

Multi-Value Circulation

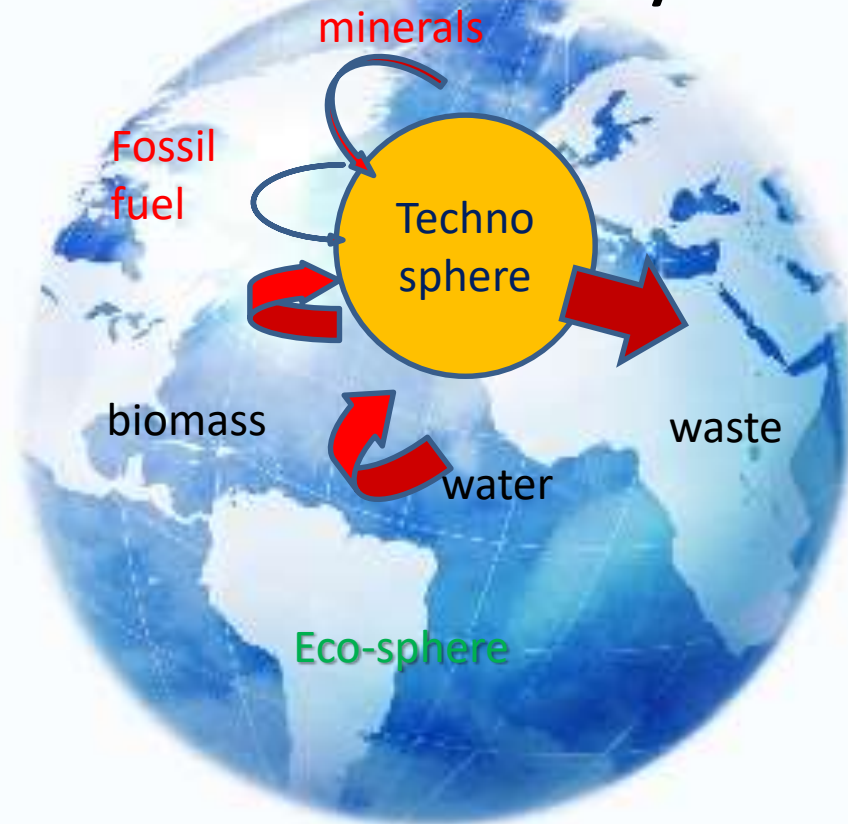
Resource Efficiency, Circular Economy and Material Technology

Kohmei HALADA

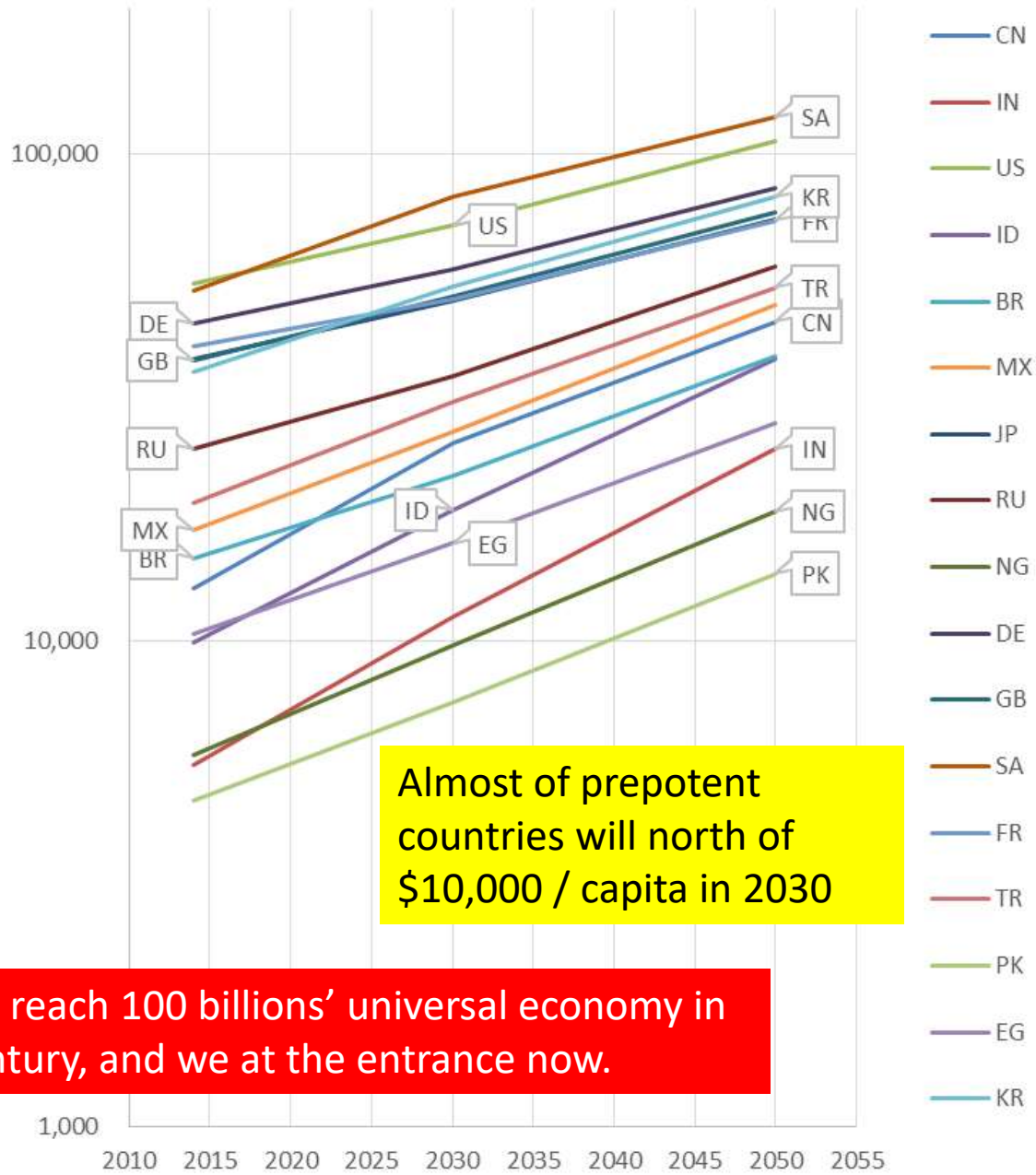
NIMS adviser, National Institute for Material Science
&
President, Sustainable Design Institute

The world at 2100

- The minerals and fossil fuels from natural resource is nearly zero.



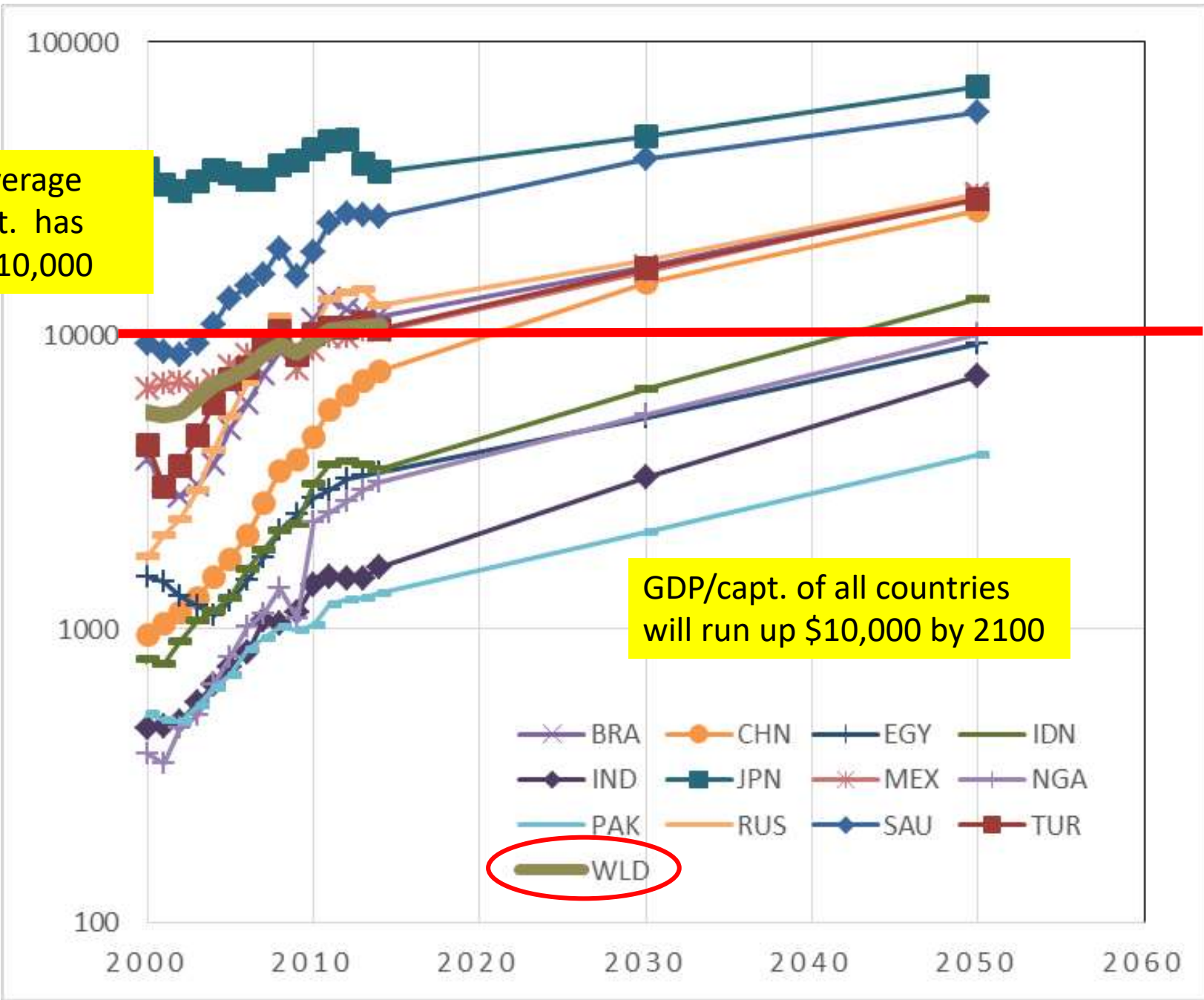
forecasted GDP per person (PPP base)



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

We will reach 100 billions' universal economy in this century, and we at the entrance now.

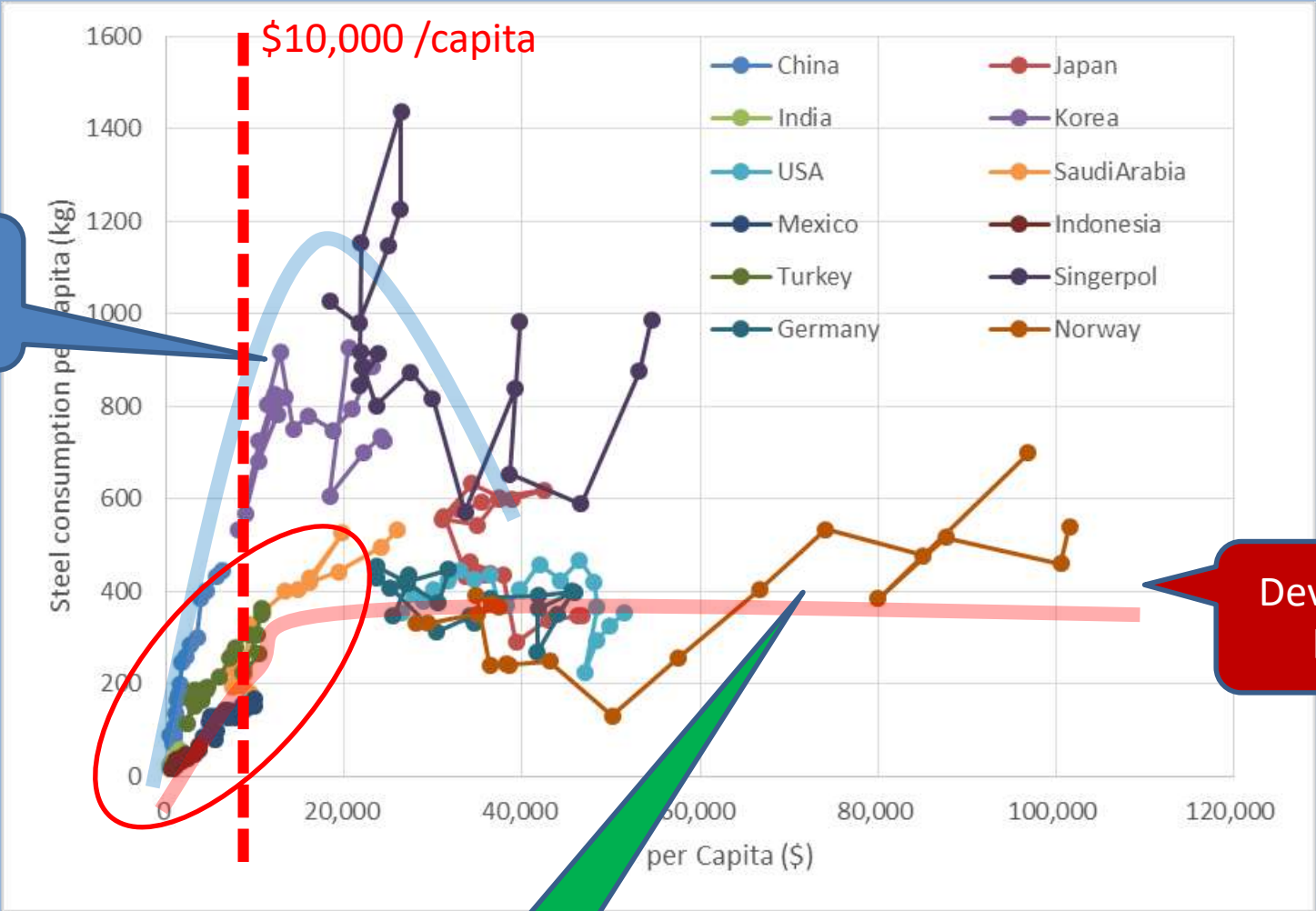
World average GDP/capt. has run up \$10,000



