# Rapid Change of Global Material Flow and the Requirement for Eco-design

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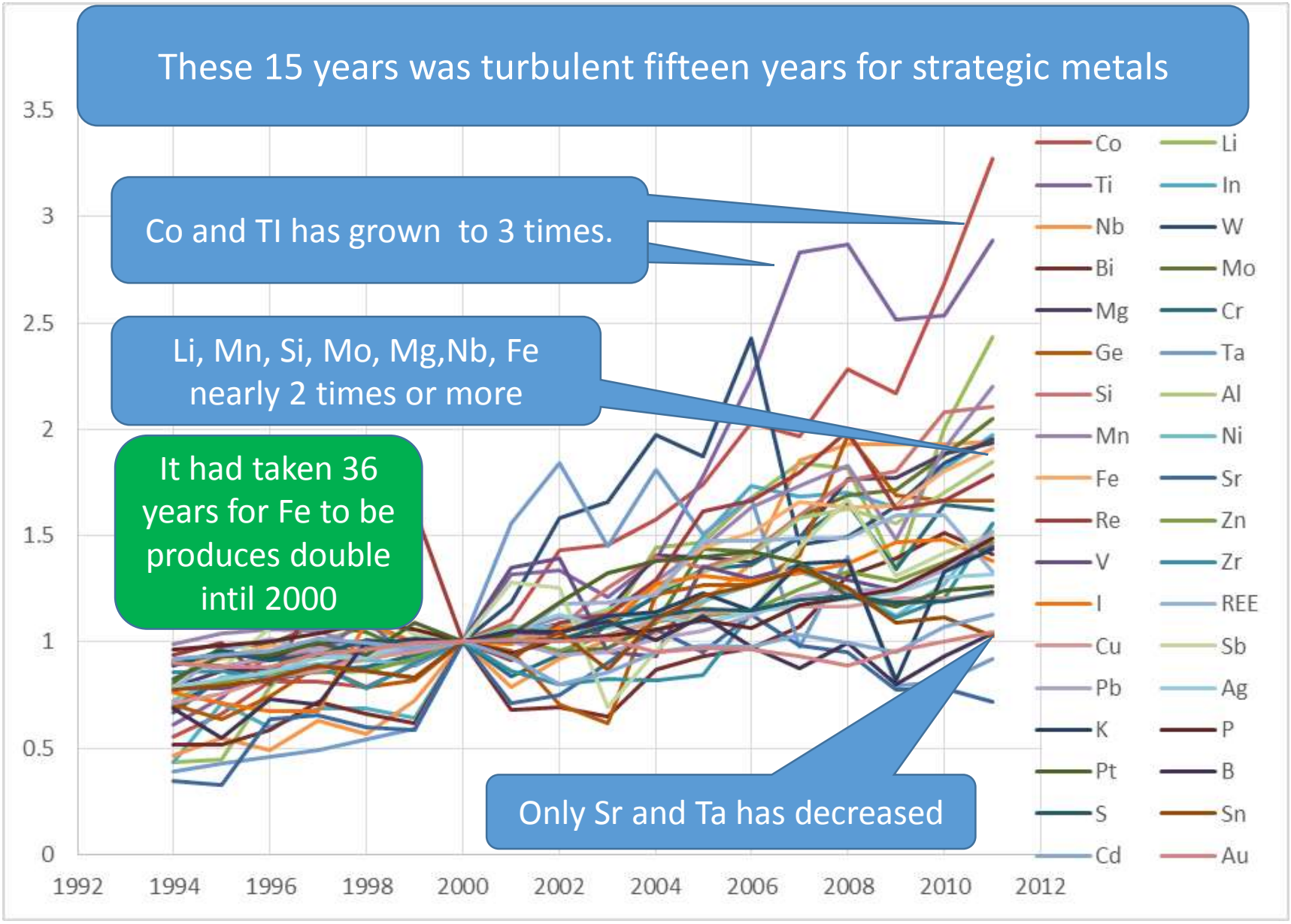
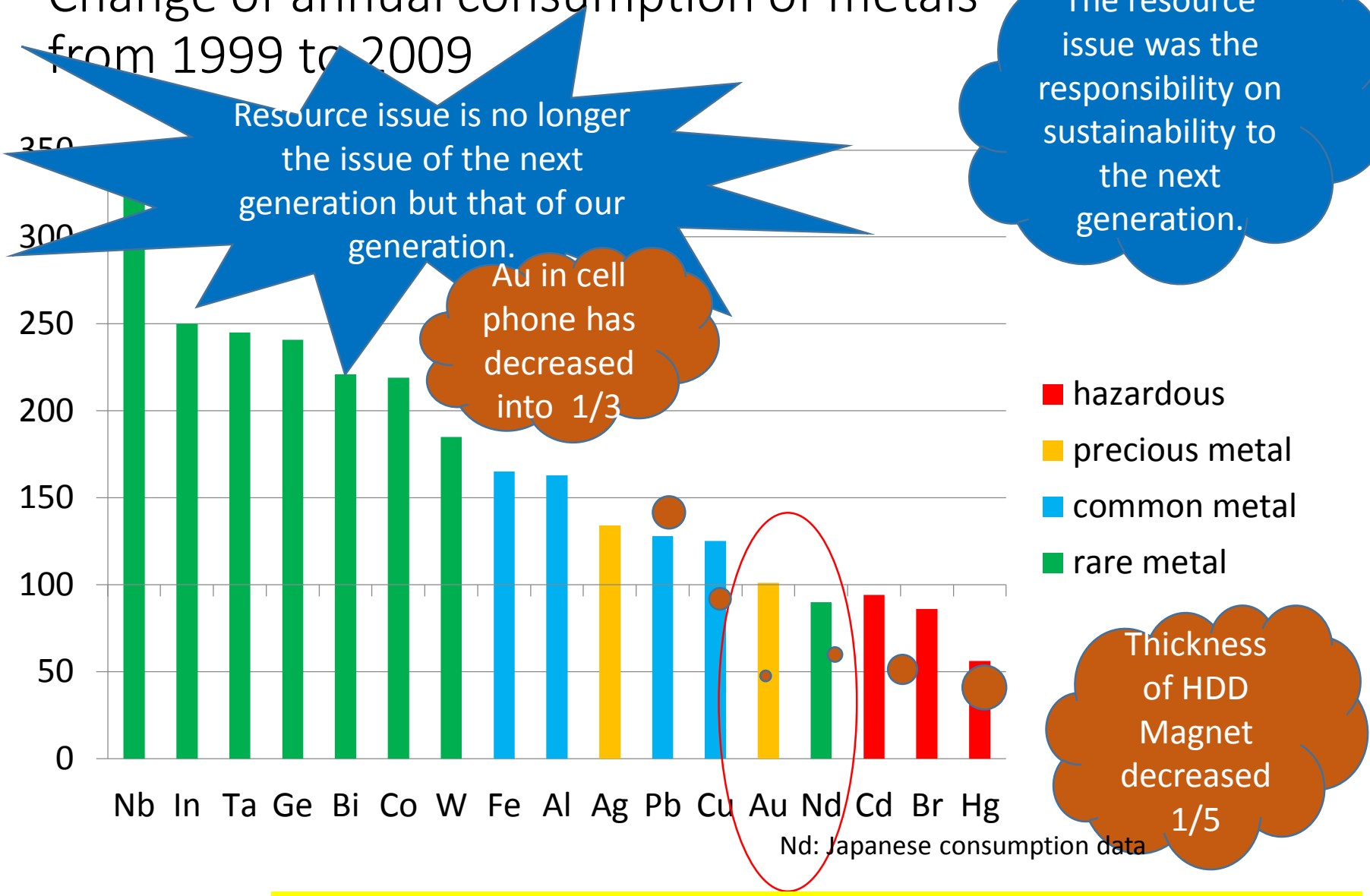

These 15 years was turbulent fifteen years for strategic metals
Co and TI has grown to 3 times.
Li, Mn, Si, Mo, Mg,Nb, Fe nearly 2 times or more
It had taken 36 years for Fe to be produces double intil 2000
Only Sr and Ta has decreased
3.5
3
2.5
2
1.5
1
0.5
0
1992
1994
1996
1998
2000
2002
2004
2006
2008
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

# Change of annual consumption of metals from 1999 to 2009



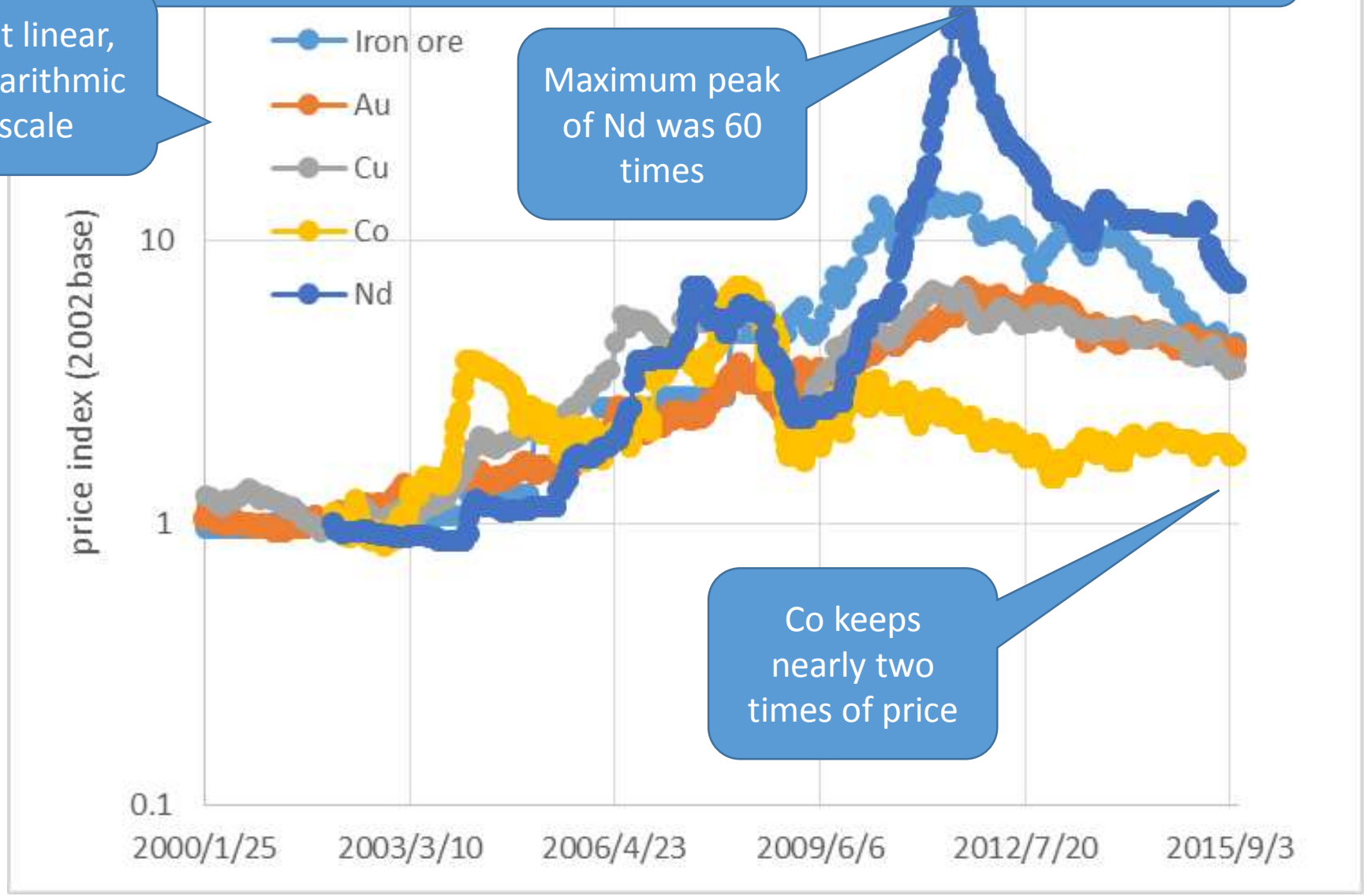

Now, we have to design products with considering resource constraint.

Prices have changed more drastically

Not linear, Logarithmic scale

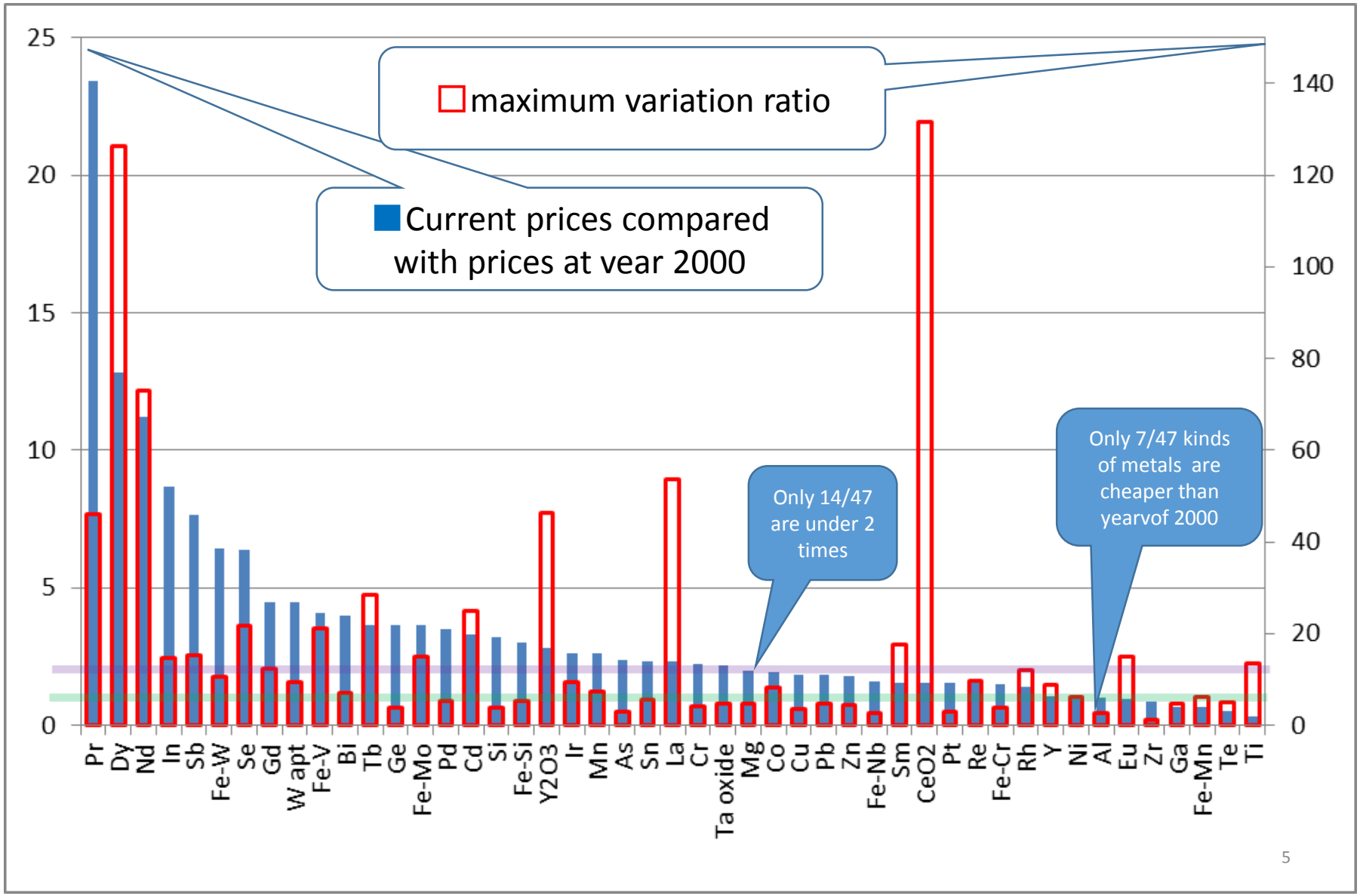
Maximum peak of Nd was 60 times

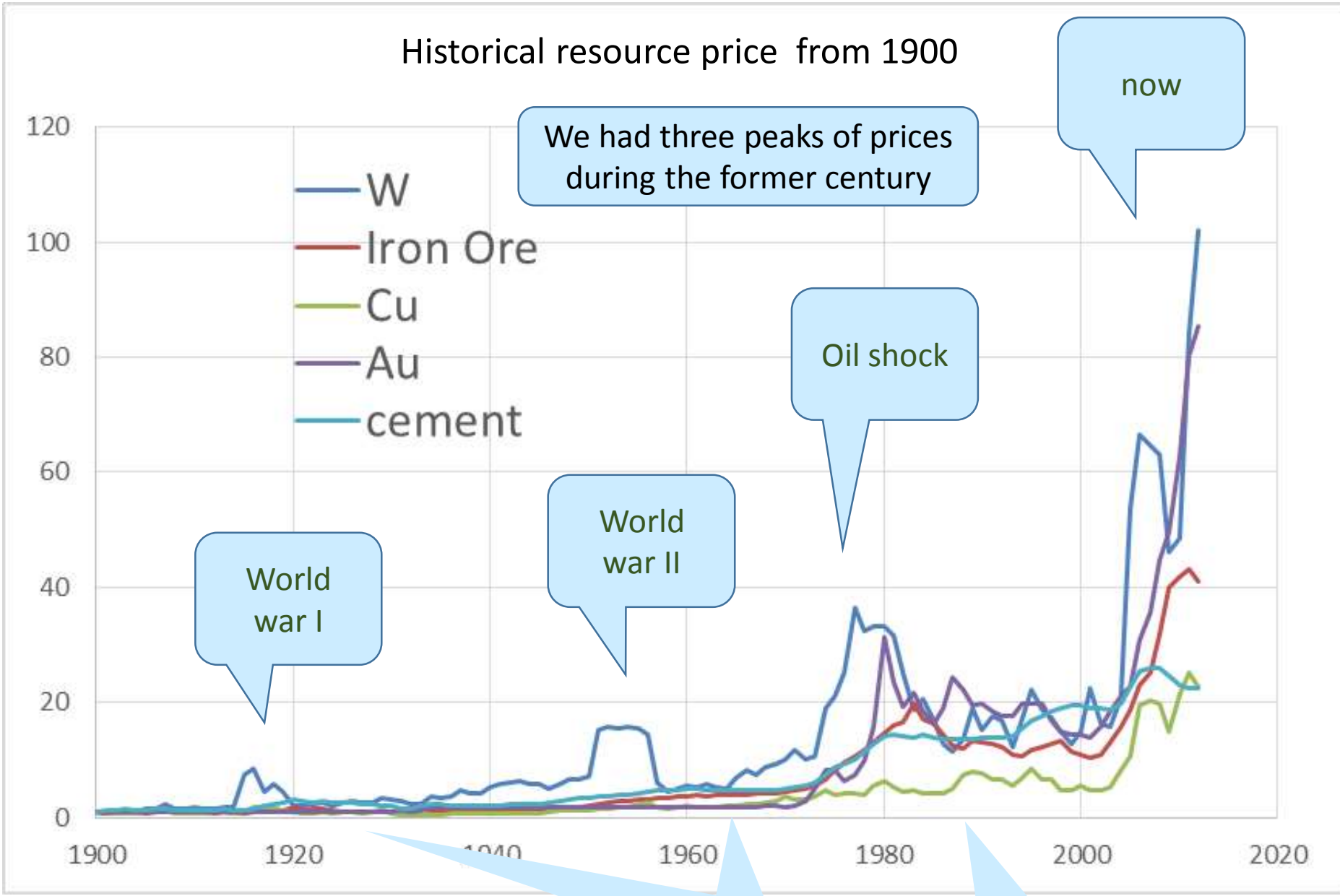
Co keeps nearly two times of price



From several dozens times to more than a hundred times of price swing occurred In these 15 years.

