

The Case Study of National-scale Material Flow Assessment — the Japan Experience

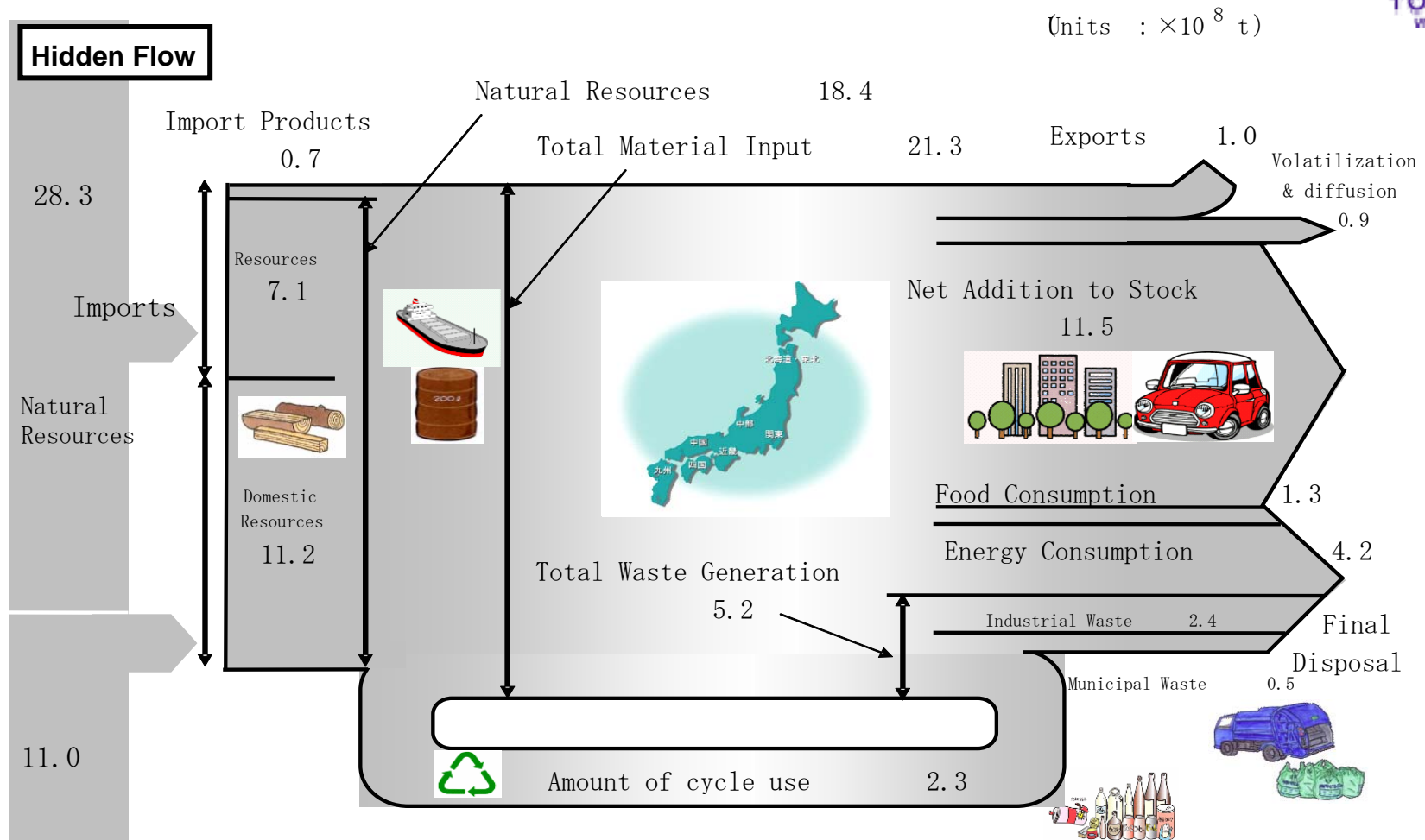


Ecomaterial Design and Process Engineering
Graduate School of Environmental Studies
Tohoku University, Sendai, Japan
YOKOYAMA Kazuyo NAGASAKA Tetsuya

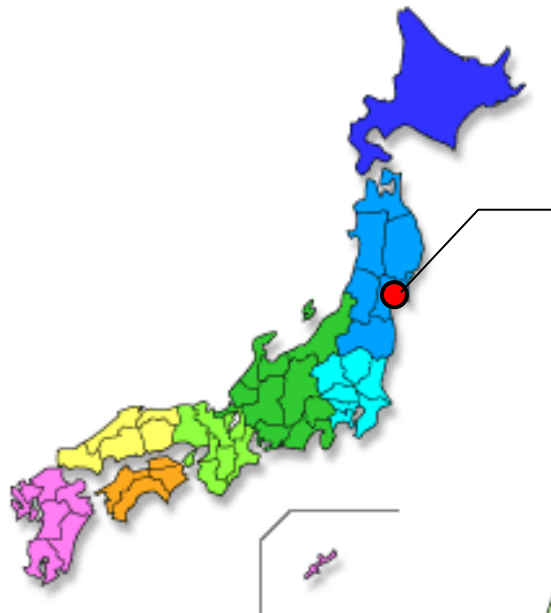
東北大学大学院環境科学研究科
横山 一代 長坂徹也

17, January, 2007 Environmental & Energy International Conference , Taipei,
Taiwan

Material flow of Japan (2000 year basis)

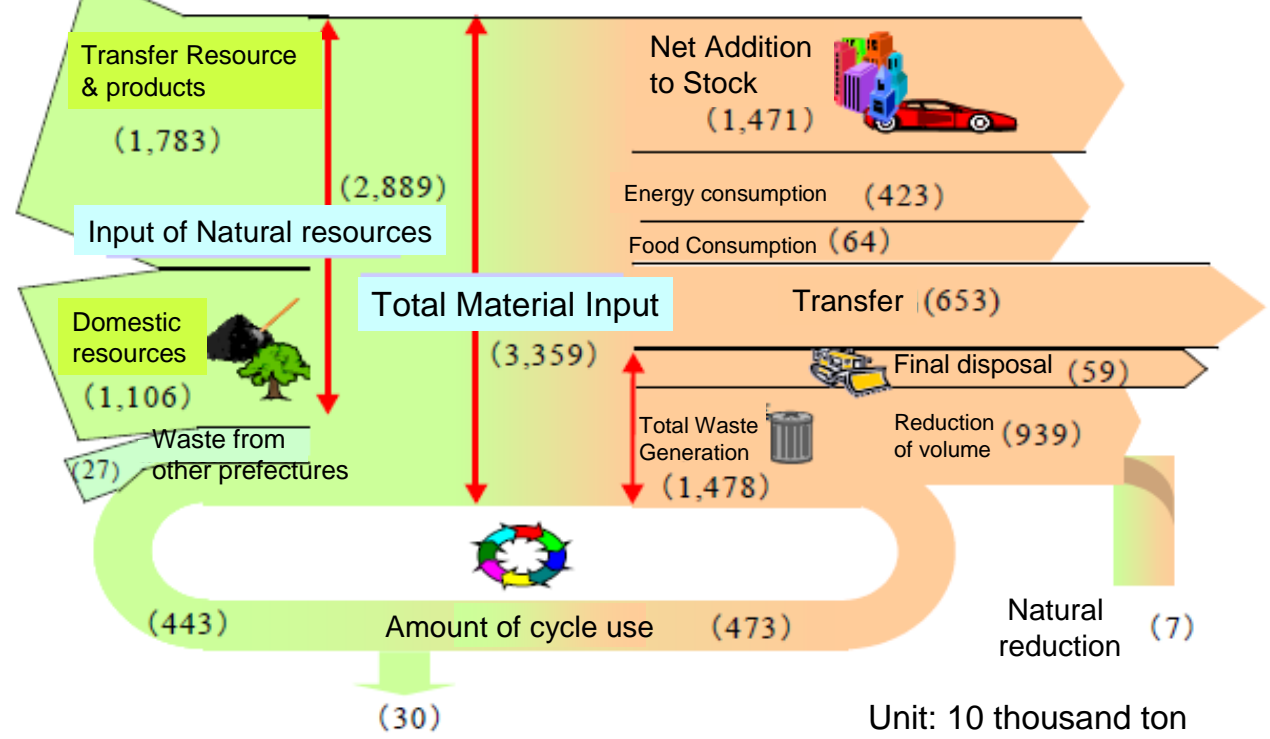


The total land area is approximately 380,000 km². The islands stretch nearly 3,000 km from north to south. Population = 127 Million



Sendai
仙台

Material flow of Miyagi Prefecture (2003 FY basis)



Unit: 10 thousand ton

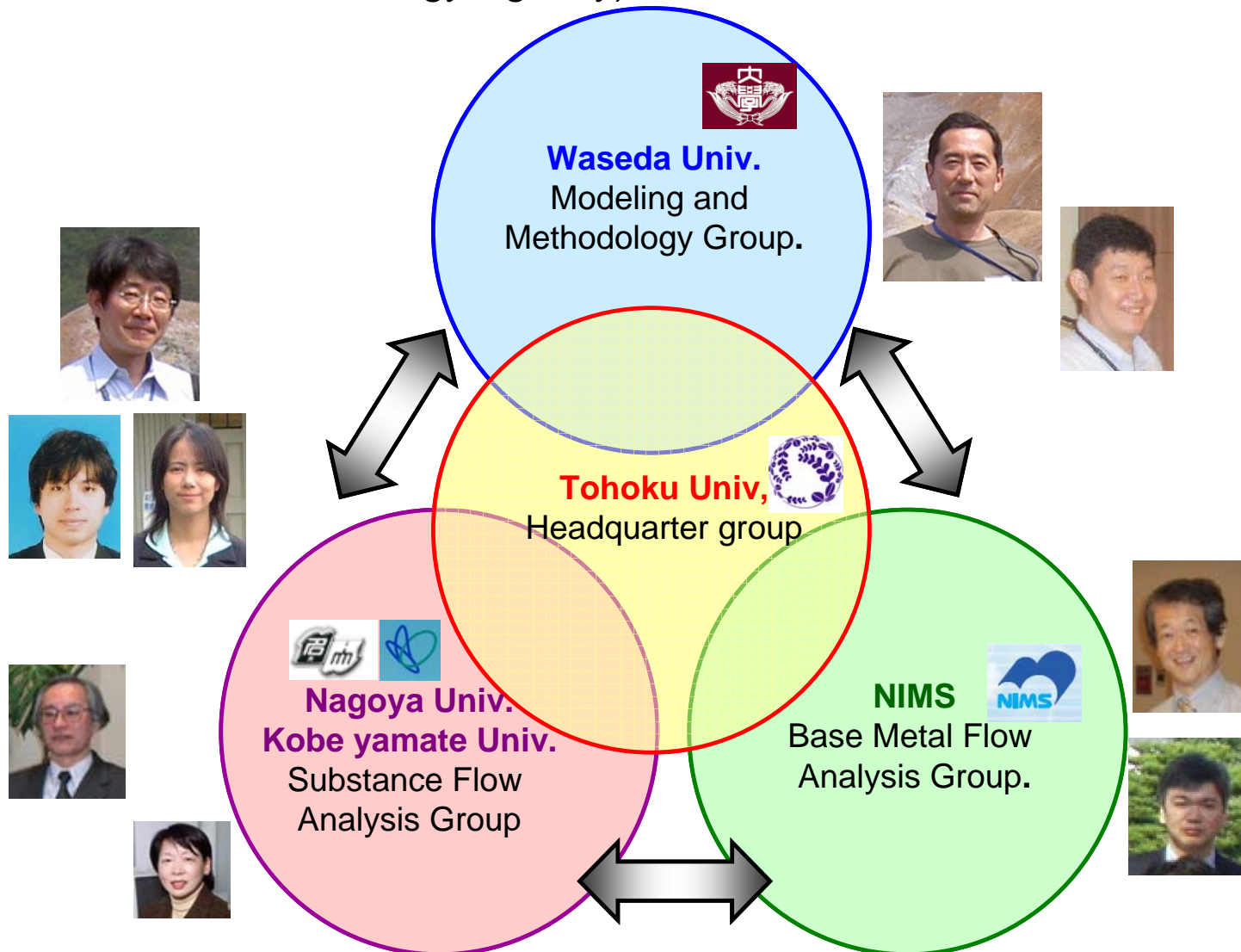
- For sound social metabolism, or efficient and sustainable management of resources...
- We need more and more detail information about following questions.
- **Where and how much** the valuable materials **exist** in our society?
- **When and how** we can / should **recover** the materials from the durable commodities as secondary resources?
- **How** we should **manage** valuable materials in our society?