GDP/capt. of all countries will run up \$10,000 by 2100

Consumption/capt. reaches developed level when GDP capt. reaches \$10,000

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

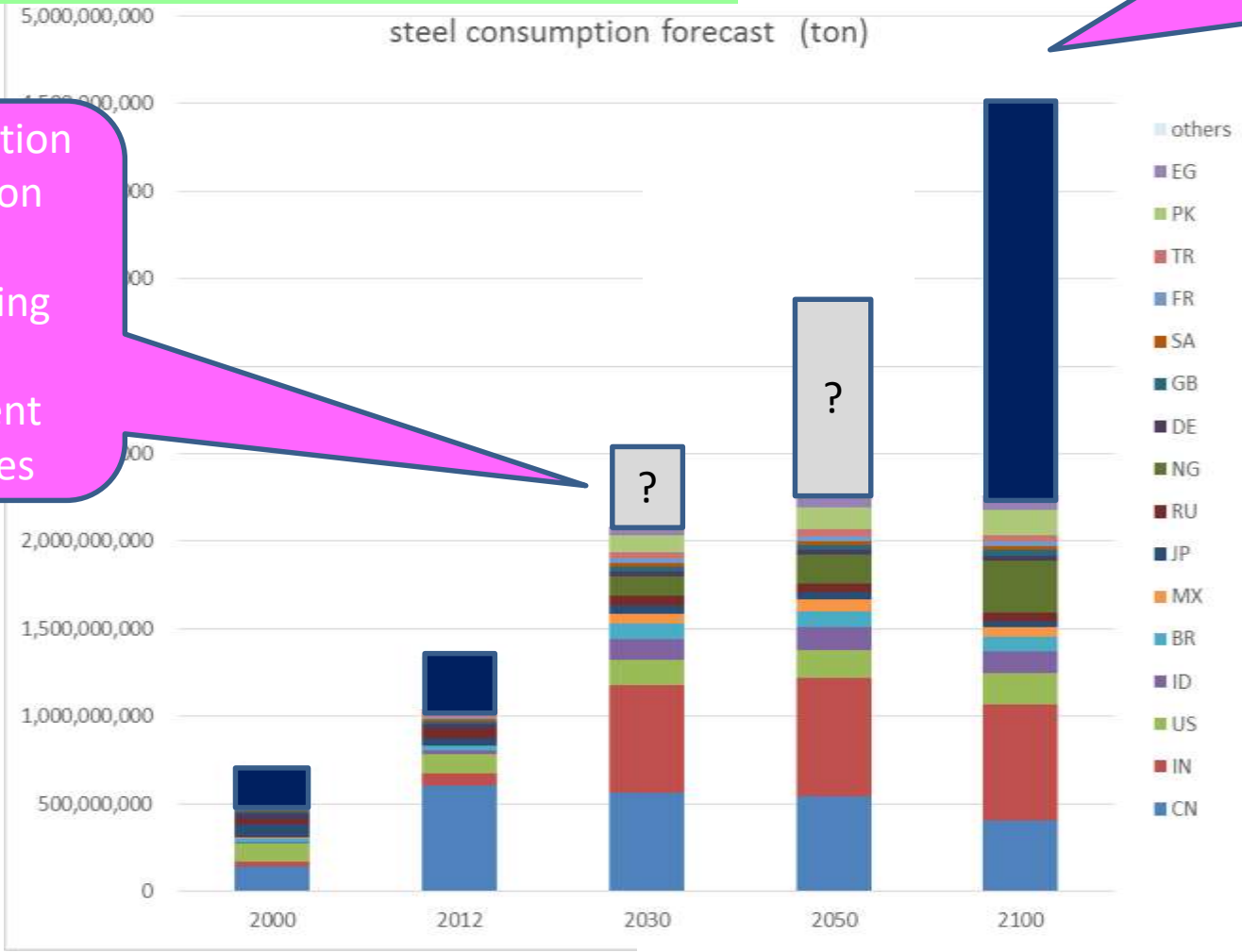


Exporting countries

Developed level

Consuming countries

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



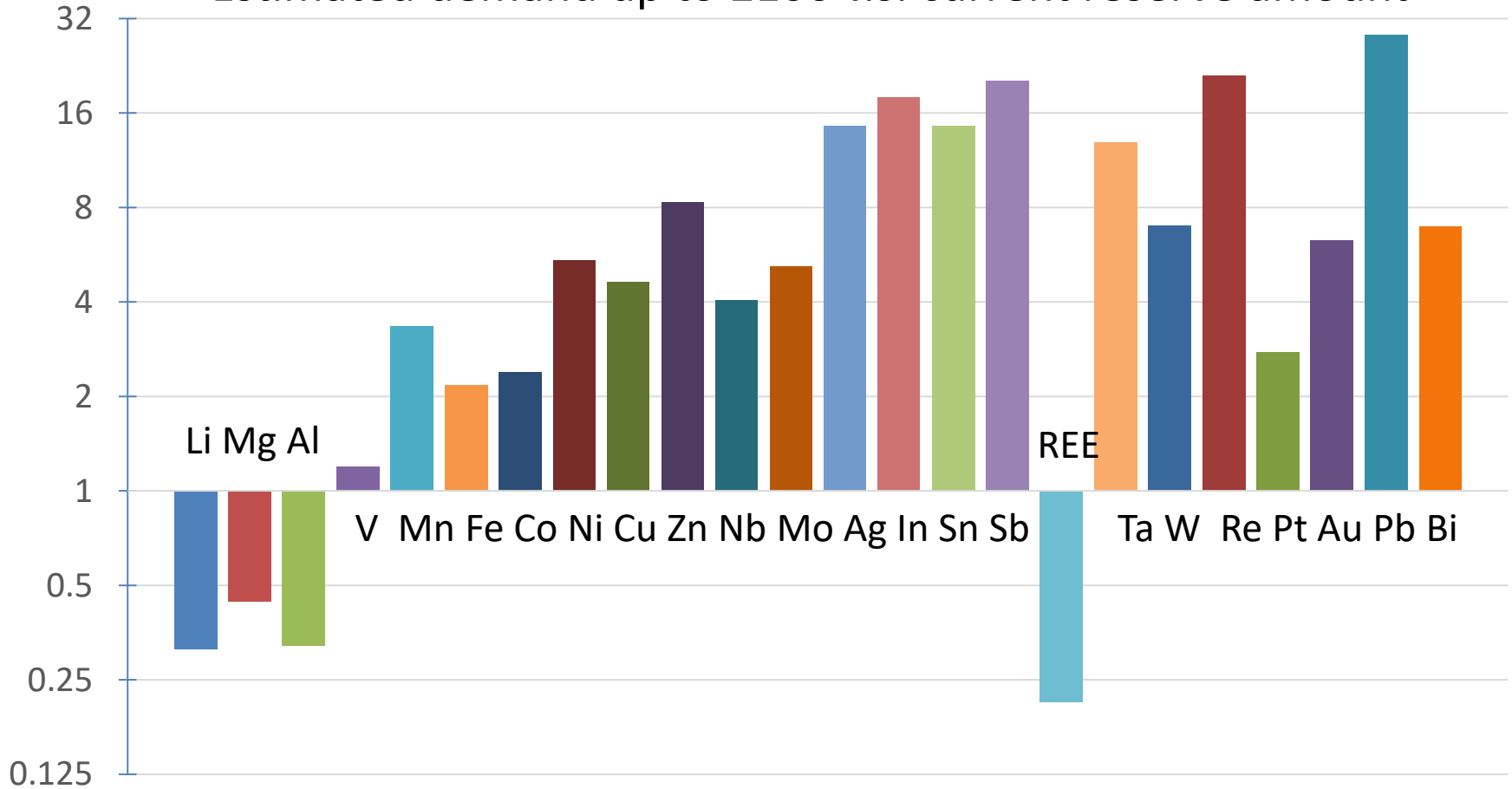
Consumption prediction with concerning only prepotent countries

Every country reaches developed level of consumption per capita

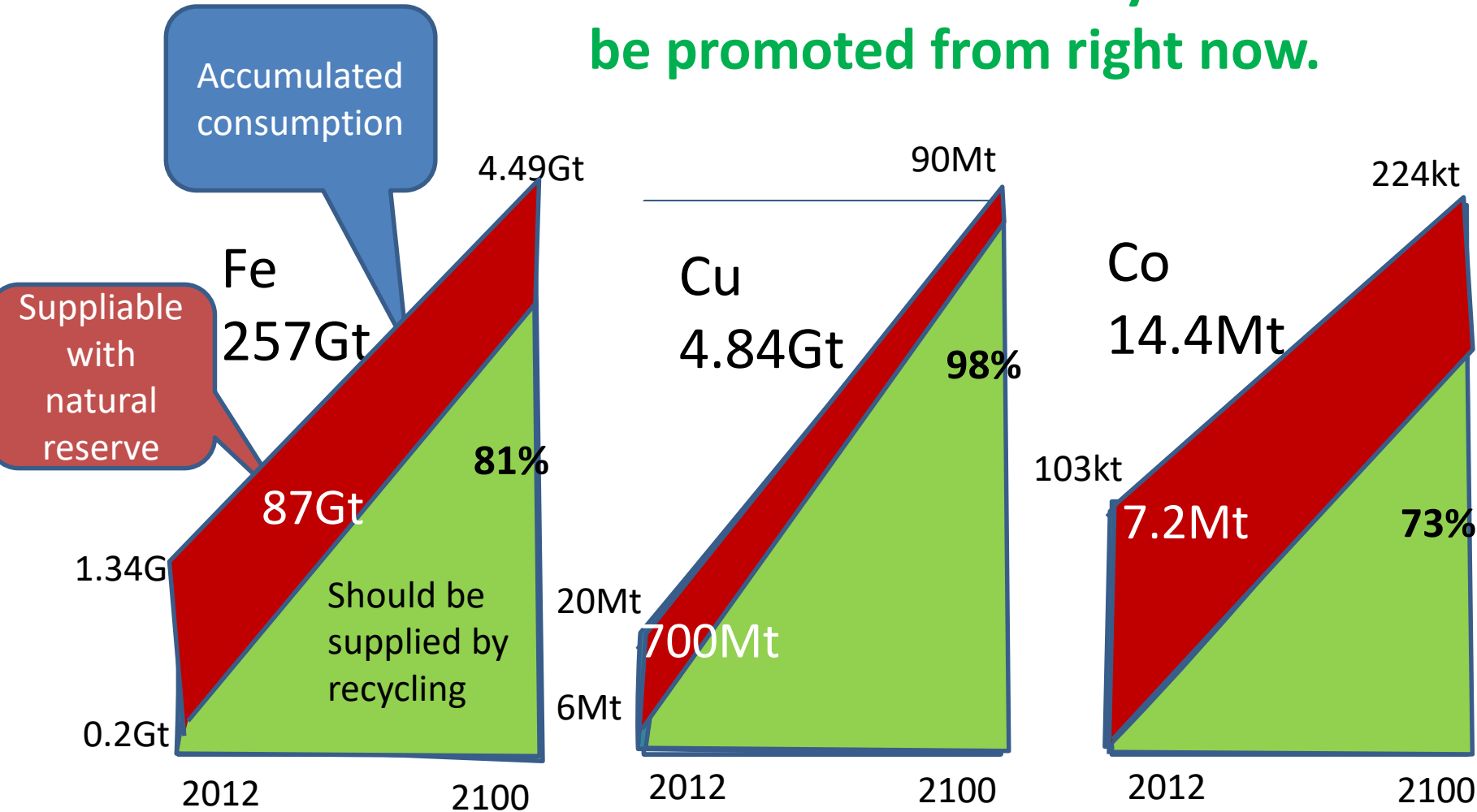
metal	Fe
Consumption/year at 10Gperson world	4.5Gton/year
Reserve	87Gton

Much more times of resources will be required by 2100.

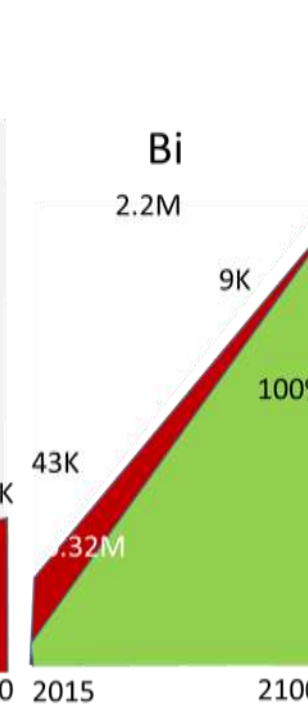
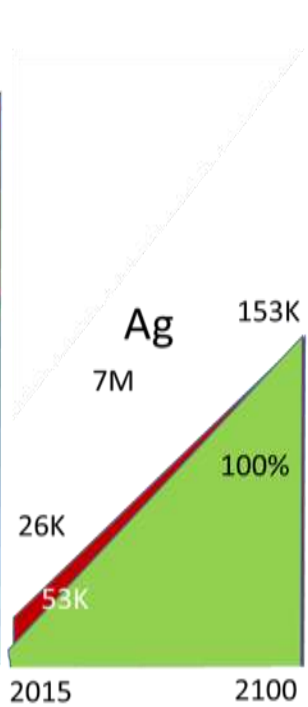
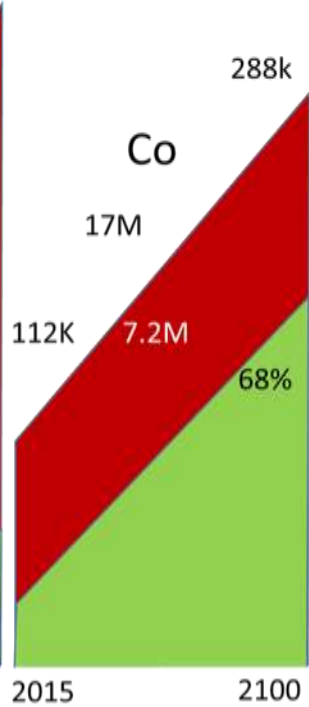
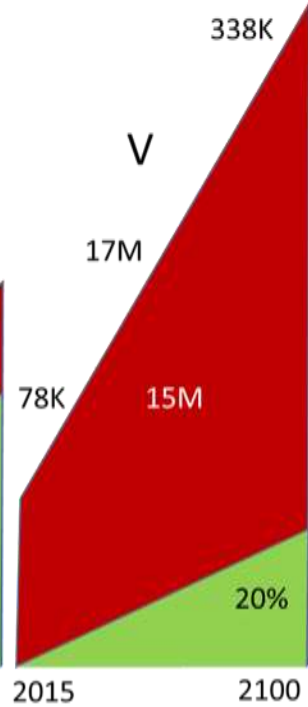
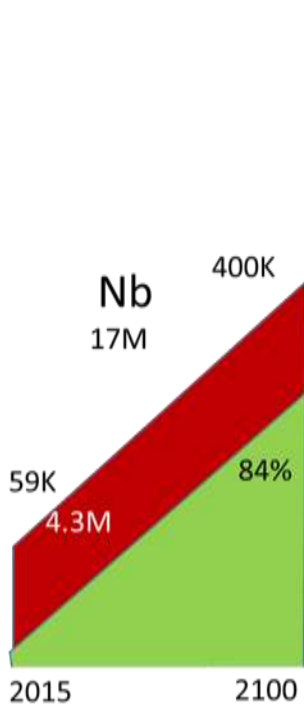
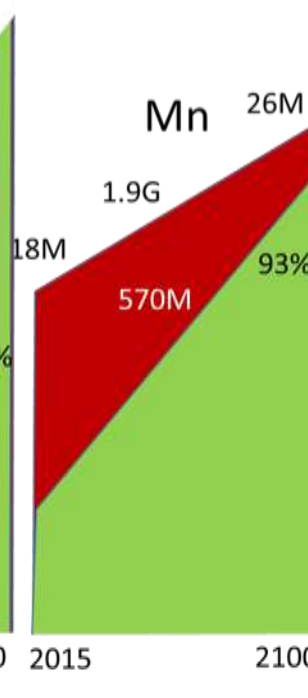
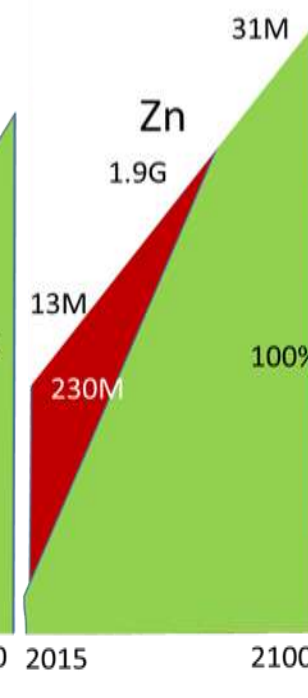
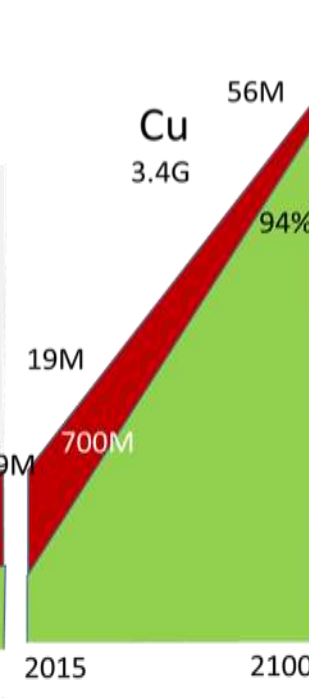
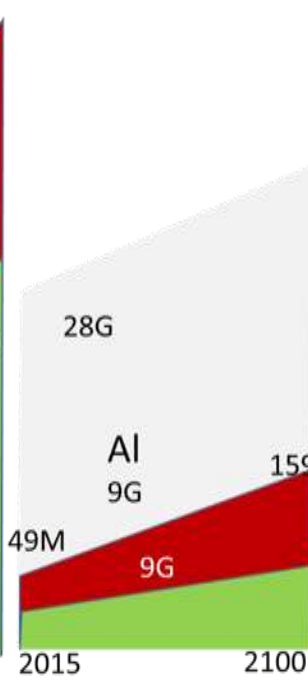
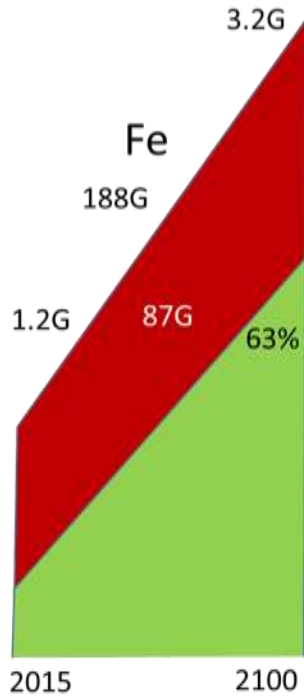
Estimated demand up to 2100 v.s. current reserve amount