**Prices stays higher level comparing the prices at the beginning of this century**

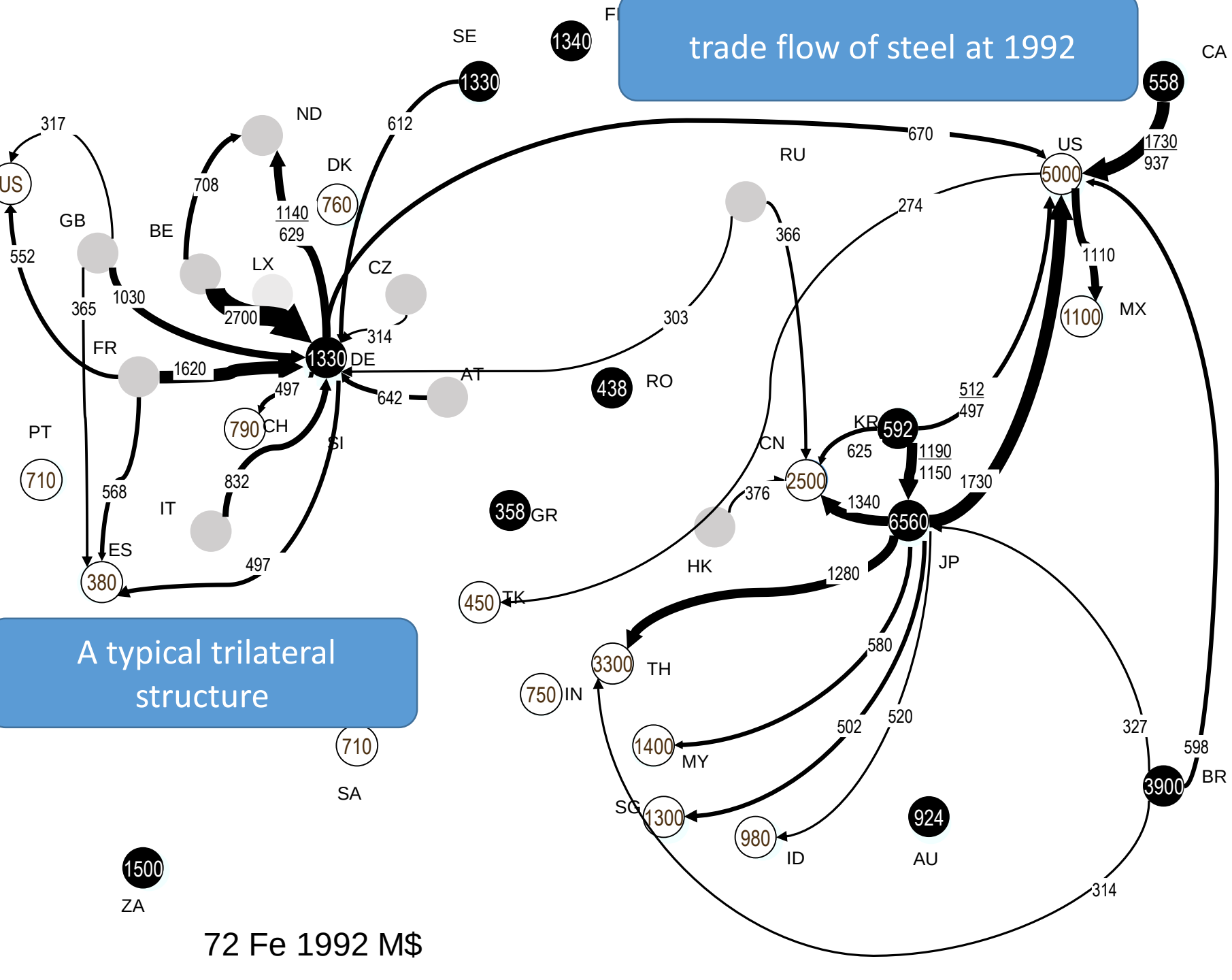


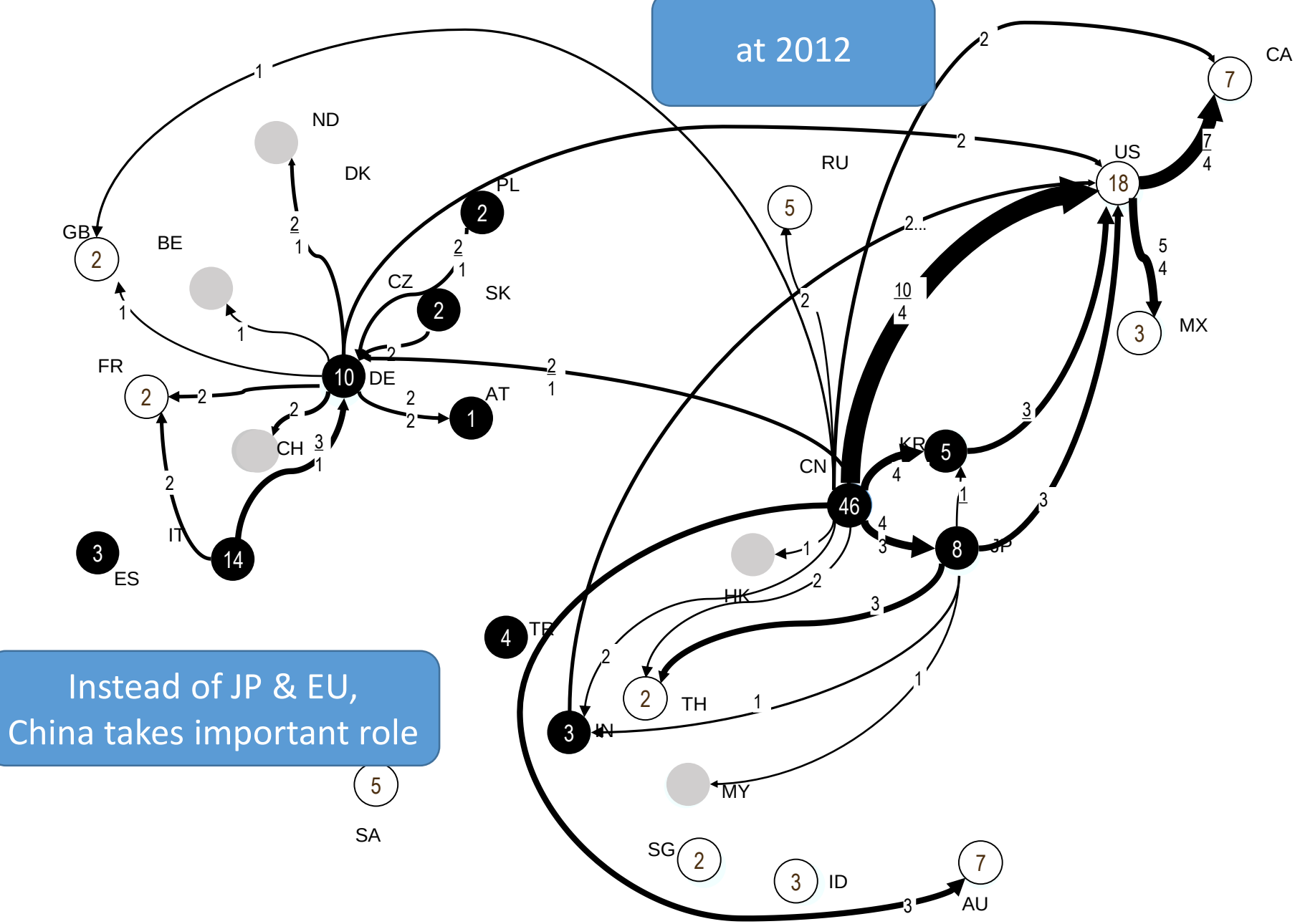

Historical resource price from 1900
now
We had three peaks of prices during the former century
W
Iron Ore
Cu
Au
cement
Oil shock
World war II
World war I
120
100
80
60
40
20
0
1900
1920
1960
1980
2000
2020
After the peak, prices shifted higher levels

# What is happening ?  What will come after?

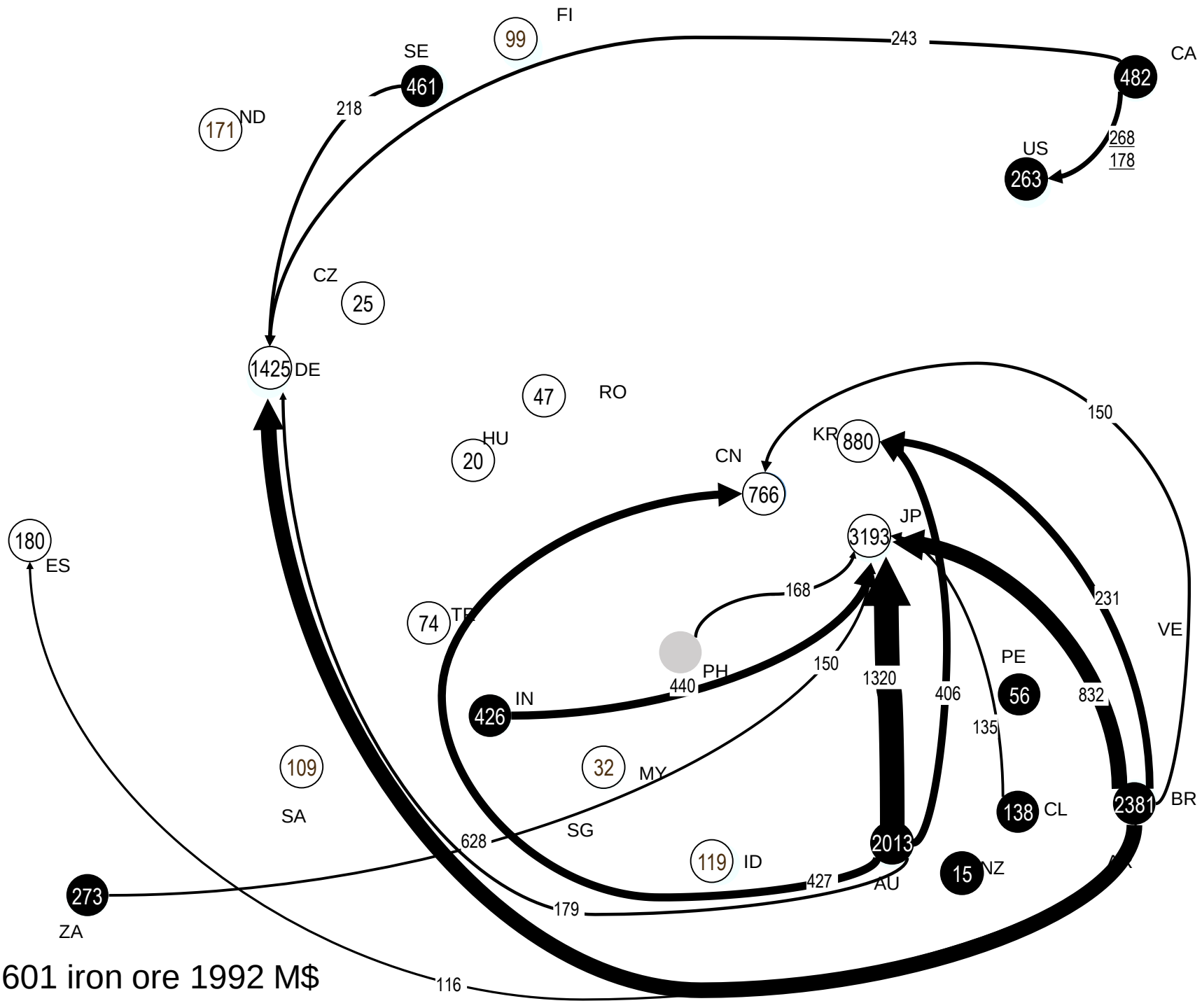
Shift form the structure of the 20th century to the 21th century.

From trilateral structure of EU, US, JP to *universal power economy* through "the factory of the world"

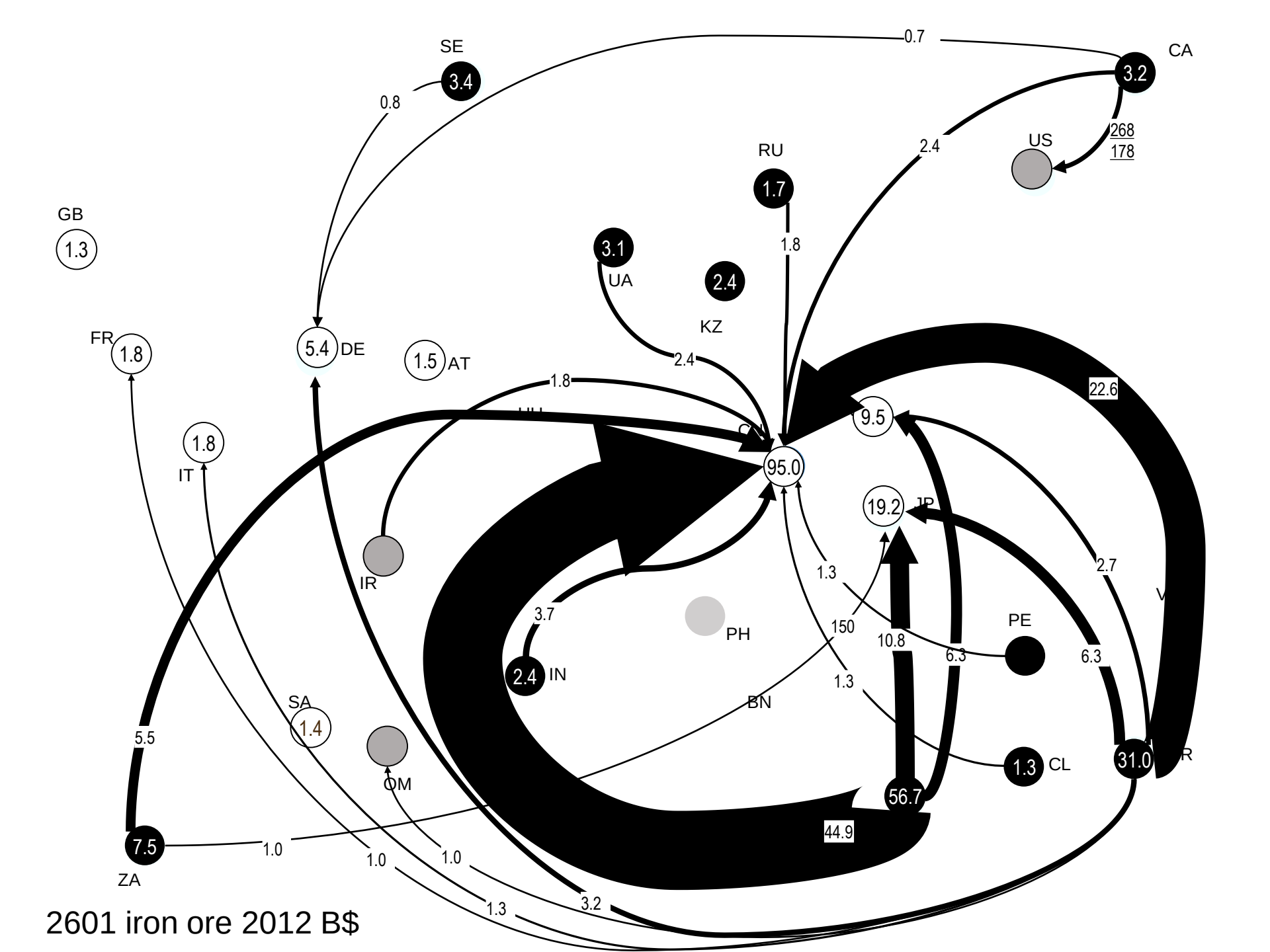

trade flow of steel at 1992
A typical trilateral structure
72 Fe 1992 M$
SE
1340
1330
CA
558
317
ND
612
670
US
1730
937
US
DK
RU
5000
708
760
1140
629
GB
BE
366
274
552
LX
CZ
1110
365
1030
2700
303
1100
MX
314
FR
1330
DE
1620
AT
497
438
RO
642
512
497
790
CH
KR
592
PT
SI
CN
625
1190
1150
710
568
832
2500
376
1730
IT
1340
358
GR
6560
ES
497
HK
JP
380
1280
450
TK
580
3300
TH
750
IN
710
SA
1400
MY
502
520
327
598
3900
BR
SG
1300
980
ID
924
AU
1500
ZA
314


at 2012
Instead of JP & EU,
China takes important role
ND
DK
PL
RU
US
CA
GB
BE
CZ
SK
FR
DE
AT
CH
IT
ES
CN
KR
JP
HK
TW
TH
IN
MY
SG
ID
AU
SA
MX

