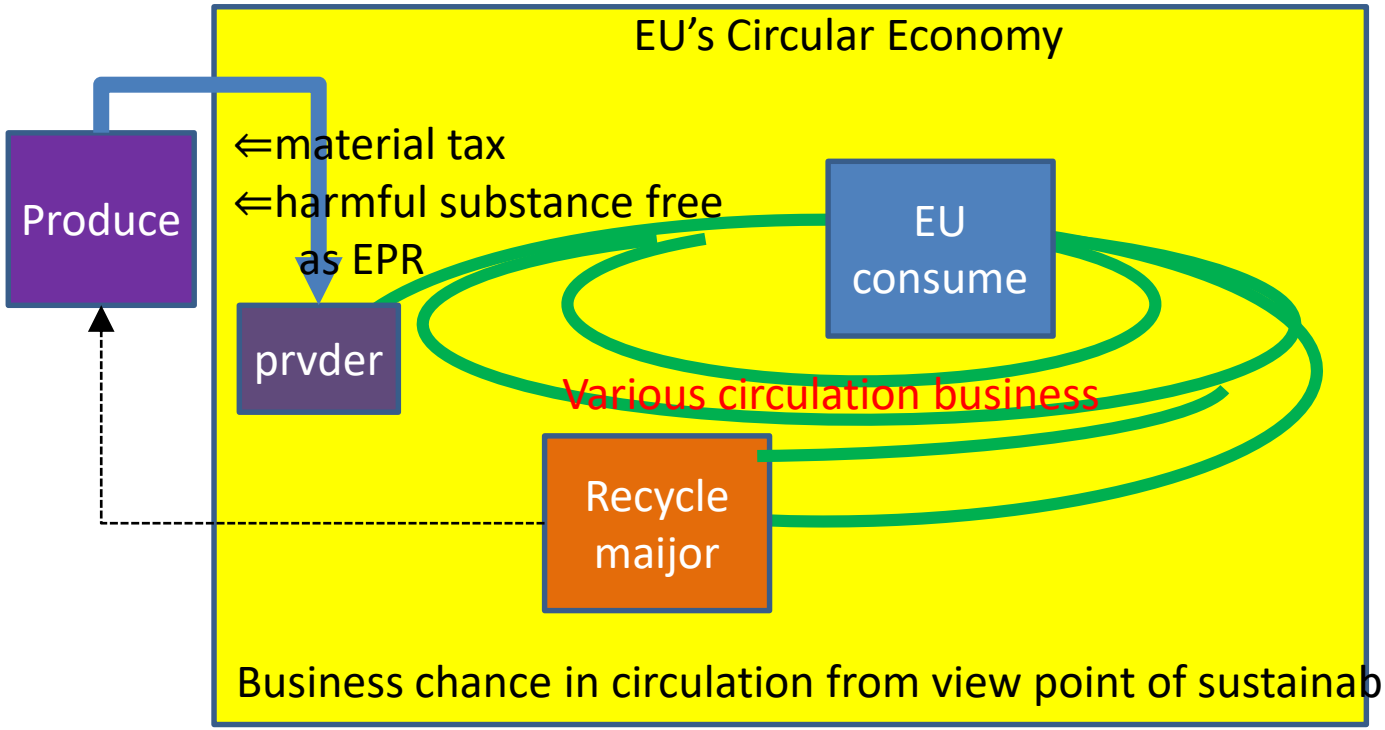
# Difference of Circular Economy(CE) from Japanese 循環型社会(3R)

| | 3R | CE |
|---|---|---|
| aim | Reduction of final disposal (output oriented) | Improvement of Resource Efficiency (input oriented) |
| benefit | Reduction of extra economic burden of the society | Creation fo new business different from mas consumption |
| measure | Recovery of secondary raw material | Multiple utilization of EoF products |
| EoF products | Subjects to be recycled as raw material | Subjects to be used again. |
| Economic entity | Recyclers, mining company | Service suppliers, SME producers |
| motivation | Social responsibility | Add-value toward sustainability |

# Different circulation society of EU from JP




Arrange the outer ward of material circulation In the society

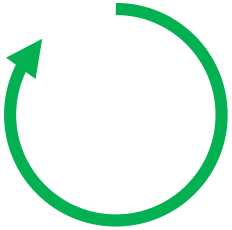



Create multiple inner route of gods circulation In the society

循:rotary along something

遍:everywhere

環:embrace



廻:itinerant to return

# 遍廻型社会

## ubiquitous circulation society

## *ubi-culation* society

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