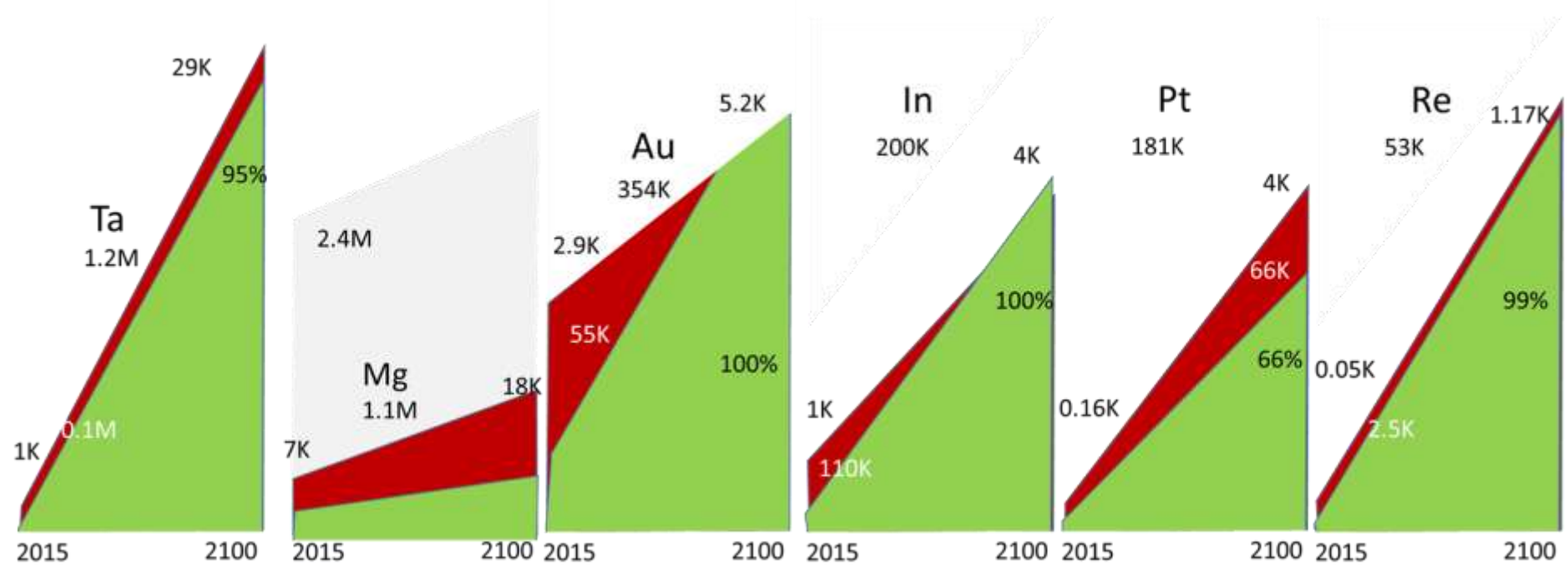
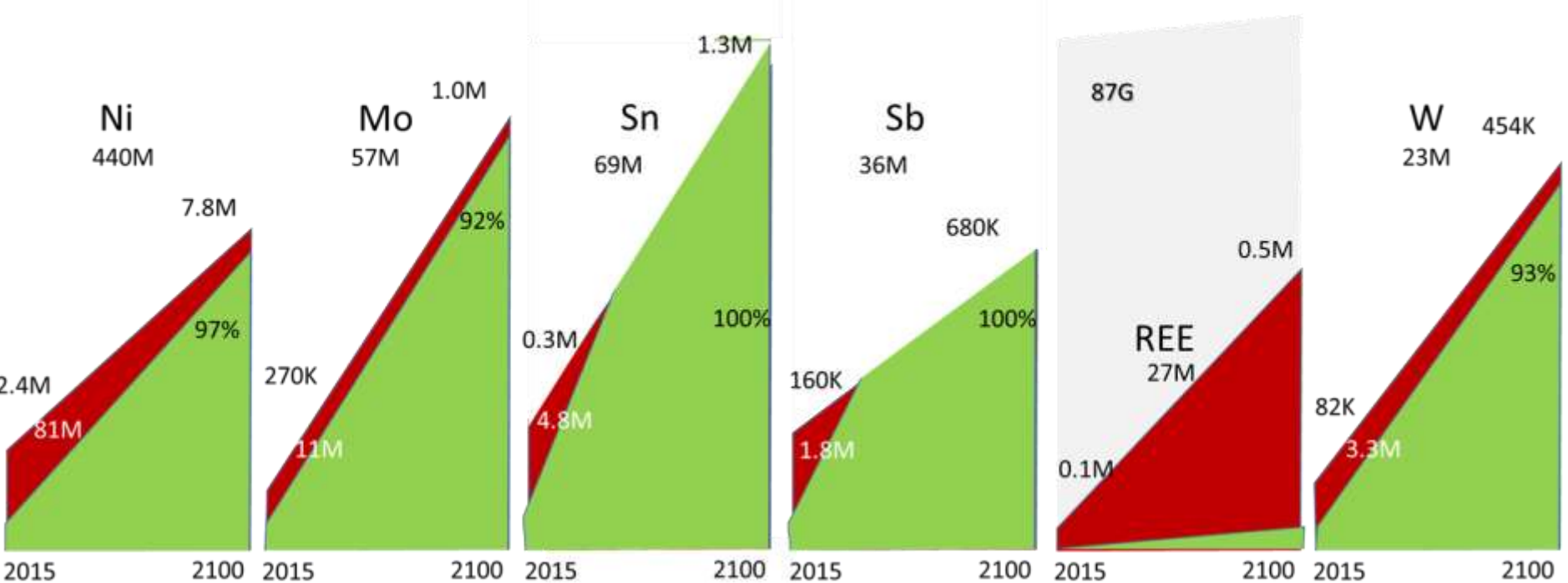


The circulation society must be promoted from right now.



Estimated accumulated consumptions till 2100 with simple assumption of linear growth





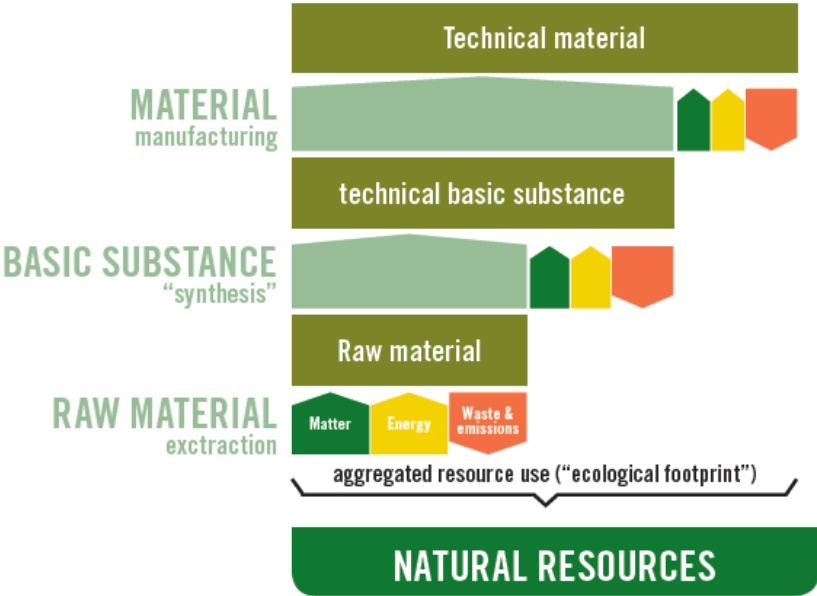
Resource efficiency

How can we make our economy circular and resource efficient?

Currently, we are using more resources than our planet can produce in a given time. We need to reduce the amount of waste we generate and the amount of materials we extract.



Figure 4: Aggregated resource use for technical materials



12.4

tonnes of materials per capita were **extracted** in the EU.

3.2

tonnes of materials per capita were **imported** to the EU.

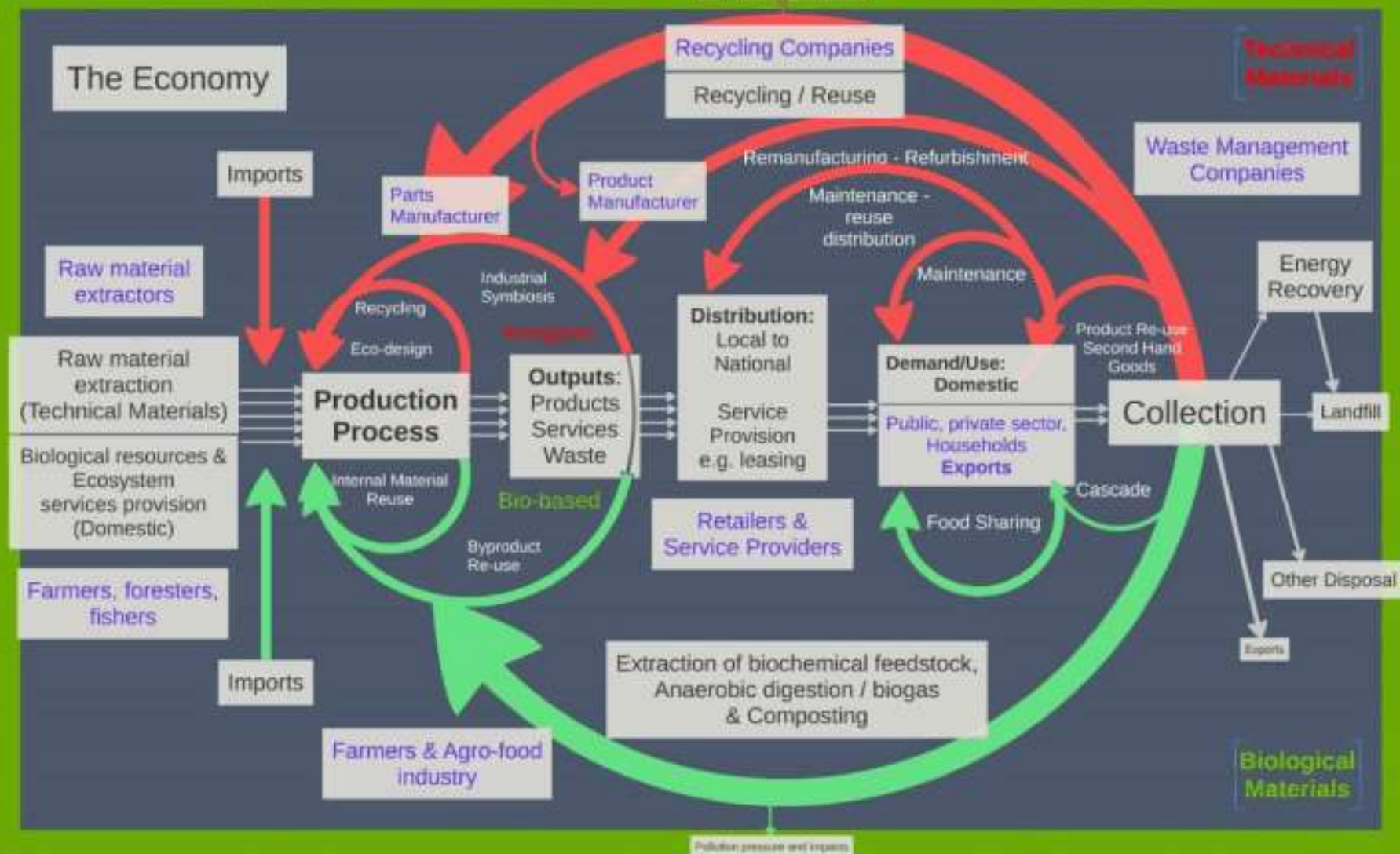
1.3

tonnes of material per capita were **exported** from the EU.

