Legal Statement

The purpose of the information in this presentation is to guide ICA programs and provide members with information to make independent business decisions.

Antitrust Guidelines

Antitrust Guidelines for Copper Industry Trade Association Meetings

The following guidelines with respect to compliance with antitrust laws of the United States, Japan and European Community[1] are intended to govern the conduct of participants in copper industry trade association meetings, both at the meeting itself and in informal discussions before or after the formal meeting.

Price: Competitors should not discuss future prices (including terms of sale) of their products. There is no blanket prohibition against the mention of or reference to current or past prices but limits must be observed. Such references or mentions should occur only when necessary in connection with the development of association programs. For example, reference to a particular price level in comparing the cost of a copper product to a competing product is permitted. Whenever possible, such references should be discussed in advance with legal counsel.

Competitive Information: Competitors should not discuss the market share of a particular copper producer or copper fabricator's products. Furthermore, nothing should be said at a meeting which could be interpreted as suggesting prearranged market shares for such products or producer production levels. The overall market share of copper products may be discussed with regard to competition with non-copper products and general market acceptance.

New Products: Competitors should not encourage or discourage the introduction of a new product by another competitor or reveal a particular copper company's plans to change the production rate of an existing product or to introduce a new product. No company should disclose to another company whether it is in a position to make or market a new product. New products may be discussed in a technical manner or from the standpoints of competition with non-copper products and general market acceptance. In addition, proposed methods for and results of field and laboratory testing can be considered.

The Role of Legal Counsel: Legal counsel attends association meetings to advise association staff and other meeting attendees regarding the antitrust laws and to see that none of the matters discussed or materials distributed raise even the appearance of antitrust improprieties. During the course of a meeting, if counsel believes that the discussion is turning to a sensitive or inappropriate subject, counsel will express that belief and request that the attendees return the discussion to a less sensitive area.

A paper entitled 'Copper Industry Trade Associations and Antritrust Laws' is available upon request.