Contents

- “Substance/material flows as sustainability indexes”
 - funded by RISTEX-JST
 - ❑ Demand and supply of rare metal in Japan
 - ❑ SFA of molybdenum associated with iron and steel cycle in Japan
 - ❑ Material flow of Phosphorus in Japan
- “Development of Material Stock Account Framework and Its Application: Strategies for Waste / Resource Management”
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 - ❑ Application of MSA and Scenario Analysis

Substance/material flows as sustainability indexes

as a Contract Research Program “The Study on Sustainable Society”
funded by RISTEX-JST (Research Institute of Science and Technology for Society -
Japan Science and Technology Agency). : 2003~2006



Substance/material flows as sustainability indexes

RISTEX-JST : 2003~2006



Symposium on Advanced Material Flow Analysis for the Sustainable Society

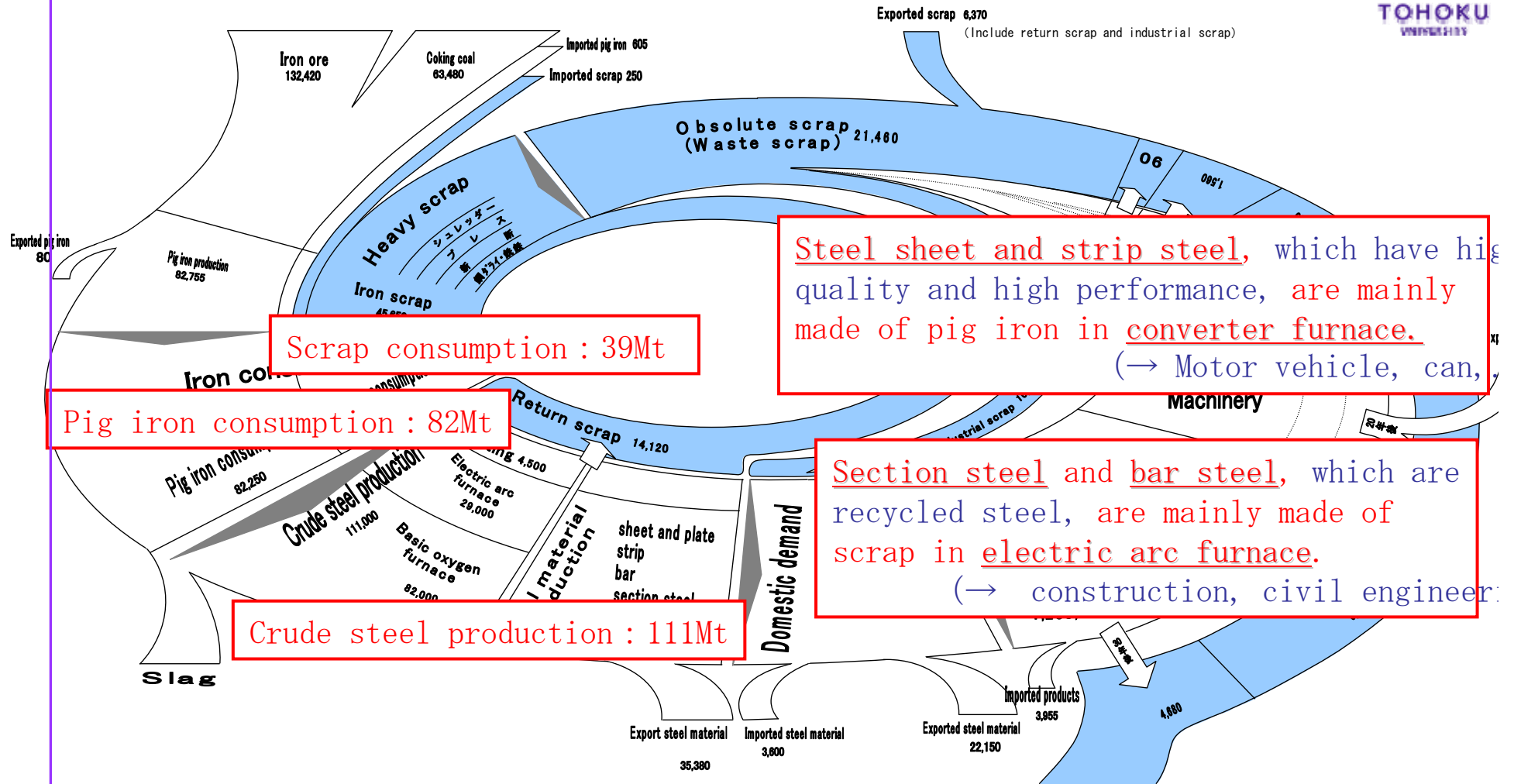
September 25 – 26, 2006

Tohoku University, Sendai, Japan

Sponsored by

RISTEX (Research Institute of Science and Technology for Society),
JST (Japan Science and Technology Agency)

Iron and steel cycle in Japan



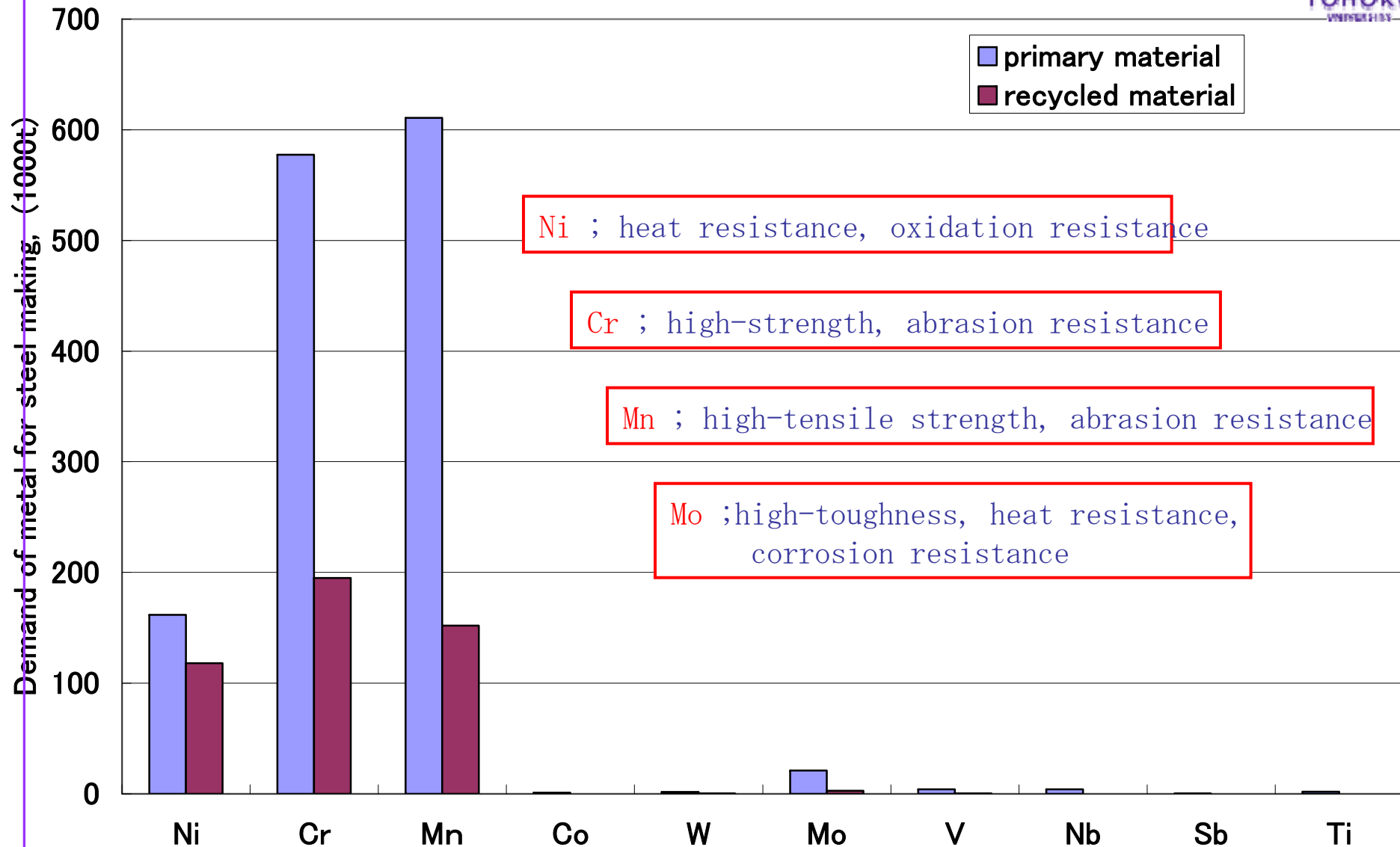
Iron and steel cycle in Japan (2003fy)
(unit: 1000t)

Data: The Japan ferrous raw materials association



Demand of rare metals in Japan

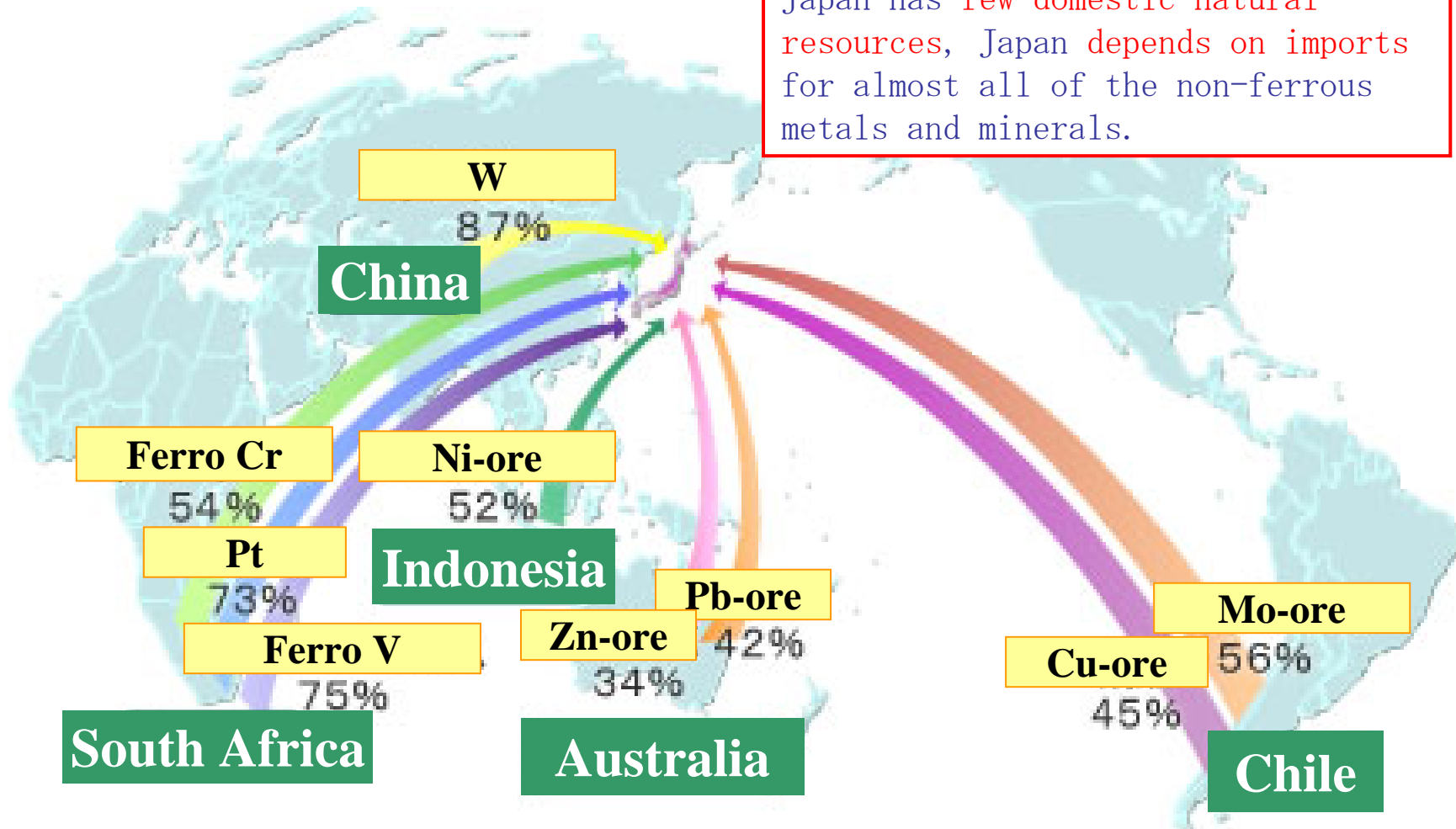
Rare metals (Ni, Cr, Mn, Mo, ...etc.) are used for steel making process in order to...



Demand of rare metal for steel making (2003)

Demand of rare metals in Japan (import)

Japan has few domestic natural resources, Japan depends on imports for almost all of the non-ferrous metals and minerals.



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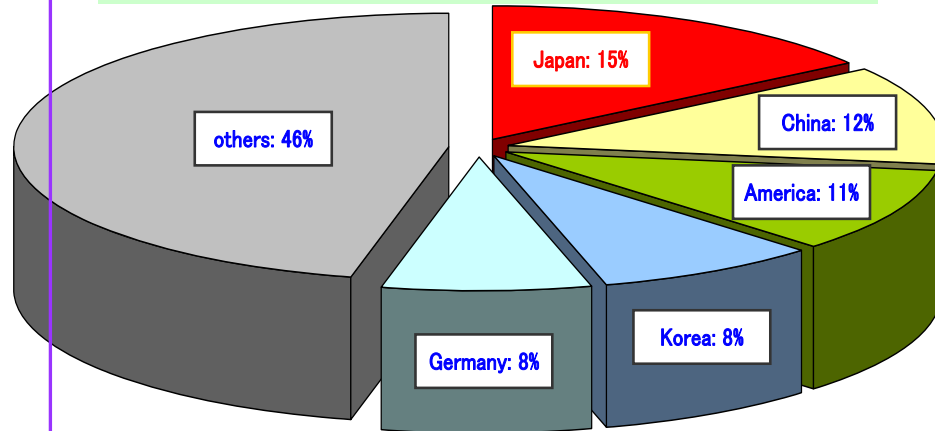


Demand of rare metals in the world

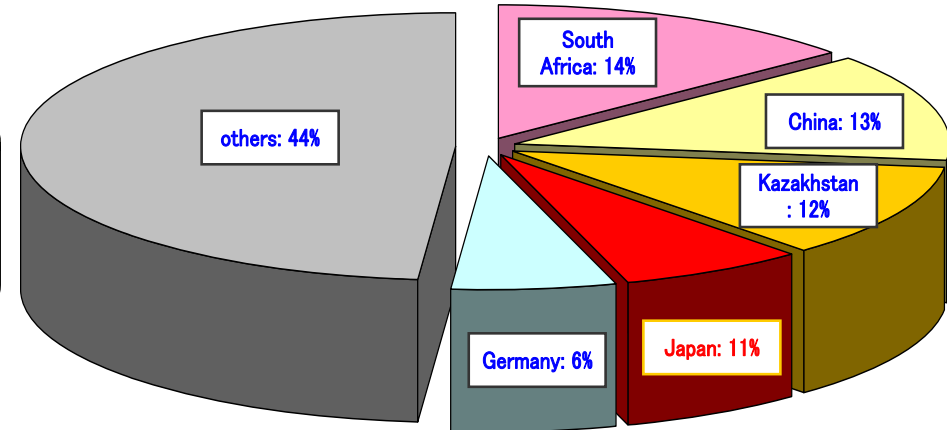
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Large amount of rare metals are consumed in Japan. On the other hand, it is expected to **increase consumption** of rare metals **in other Asian countries** (China, Korea...) with industrial development.