Figure E2: Simplified illustration of a circular economy

Circular Economy is inevitable

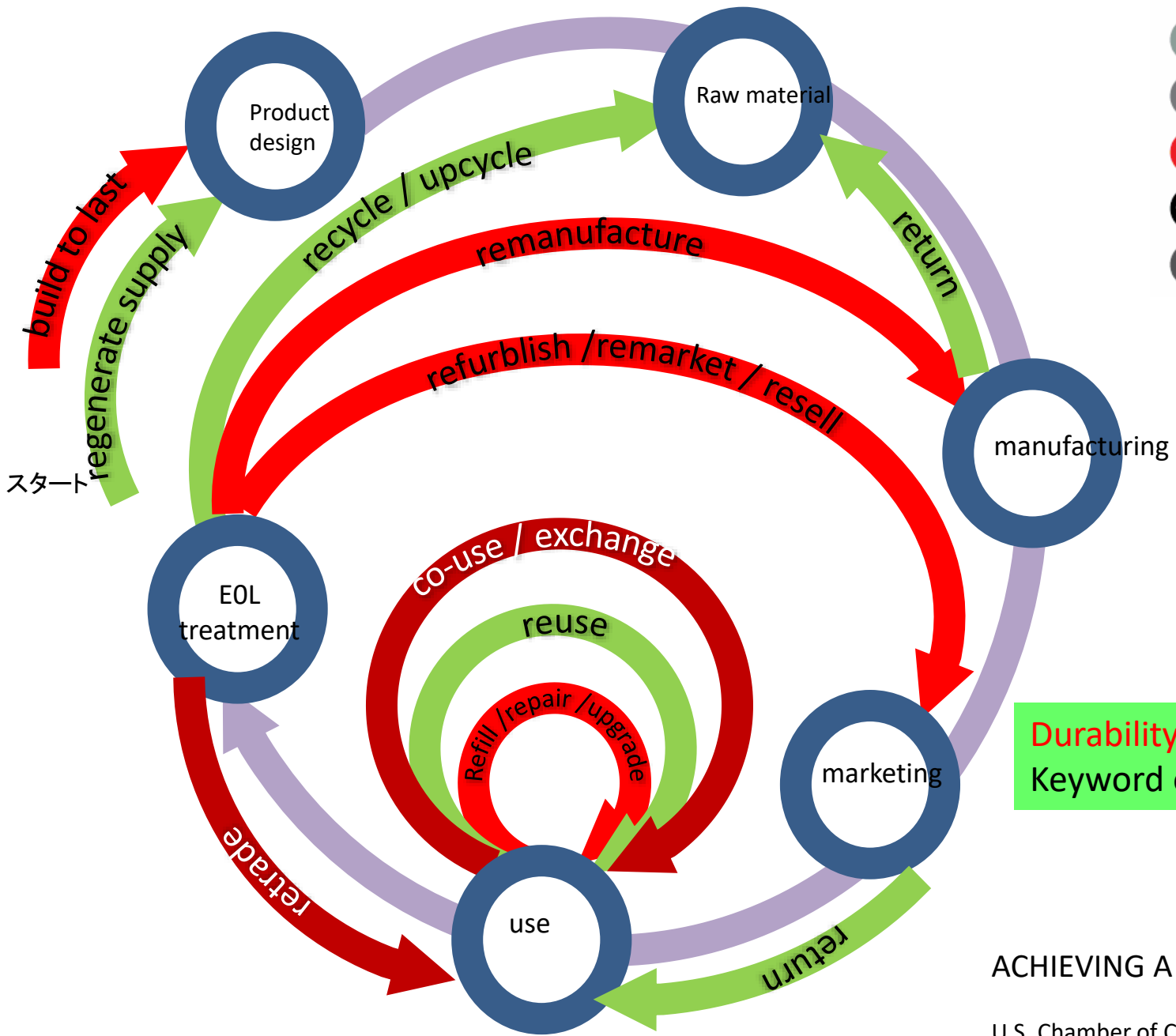
The Environment



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

BUSINESS MODELS

-  CIRCULAR SUPPLY-CHAIN
-  RECOVERY & RECYCLING
-  PRODUCT LIFE-EXTENSION
-  SHARING PLATFORM
-  PRODUCT AS A SERVICE



Durability becomes the greatest Keyword of Ecodesign

ACHIEVING A CIRCULAR ECONOMY

U.S. Chamber of Commerce Foundation,
Supported by CCC's Circular Economy Network

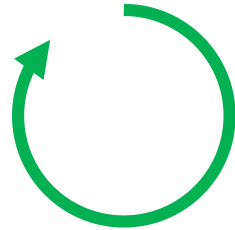
Difference of Circular Economy(CE) from Japanese 循環型社会(3R)

	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

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.

勿体無い

essence of material

loss

cut blocks with a razor

Ms Wangari Muta Maathai insisted

mottainai

- ① blaspheme against God and Ancestors
- ② awful to overmuch hospitality
- ③ spare material over-consumption

物の本体を失する意

神仏などに対して不都合である。

過分のことで畏れ多い。

そのものの値打ちが生かされず
無駄になるのが惜しい。

Mottainai Society

Communication value

Behavior value

Utility value

Value as Function unit

Value as Parts

Value as Material

Value as Resource

Shared space

IoE

ICT



Co-use

repair

Service share

???

direct Reuse



Repair

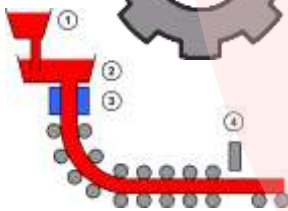
Parts

Re-manufacturing

Elements

Reuse/refurbish

Substance-recycle



Drag out the retained value of a product throughly

Personal space

Entity-centered to Behavior-centered

Mono モノ 物

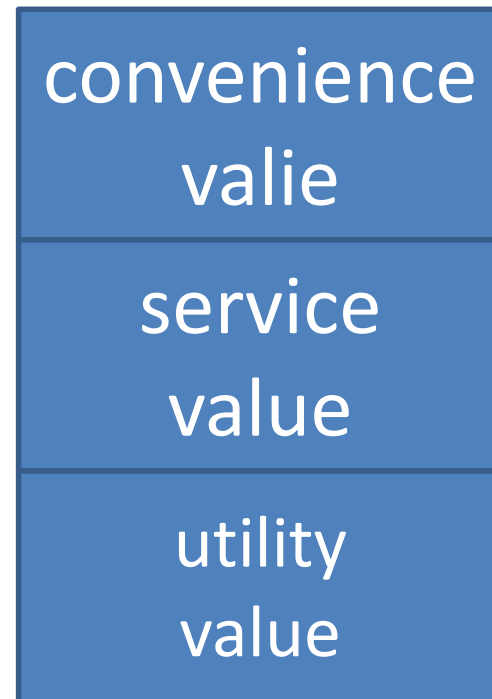
Koto コト 事



Mass production

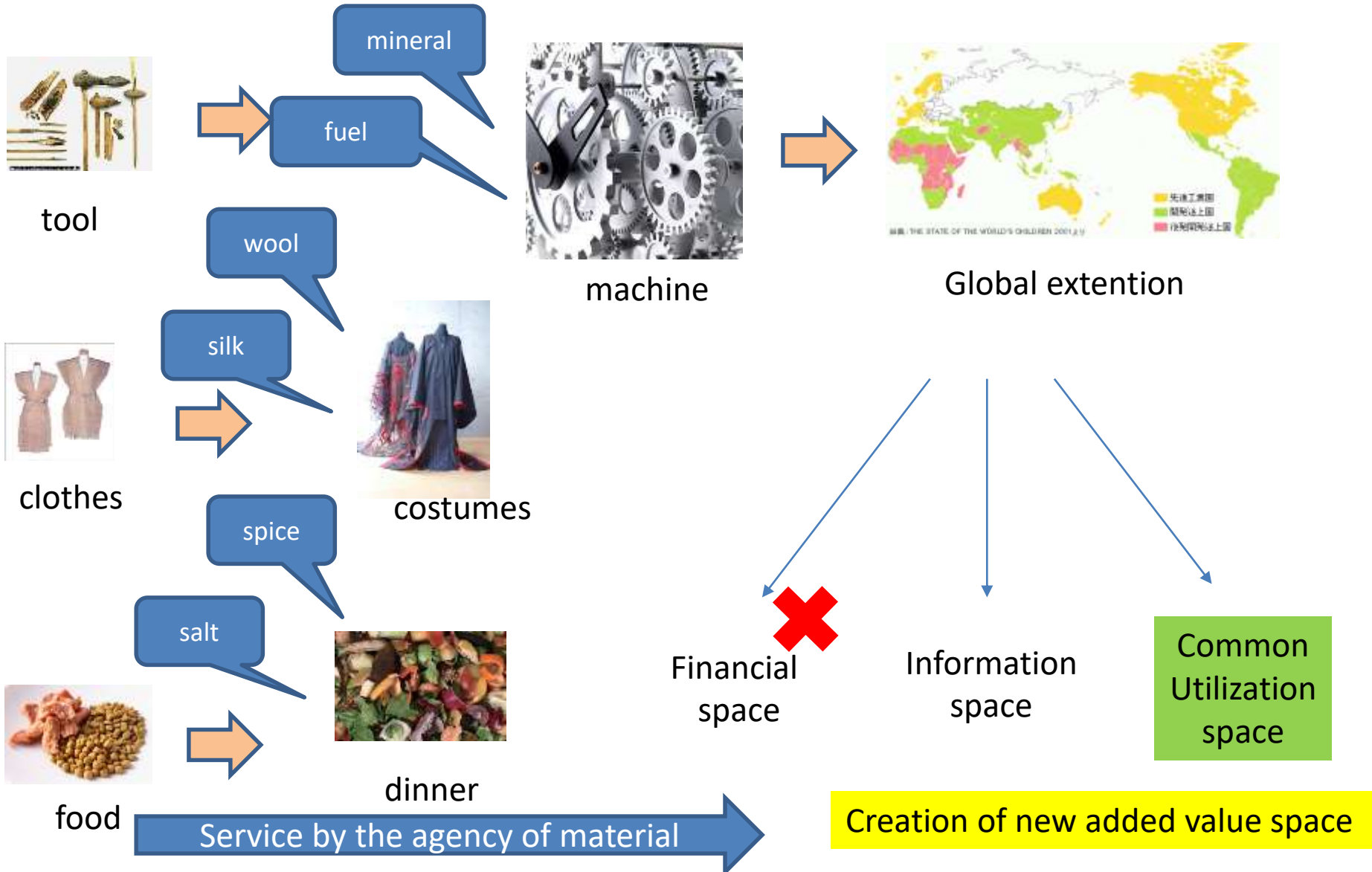


IoE: internet of everything
ICT information communication
technology



RRRDR

Evolution of added value



Wide-area
community
neighborhood
personal

Wide area delivery



Information service



Collect, gather



Management service



gather the mind

Waste treatment



Final stabilization



Reliability



possess

Material space repose space Reliable system space Active participation space

Door2door collection of small electric households using home delivery system.



希望日時に回収!最短翌日!

インターネット（パソコンまたはスマートフォン）からお申し込み

ダンボール箱等に詰めるだけ♪
詰める箱が無い方へ、箱の事前
お届けも可能!

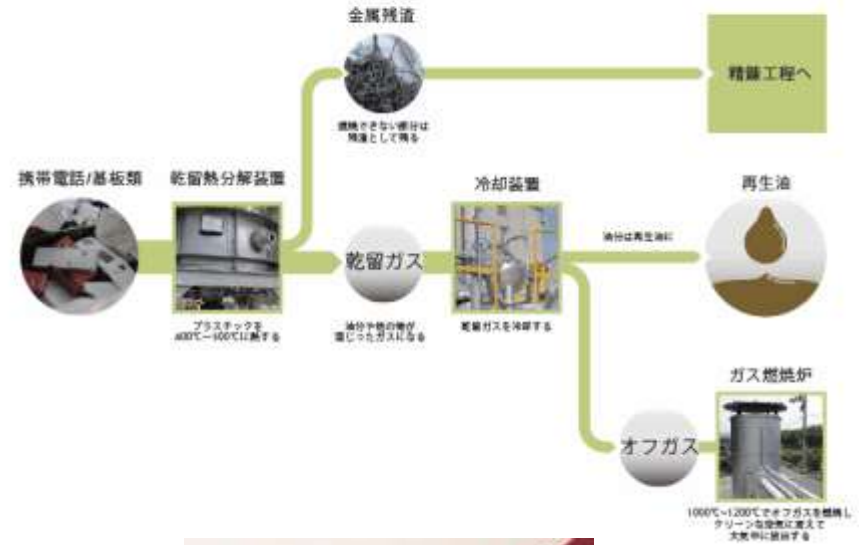
佐川急便が、ご希望の日時に回収へお伺いします。最短翌日!

URL <http://www.renet.jp/>

JEPLAN, INC

プラスチックリサイクル技術
プラスチックから再生油に。

プラスチックを地球のプラスに。
PLA-PLUS プロジェクト

平成25年度 参加企業

回収参加企業



サポート企業



袋を回収ボックスに入れて回収

Organize the mind for recycling

Communication value

Behavior value

Utility value

Value as Function unit

Value as Parts

Value as Material

Value as Resource

Shared space

IoE

ICT



Co-use

repair

Service share

direct Reuse

???



Repair

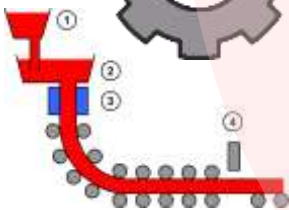
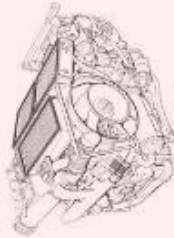
Parts