10/92, 5/93, 10/10

1. Other foreign competition laws apply to International Copper Association, Ltd. (ICA)'s activities worldwide.

A GLOBAL, DYNAMIC STOCK-AND-FLOW MODEL FOR LEADED BRASS

Dr. Luis Tercero Espinoza
April 2018

Fraunhofer ISI

Motivation and goals

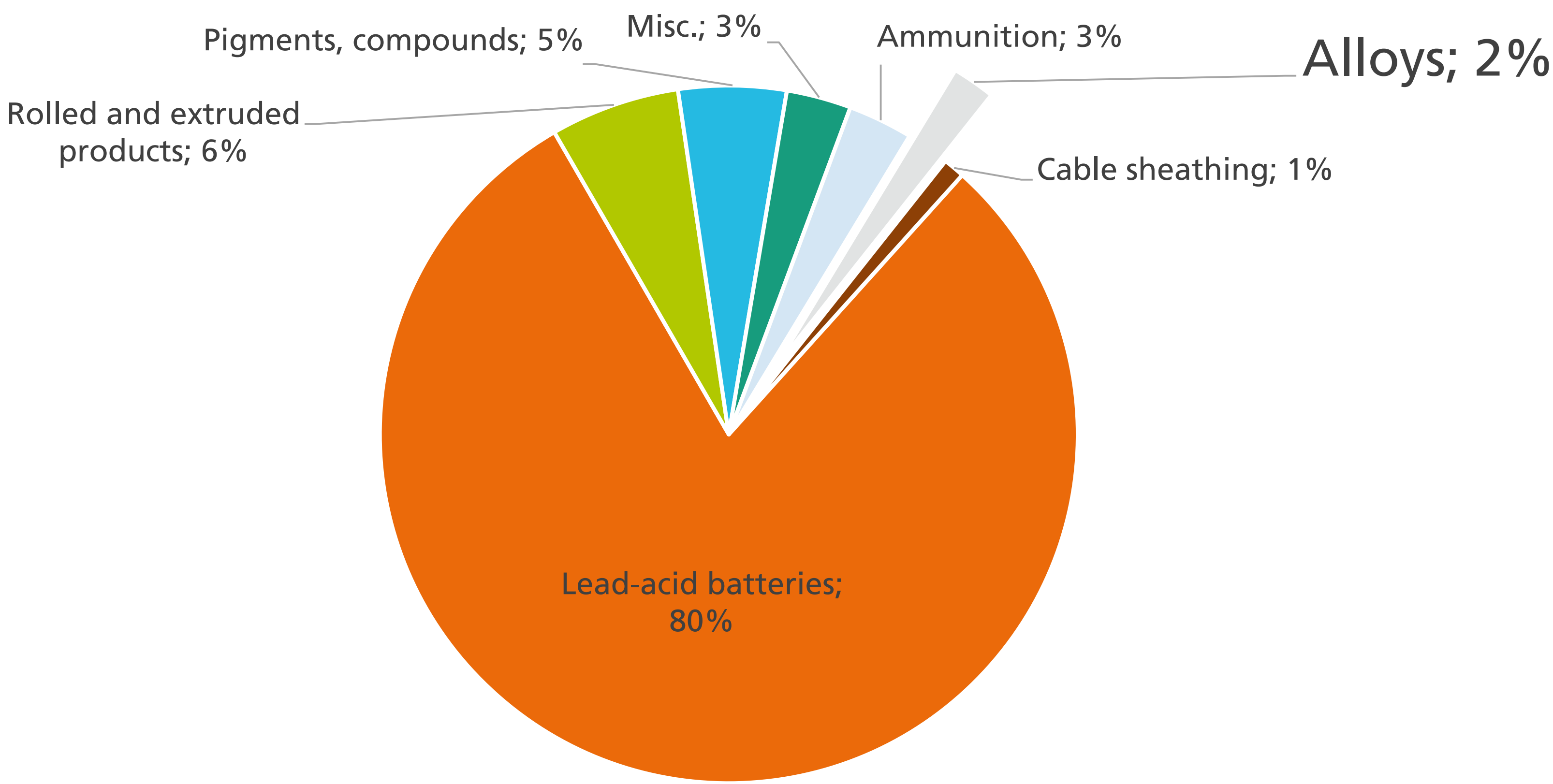
Status quo

- Dynamic stock-and-flow models for copper are available at the global and regional level
- The models do not track alloying metals such as zinc (Zn), tin (Sn) or lead (Pb)
- Pb is being targeted for more restrictive regulation, which would have a significant impact on the industry
- There is a need for more transparency in the stocks and flows of leaded brass

Therefore, we aimed to

1. Design and implement a dynamic stock-and-flow model for leaded brass
2. Enable calculation of quantitative scenarios for the future of lead content in brass at the global scale

Why is existing (extensive) work on Pb not directly useful?