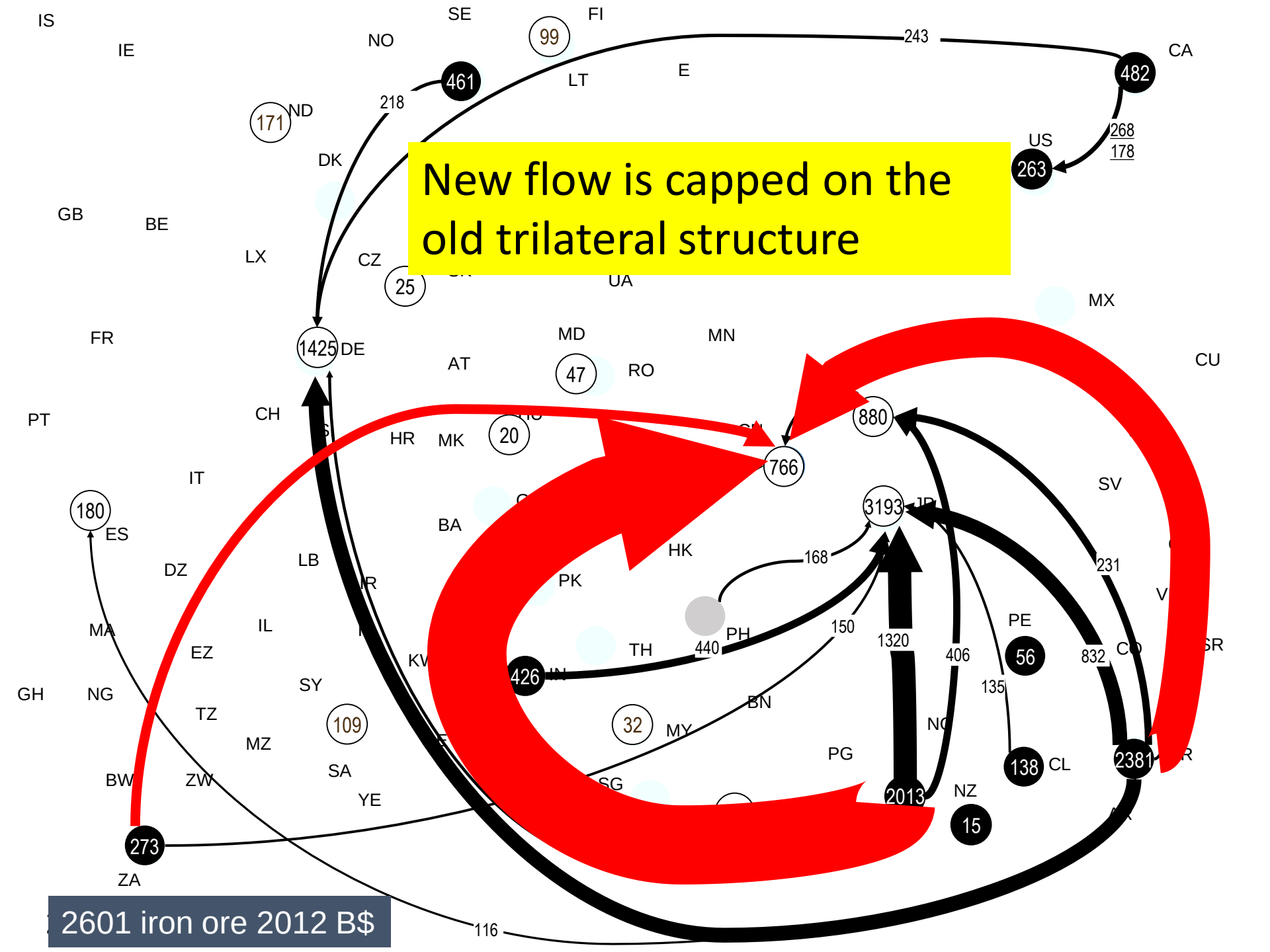
72 Fe 2012 B$

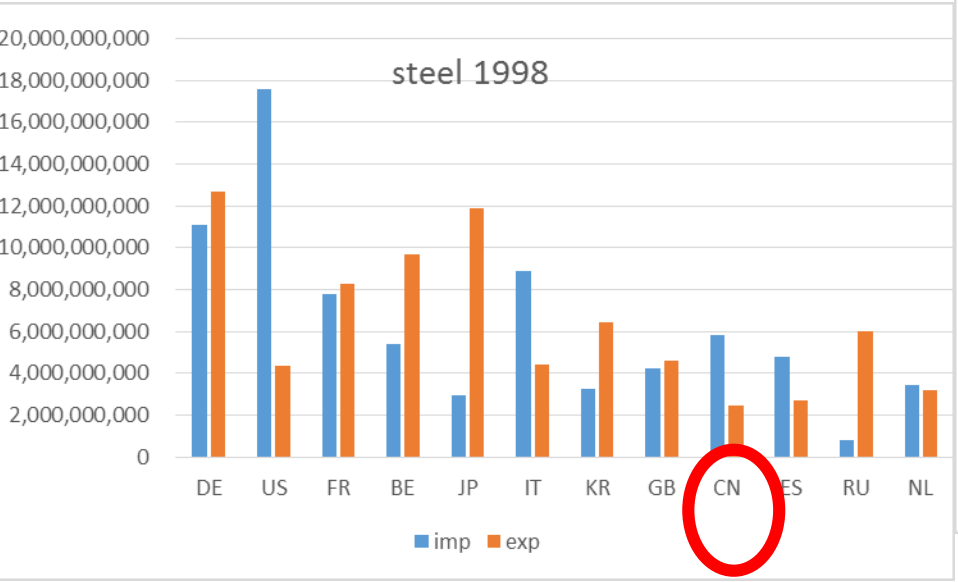


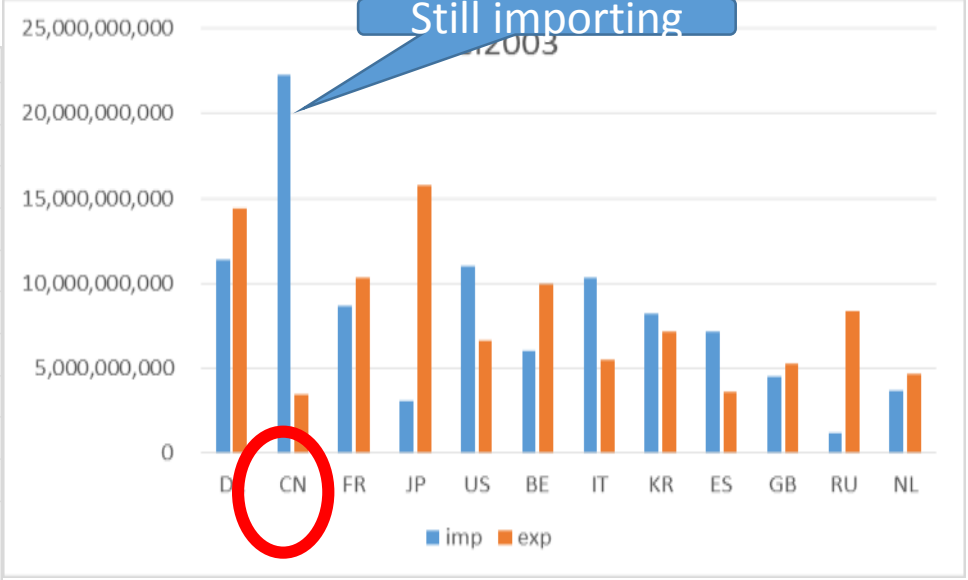

2601 iron ore 1992 M$

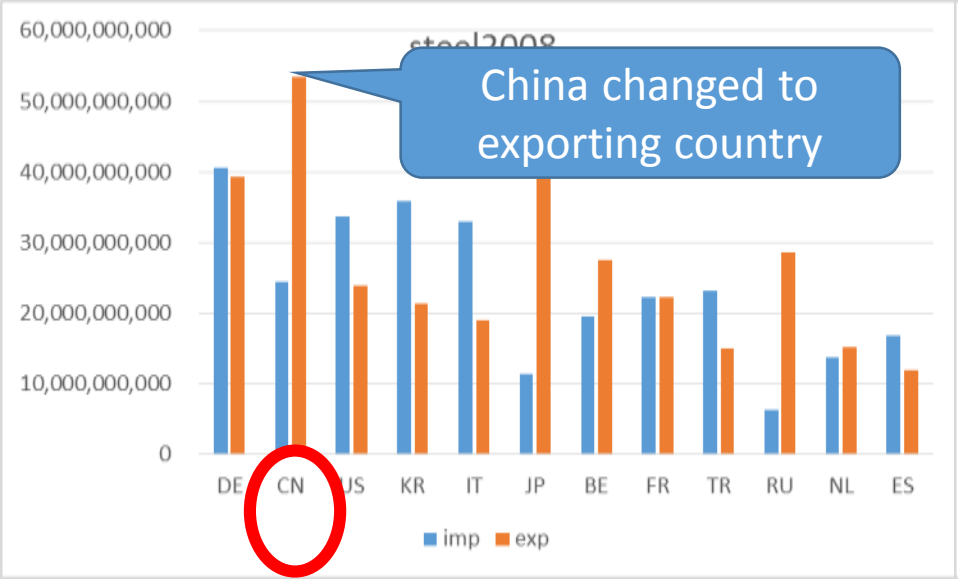


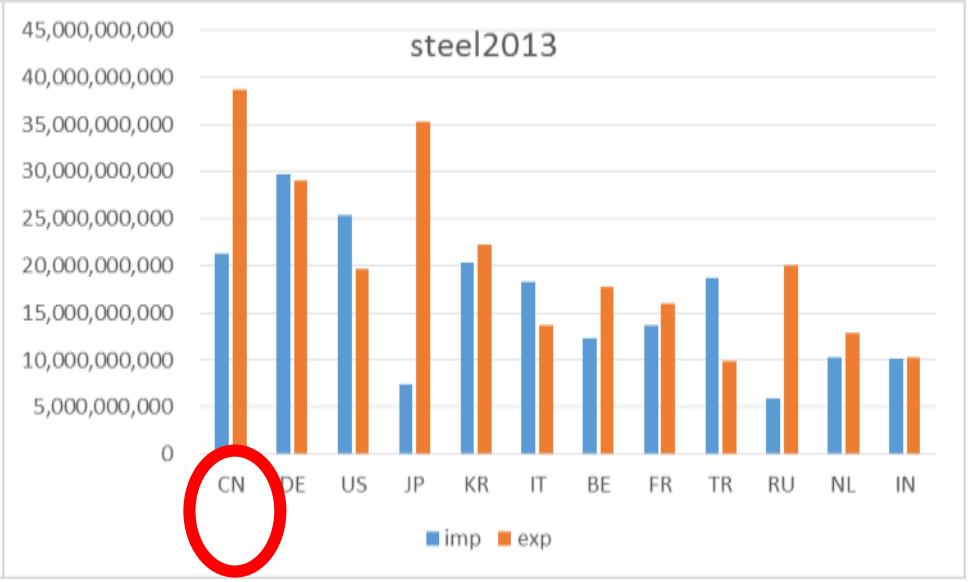

2601 iron ore 2012 B$


New flow is capped on the old trilateral structure
2601 iron ore 2012 B$
IS
IE
SE
NO
FI
99
243
CA
482
461
218
LT
E
171
ND
DK
US
263
268
178
GB
BE
LX
CZ
25
UA
MX
FR
1425
DE
MD
MN
CU
AT
47
RO
PT
CH
HR
MK
20
880
766
IT
SV
180
ES
3193
BA
HK
168
231
DZ
LB
PK
MA
IL
EZ
PH
150
1320
406
PE
56
832
CO
SR
426
TH
440
KW
GH
NG
SY
BN
135
TZ
109
32
MY
MZ
PG
138
CL
2381
BW
ZW
SA
SG
2013
NZ
YE
15
273
ZA
116


steel 1998
20,000,000,000
18,000,000,000
16,000,000,000
14,000,000,000
12,000,000,000
10,000,000,000
8,000,000,000
6,000,000,000
4,000,000,000
2,000,000,000
0
DE US FR BE JP IT KR GB CN ES RU NL
imp exp


Still importing
25,000,000,000
20,000,000,000
15,000,000,000
10,000,000,000
5,000,000,000
0
CN FR JP US BE IT KR ES GB RU NL
imp exp


China changed to exporting country
60,000,000,000
50,000,000,000
40,000,000,000
30,000,000,000
20,000,000,000
10,000,000,000
0
DE CN US KR IT JP BE FR TR RU NL ES
imp exp

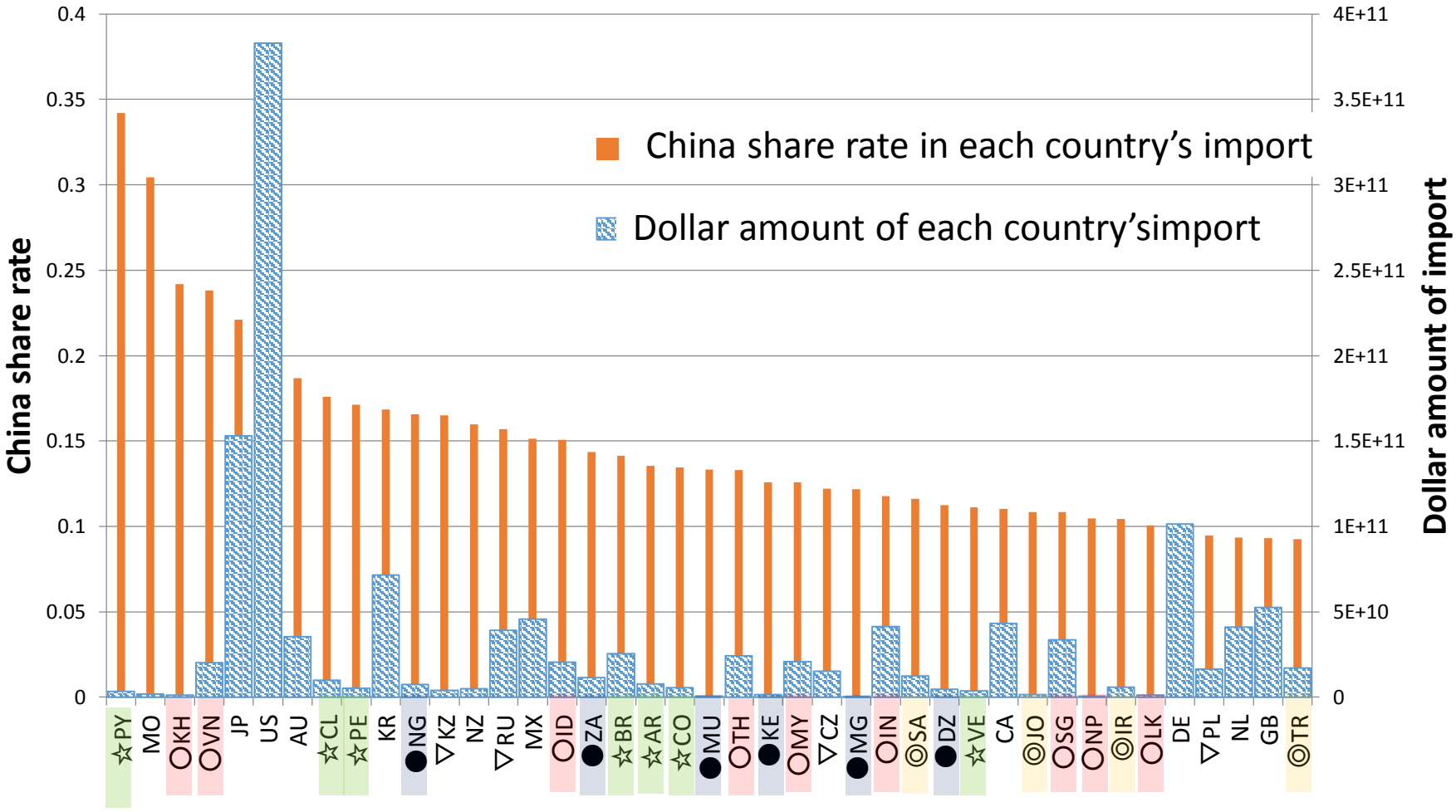

steel2013
45,000,000,000
40,000,000,000
35,000,000,000
30,000,000,000
25,000,000,000
20,000,000,000
15,000,000,000
10,000,000,000
5,000,000,000
0
CN DE US JP KR IT BE FR TR RU NL IN
imp exp