Re-manufacturing

Elements

Reuse/refurbish

Substance-recycle

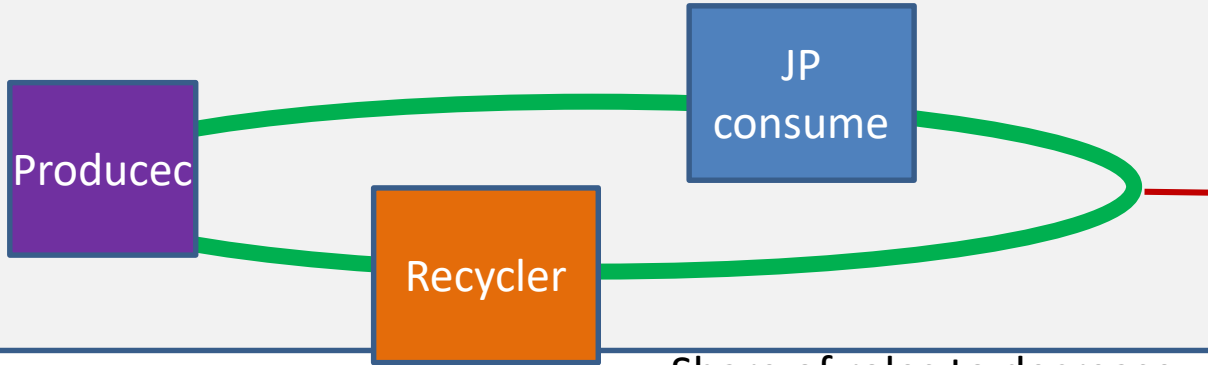


Personal space

Drag out the retained value of a product throughly

Different circulation society of EU from JP

Japanese circulation society

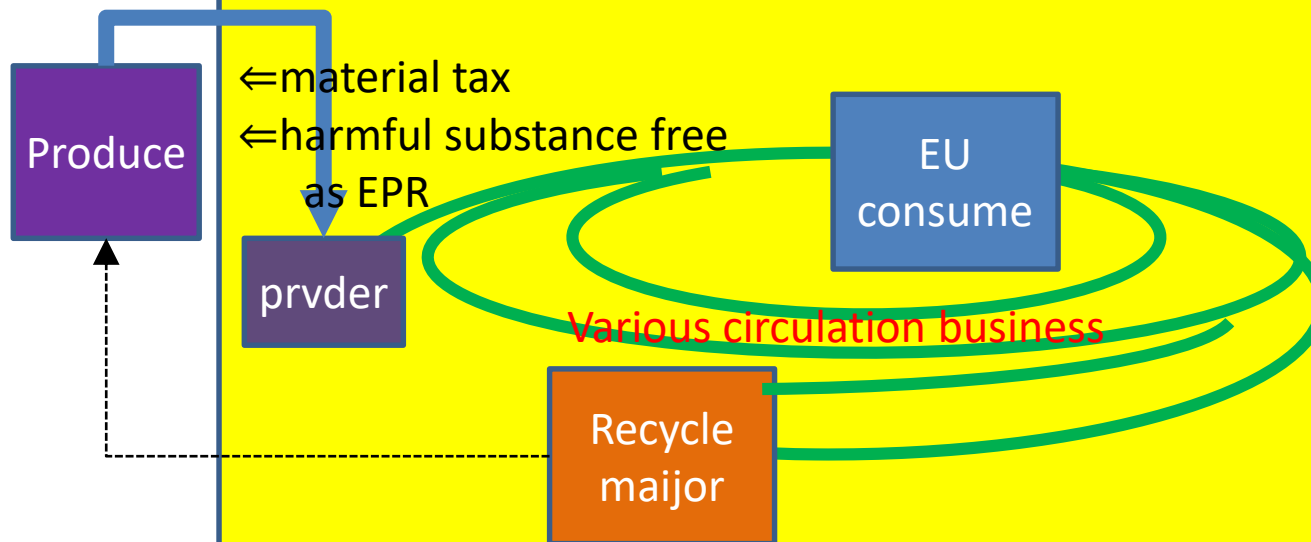


Arrange the outer ward of material circulation In the society

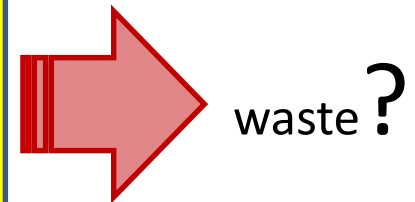
Zero emission
or
Low waste

Share of roles to decrease waste

EU's Circular Economy



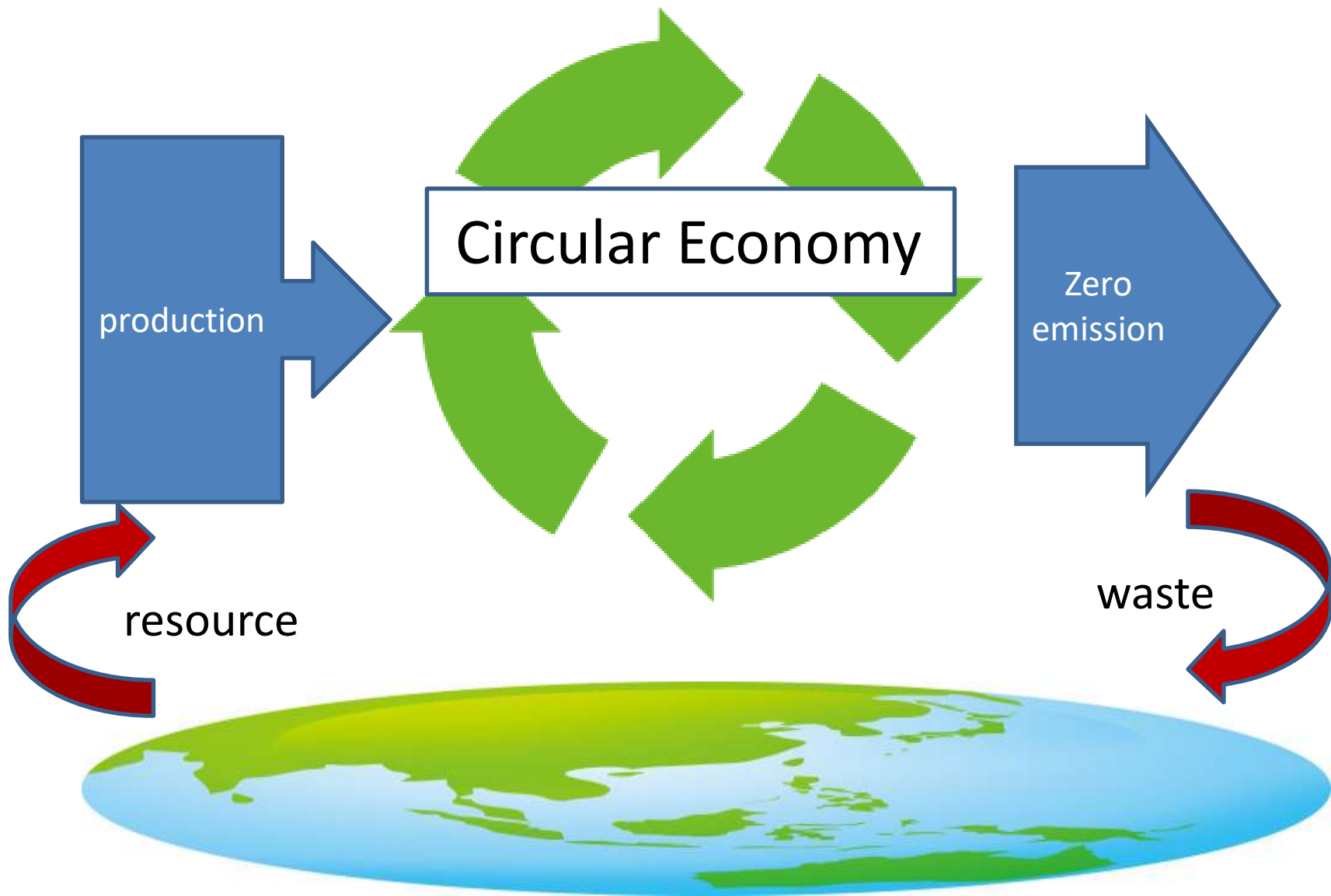
Create multiple inner route of goods circulation In the society



waste ?

Business chance in circulation from view point of sustainable consumption

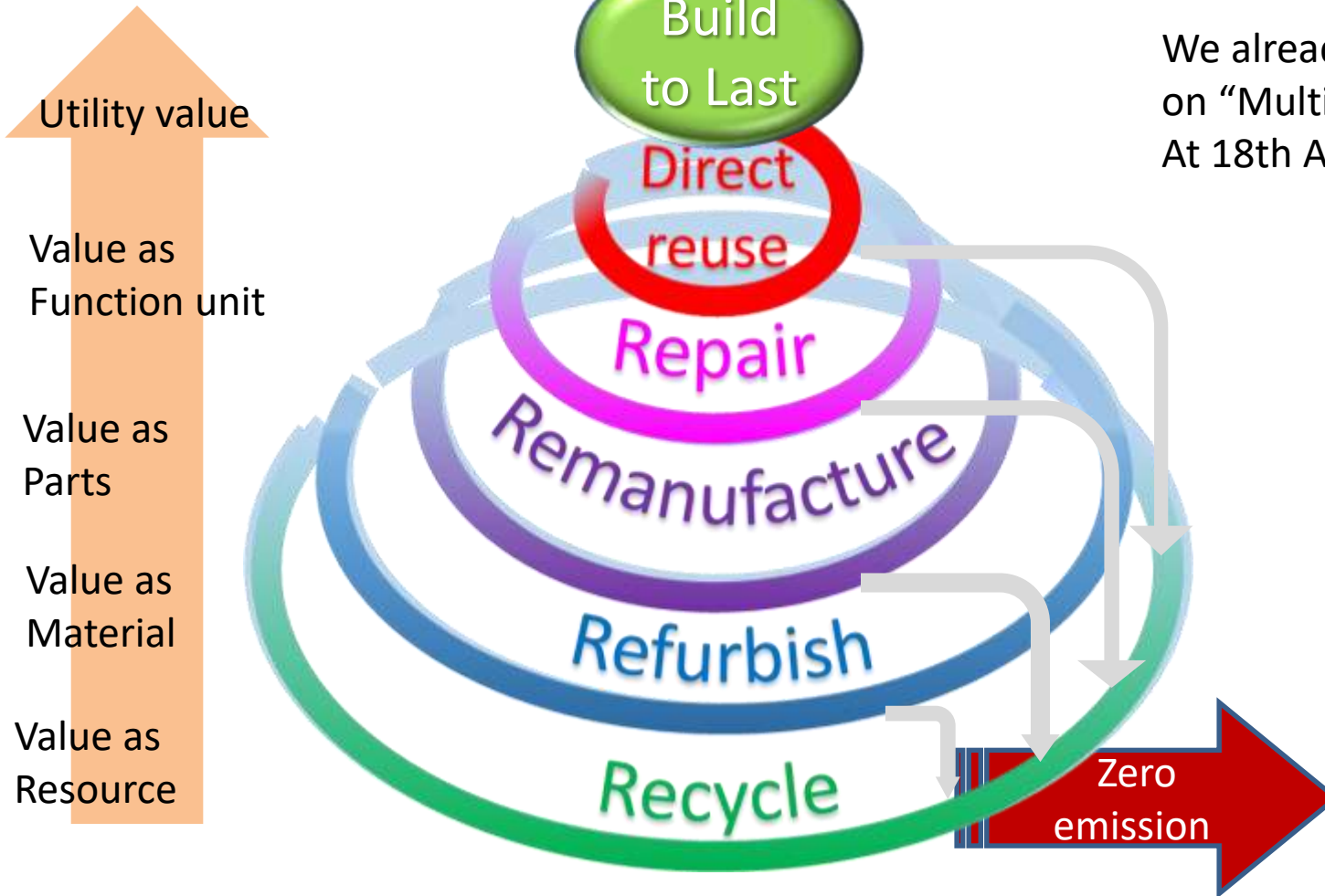
Total Life-cycle management is required for the improvement of Resource Efficiency



Multi-value Circulation

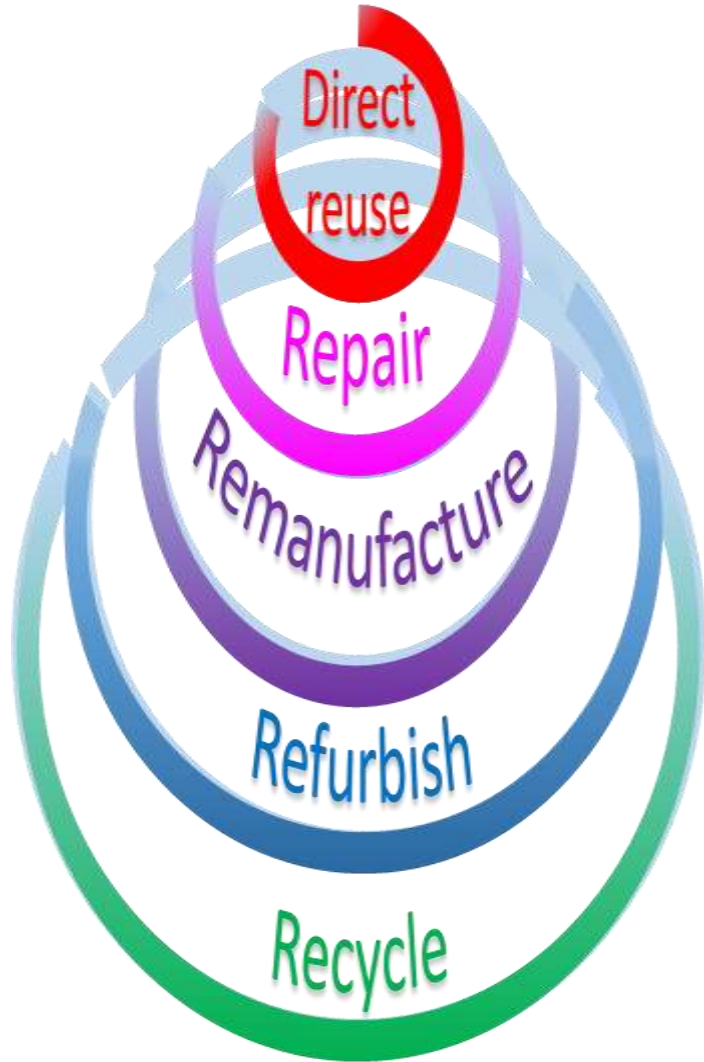


We already had a symposium on “Multi-Value Circulation At 18th August”



Requisite for materialization on Multi-Value Circulation

Monozukuri



Long life

Renewalizing technology

degration detectation

Multi material design

Technical Barriers o remanufacturing

プロセス技術

Deterioration of material

Fracture



Fatigue



Wear



Corrosion



Surface treatment & Mending



Welding



Cold Spray



Submerged Arc
Welding



Plasma
Transferred Wire
Arc

出典：M.Haselkorn, RIT

Requisite for material in the multi-value circulation society

- Long-life several times longer than goods
- Higher and visible reliability indispensable for RRRDR
- Repairable : detachmentable
- Repairable : material hearing
- Repairable : localized mending
- Easy Cleansing, refreshing : dry cleansing technology etc.
- In-situ Customizing processing such as localized additive manufacturing

Structural material for sustainable society

strong, tender and dependable material for the social system of sustainability

Strong as
elder brother



哥哥的強
gē gē de qiáng

Expand the human's activity frontier toward new environment, such as space, marine and underearth.
strong, tough, anticorrosion, heat resistant, light-weight, multi-function

Tender as
mother



母的和
Mǔ de hé

Multi-Function structural materials which provide well-being in the nature-harmonized living space of the future.

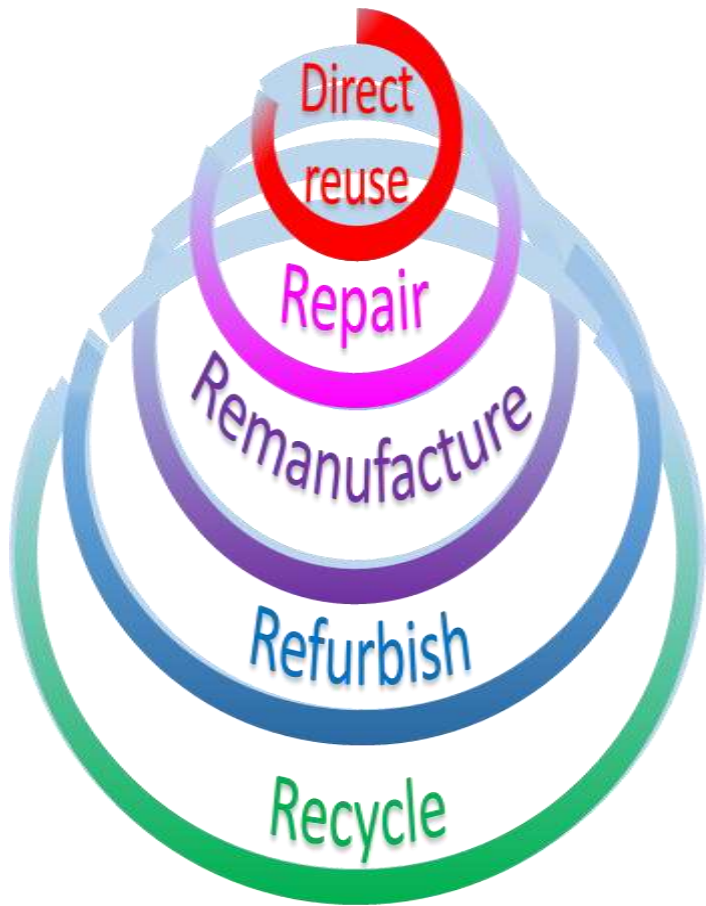
視sight : diversified design
聽aural: selective insulation
觸touch: organic-touch inorganics
膚skin: moisture control etc.