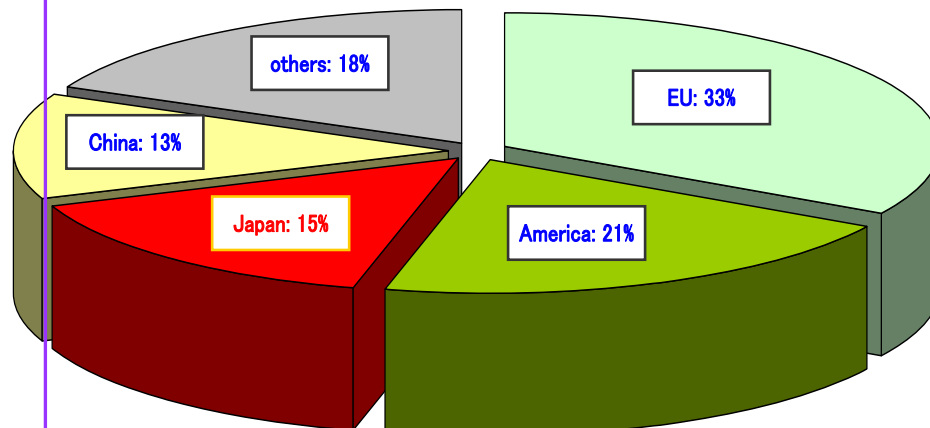
(a) Ni, Consumption(World) :
 $1,253 \times 10^3$ Ni-t (2004)



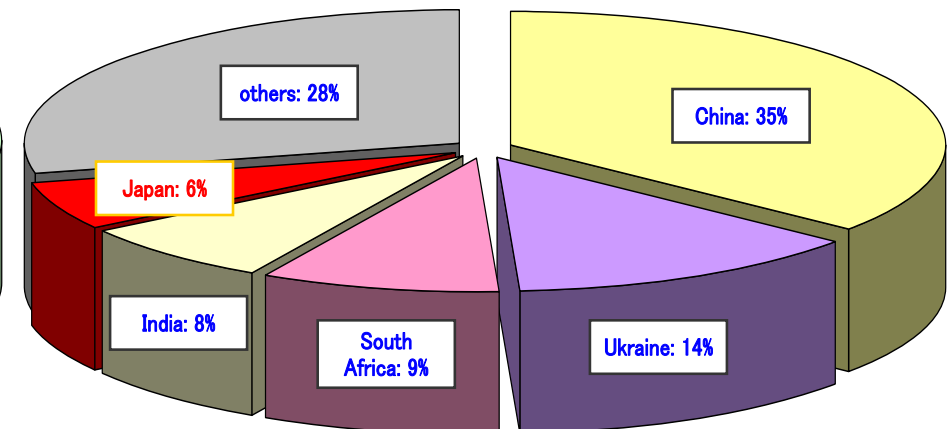
(b) Cr, Consumption(World) :
 $4,695 \times 10^3$ Cr-t (2003)



(c) Mo, Consumption(World) :
 175×10^3 Mo-t (2004)



(d) Mn, Consumption(World) :
 $19,630 \times 10^3$ t (2001)



National stockpiling program in Japan

Since 1983, **JOGMEC** (Japan Oil, Gas and Metals National Corporation) has managed the national stockpiling of rare metals to prevent any short-term supply shortage.

At present, JOGMEC stockpiles 7 materials : nickel, chromium, tungsten, cobalt, molybdenum, manganese, and vanadium.



Nickel



Tungsten



Molybdenum



Vanadium



Chromium



Cobalt



Manganese

Stockpiling program of non-ferrous materials in Japan

A management of these metals is important from the viewpoint of the material-cycle and the strategic resource utilization...

Material flow data in Japan

Supply and demand data

1) Ministry of Economy, Trade and Industry

METI: “Yearbook of iron and steel, non-ferrous metals, and fabricated metals statistics”, (2005)

Material flow data

2) JOGMEC

JOGMEC: “Koubutsu Shigen Material Flow 2004 (in Japanese)”, (2005)

3) NIMS, Tohoku Univ., University of Tokyo, and NIES

M.SHIMADA, K.IJIMA, Y.SAWATANI, K.NAKAJIMA, T.NAGASAKA, T.TSUKIHASHI, Y.MORIGUCHI, and K.HALADA: “New Trend of Material Flow in the Era of Globalization”, Advance in Ecomaterials, pp.620-633, (2005)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	lanthanoid	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	actinoid															
lanthanoid	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu		
actinoid	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr		

 JOGMEC²⁾

 NIMS et al.³⁾

Target elements (JOGMEC: 44, NIMS et al: 22)

Contents

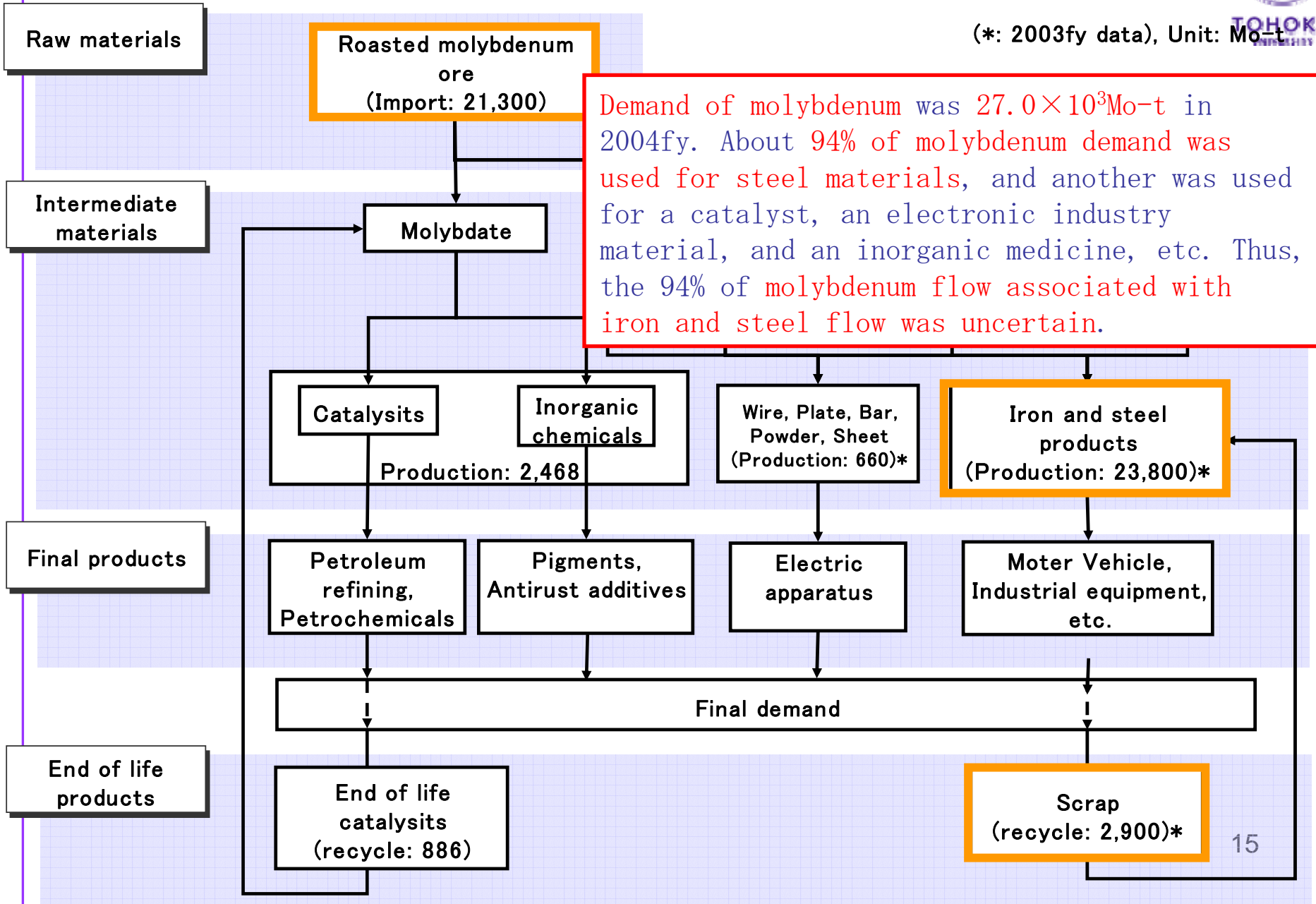
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Molybdenum flow in Japan(FY2004)

Data: <http://www.jogmec.go.jp>



(*: 2003fy data), Unit: Mo-t

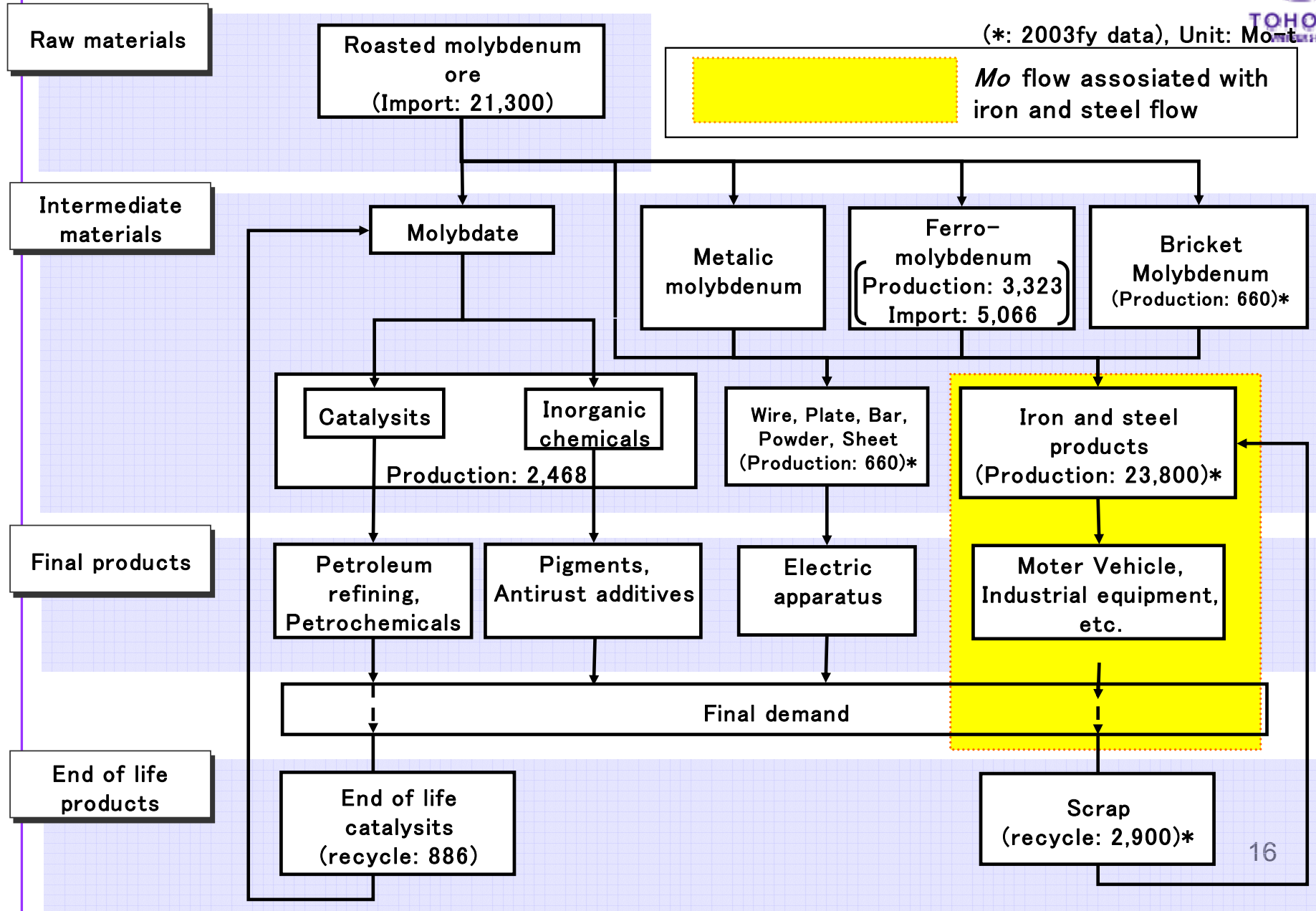


Molybdenum flow in Japan(FY2004)