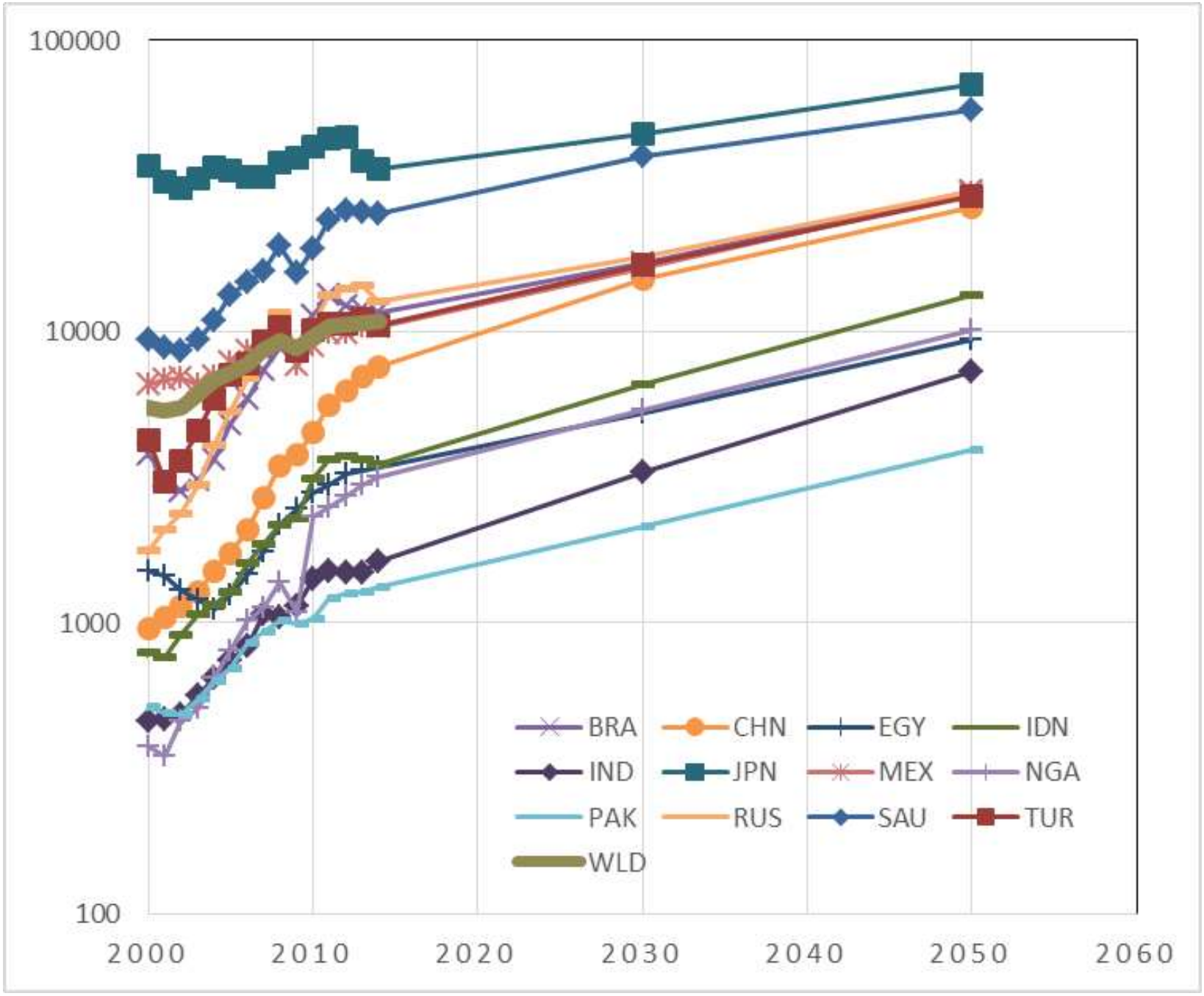
| | Import | | Export | | | Import | | Export | |
|---|---|---|---|---|---|---|---|---|---|
| | 1998 | 2013 | 1998 | 2013 | | 1998 | 2013 | 1998 | 2013 |
| Fe | US | | JP | **CN** | W | DE | DE | US | **CN** |
| Cu | US | **CN** | CL | CL | Mo | DE | KR | AT | **CN** |
| Ni | US | **CN** | CA | CA | Ta | MX | US | US | CN |
| Al | US | | | **CN** | Co | US | **CN** | CA | |
| Zn | US | **CN** | CA | CA | Au | | **HK** | KR | GB |
| Pb | US | US | AU | AU | Ag | GB | (IN) | | (MX) |
| Mg | US | | CN | **CN** | Pt | US | **CN** | ZA | ZA |

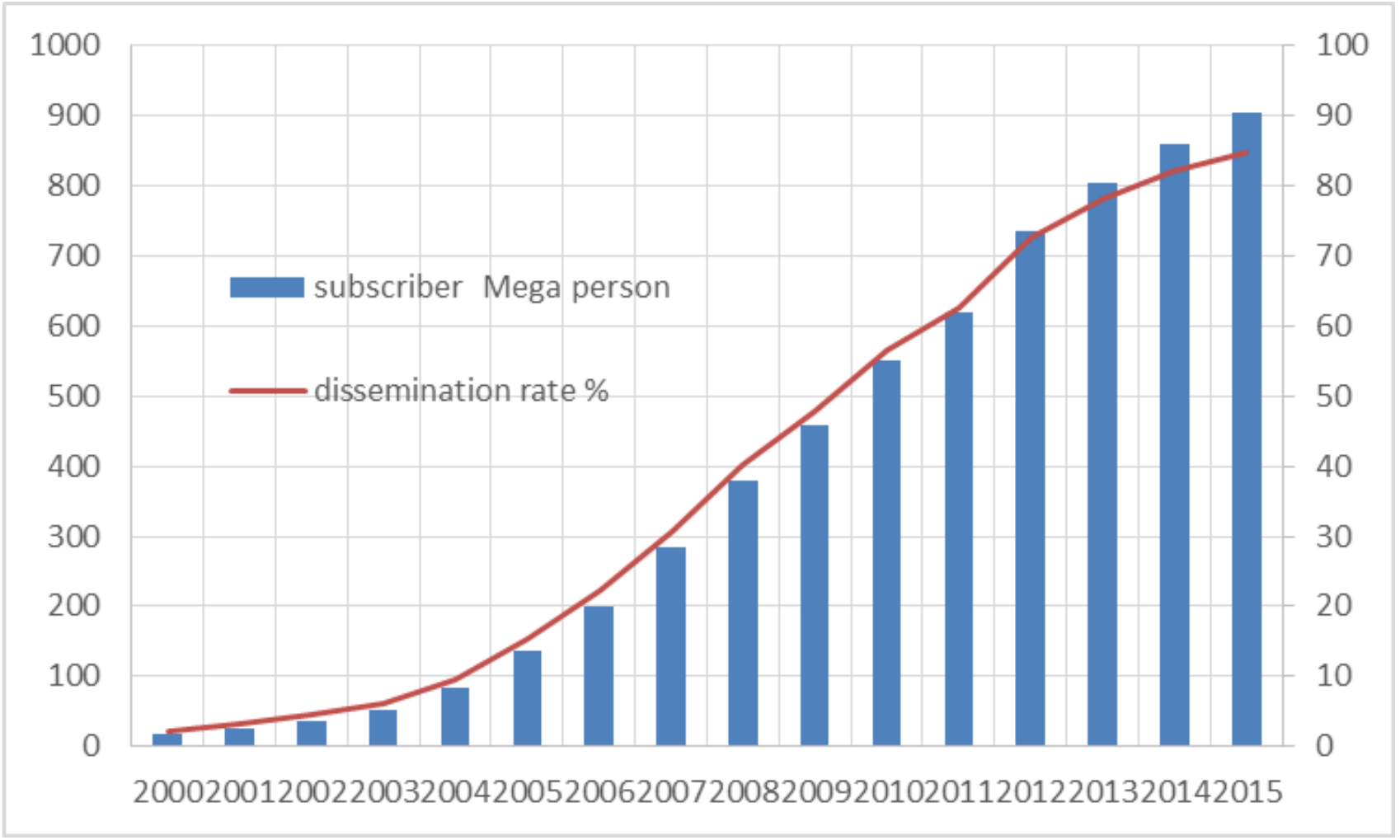
*Table 1: change of leading country of each metal trade from 1998 to 2013*

China exports products to developing countries all over the world as “the factory of the world.

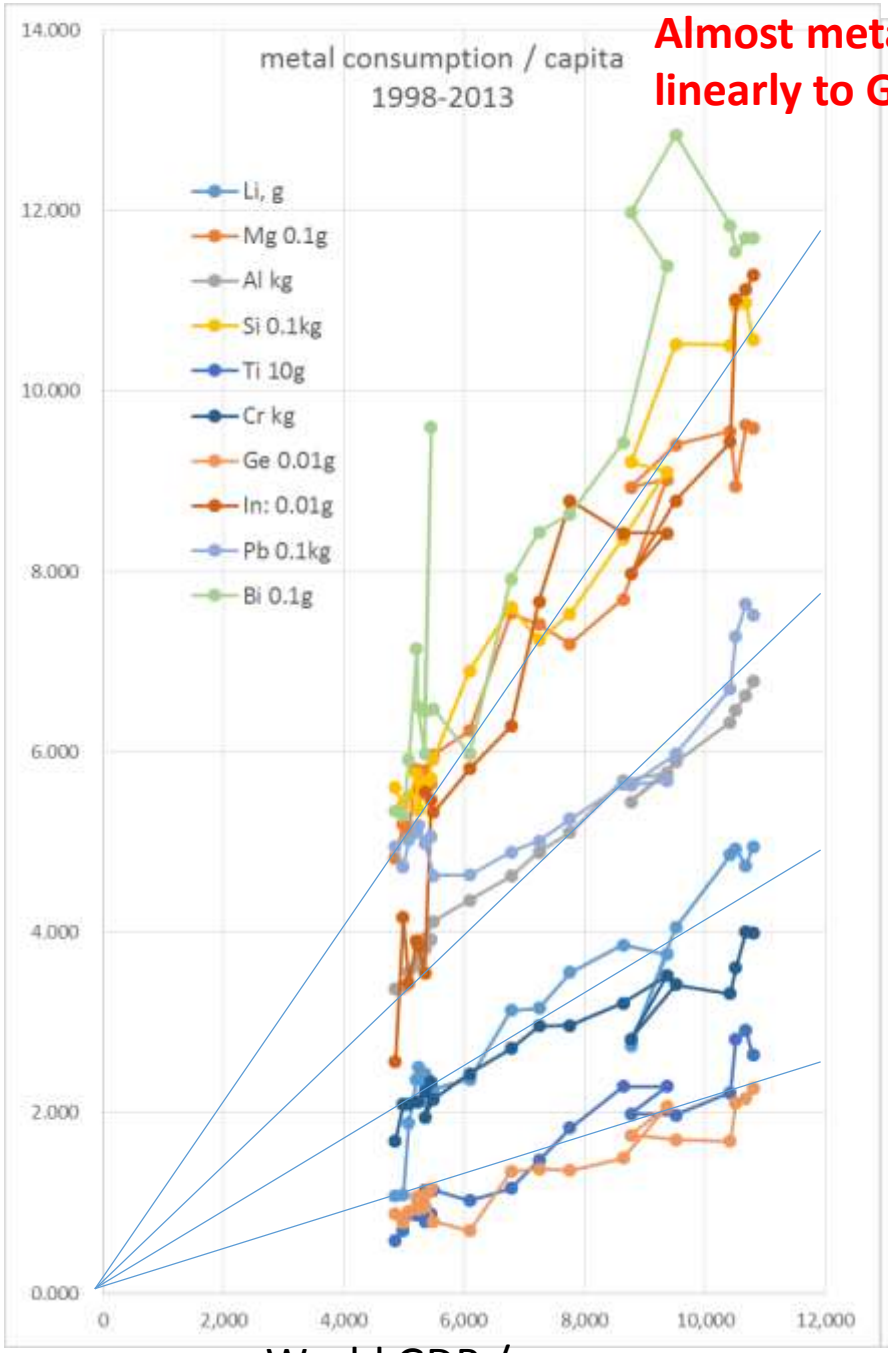
Behind the concentration of resources to China, the requirement of developing countries exists widely.