Dependable as
father 父的壯
Fù de zhuàng

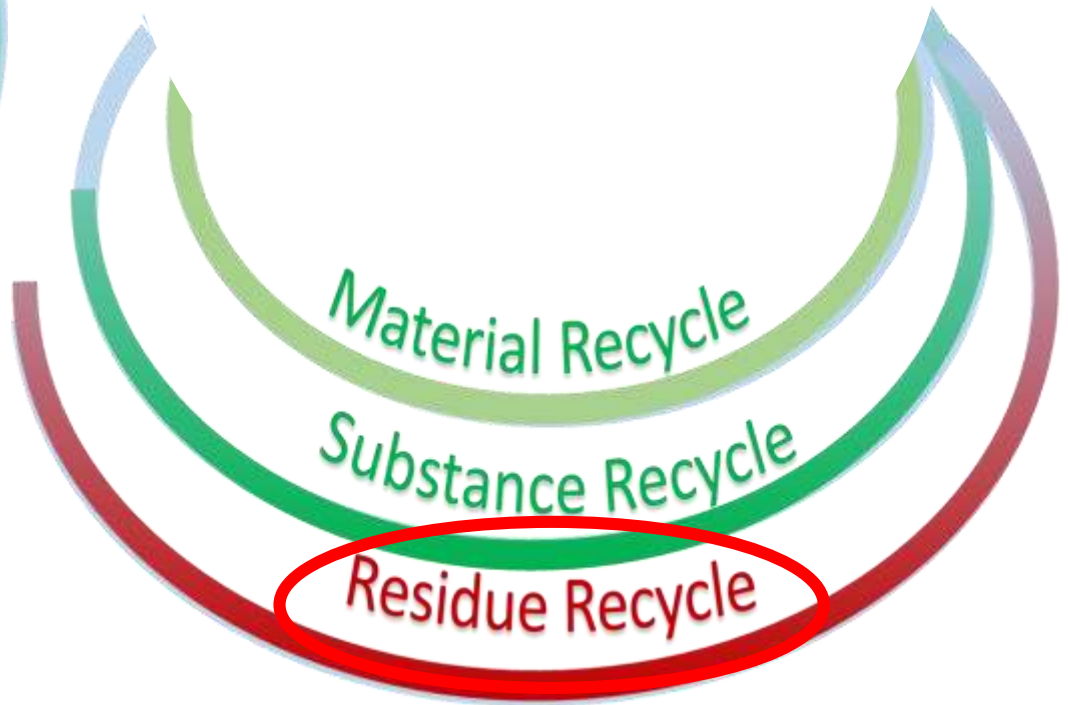


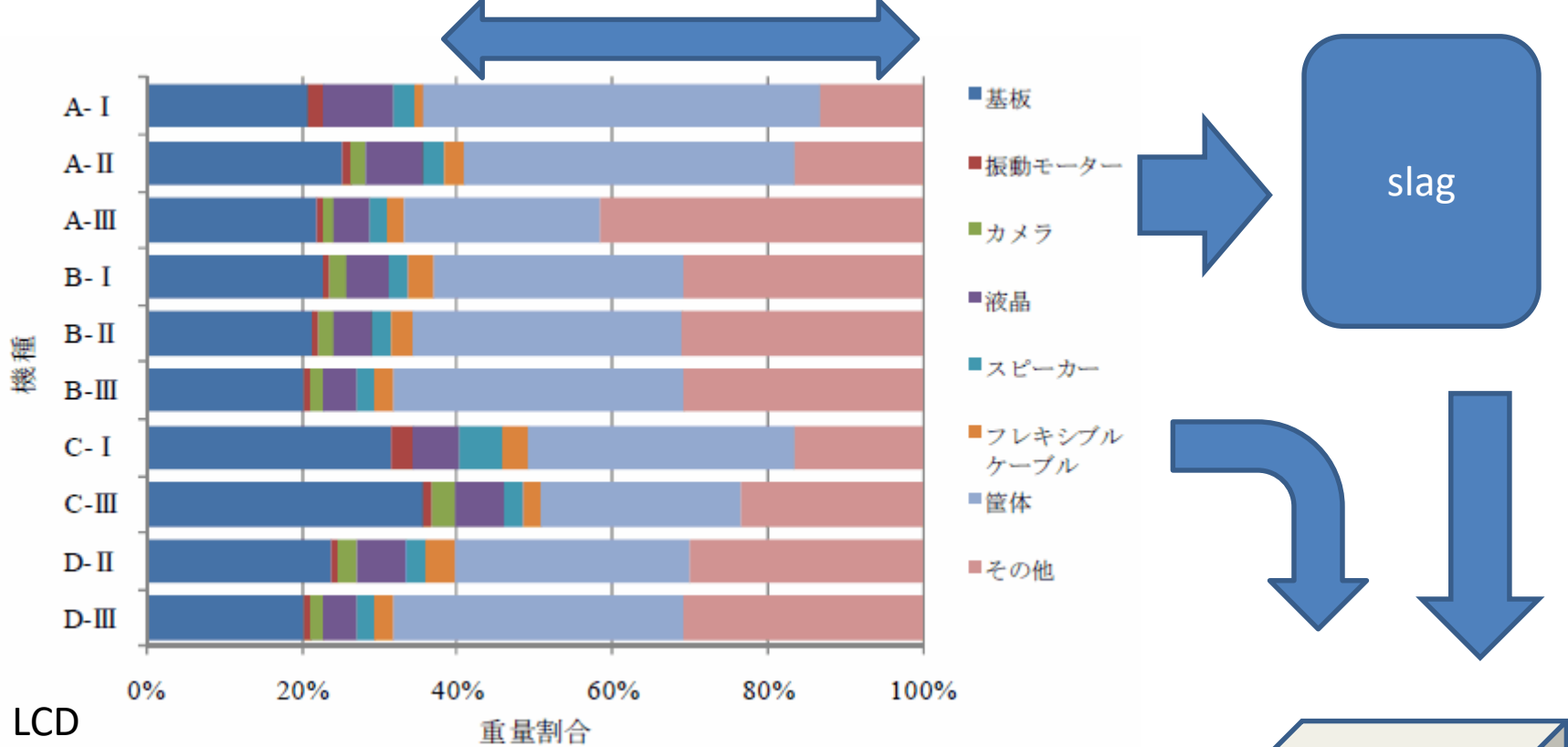
Dependable materials which have reliability of endurance for sever stress and its rapid fluctuation. Intelligent materials which predict , diagnose and respond to deterioration.

Halada: Sept. 2013 at Beijin



Recycle has three roles





LCD

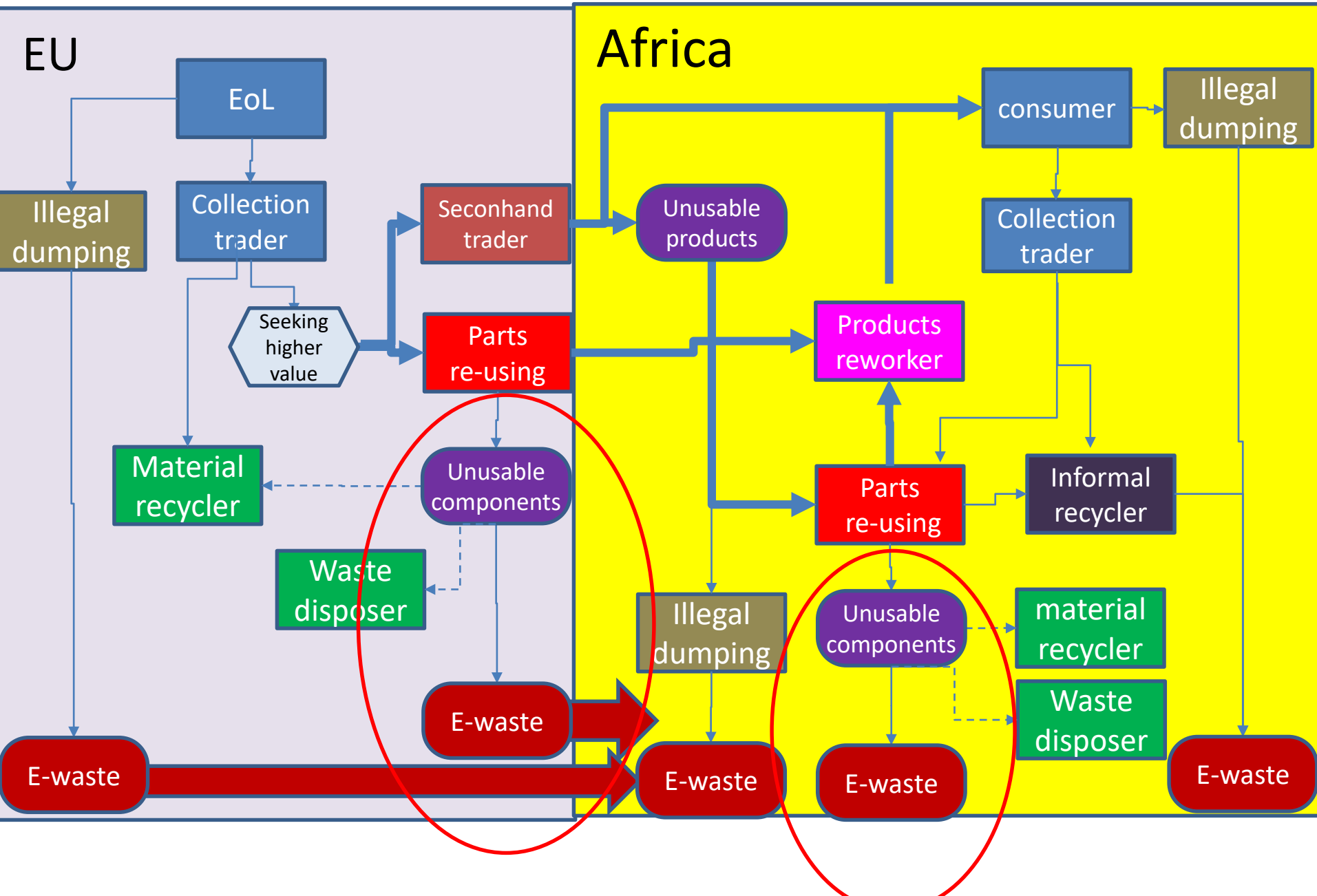
元素	2000-2002年
Ag	A-I
Al	1~5
As	
Au	
B	1~5
Ba	0.5~3
Ca	0.5~3
Cr	
Cu	0.01~0.1
Fe	
In	0.01~0.1
Mg	0.1~1
Mn	
Mo	
Ni	
Sb	
Si	10~30
Sr	
Ti	0.005~0.05
W	
Zn	

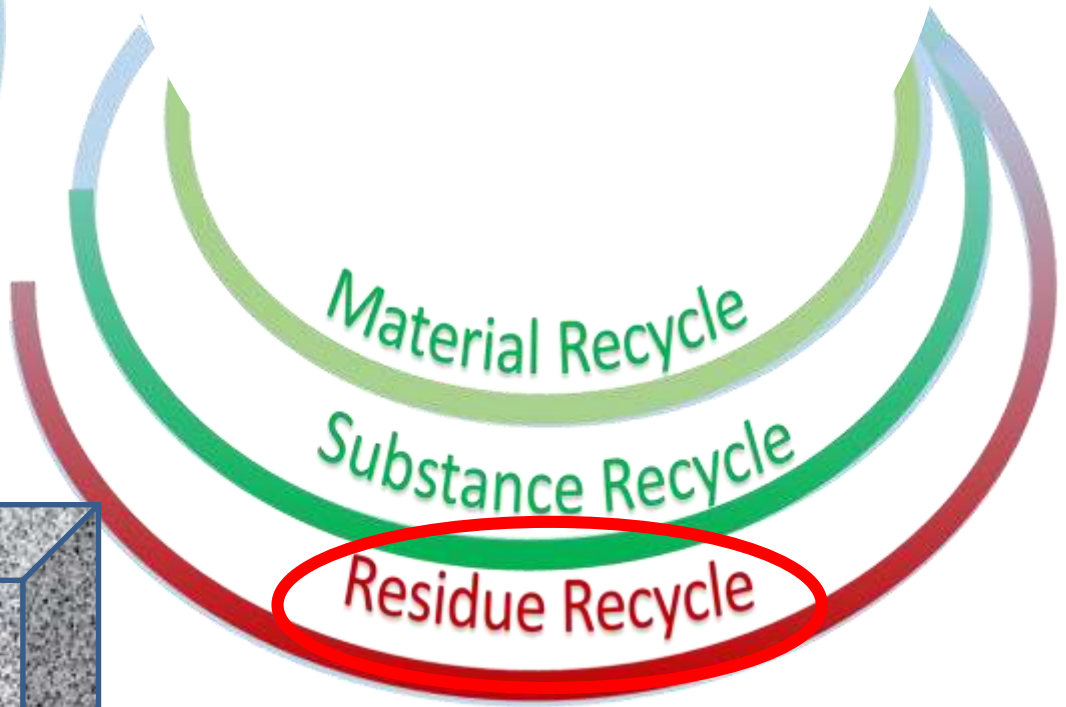
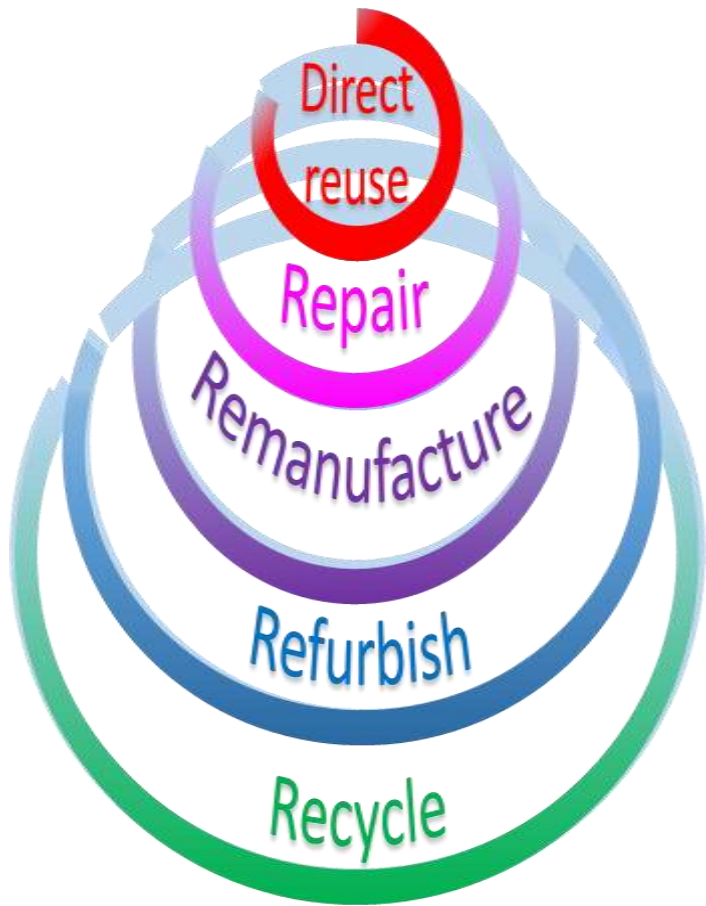
PCB