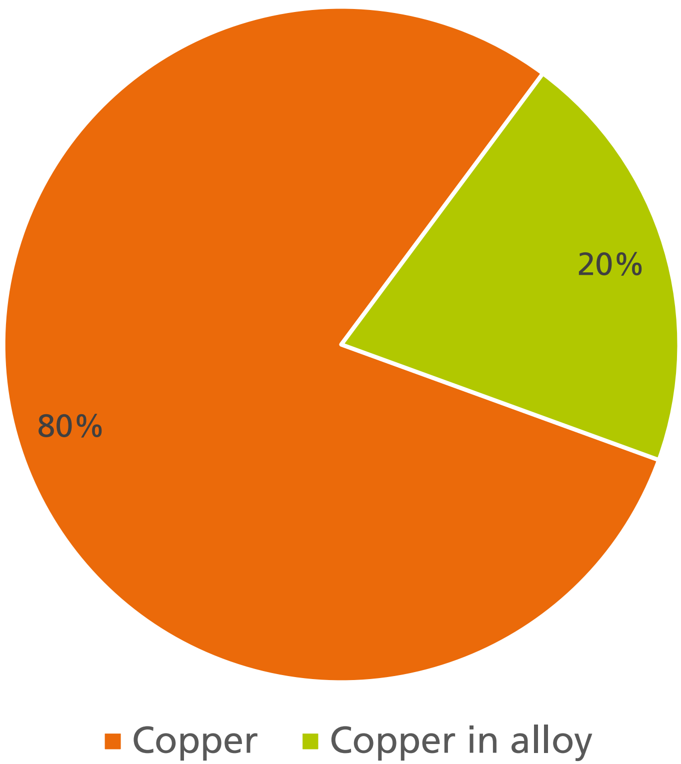


ILZSG (2018) , http://www.ilzsg.org/static/enduses.aspx?from=1

Fraunhofer ISI

Importance of brass for the copper market

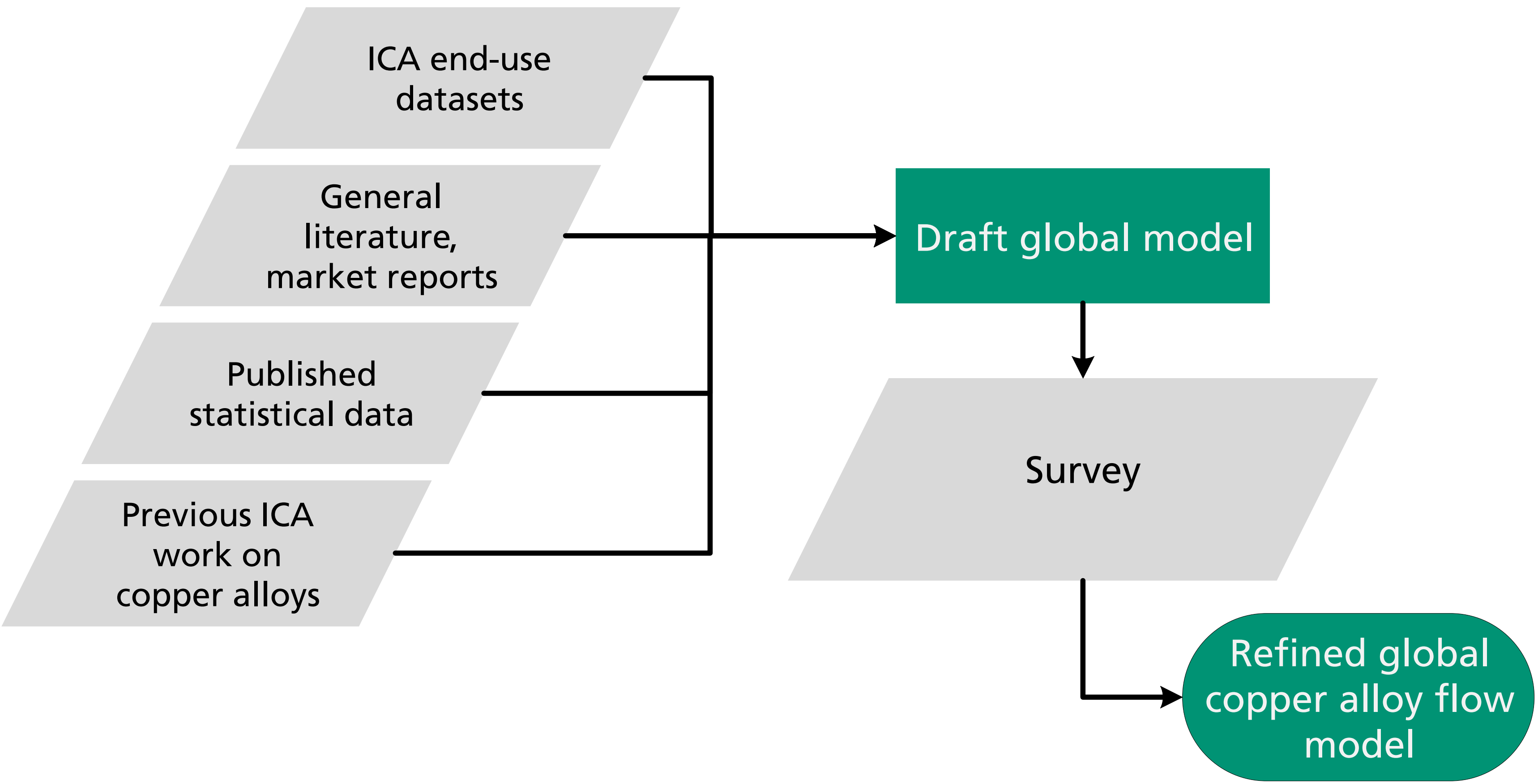
Alloys in the copper market