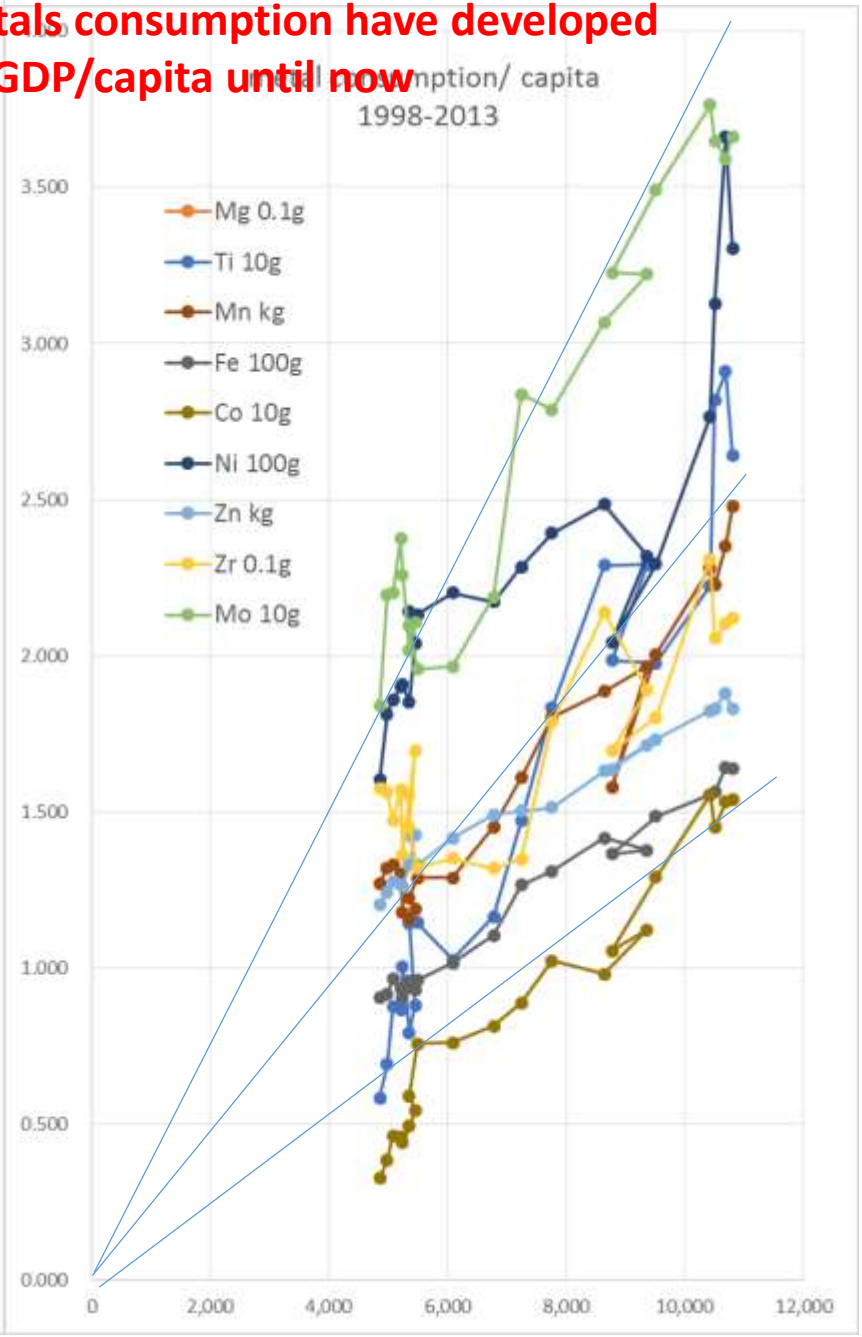



100000
10000
1000
100
2000
2010
2020
2030
2040
2050
2060
BRA
CHN
EGY
IDN
IND
JPN
MEX
NGA
PAK
RUS
SAU
TUR
WLD


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**

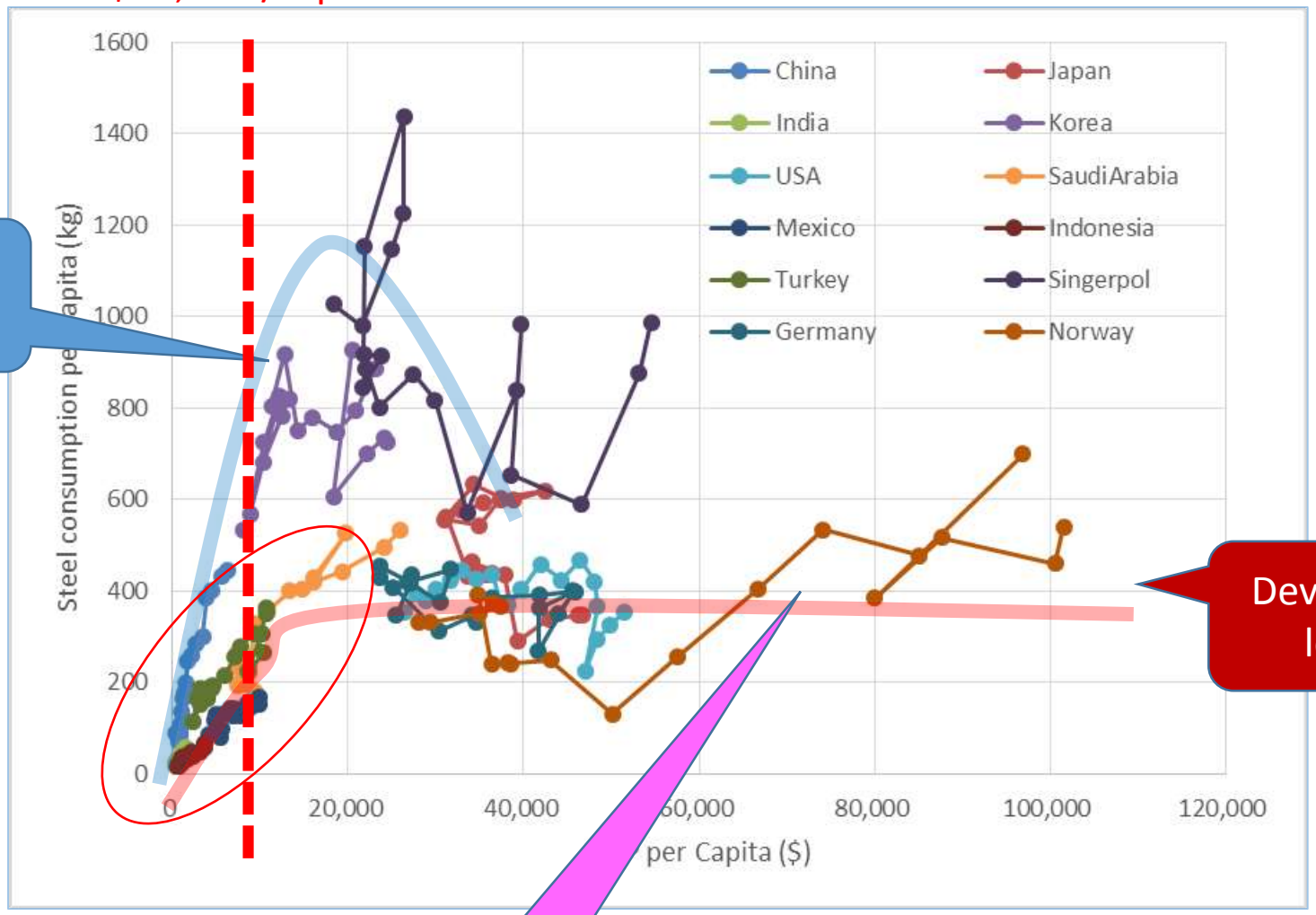



World GDP / person

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

$10,000 /capita




Exporting countries

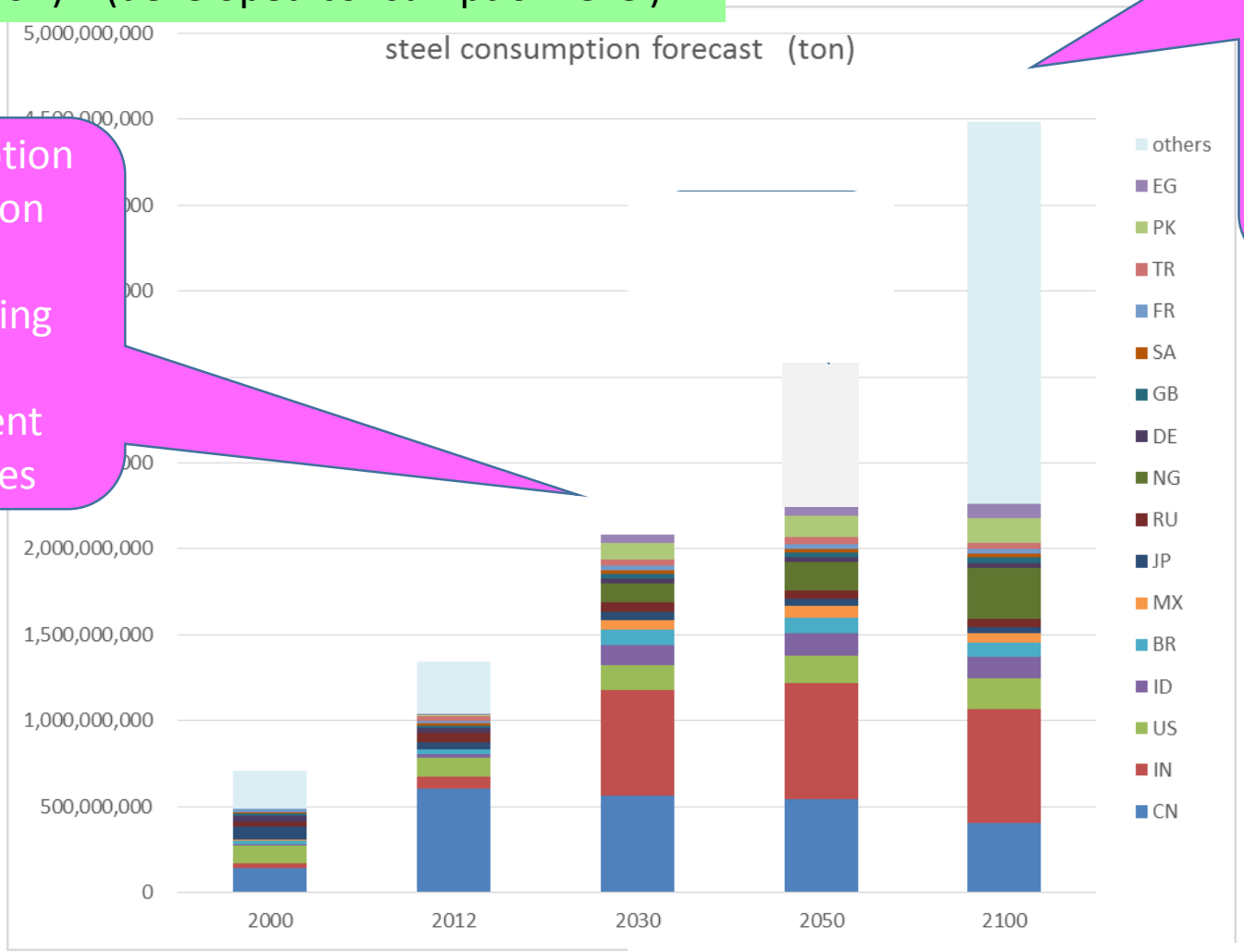
Developed level

Consuming countries

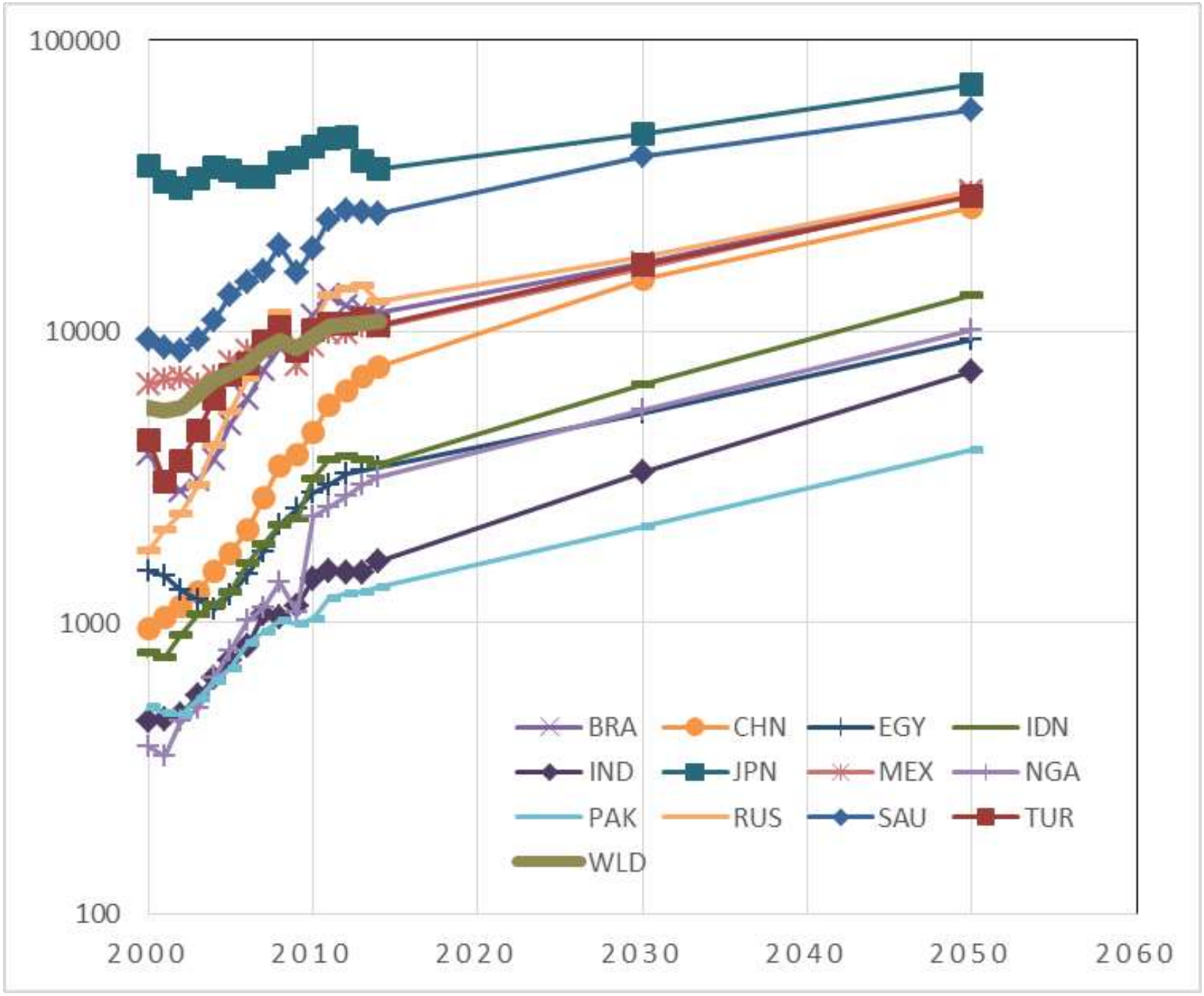
Rough forecast gets to be simpler,
(population) x (developed consumption level)

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 |


100000
10000
1000
100
2000
2010
2020
2030
2040
2050
2060
BRA
CHN
EGY
IDN
IND
JPN
MEX
NGA
PAK
RUS
SAU
TUR
WLD

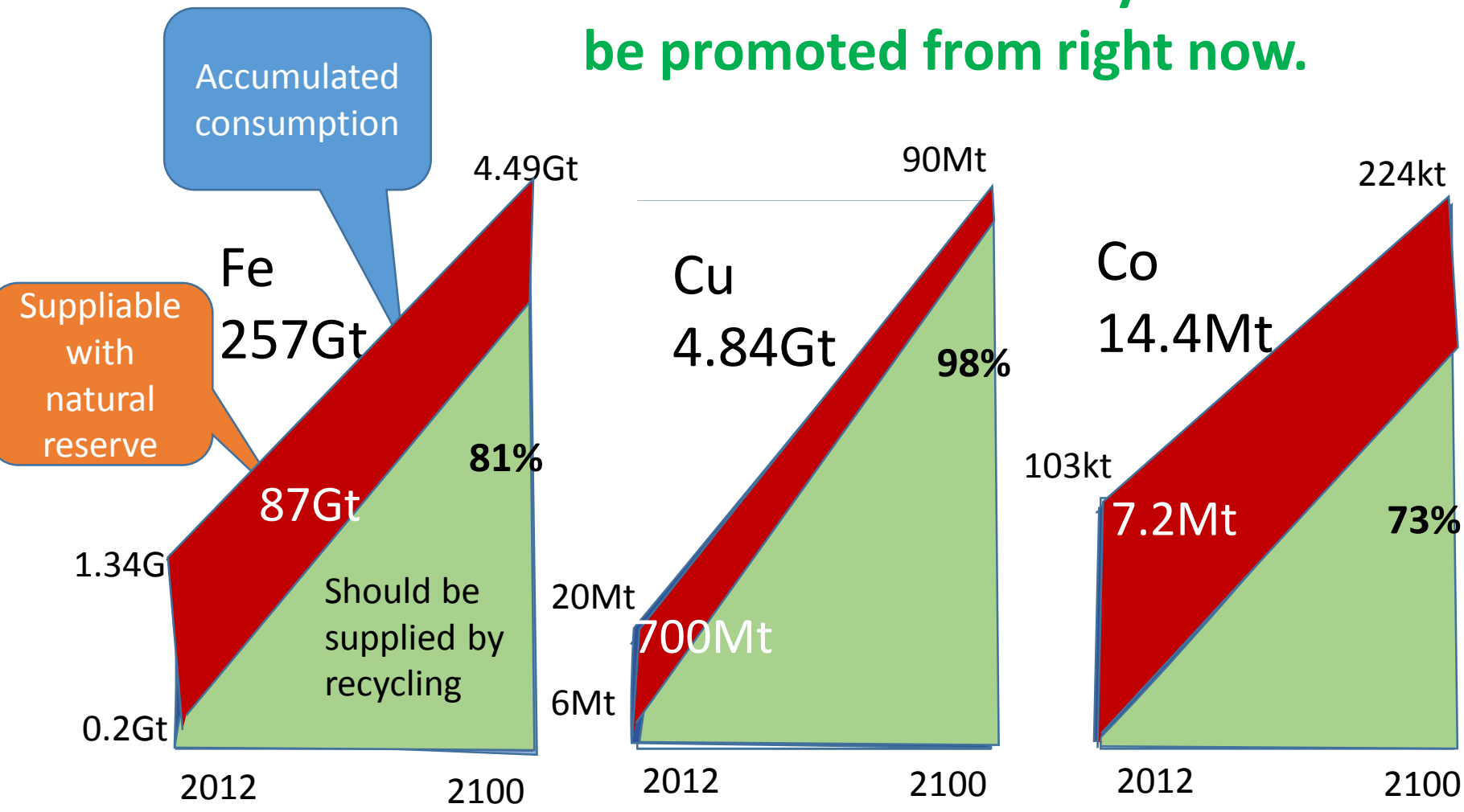
Are the reserves  enough for the 10 billions’  universal economy?

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

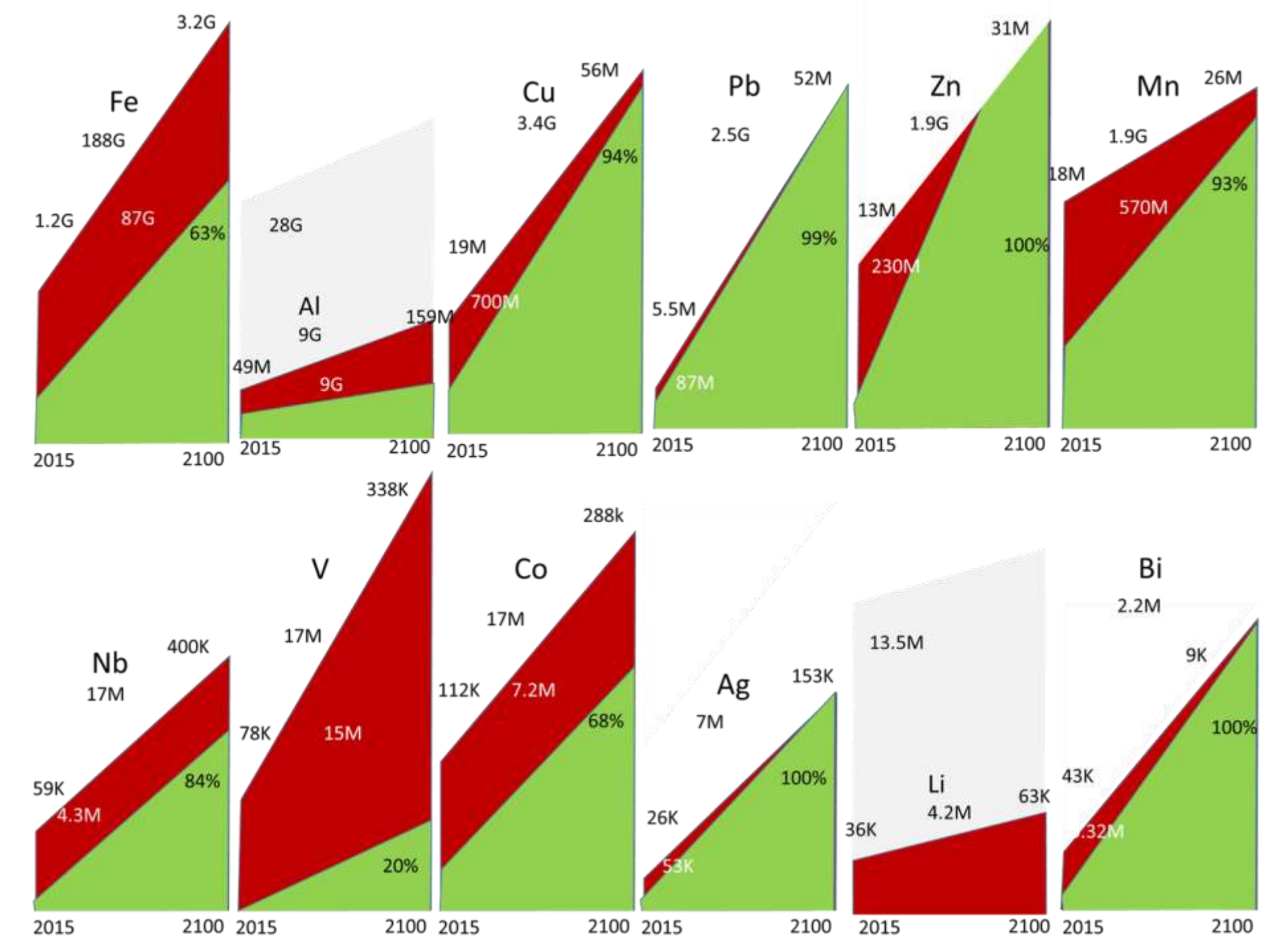

It is said that reserve increase when the price rises.