Data: <http://www.jogmec.go.jp>



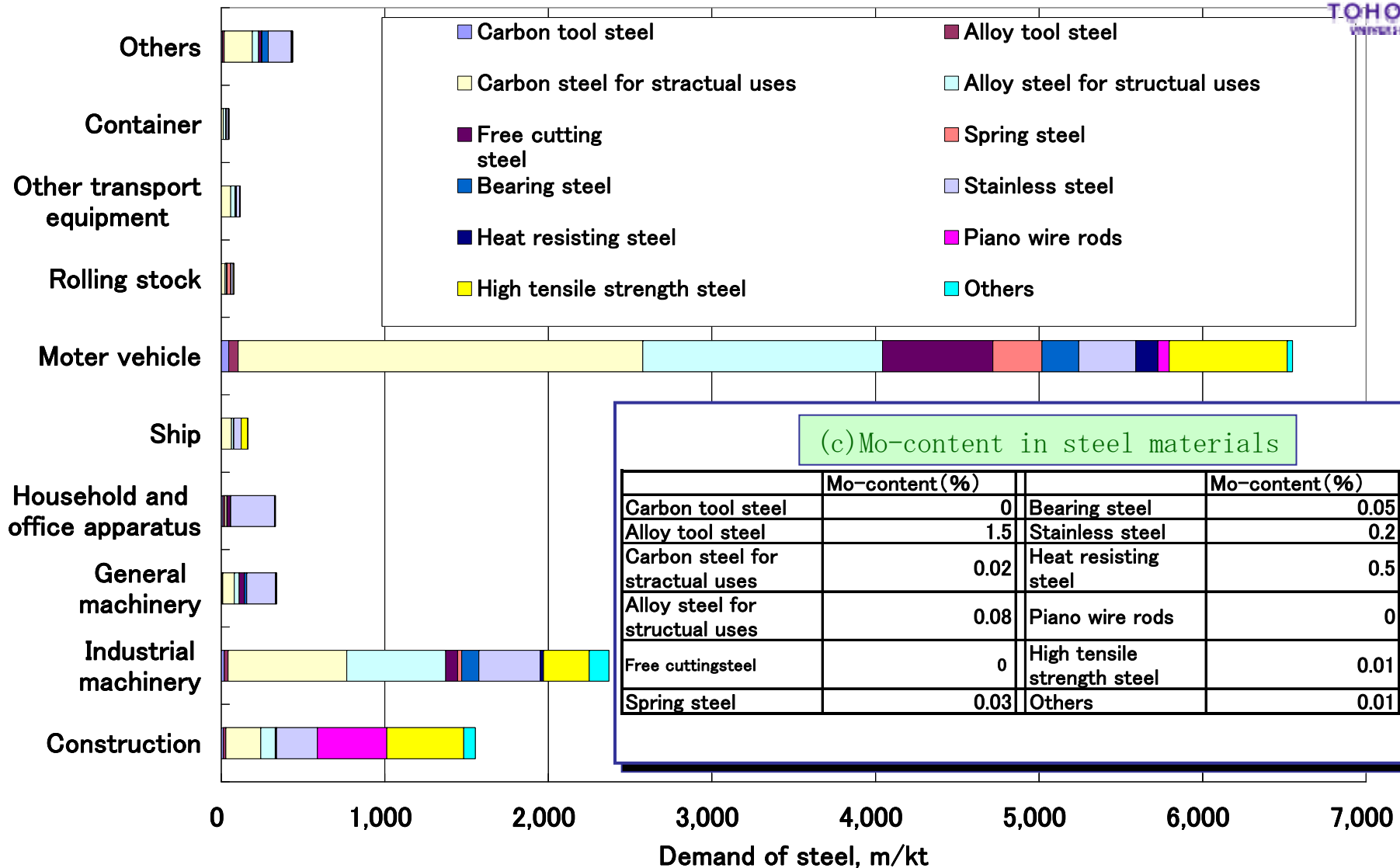
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Demand of special steel materials, and Mo-content in steel materials

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(c) Mo-content in steel materials

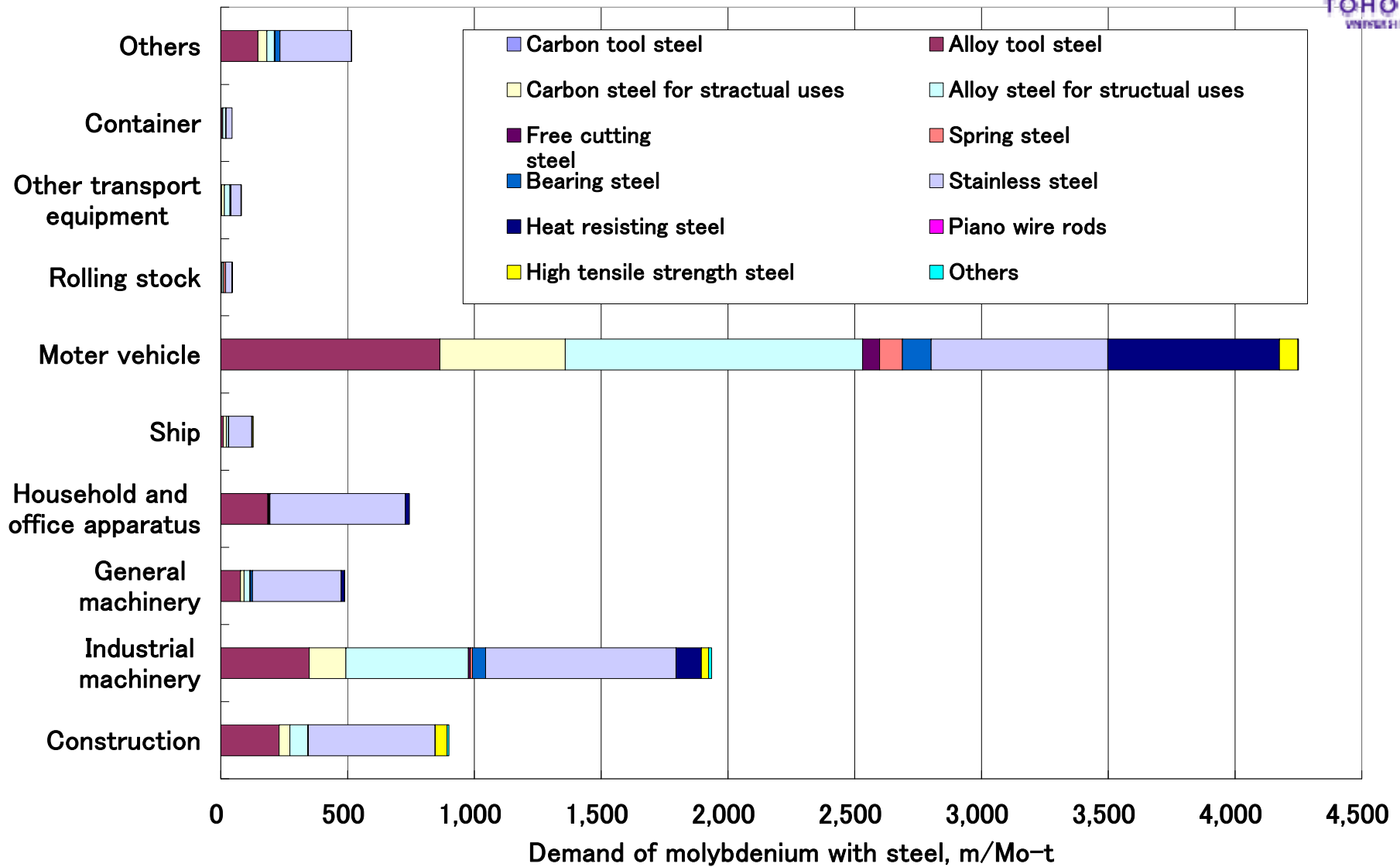
	Mo-content (%)		Mo-content (%)
Carbon tool steel	0	Bearing steel	0.05
Alloy tool steel	1.5	Stainless steel	0.2
Carbon steel for structural uses	0.02	Heat resisting steel	0.5
Alloy steel for structural uses	0.08	Piano wire rods	0
Free cutting steel	0	High tensile strength steel	0.01
Spring steel	0.03	Others	0.01

(b) Demand of special steel materials by final commodity production (2004fy)



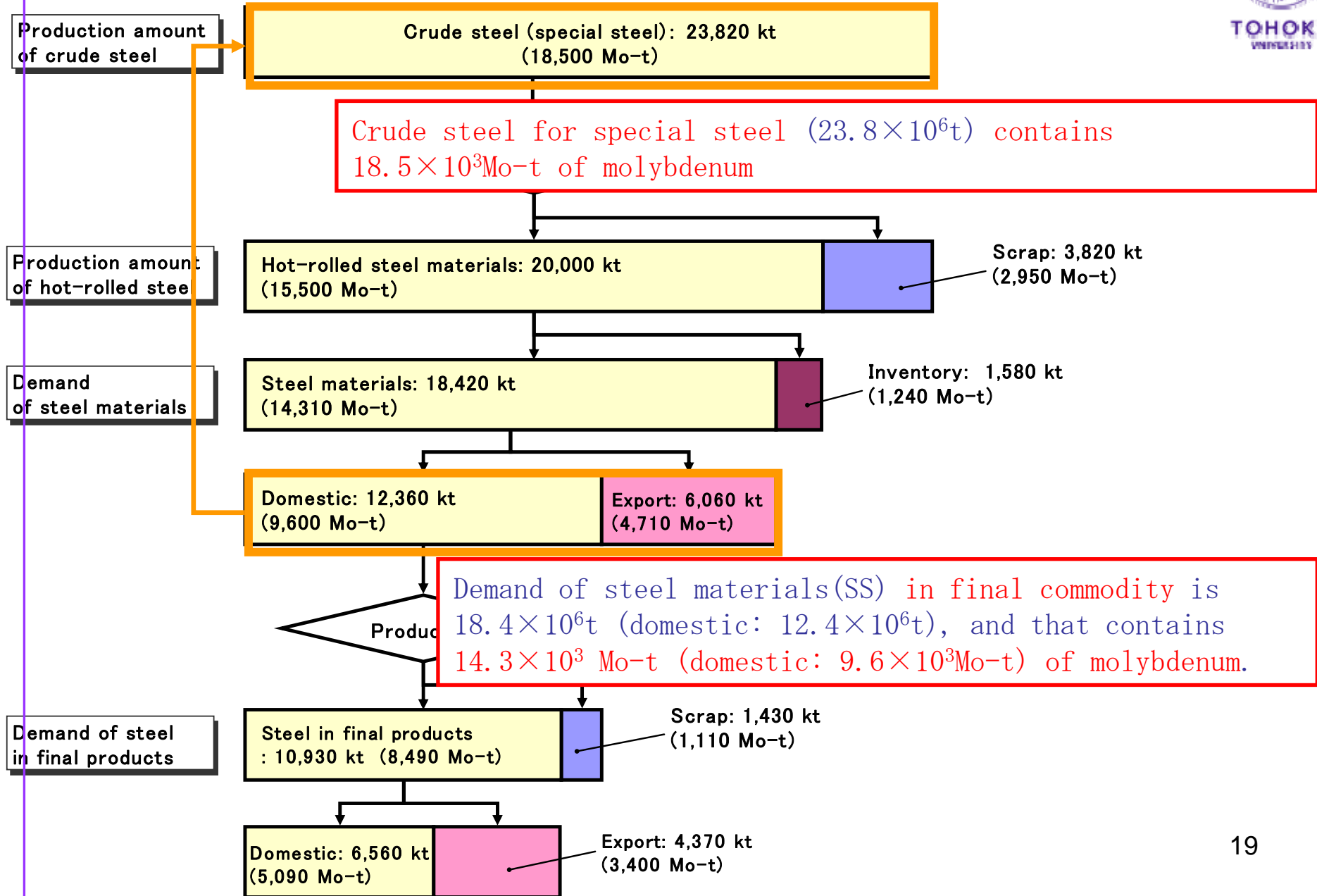
Demand of Mo by final commodity production (Estimated result)

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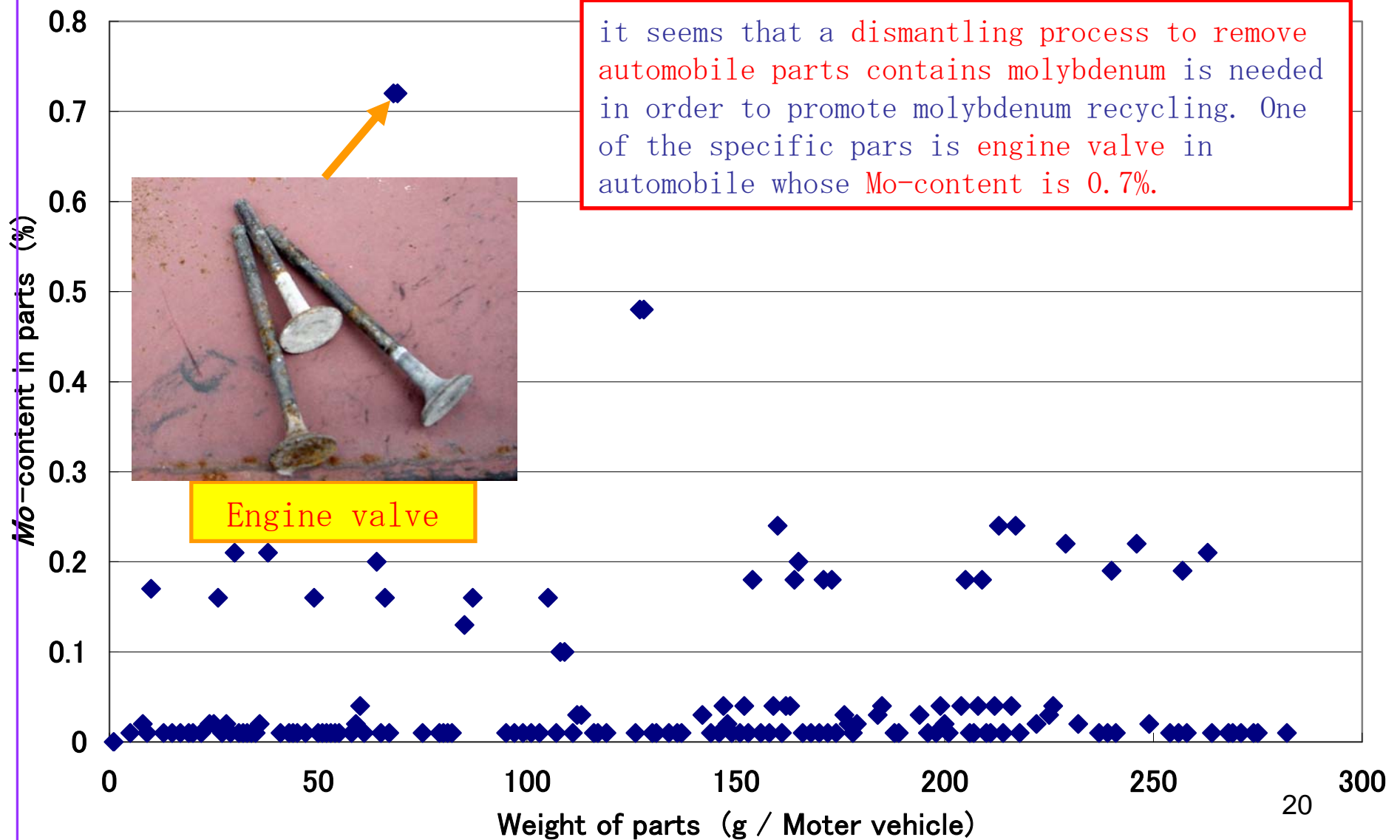


(e) Demand of Mo by final commodity production (originated from special steel) (2004fy)

Demand of Mo associated with iron and steel cycle(2004fy)



Molybdenum parts used in motor vehicle



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Present status of the world phosphorus resources

- Main use : raw materials for fertilizer
- It completely depends on import.