基板	
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%

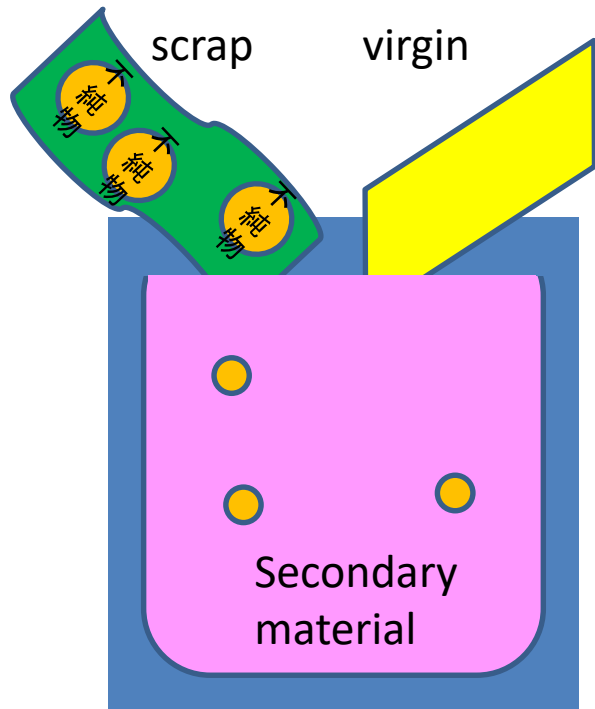
Structure of the issue of E-waste





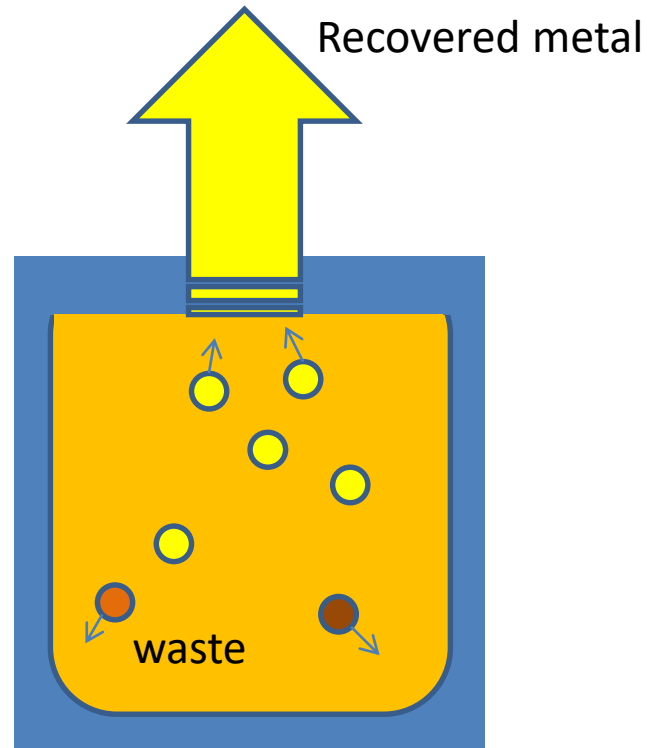
Slag, Ash, Mud to
Social infrastructure

Two different types of recycling



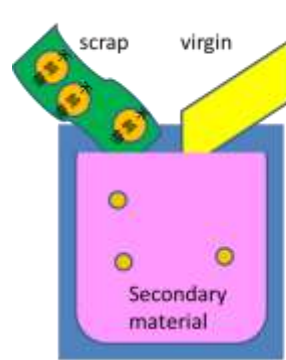
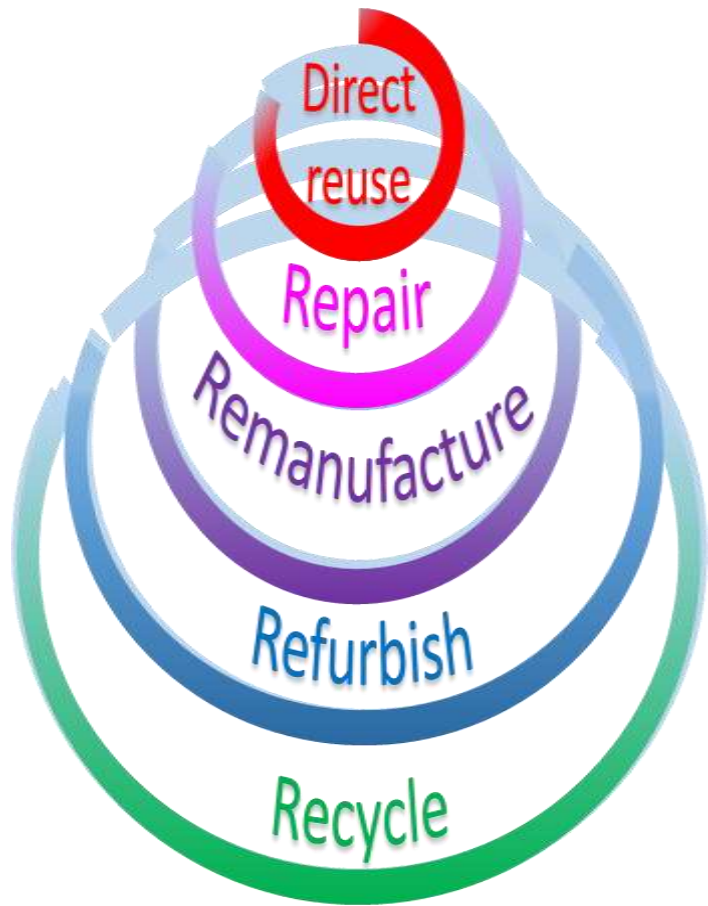
Dilution-type

: Fe, Al, plastic, paper, glass
De-grading of material

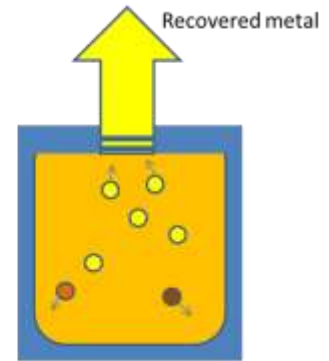


Extraction-type

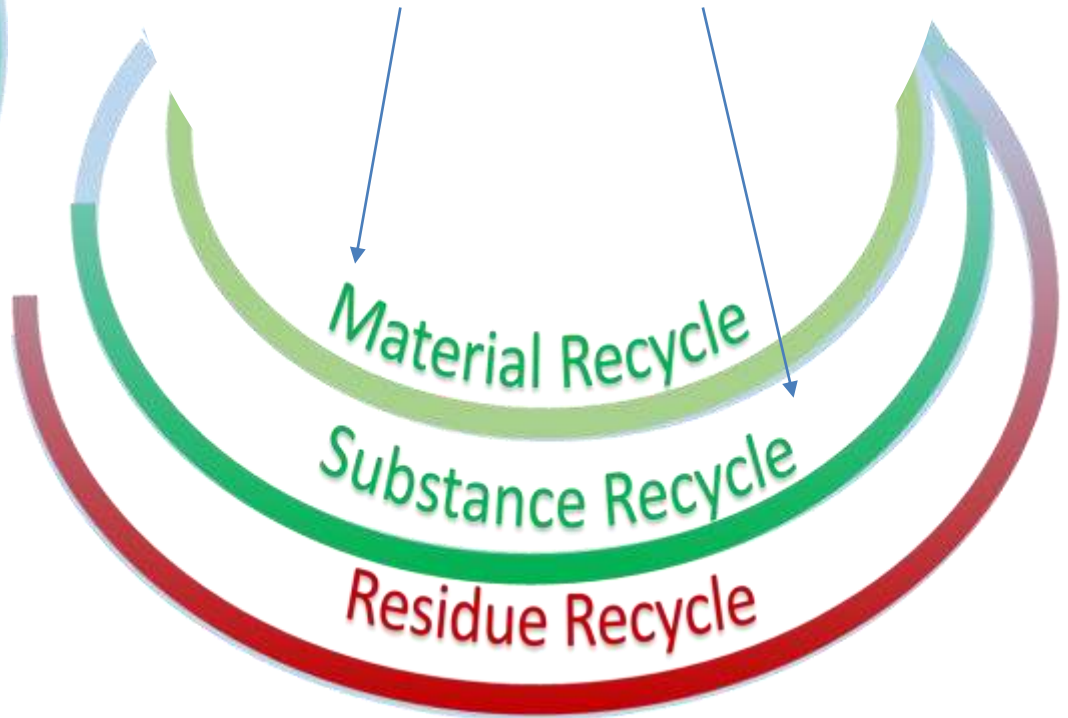
Rare metals, precious metals
much waste than obtained



Dilution-type
: Fe, Al, plastic, paper, glass
De-grading of material

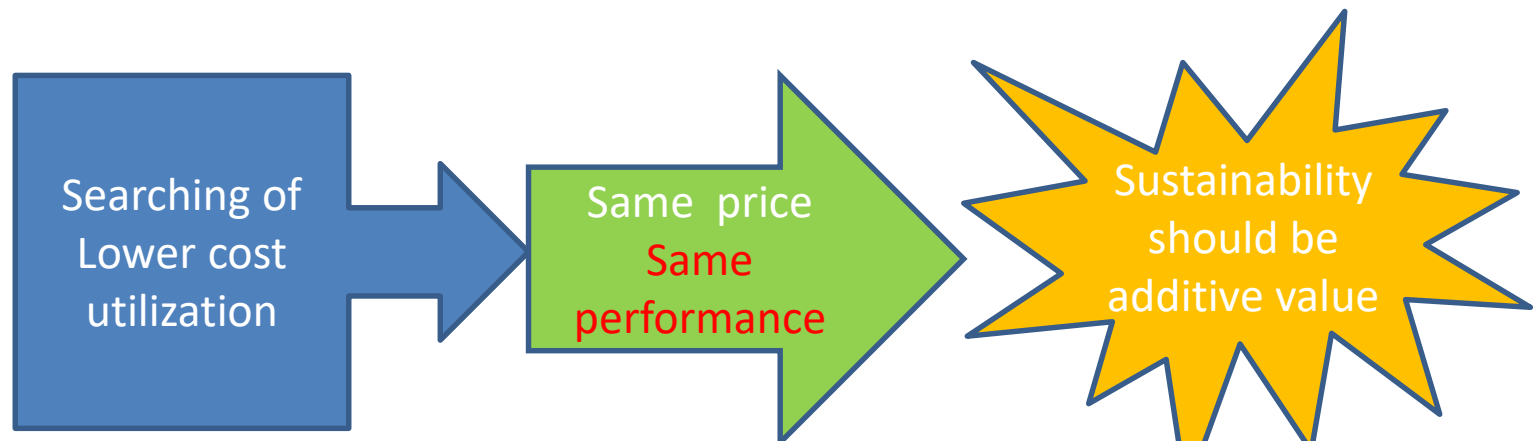


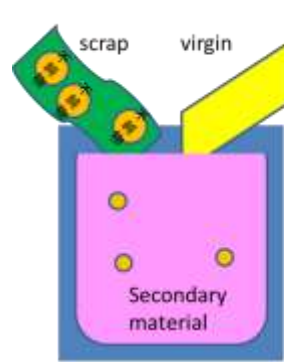
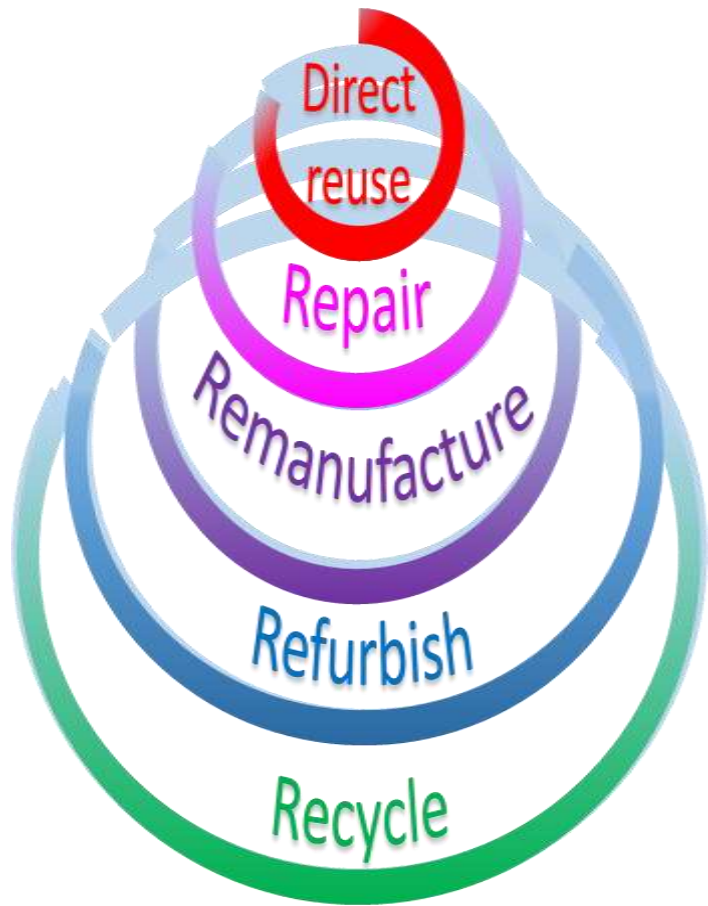
Extraction-type
Rare metals, precious metals
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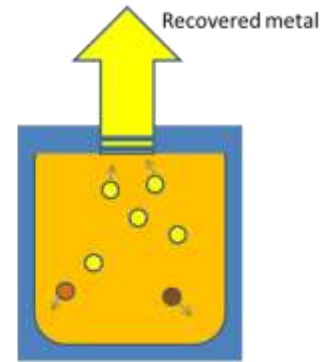
Technology for horizontal recycling

- Metal : control by structure not by composition ○
- Plastic : science of strength of polymer and additives
- ceramic : healing technology of damage

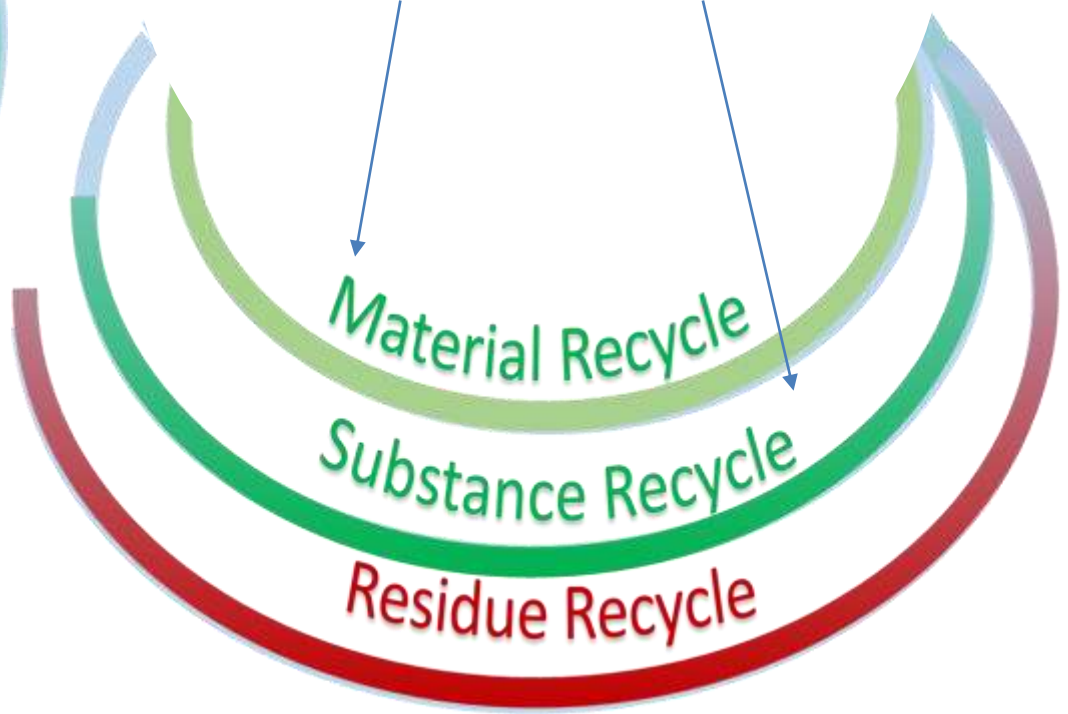




Dilution-type
: Fe, Al, plastic, paper, glass
De-grading of material



Extraction-type
Rare metals, precious metals
much waste than obtained



Rout of electric appliance recycle

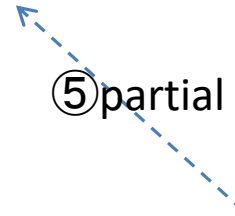
- ① resource from all over world ② High-tech manufactures ③ produce high-tech products



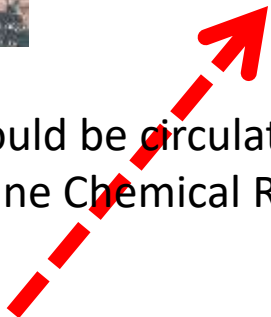
④ collect EOLs



⑤ partial reuse



⑨ it should be circulated!!!
as Fine Chemical Recycle



plastic, iron etc.