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

# 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
100%
13M
230M
2015
2100
Mn
26M
1.9G
93%
18M
570M
2015
2100
Nb
400K
17M
84%
59K
4.3M
2015
2100
V
338K
17M
78K
15M
20%
2015
2100
Co
288k
17M
112K
7.2M
68%
2015
2100
Ag
153K
7M
100%
26K
53K
2015
2100
Li
13.5M
63K
4.2M
36K
2015
2100
Bi
2.2M
9K
100%
43K
.32M
2015
2100

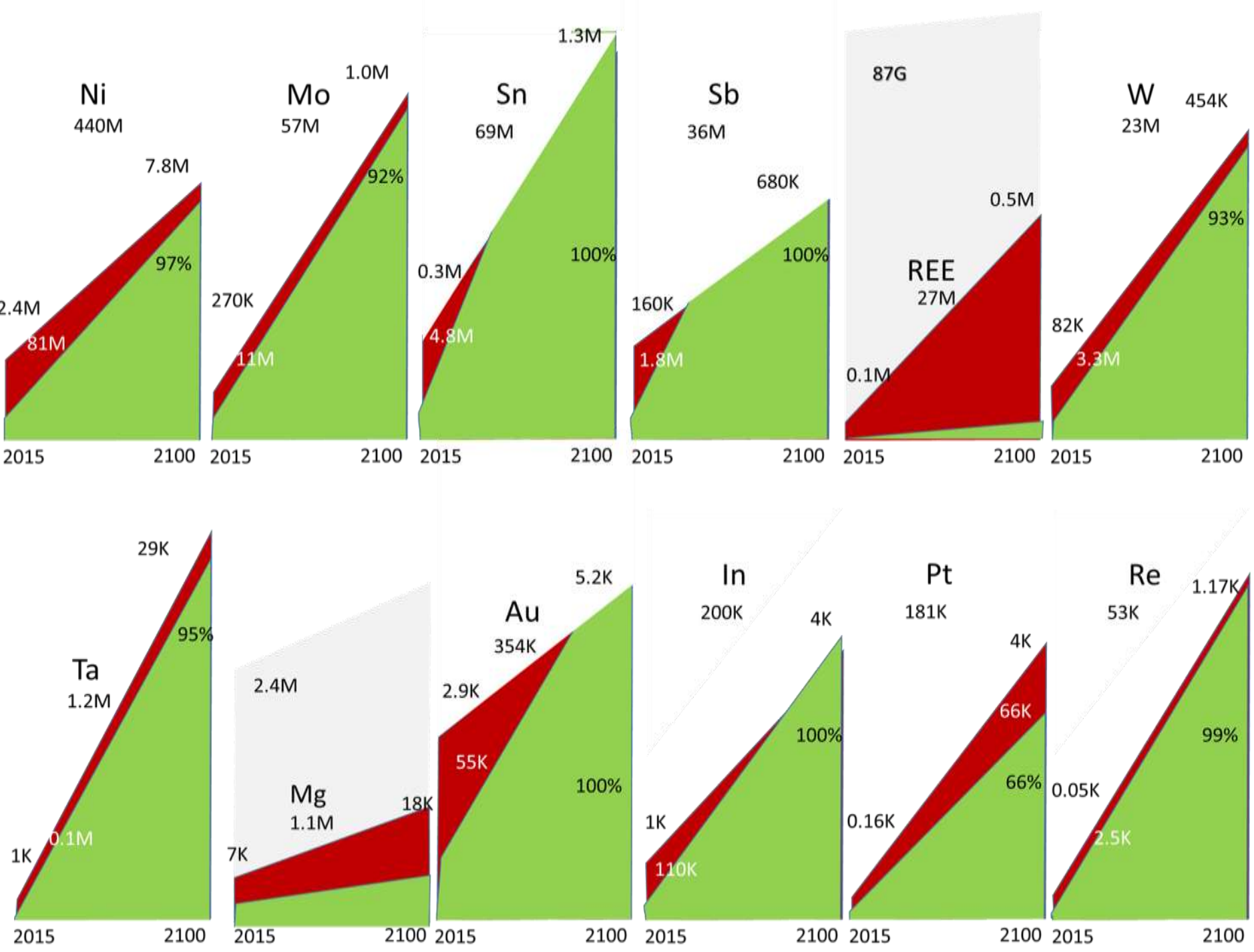
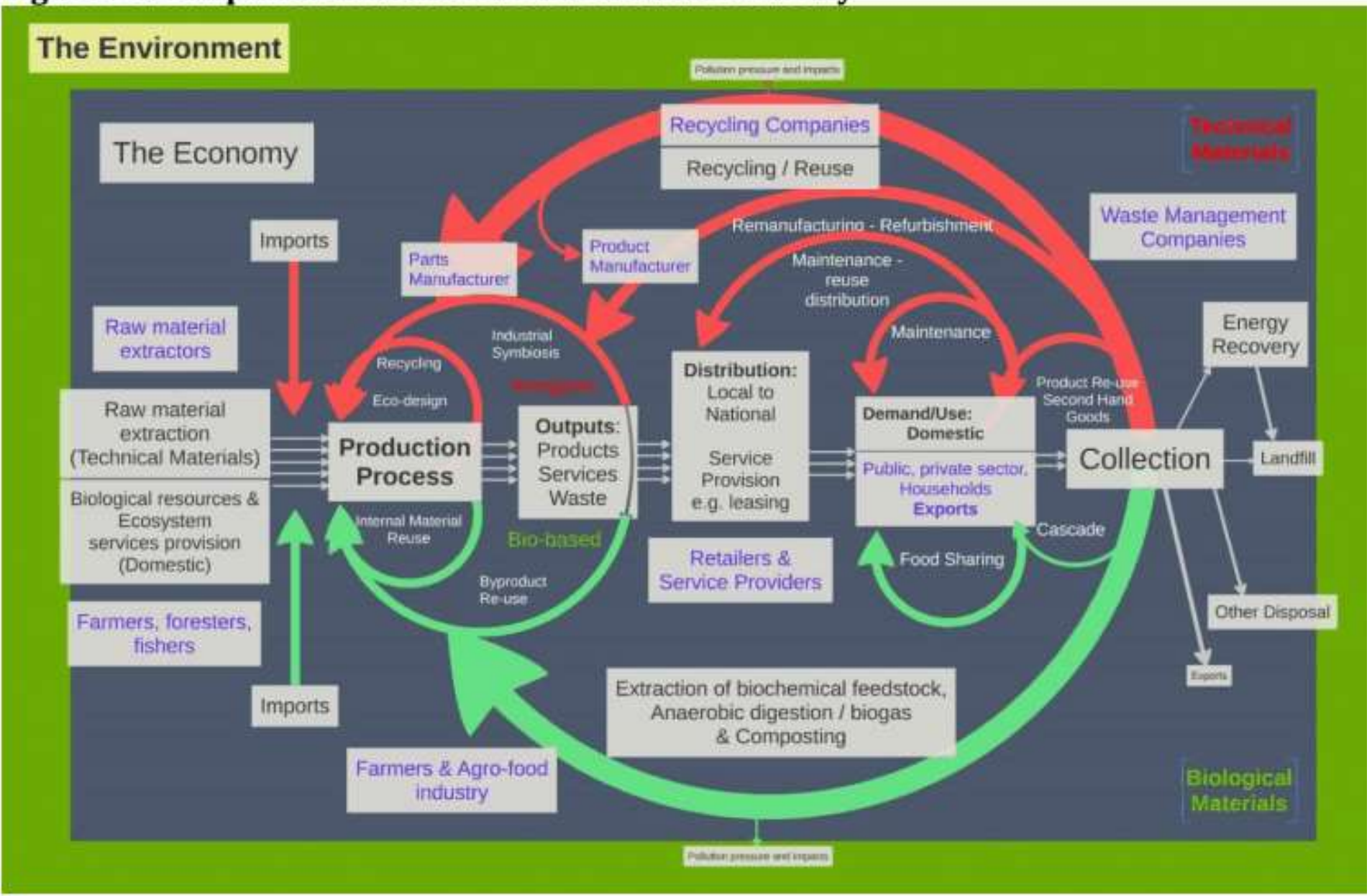
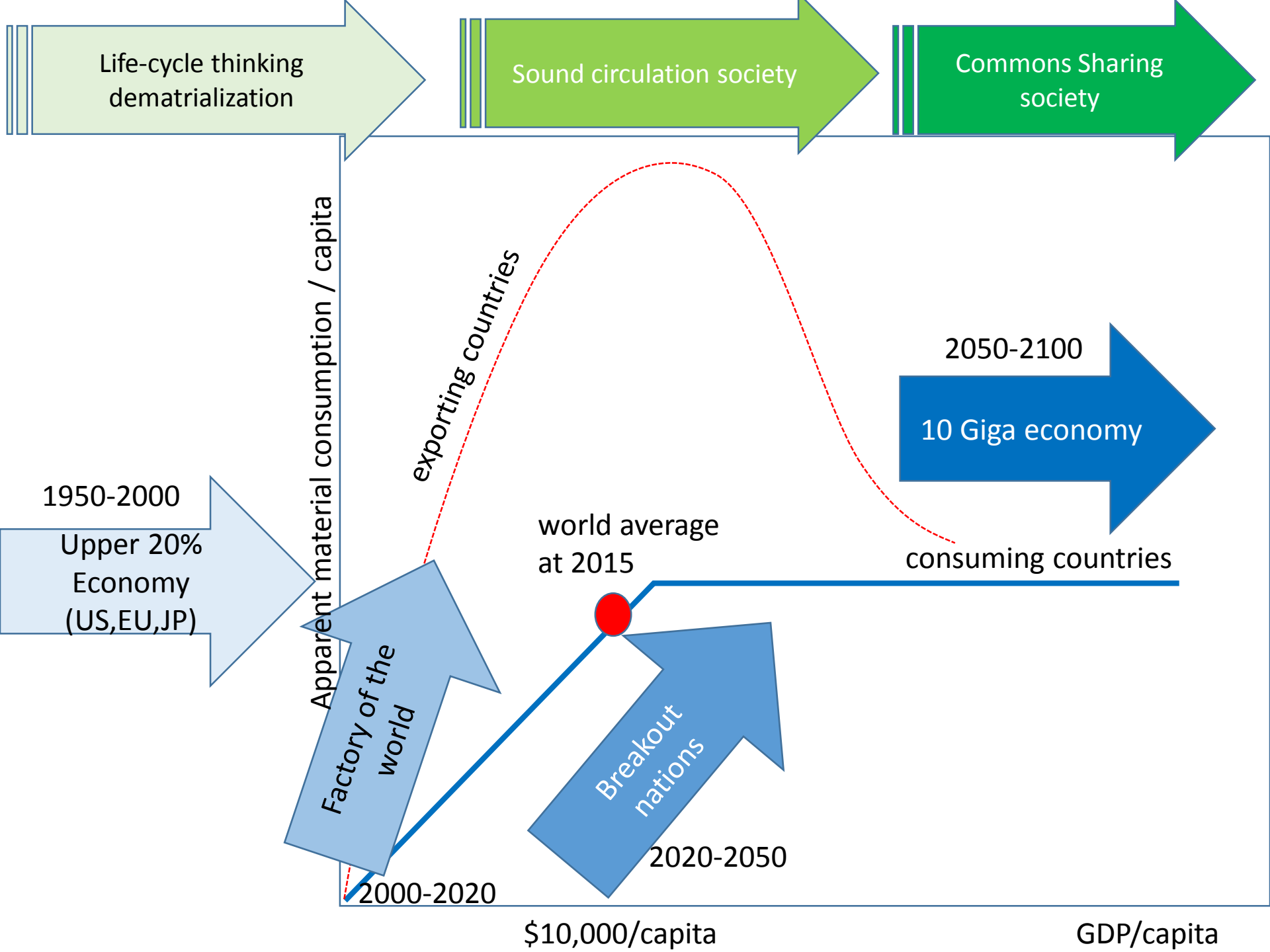
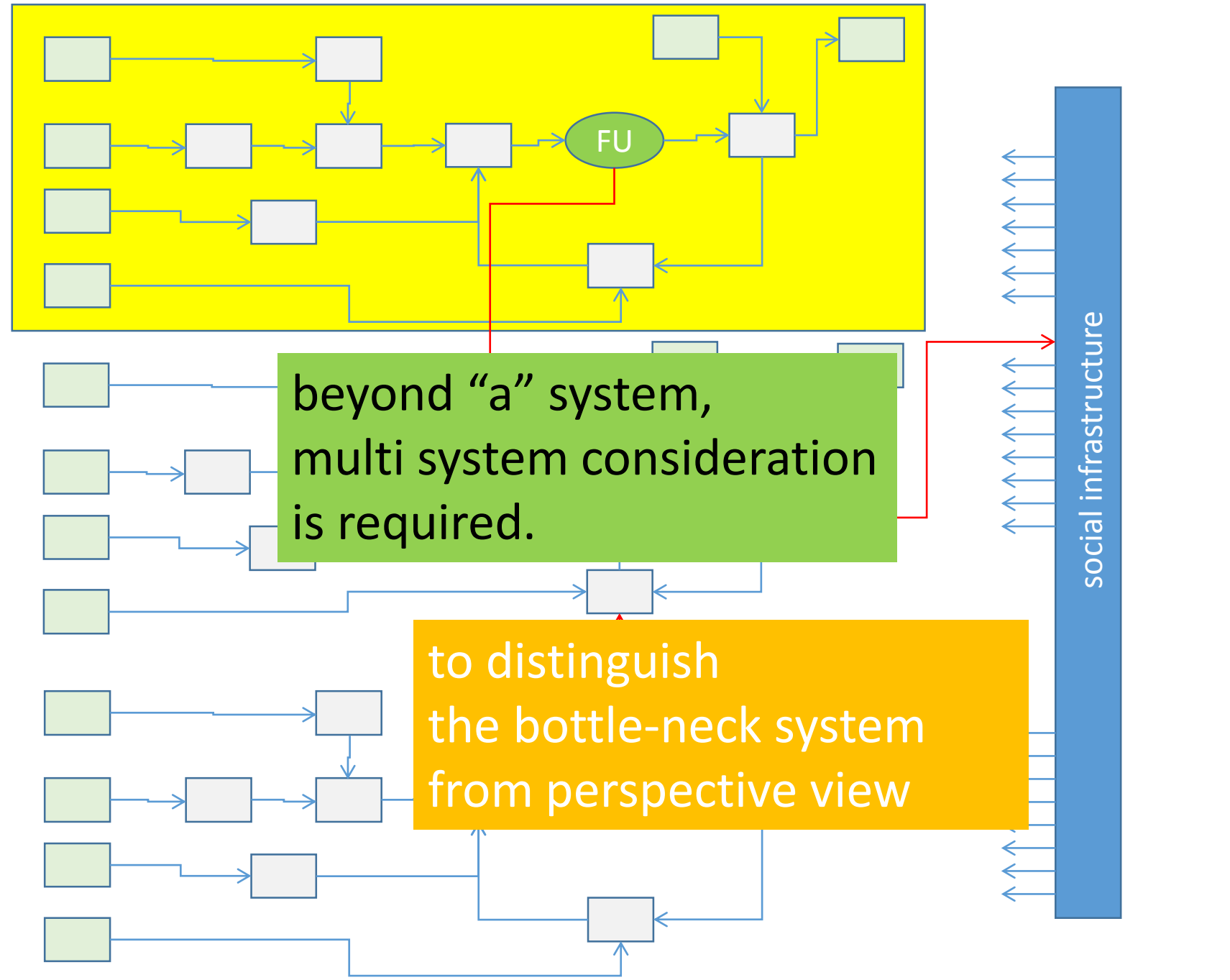

Ni
440M
7.8M
97%
2.4M
81M
2015
2100
Mo
57M
1.0M
92%
270K
11M
2015
2100
Sn
69M
1.3M
100%
0.3M
4.8M
2015
2100
Sb
36M
680K
100%
160K
1.8M
2015
2100
87G
REE
27M
0.5M
0.1M
2015
2100
W
23M
454K
93%
82K
3.3M
2015
2100
Ta
1.2M
29K
95%
1K
0.1M
2015
2100
2.4M
Mg
1.1M
18K
7K
2015
2100
Au
354K
5.2K
2.9K
55K
100%
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**

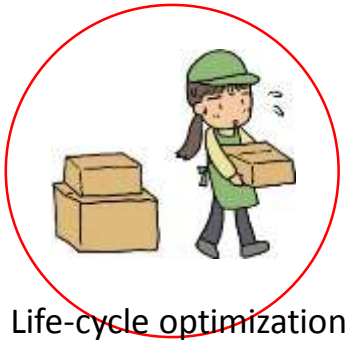



**Source:** Own representation, P ten Brink, P Razzini, S. Withana and E. van Dijl (IEEP), 2014


Life-cycle thinking
dematrialization
Sound circulation society
Commons Sharing
society
Apparent material consumption / capita
exporting countries
2050-2100
10 Giga economy
1950-2000
Upper 20%
Economy
(US,EU,JP)
world average
at 2015
consuming countries
Factory of the
world
Breakout
nations
2020-2050
2000-2020
$10,000/capita
GDP/capita