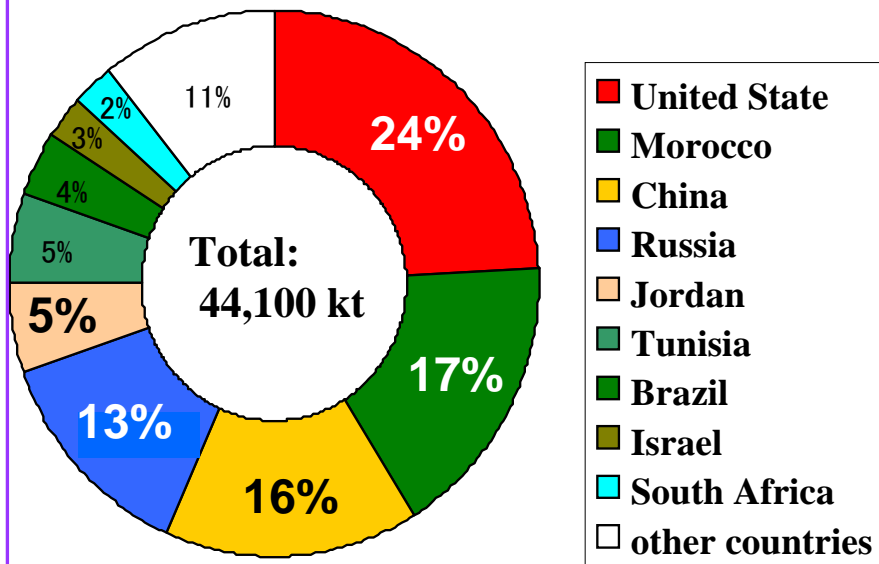


Fig. Phosphate rock production rate in the world. (2002)

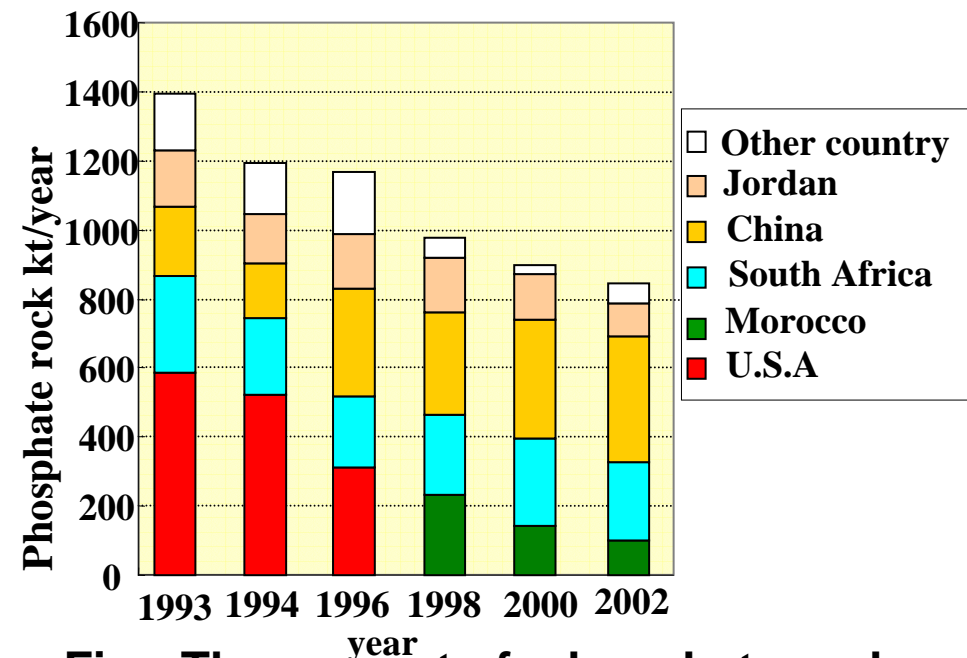


Fig. The amount of phosphate rock imported.

Domestic material flow of phosphorus (Conventional type)

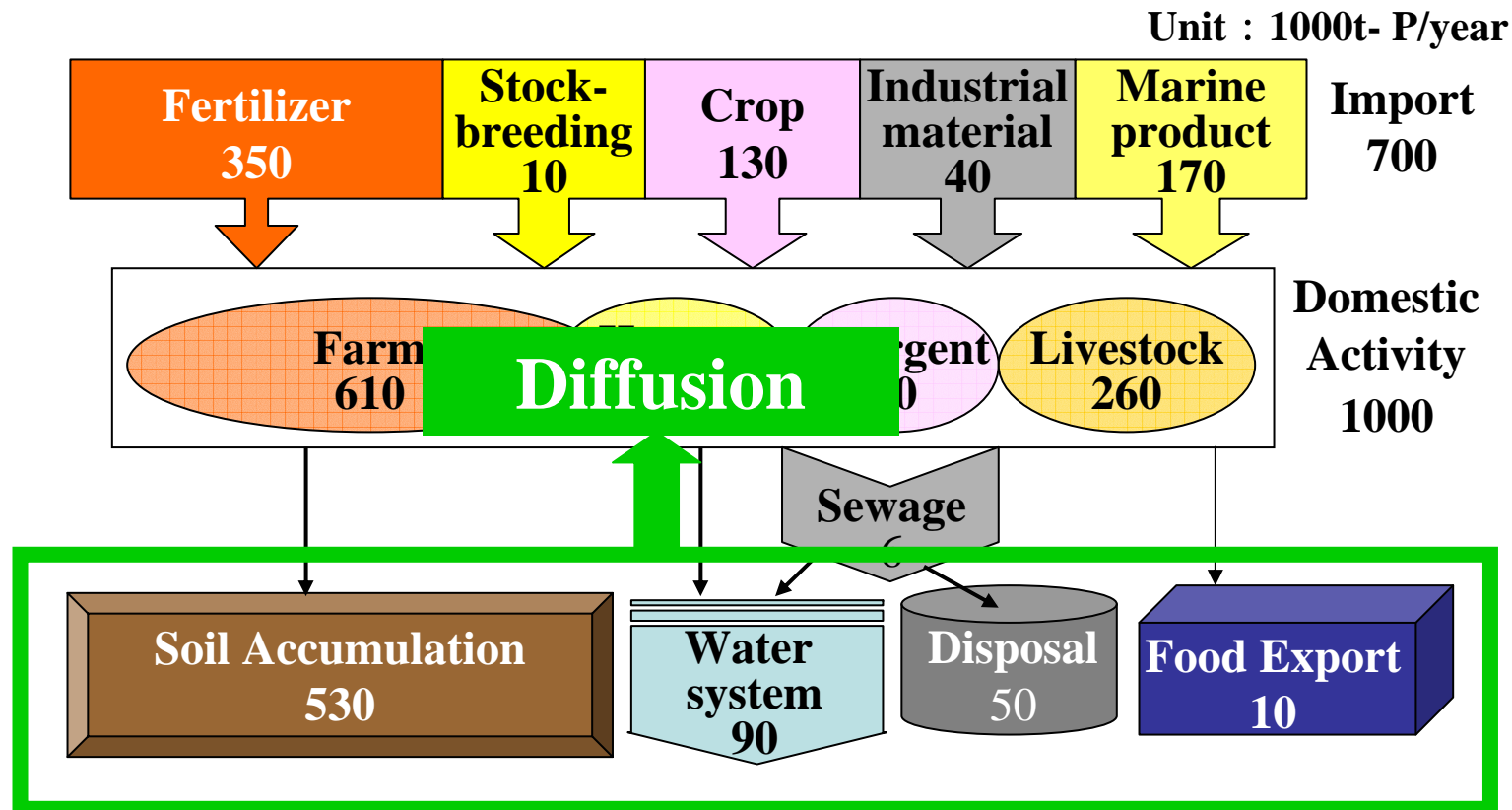


Fig Material flow of phosphorus in Japan, 1993

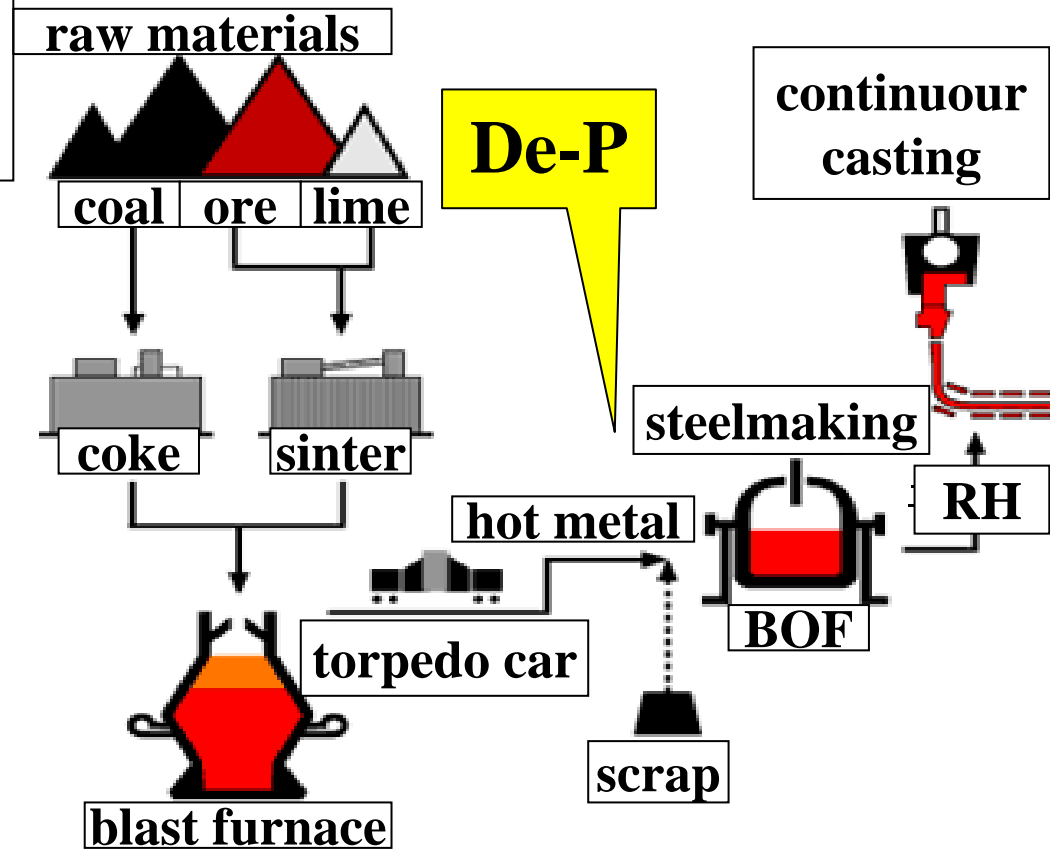
H. Mishina "Saisei to Riyo" Vol. 26 No. 98 2003/1

Dephosphorization of steel with slag

Phosphorus is a natural enemy for steel, because it enhances cold brittleness of steel product.

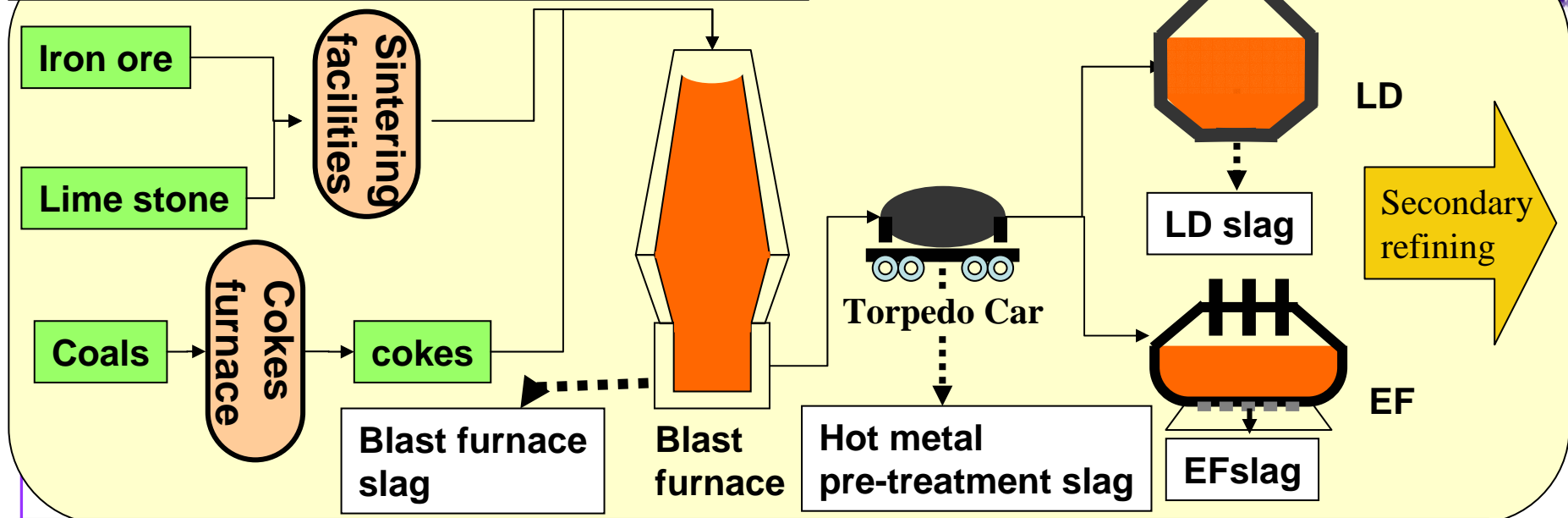
One of the most important roles of steelmaking slag is dephosphorization of molten steel.

The slag after the dephosphorization contains approximately 2 to 10 mass% of P_2O_5 together with FeO , CaO and SiO_2 .