⑤ dismantle



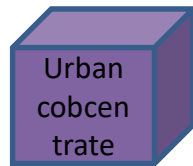
⑥ full separate
full recycle



Residue
recycling

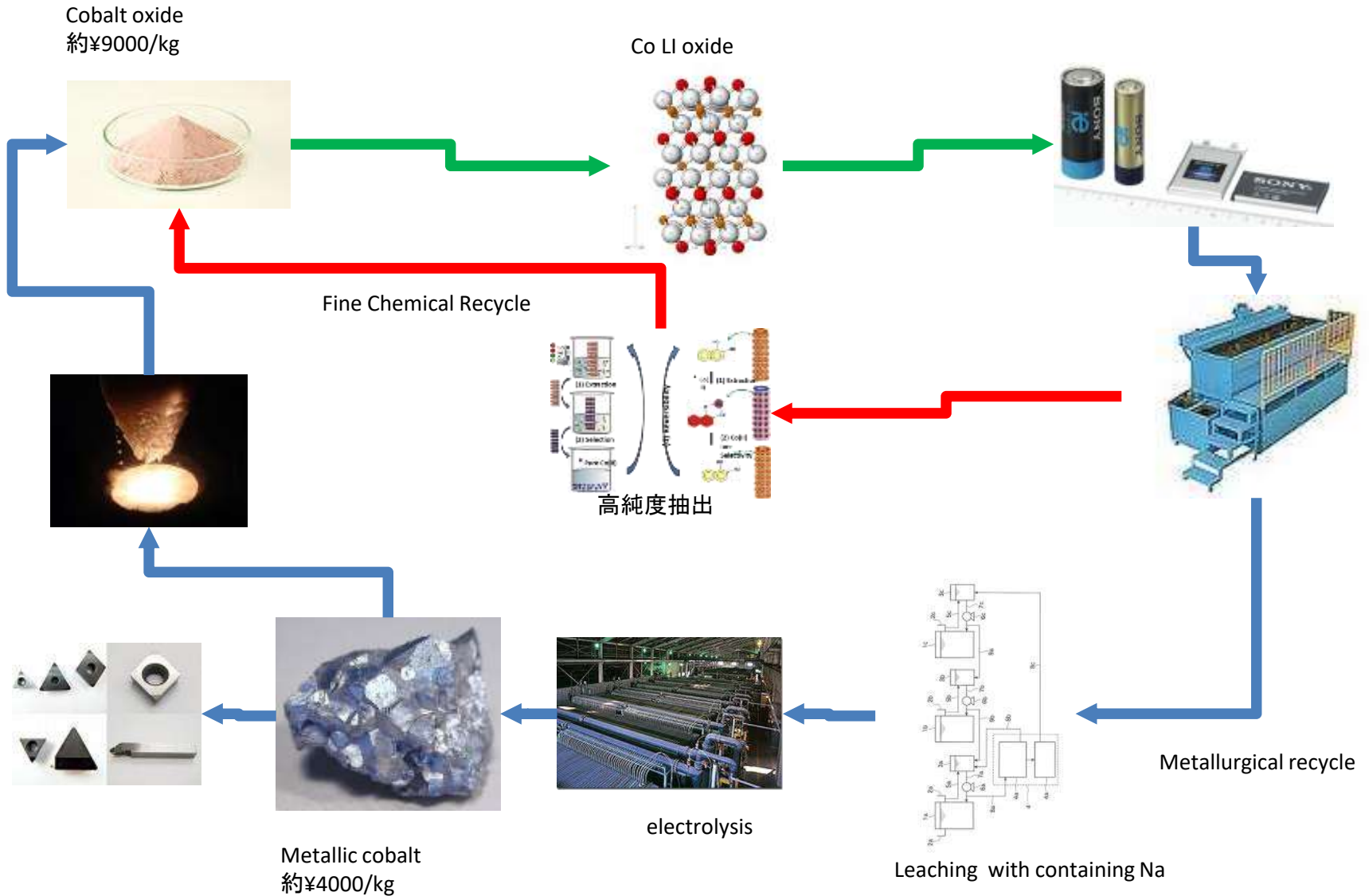


⑦ smelt to metal

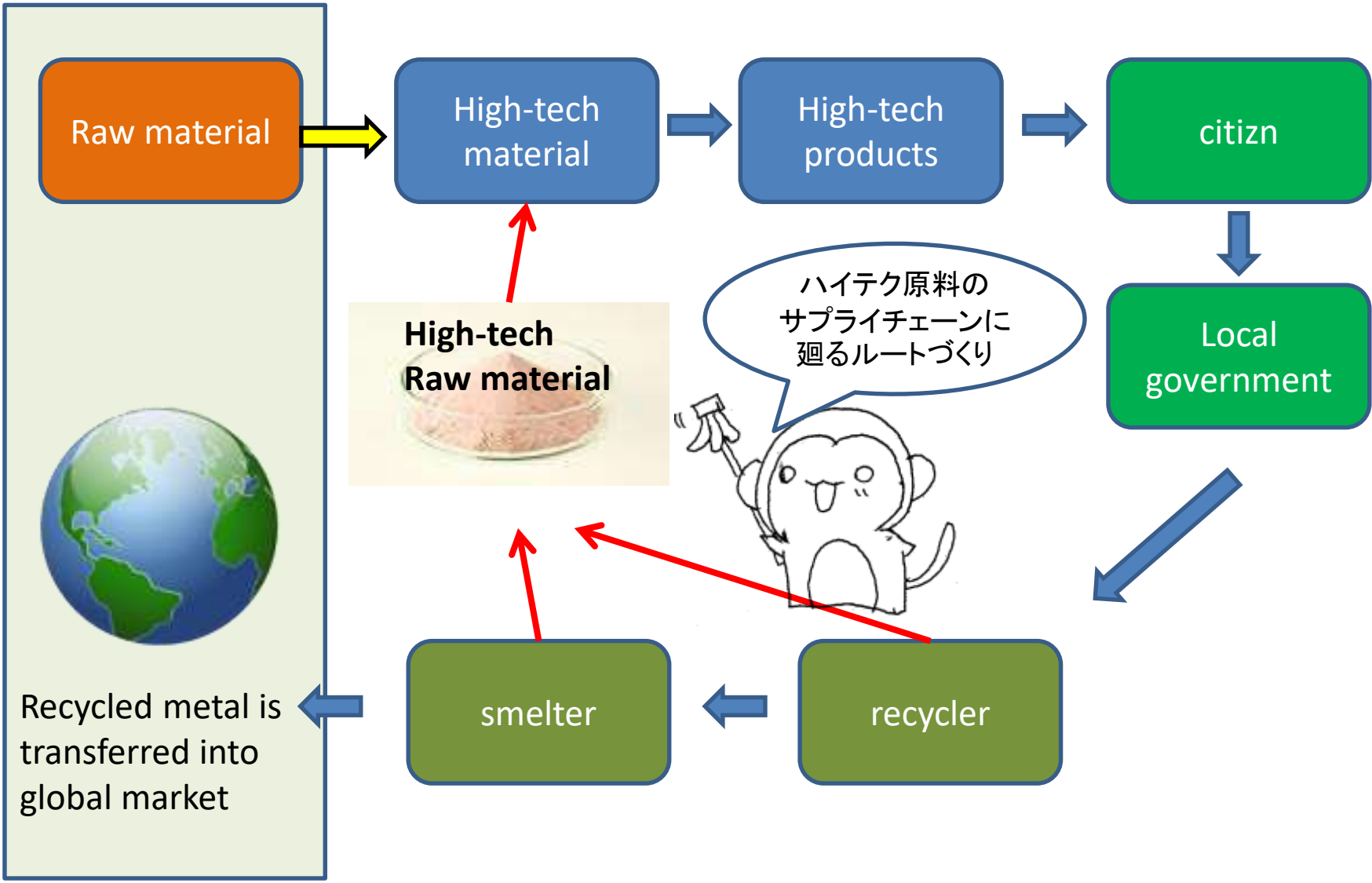


⑧ sold in the market as secondary metal ingot

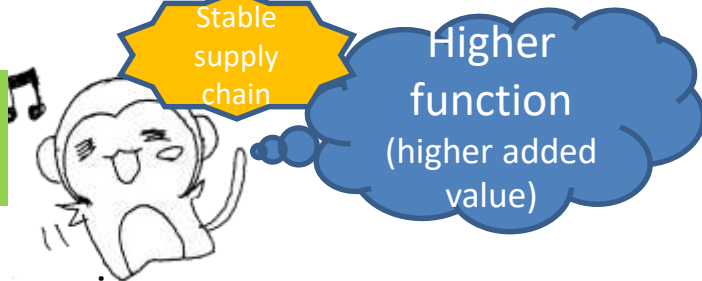
Fine chemical recycle of Co from LiB



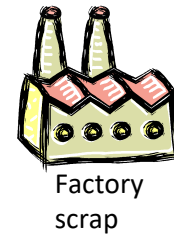
Recycling goes back to supply chain



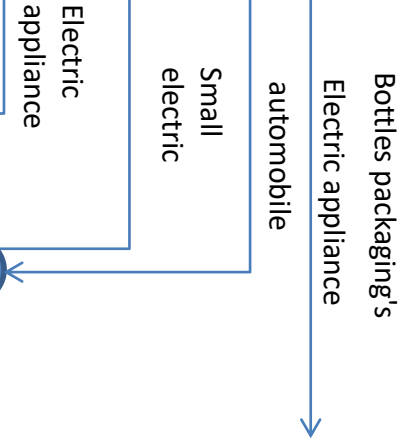
Raw material acquisition



Requisites raw is
Acquired by recycle



New wave



High grade
Less impurity



File chemical



Find value
Make value
Valuables are converted Into **Goods**

Generalize



General material



Burden share

Robustness, stability



Construction

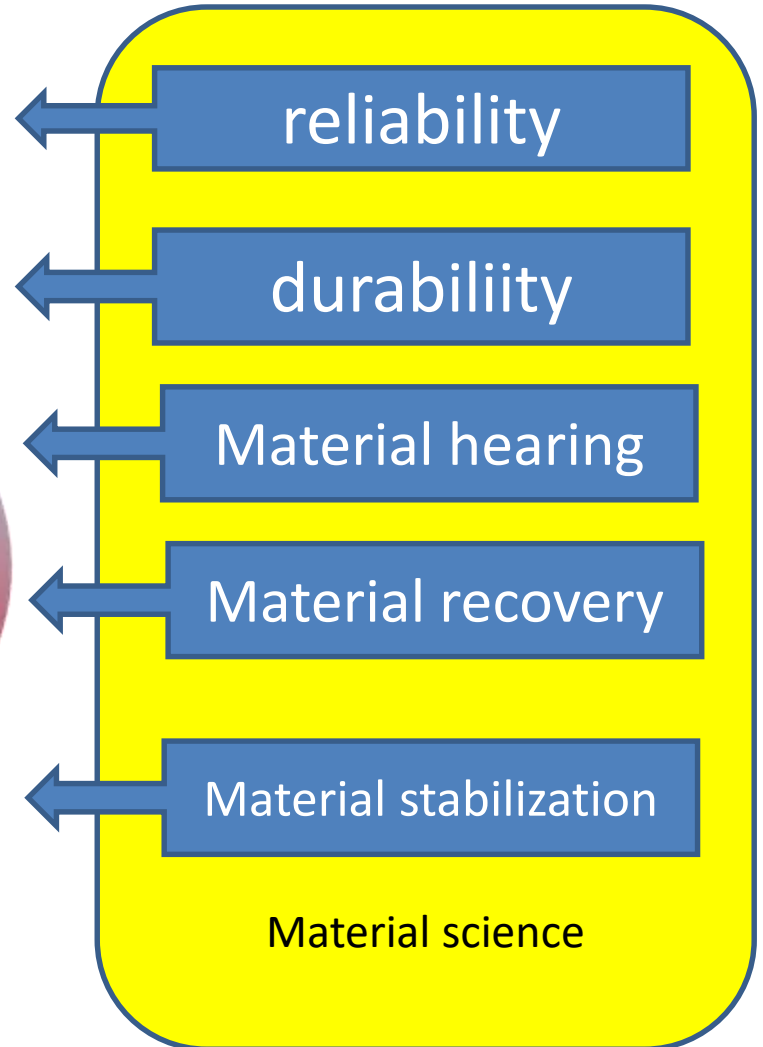
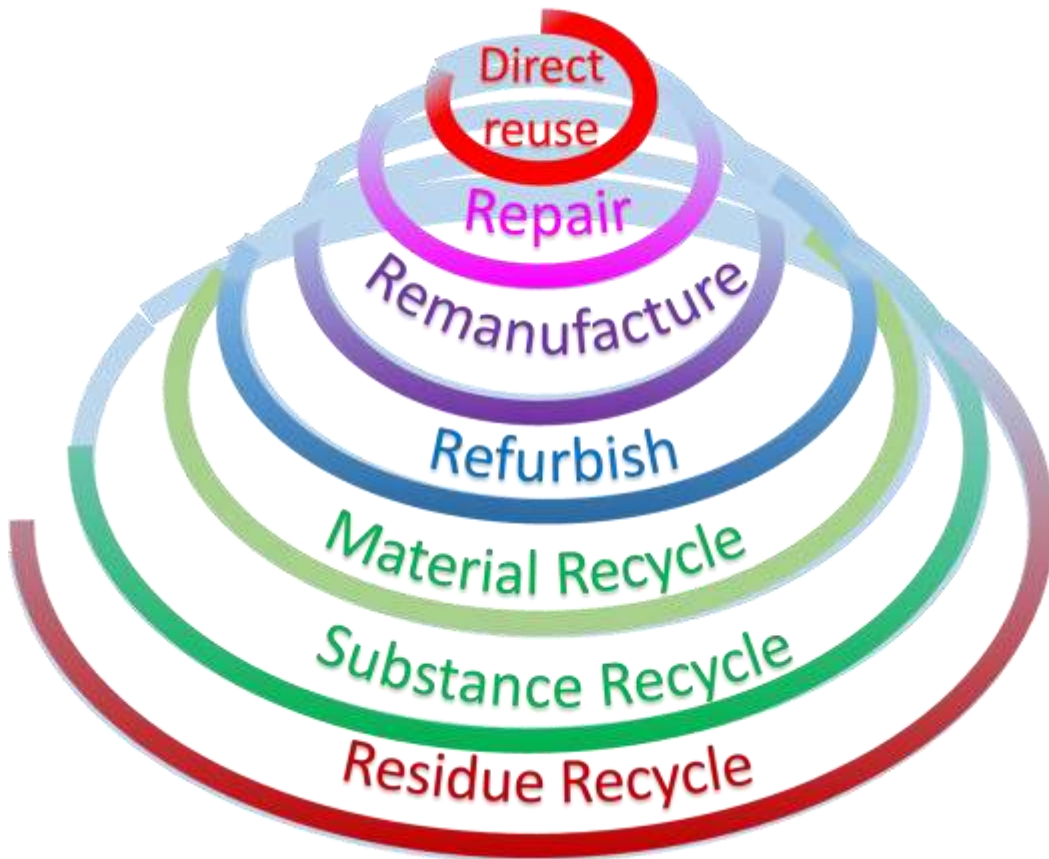
Waste lay off recycling

Bads is salvaged and defused



Wide-area Multi-value Circulation

Circular Economy of productive Asia



Thank you !

Let's go toward Mottainai Society
with Multi-Value Circulation !