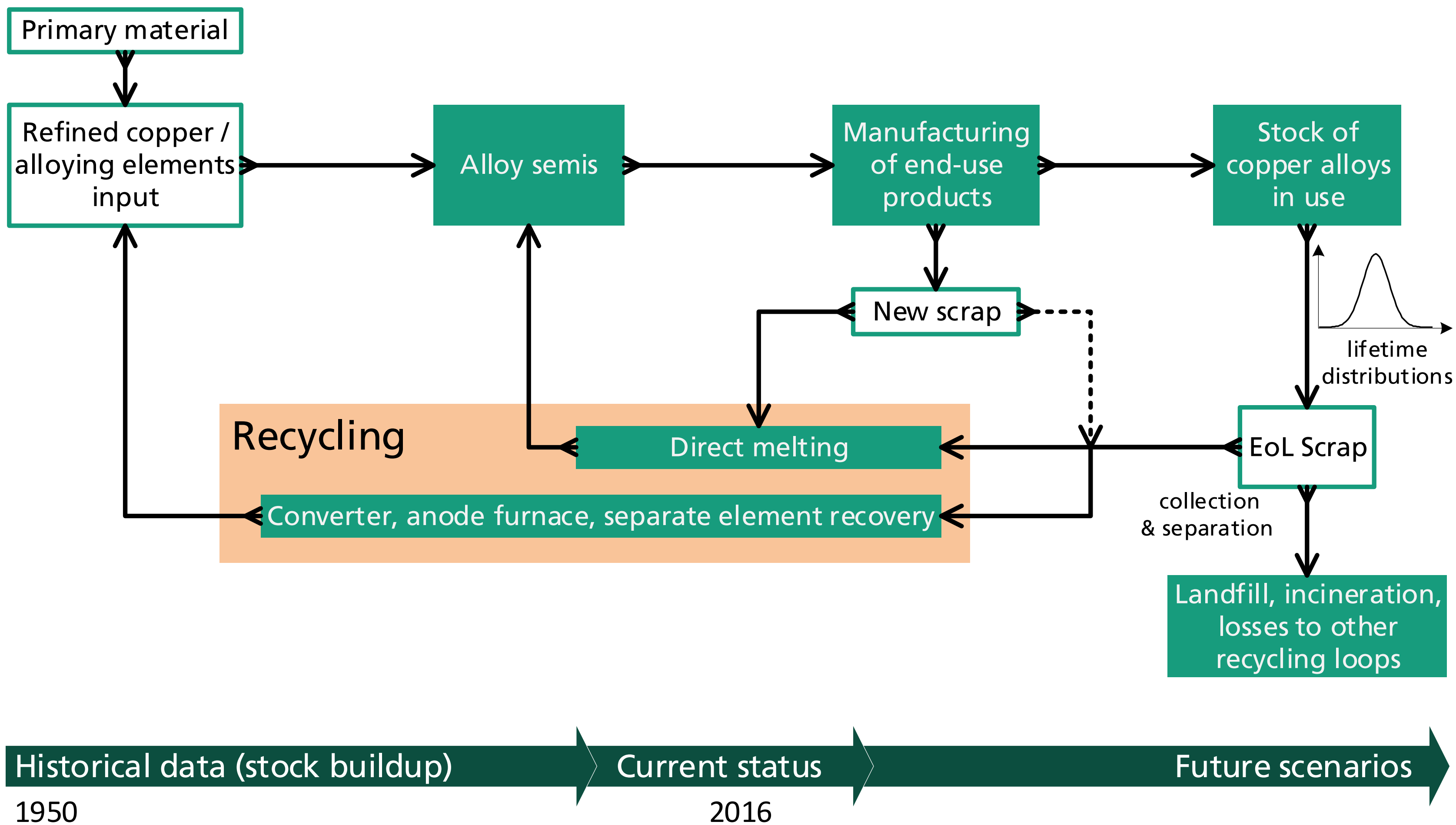
- Brass is used in
  - Tubes
  - Rods, bars
  - Plate, sheets
  - Mechanical wire
  - Castings
- Adding alloying elements gives a total volume of close to **8 million tonnes** of copper alloy