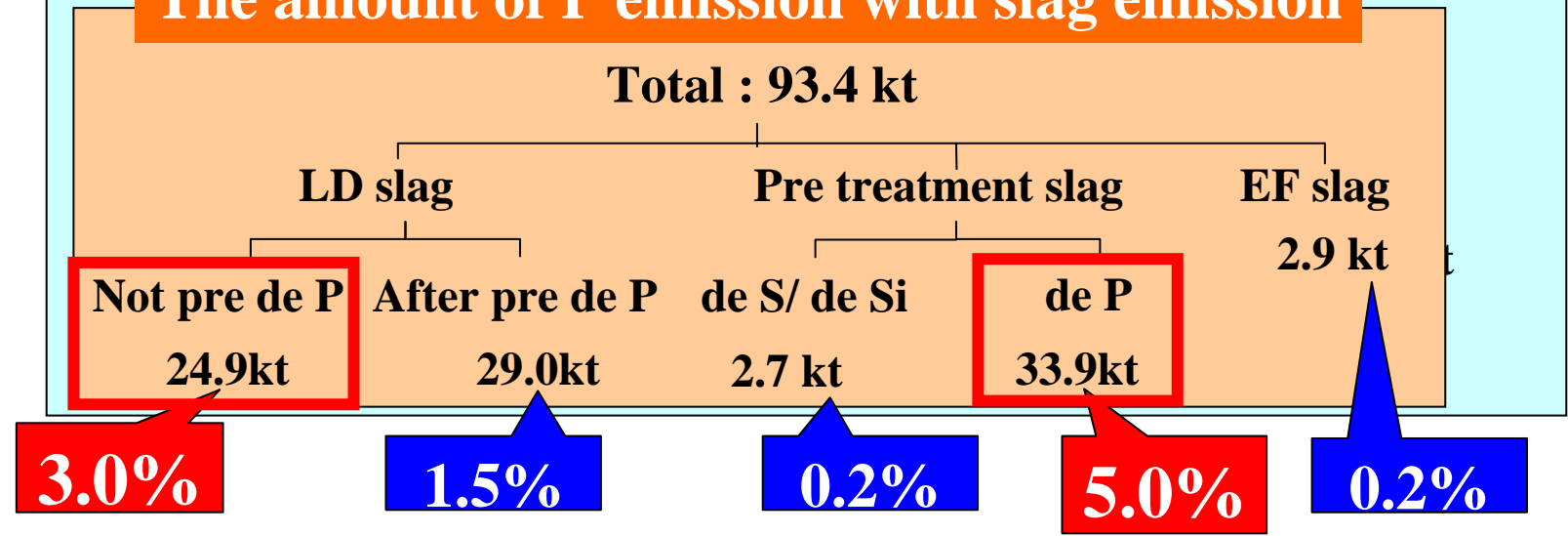
Iron- and steelmaking process

Steelmaking process outline

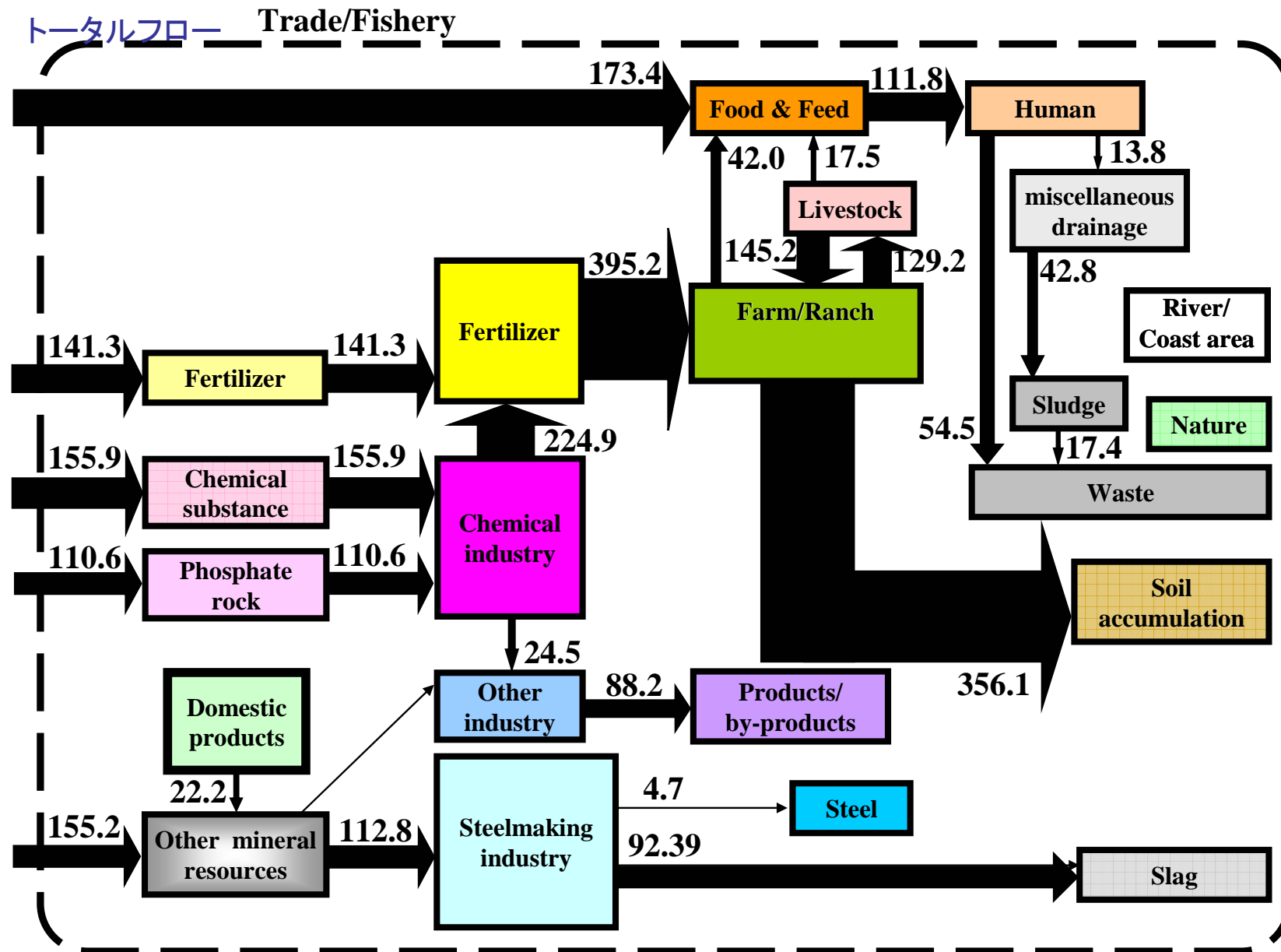


The amount of slag generation based on slag emission intensity

The amount of P emission with slag emission



Material flow of Phosphorus in Japan: Part 1



Material flow of Phosphorus in Japan: Part 2

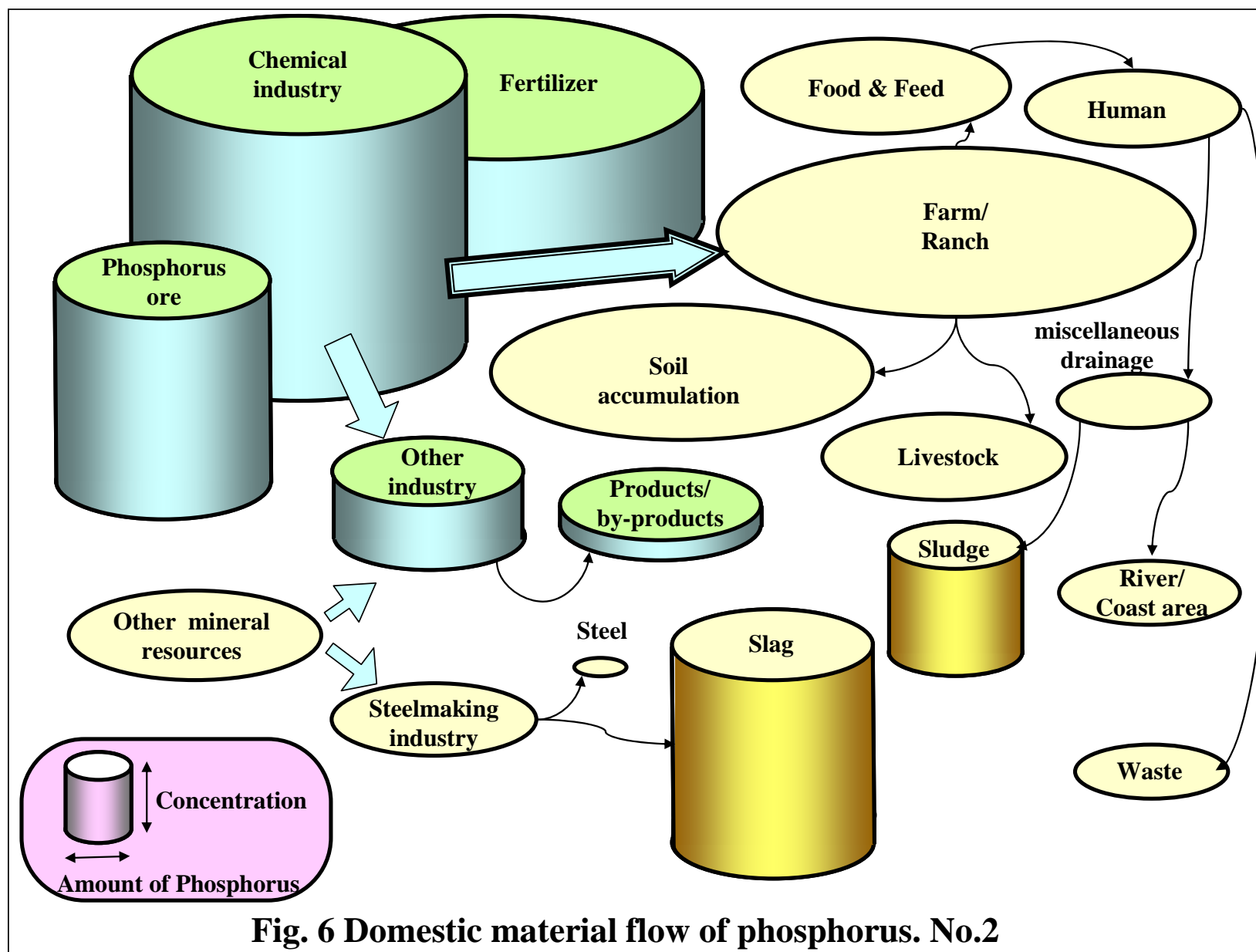


Fig. 6 Domestic material flow of phosphorus. No.2

Substance/material flows as sustainability indexes

RISTEX-JST : 2003~2006

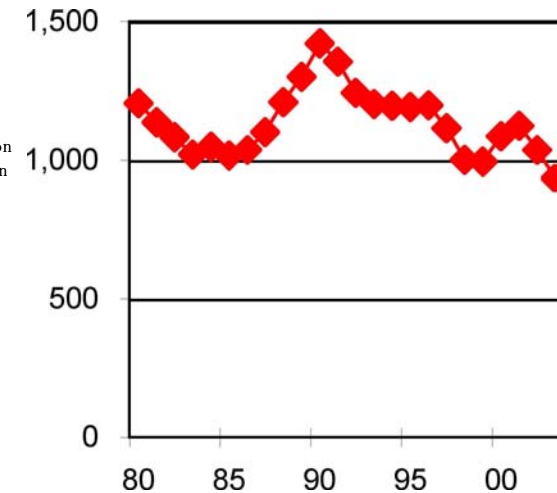
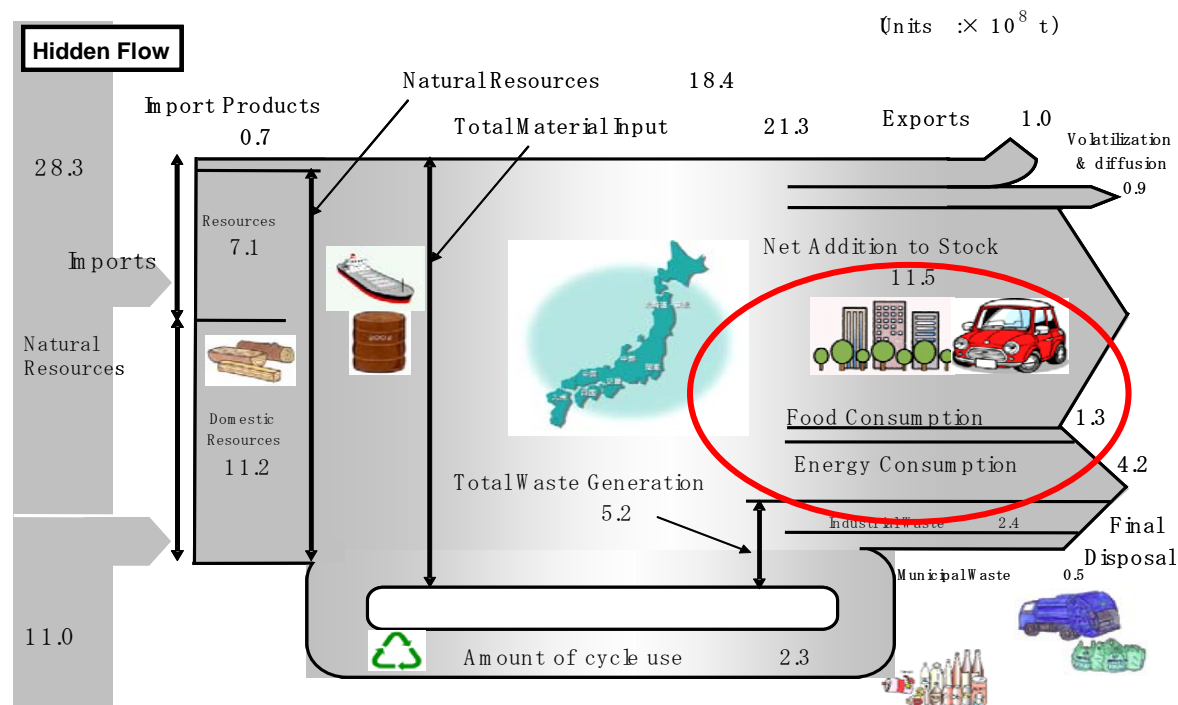


- Our main outcomes are
 - to quantitatively investigate flows of base materials, such as Fe, Al, Cu and associated substances, such as Mo, In, P by using the methods of material flow analysis (MFA), substance flow analysis (SFA), and waste input-output analysis,
 - to develop WIO-MFA model as a mathematical model that enables integrative assessment and analysis of these data from temporal and spatial axes.