FU
social infrastructure
beyond “a” system,
multi system consideration
is required.
to distinguish
the bottle-neck system
from perspective view
natural resource
social resource

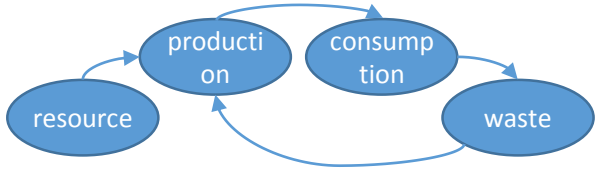
# Single system optimization is important, but it cannot deal with 10 billion's economy

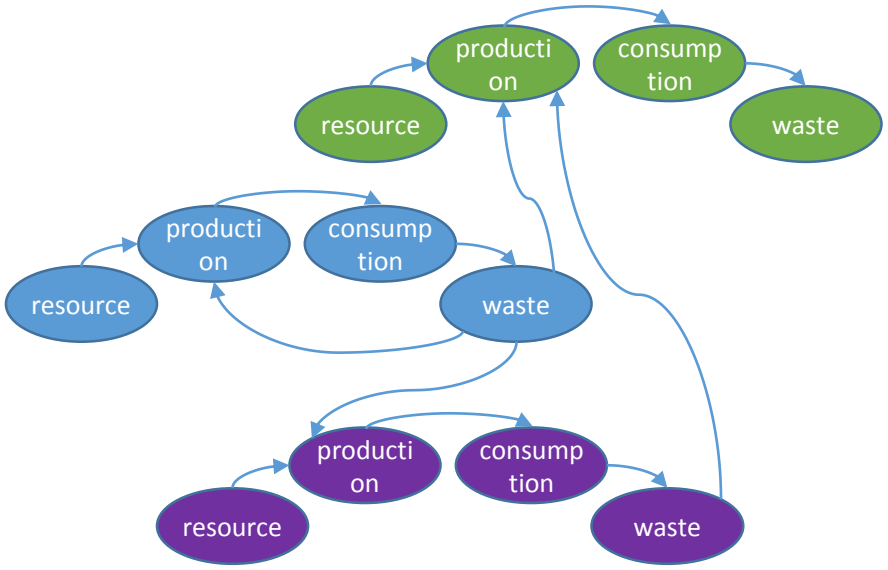


Life-cycle optimization

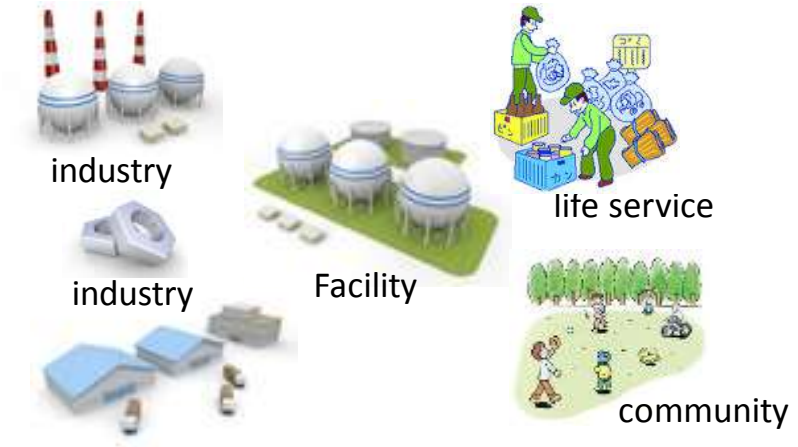
# Life-cycle consideration → multi system consideration

Re-use → Trans-use




SHARING

# DELIVERING RESOURCE-EFFICIENT PRODUCTS

How Ecodesign can drive a circular economy in Europe

EUROPEAN ENVIRONMENTAL BUREAU

## HOW TO CUT RESOURCE USE WITH ECODESIGN

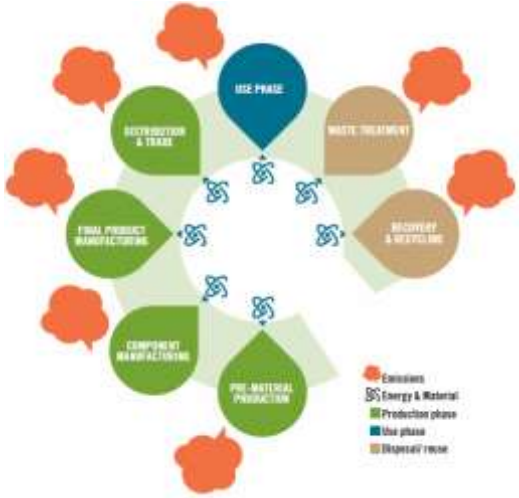
BETTER REPAIRABILITY AND DURABILITY of products

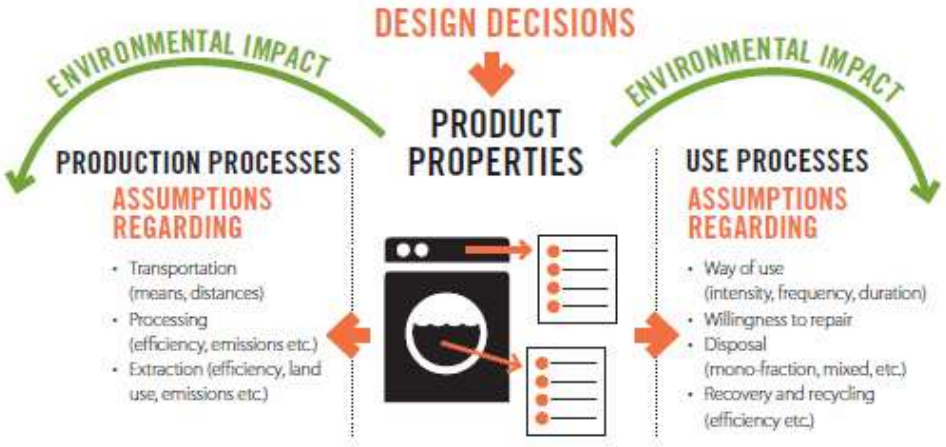
+

HIGHER RECYCLABILITY of materials

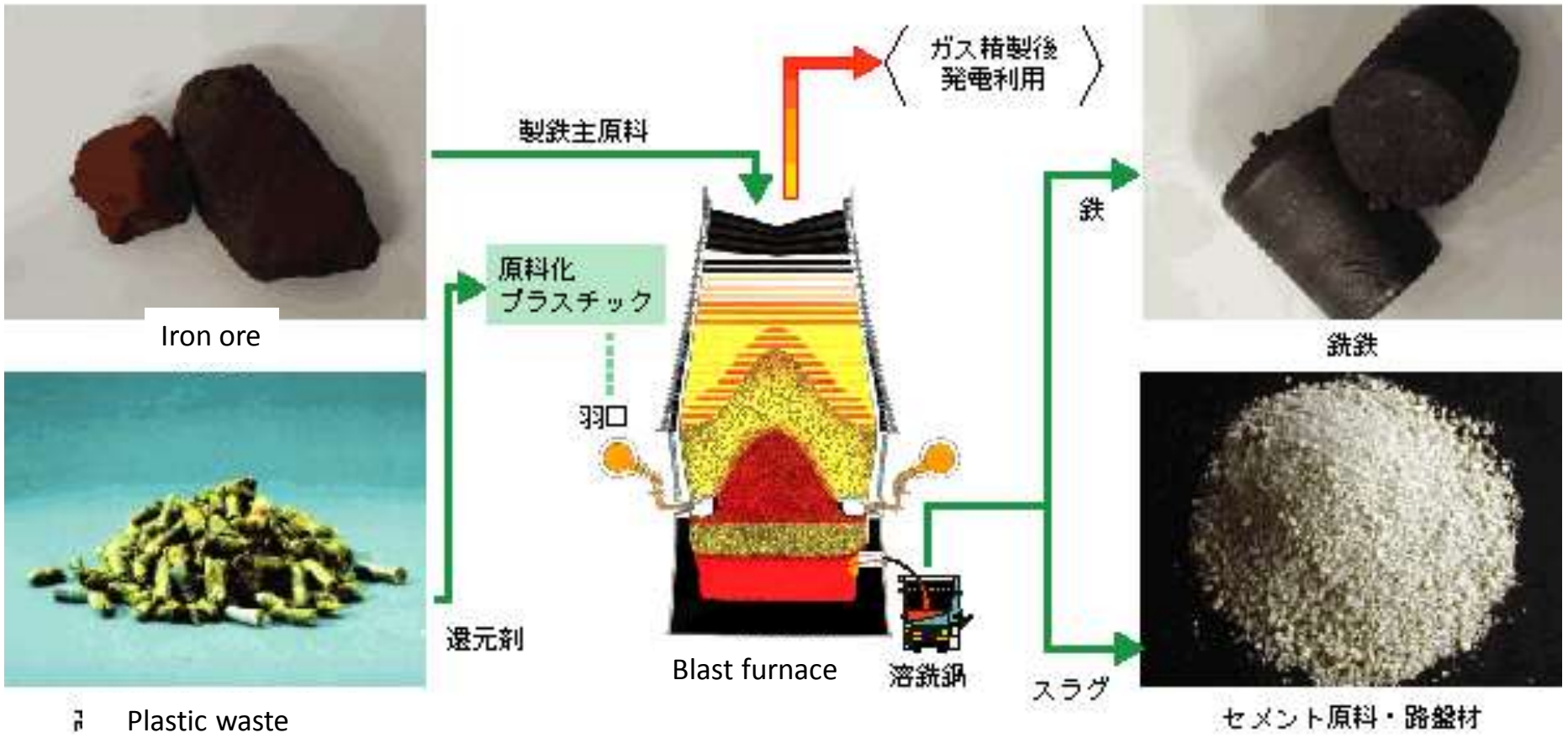
+

REMOVAL OF HAZARDOUS SUBSTANCES



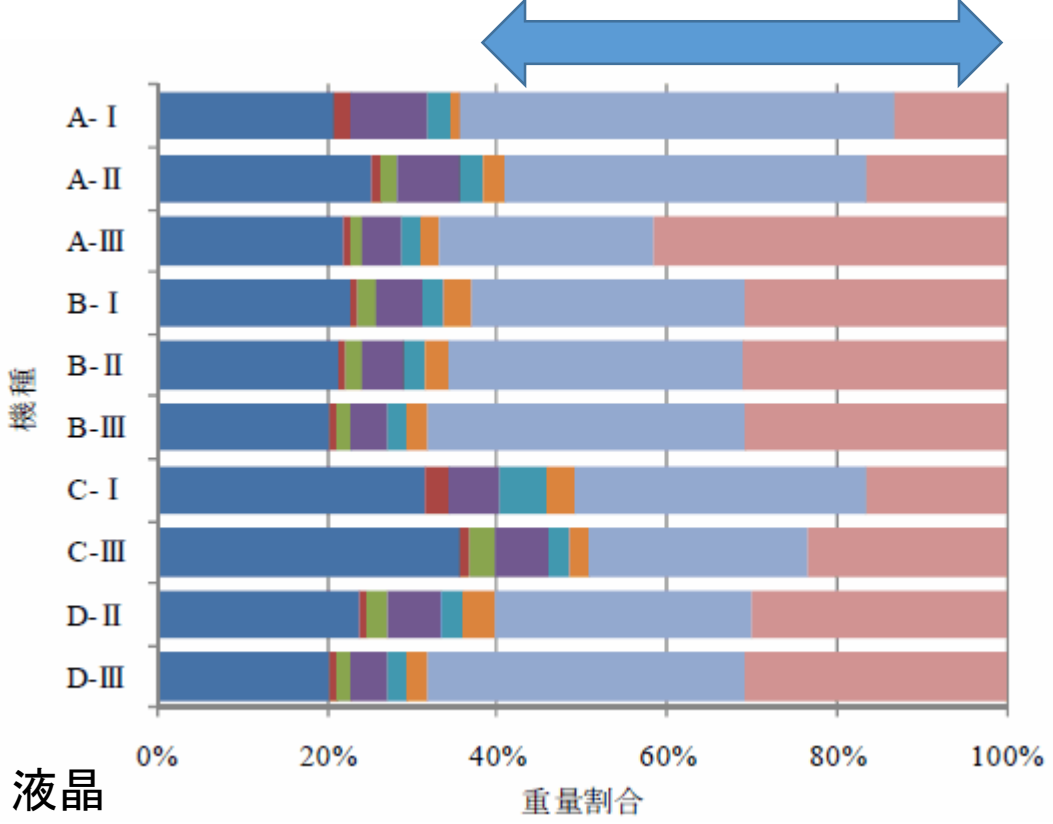



# Chemical recycle of plastic in iron making




資料：ＪＦＥスチール（株）

Good collaboration of “iron making system” and “plastic waste management system”




Smelting facilities

slag

Cement industry facilities

cement

液晶

| | 2000-2002年 |
|---|---|
| 元素 | A-Ⅰ |
| Ag | |
| Al | 1～5 |
| As | |
| Au | |
| B | 1～5 |
| Ba | 0.5～3 |
| Ca | 0.5～3 |
| Cr | |
| Cu | 0.01～0.1 |
| Fe | |
| In | 0.01～0.1 |
| Mg | 0.1～1 |
| Mn | |
| Mo | |
| Ni | |
| Sb | |
| Si | 10～30 |
| Sr | |
| Ti | 0.005～0.05 |
| W | |
| Zn | |