ICA/IWCC Global 2017 Semis End-Use Dataset

Workflow


ICA end-use datasets
General literature, market reports
Published statistical data
Previous ICA work on copper alloys
Draft global model
Survey
Refined global copper alloy flow model

Simple sketch of the dynamic model

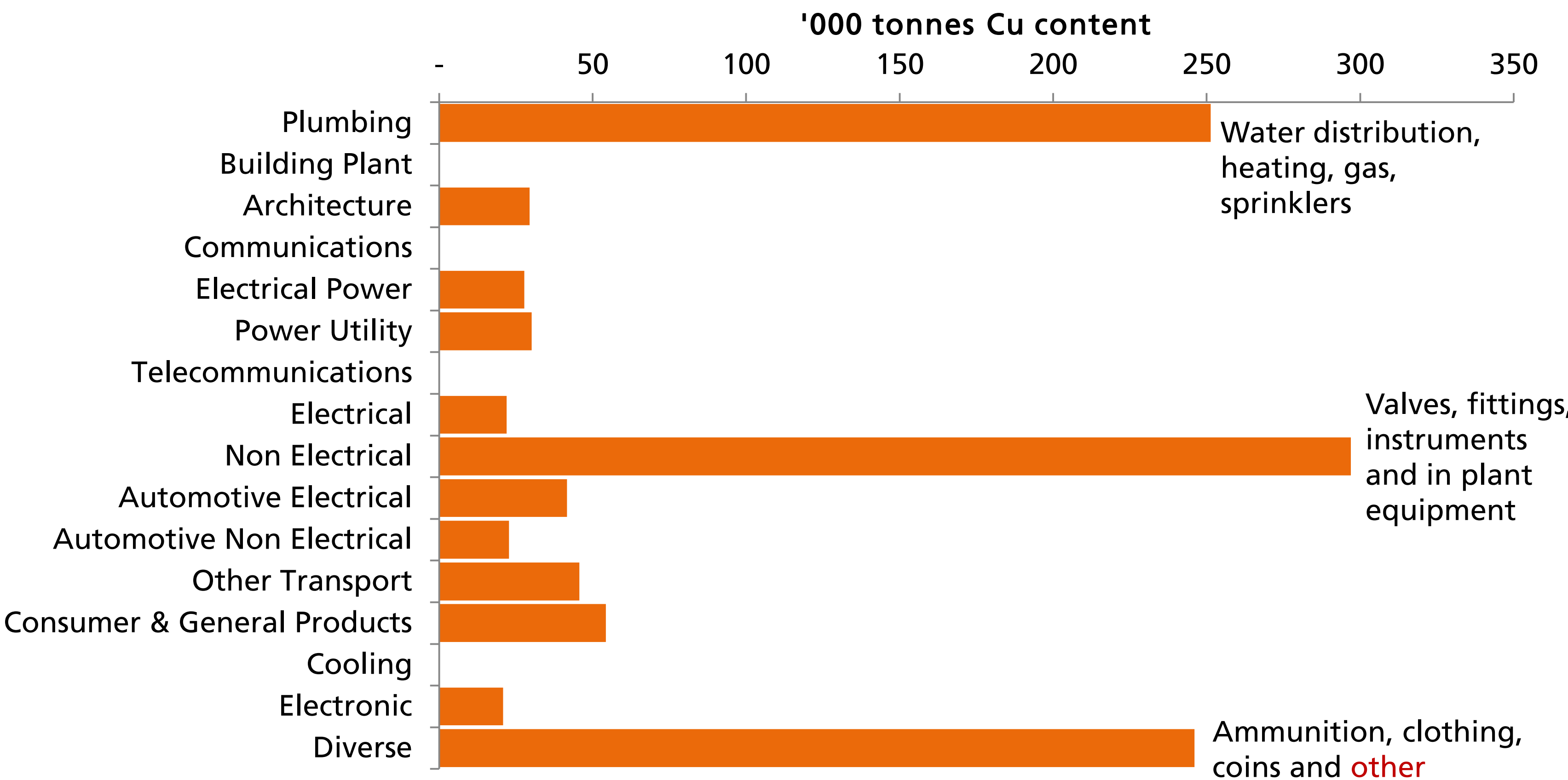


Data challenge #1: Diversity of Cu-alloys, many of them containing Pb

Generic name	UNS No.	Major alloying elements	Lead content wt%
Wrought alloys			
Brasses	C20100-C28000	Cu-Zn	<0.3 %
Leaded brasses	C31200-C38500	Cu-Zn-Pb	2 - 4 %
Tin brasses	C40400-C48600	Cu-Zn-Sn-Pb	2 - 2.5 %
Phosphor bronzes	C50100-C52480	Cu-Sn-P	0.5 %
Leaded phosphor bronzes	C53400-C54400	Cu-Sn-Pb-P	2 - 4 %
Nickel silvers	C73500-C79830	Cu-Ni-Zn-Pb	0-2 %
Brazing alloys (copper, silver, phosphor)	C55180-C55284	Cu-P-Ag	<0.3 %
Aluminium bronzes	C60800-C64210	Cu-Al-Ni-Fe-Si-Sn	<0.3 %
Silicon bronzes	C64700-C66100	Cu-Si-Sn	<0.3 %
Copper nickels	C70100-C72950	Cu-Ni-Fe	<0.5 %
Other wrought copper alloys	C66300-C69710	Cu-Zn-Mn-Al-Ni-Fe-Si-Sn-Co	<0.5 %
Cast alloys			
Red and leaded red brasses	C83300-C83810	Cu-Zn-Sn-Pb	2-5 %
Semi red leaded brasses	C84200-C84800	Cu-Zn-Sn-Pb	3-6 %
Yellow and yellow leaded brasses	C85200-C85800	Cu-Zn-Pb	1-3 %
Tin bronzes (cast)	C90200-C91700	Cu-Sn-Zn	<0.3 %