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Material flow of Japan (2000 year basis)



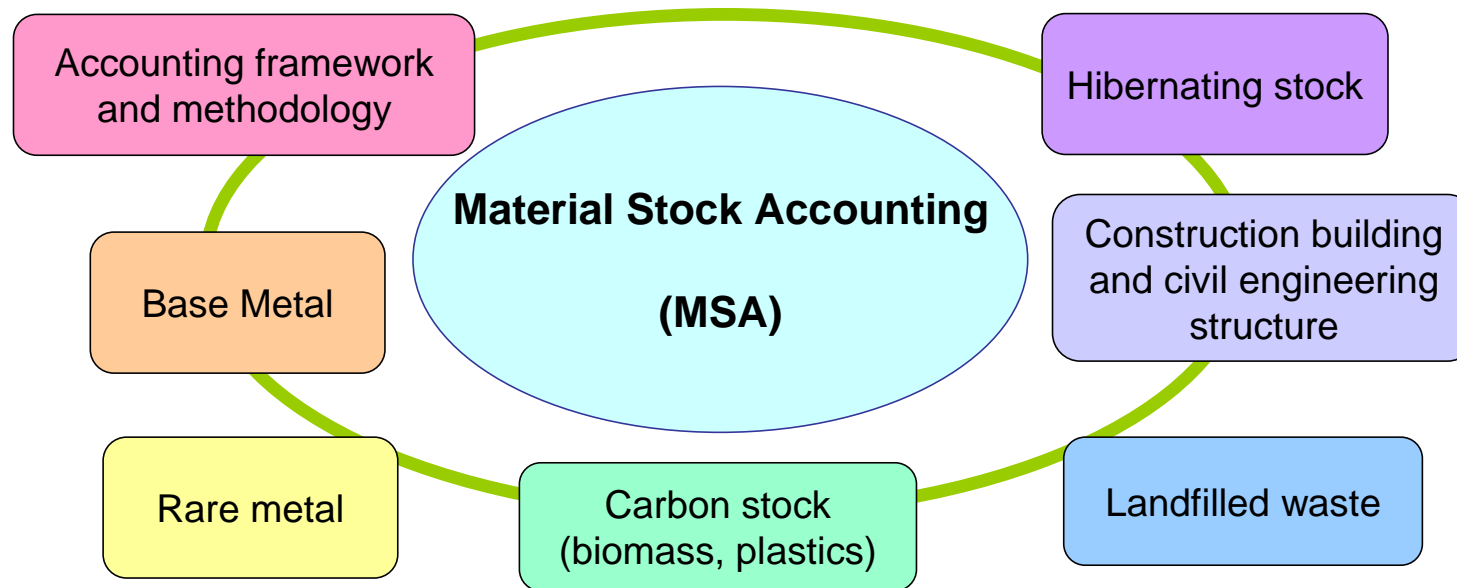
Most materials which have been exploited in the past centuries are still “hibernating” somewhere in the anthroposphere.

Brunner (1999,2004)



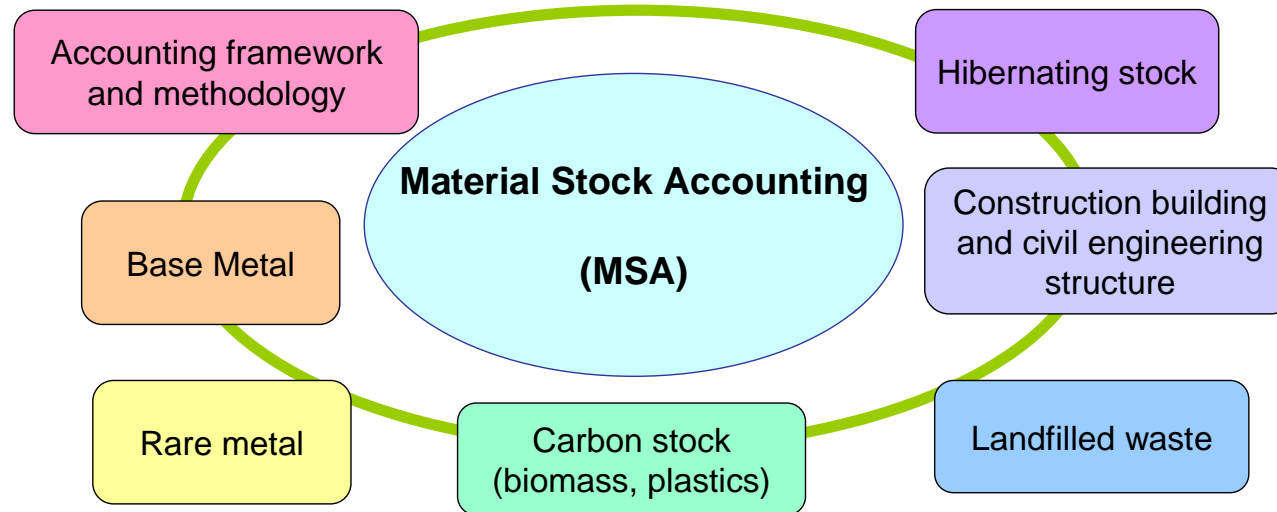
Development of Material Stock Account Framework and Its Application: Strategies for Waste / Resource Management

Grant-in-Aid for Scientific Research for Waste treatment:2006~2008



1. Development of MSA Framework that is consistent with Economy-Wide MFA Framework
2. Application of MSA and Scenario Analysis

Development of Material Stock Account Framework and Its Application: Strategies for Waste / Resource Management



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 Yokohama National University
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 The University of Tokyo
 Tohoku University
 Tohoku University
 National Institute for Advanced Industrial Science and technology
 Kyoto University

What is “material stock”?



Taiwan High Speed Rail



Unused/left products



Unused infrastructures



Taipei 101



Dissipated/left wastes



Landfilled wastes



Unknown export of used products

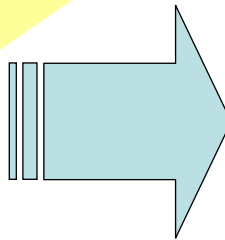
What is “material stock”?



Taiwan High Speed Rail



Taipei 101



Potential wastes
Potential Resources



What is “material stock”?

Collectability?
Value?
Market?



Unused
infrastructures



Dissipated/left
wastes

Unused/left
products

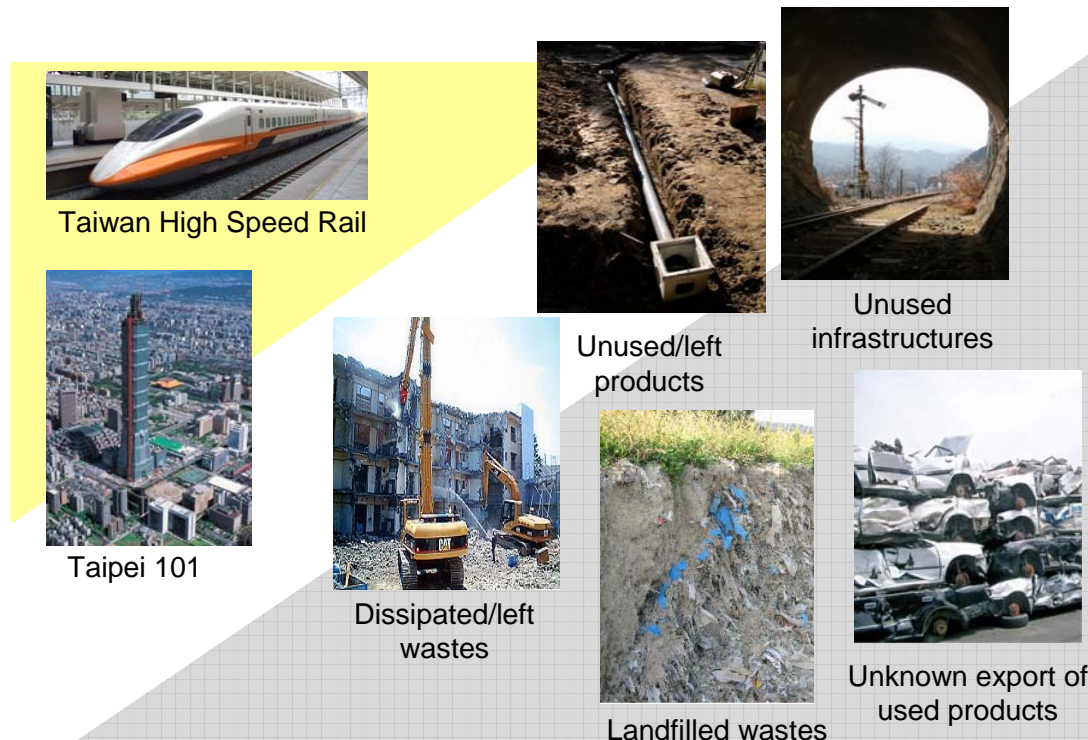


Landfilled wastes



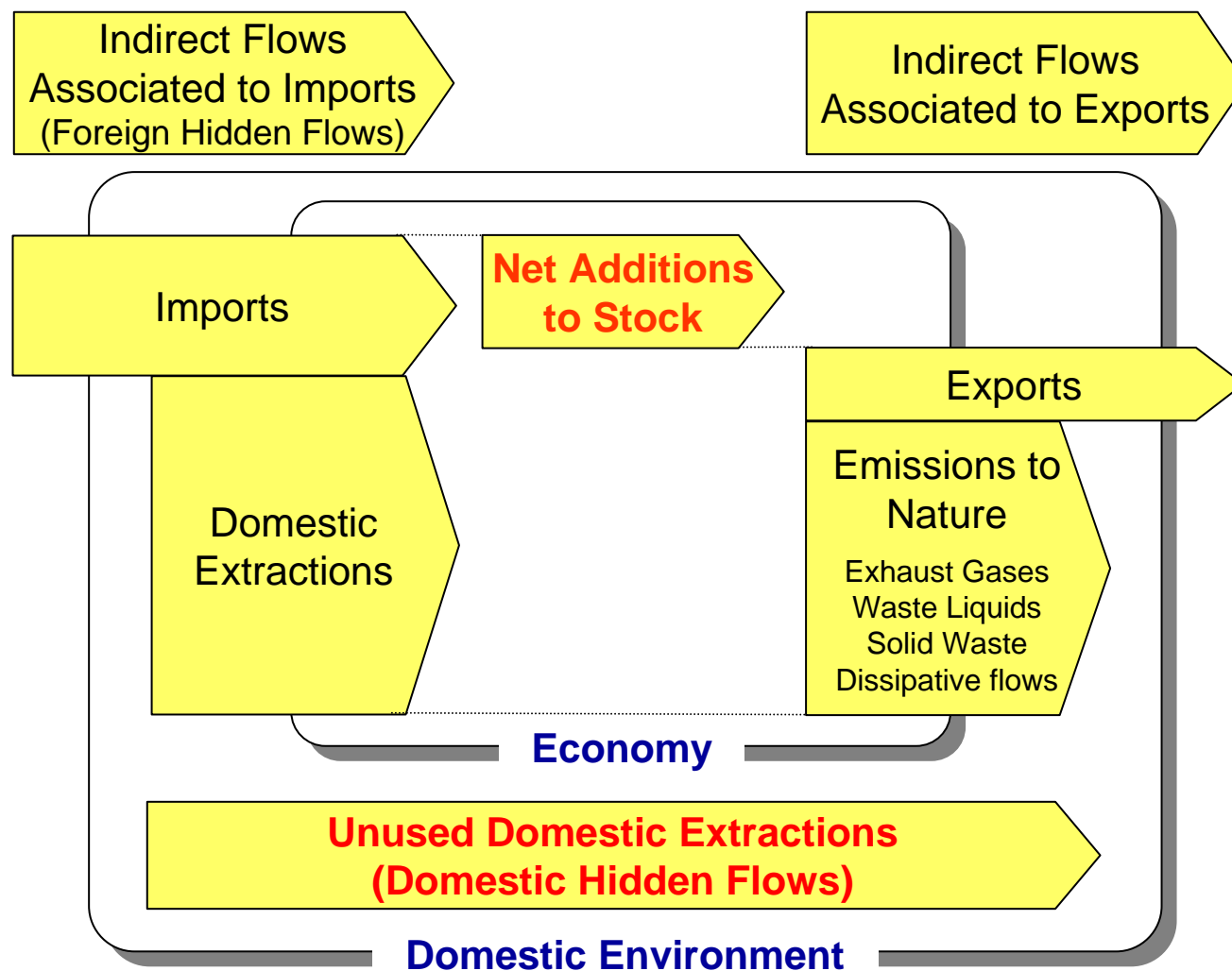
Unknown export of
used products

Objective of “Material Stock Accounting”

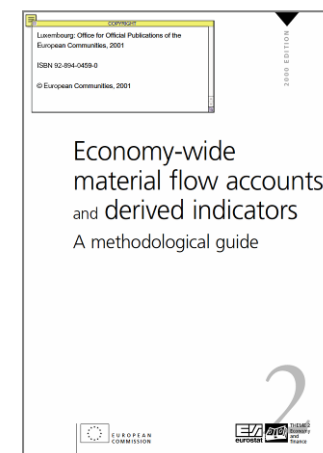


- Accurate estimation of materials that come out of hibernation for
 - Appropriate management of discarded wastes from stocks
 - Improvement of resource productivity through recovery of secondary resources from stocks

Framework of Economy-Wide Material Flow Accounts



Source: Some modifications of Eurostat (2001)



Definition and Categories of Stocked Materials

Stocked materials are defined by



Some vagueness remains in the Economy-Wide MFA. But it is difficult to define the clear boundary between the economy and the environment.



Categorization of stocked materials by condition of usage is useful. This will make a framework of MSA consistent with the framework of Economy-Wide MFA.