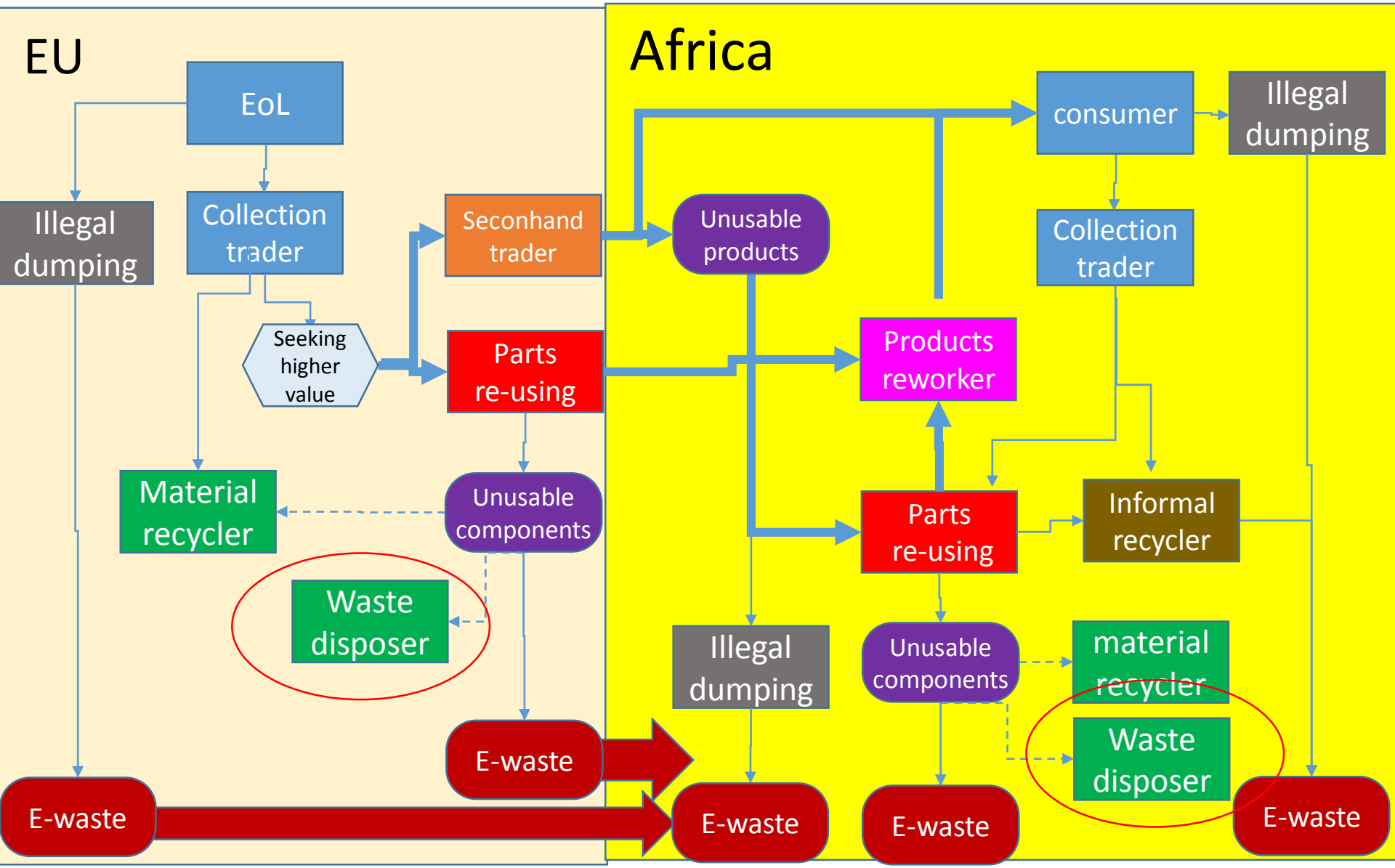
基板

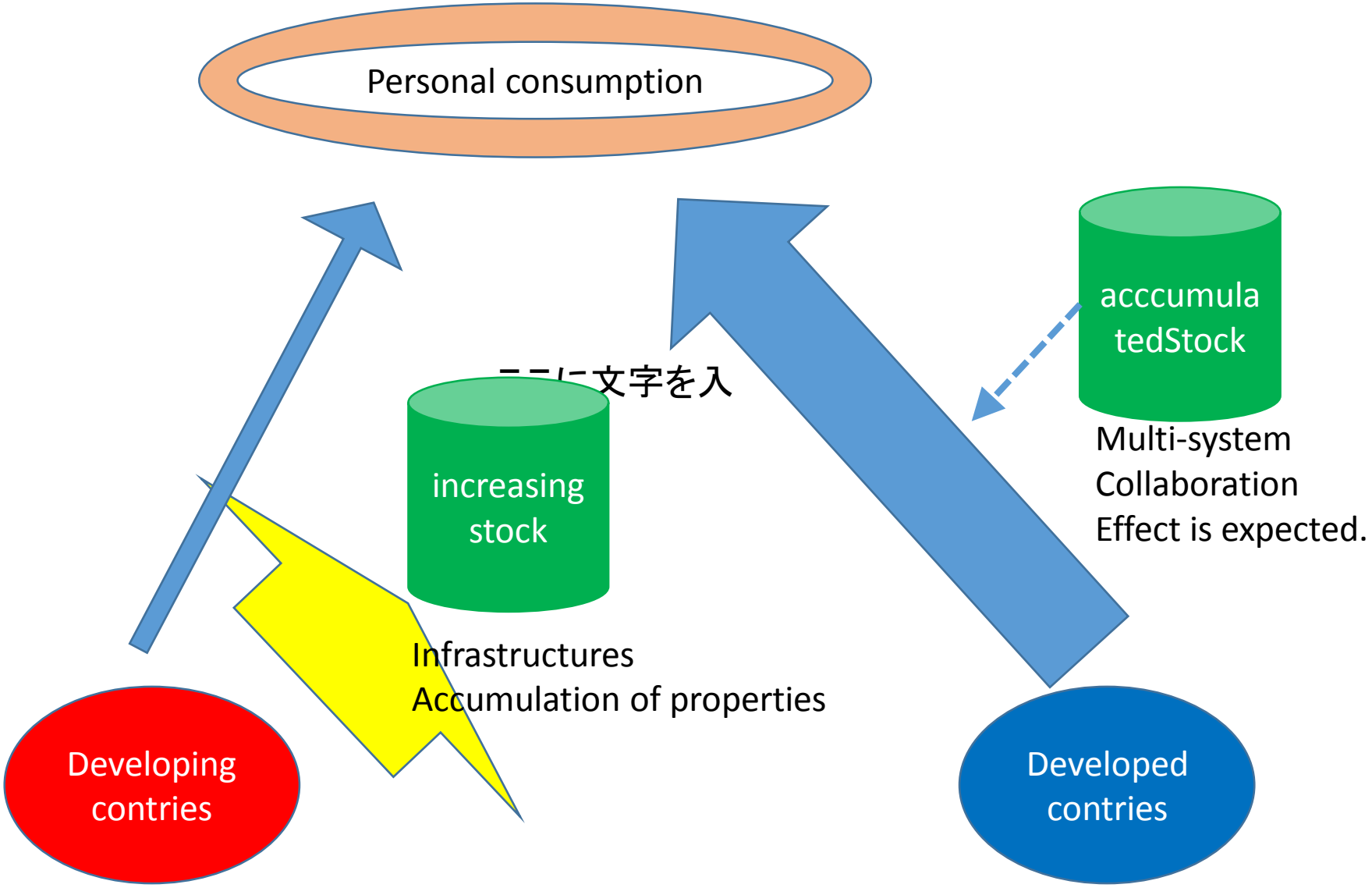
| 基板 | A-Ⅰ |
|---|---|
| 元素 | 2000-2002年 |
| Ag | 0.262 |
| Au | 0.113 |
| Co | 0.031 |
| Cu | 25.7 |
| Dy | 0.014 |
| In | 0.008 |
| Nd | 0.112 |
| Pd | 0.012 |
| Sm | ＜0.01 |
| Ta | 0.180 |
| W | 0.132 |

Ag 0.05%
Au 0.02%
Co 0.06%
Cu 5%
Dy 0.003%
In 0.0015%
Nd 0.02%
Ta 0.04%
W 0.025%

Existing facilities support the circulation

# Structure of the issue of E-waste

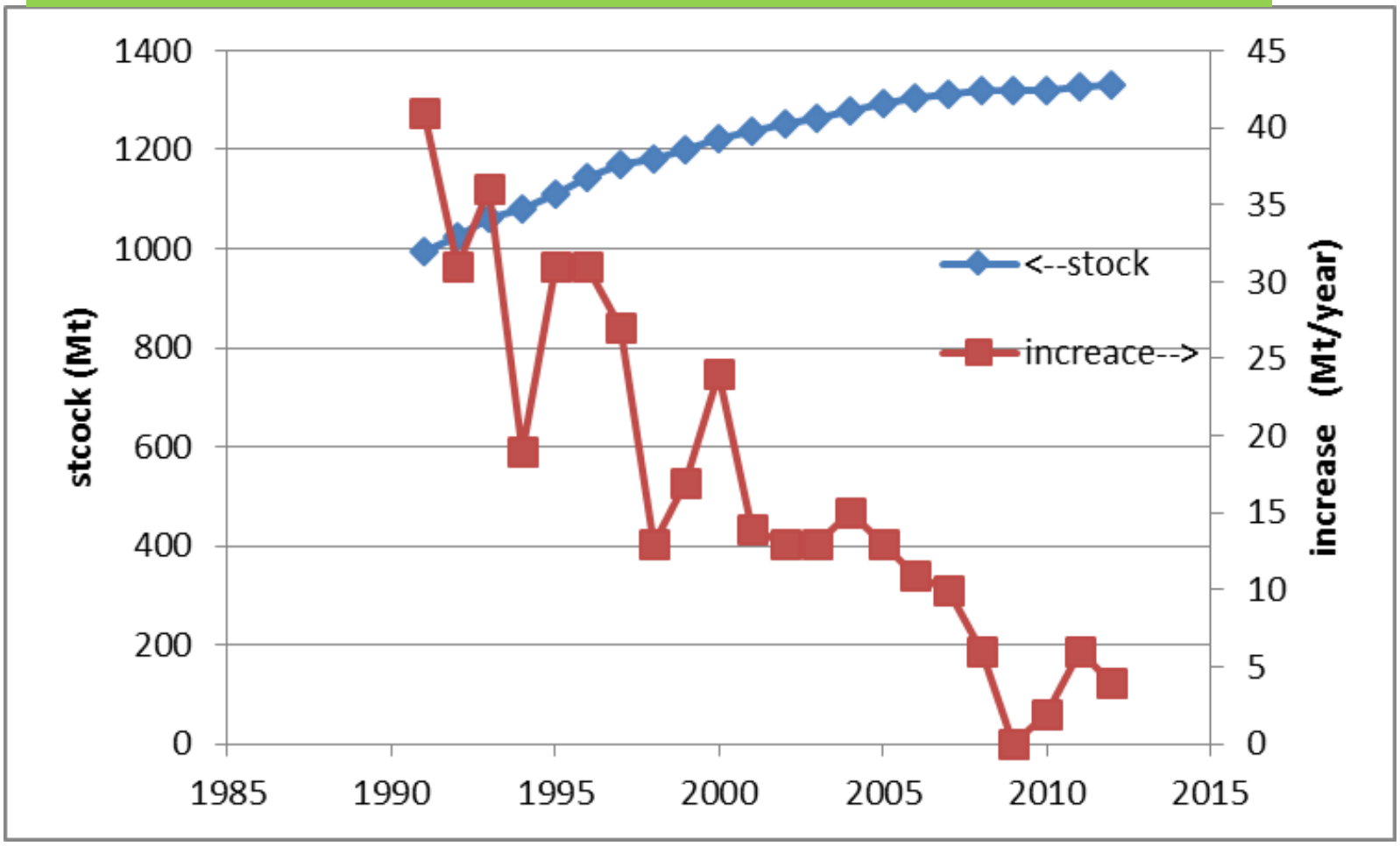





We have been discussing on sustainable consumption in mutual countries
but major material flow has becoming the stock accumulation of developing countries.

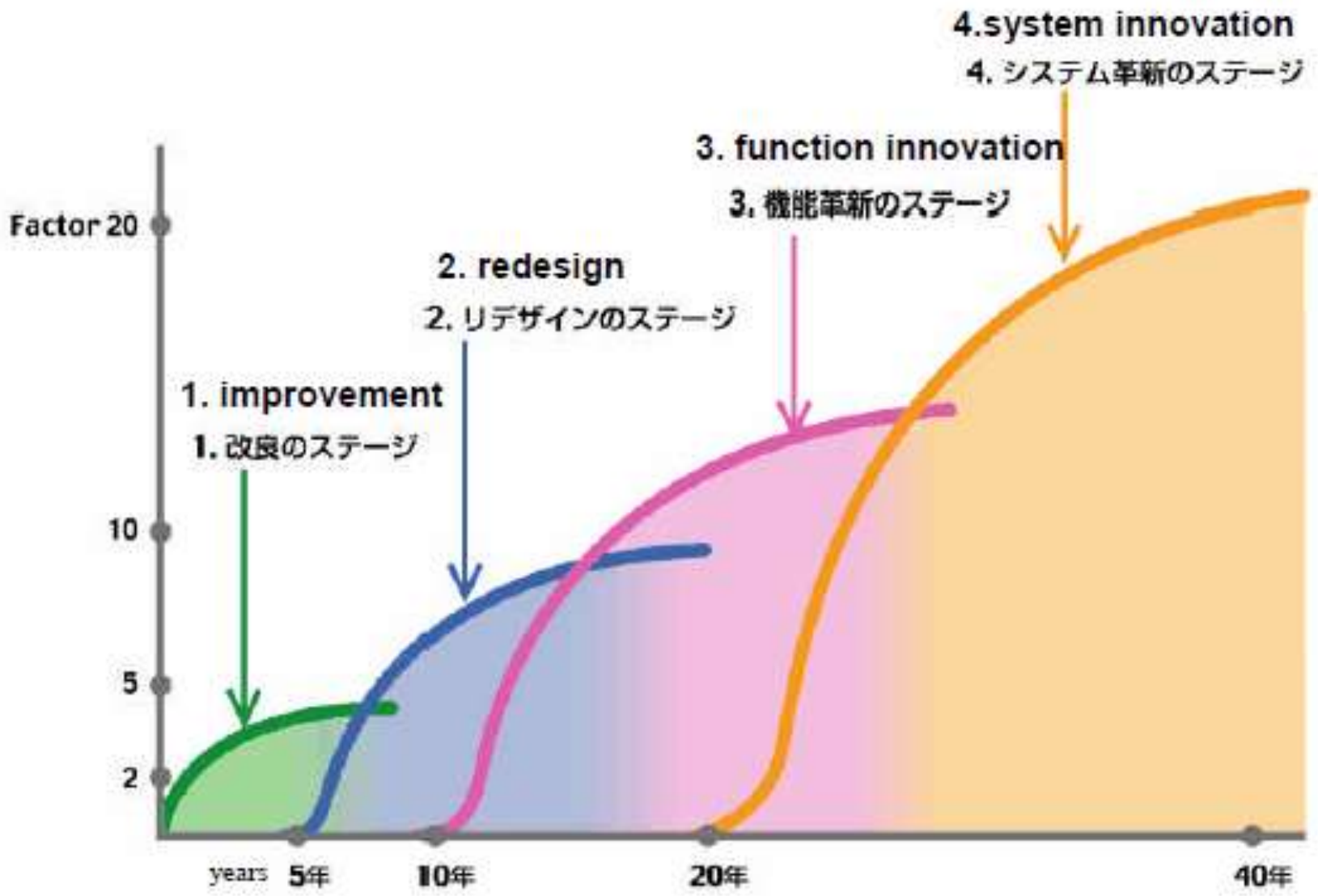
But, stock is saturating in developed country.

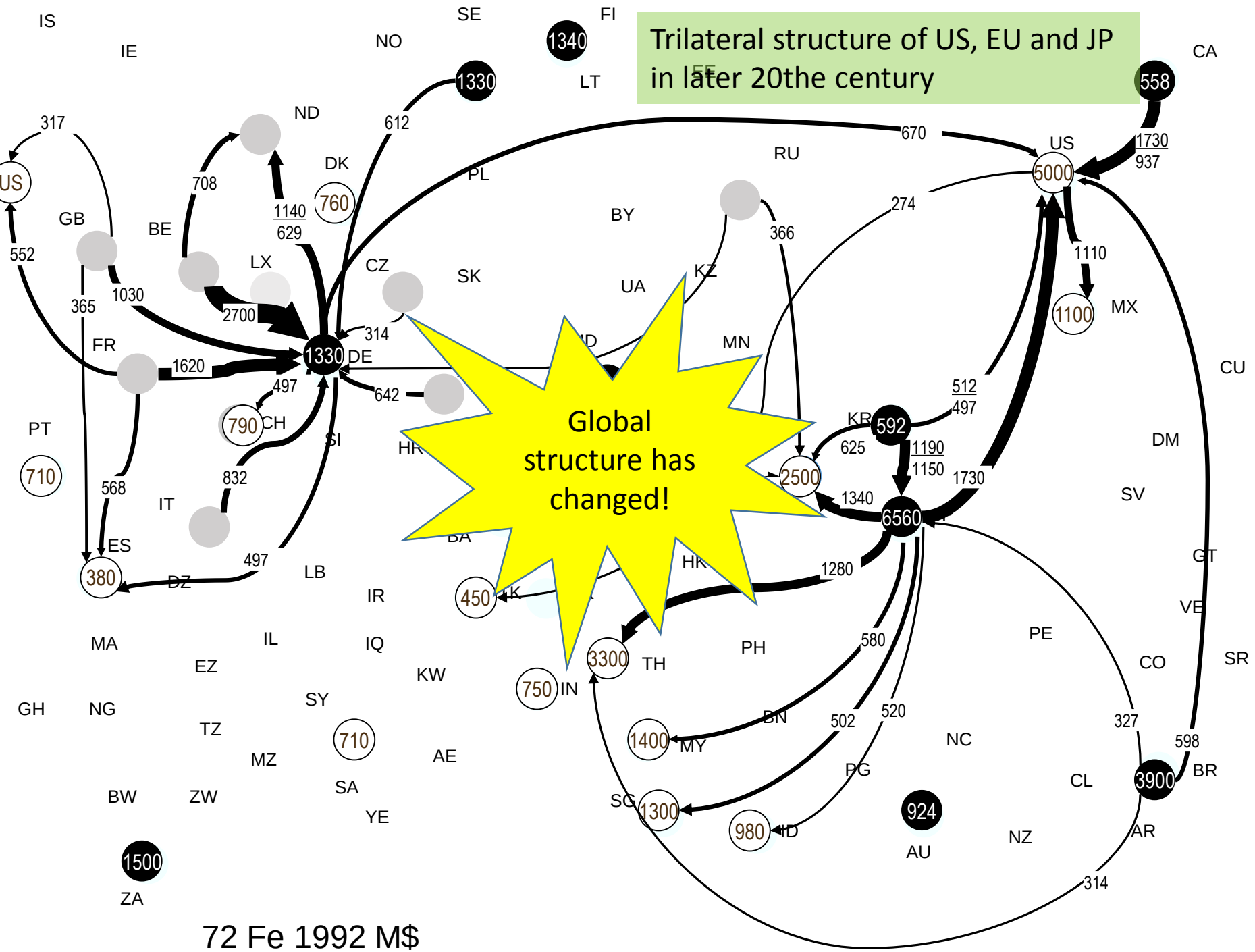
We have to pay attention on stock,
how utilize existing stock
how create appropriate stock which can be shared by multiple system



# Four steps model for Eco design innovation

By Prof. Han Brezet; TU Delft




Trilateral structure of US, EU and JP in later 20the century
Global structure has changed!
72 Fe 1992 M$
IS
IE
SE
NO
FI
1340
LT
1330
612
317
ND
DK
760
708
1140
629
670
RU
PL
BY
366
274
US
5000
1730
937
558
CA
552
GB
BE
LX
CZ
SK
UA
KZ
1110
1100
MX
365
1030
2700
314
FR
1330
DE
MN
1620
497
642
790
CH
SI
HR
512
497
592
KR
625
1190
1150
1730
2500
1340
6560
PT
710
568
IT
832
ES
380
DZ
497
LB
BA
HK
1280
450
IR
IK
MA
IL
IQ
EZ
KW
3300
TH
PH
580
750
IN
SY
GH
NG
TZ
710
MZ
AE
1400
MY
BN
502
520
PG
SG
1300
980
ID
924
AU
NC
CL
3900
BR
327
598
AR
NZ
314
BW
ZW
SA
YE
1500
ZA
CU
DM
SV
GT
VE
PE
CO
SR

Trilateral structure in latter 20th century

Based on mature consumption

# Provide superior goods by optimizing good quality process & resources

Factory of the world

Provide passable goods which can be made anyplace, more rapid, more cheap

Power economy runs ahead Sustainability

Alternative Material/Energy utilization system should be proposed

Face to face technology
Supply chain management
Servisizing
Goods to sale -> goods to use
Utilization of existing stock

prepare the solution of safety and satisfaction against the sweeping of power economy

- World is changing rapidly
- We will be in 10 billion peoples' universal economy.
- Discussion on sustainable consumption and life-cycle design has become insufficient.
- Multi-system consideration is required now.

# Thank you　ご清聴ありがとう

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