Materials now accounted as stock in Economy-Wide MFA		
Within the economy	<u>On boundary between the economy and the environment</u>	<u>In the environment</u>

Definition and Categories of Stocked Materials

Stocked materials are defined by



Considering the objectives of Material Stock Accounts, what have short life spans are not stocked materials that we are concerned with.



Categorization of stocked materials by condition of usage is useful.

Materials now accounted as stock in Economy-Wide MFA	
< 1 yr life span	> 1 yr life span

Categories of Stocked Materials

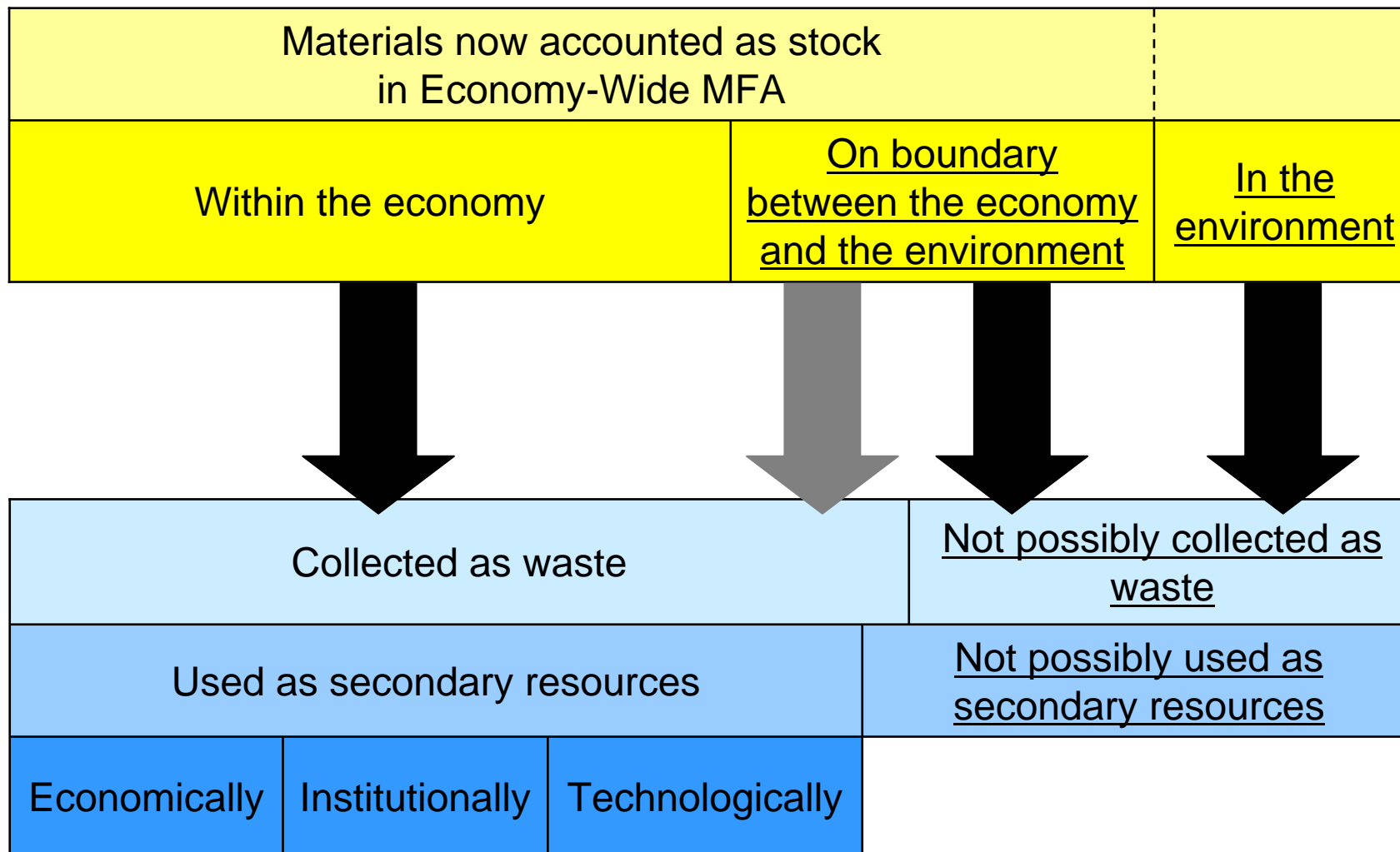
Categorization by condition of usage (tentative)

Materials now accounted as stock in Economy-Wide MFA					
Within the economy		<u>On boundary between the economy and the environment</u>		<u>In the environment</u>	
< 1 yr life span	> 1 yr life span				Dissipated/ left waste
Inventories, foods at home, etc.	Buildings, machineries, cars, etc.		Infrastructure, building foundations, etc.		
	In use	Unused/ Dead	In use	Unused/ Left	Dissipated



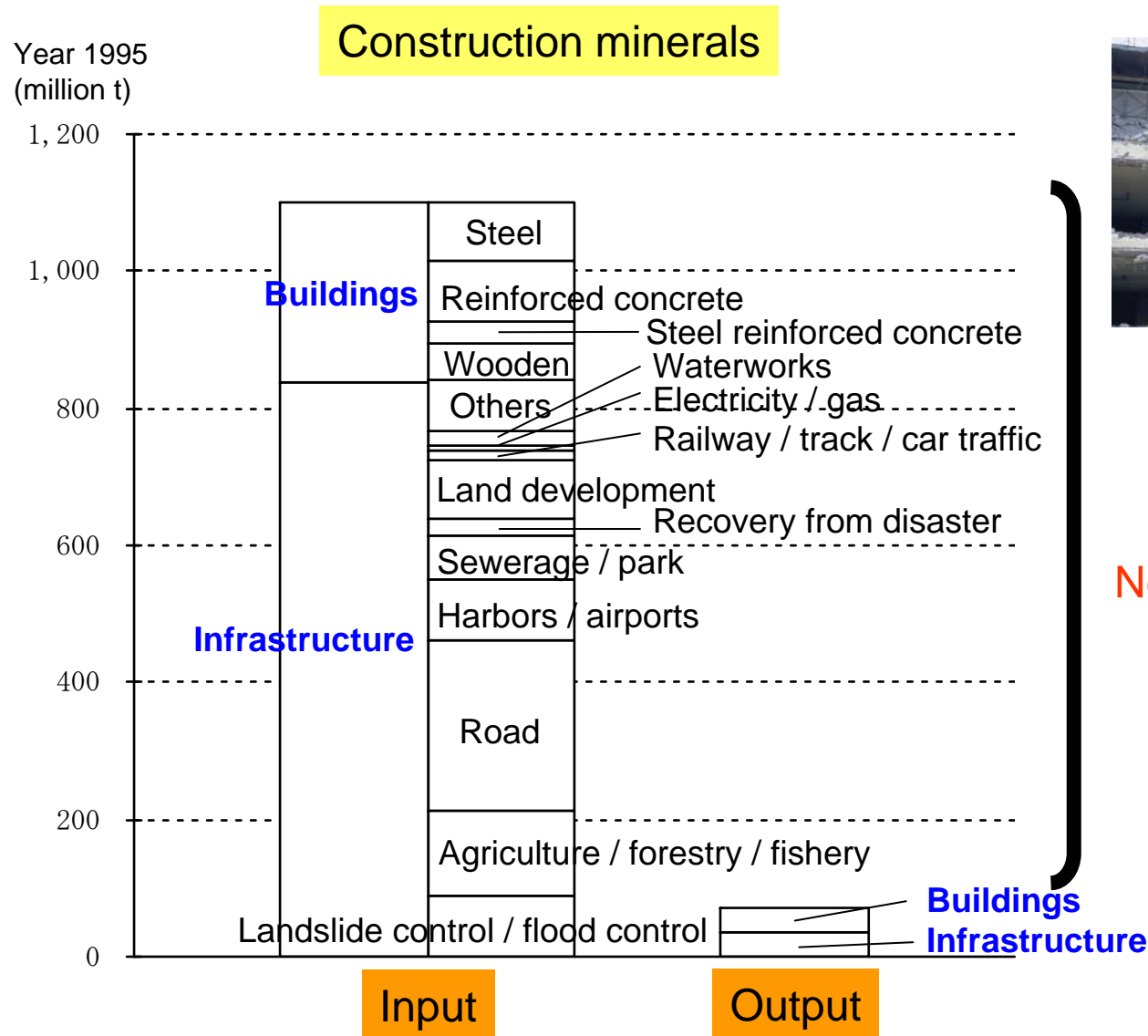
Categories of Stocked Materials

Categorization by condition of usage (tentative)



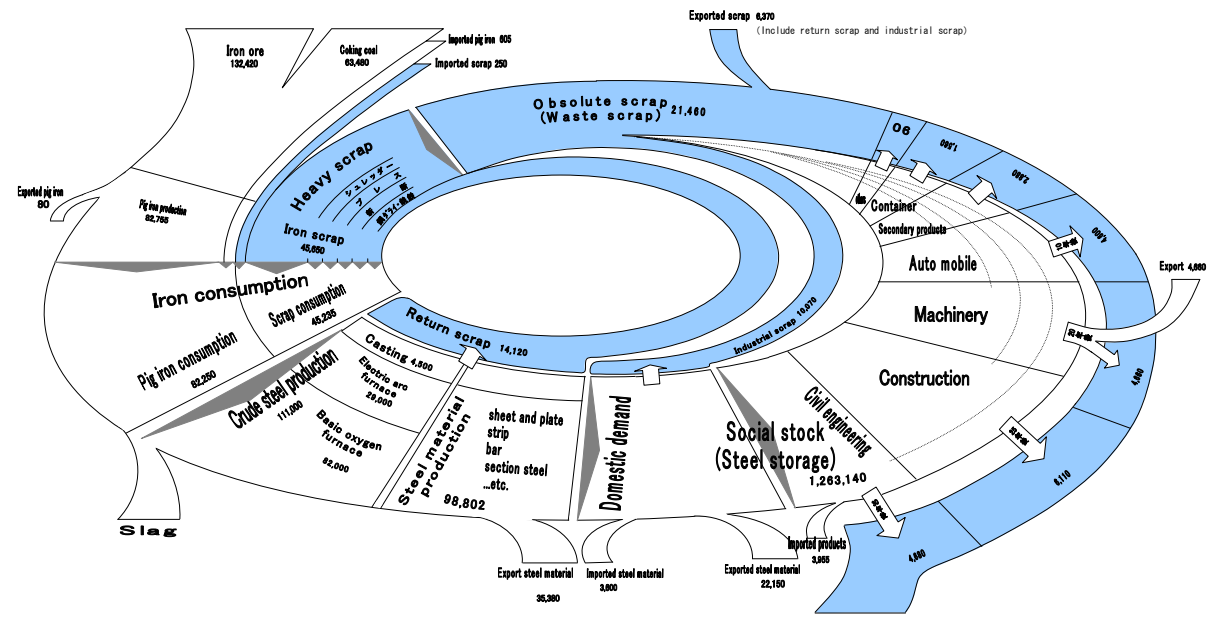
Categorization by possibility of reutilization

How much waste will be generated from stock?



Net Additions to Stock

How much secondary resources can be recovered from stock?



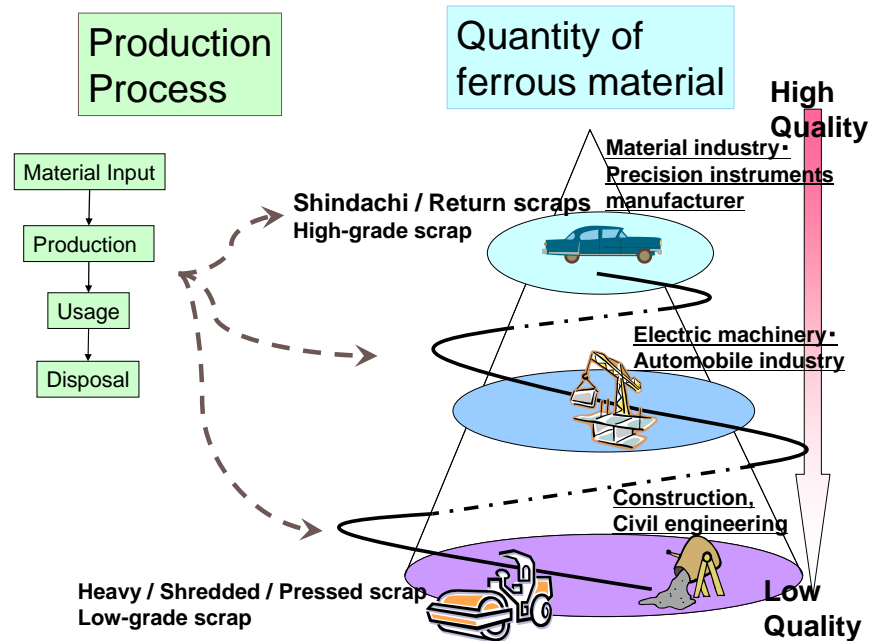
Iron and steel cycle in Japan (2003 fy)
(unit: 1000 t)

Data: The Japan ferrous raw materials association

Steel stock in Japan
1.26 billion tons (2003)
Estimated by the Japan Ferrous Raw Materials Association

How much steel in stock can be reutilized?

How we should manage such secondary resources in future?



System of National Account (SNA) and Material stock Accounting (MSA) Hybrid Accounting system

- System for Integrated Environmental and Economic Accounting (SEEA)
- Physical Input Output Table (PIOT)
- Waste Input Output Table
- ... etc

WIO Table

		Industry			Waste treatment		
		Agriculture	Materials	Construction	Incineration	Landfilled	Final dem and output
Industry	Agriculture	<div style="border: 1px solid black; padding: 5px;"> SNA IO Table (Monetary based table) </div>					
	Materials						
	Construction						
Waste	Garbage	<div style="border: 1px solid black; padding: 5px;"> Physical based table </div>					
	Metalscrap						
	Incineration ash						
	Added value						
	Emission						

Note: The diagram includes arrows labeled 'Extension' pointing from the SNA IO Table section to the Physical based table section.

Summery

- MFA of Mo:
 - from Upstream
- MFA of P:
 - from Downstream
- Material Stock Accounting:
 - Proposal of new framework

Thank you very much for kind attention.



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