leaded tin bronzes (cast)	C92200-C93100	Cu-Sn-Zn-Pb	2-5 %
High leaded bronzes (cast)	C93200-C94500	Cu-Sn-Zn-Pb	10-20 %
Nickel-tin-bronzes (cast)	C94700-C94900	Cu-Ni-Sn-Zn-Pb	0.5-4 %
Manganese bronzes (cast)	C86100-86400	Cu-Zn-Mn-Fe	<0.3 %
Leaded manganese bronzes (cast)	C86500-C86800	Cu-Zn-Mn-Fe-Pb	0.5-1.5 %
Leaded copper (cast)	C98200-C98840	Cu-Pb	30 %
Nickel Silvers (cast)	C97300-97800	Cu-Ni-Zn-Pb	1-6 %
Other cast alloys (Al, Si, Ni)	------------------------	Cu-Zn-Mn-Al-Fe-Sn-Co	<0.5 %

the list goes on...

Data challenge #2: Large proportion of "diverse" end uses



ICA/IWCC Global 2017 Semis End-Use Dataset with own additions

Fraunhofer ISI

Enhancement of the ICA / IWCC dataset by a „lead content matrix“ based on survey input

Accounting of semi-finished goods to end-uses via ICA / IWCC dataset:

												Diverse				
	Plumbing	Architecture	Electrical Power	Power Utility	Electrical Industrial	Non-Electrical Industrial	Automotive Electrical	Automotive Non-Electrical	Other Transport	Consumer & General Products	Electronic	Ammunition	Clothing	Coins	Other	
Tube		5%		25%		38%		2%	12%			9%			9%	∑ = 100%
RBS	30%	4%	4%	5%	2%	35%		3%	2%	6%		1%	1%	1%	7%	∑ = 100%
PSS					5%		15%	3%		16%	16%	9%		4%	31%	∑ = 100%
Mech.wire		2%				15%		5%		28%			24%		24%	∑ = 100%
Castings	13%	5%				36%			27%			2%	2%	7%	7%	∑ = 100%

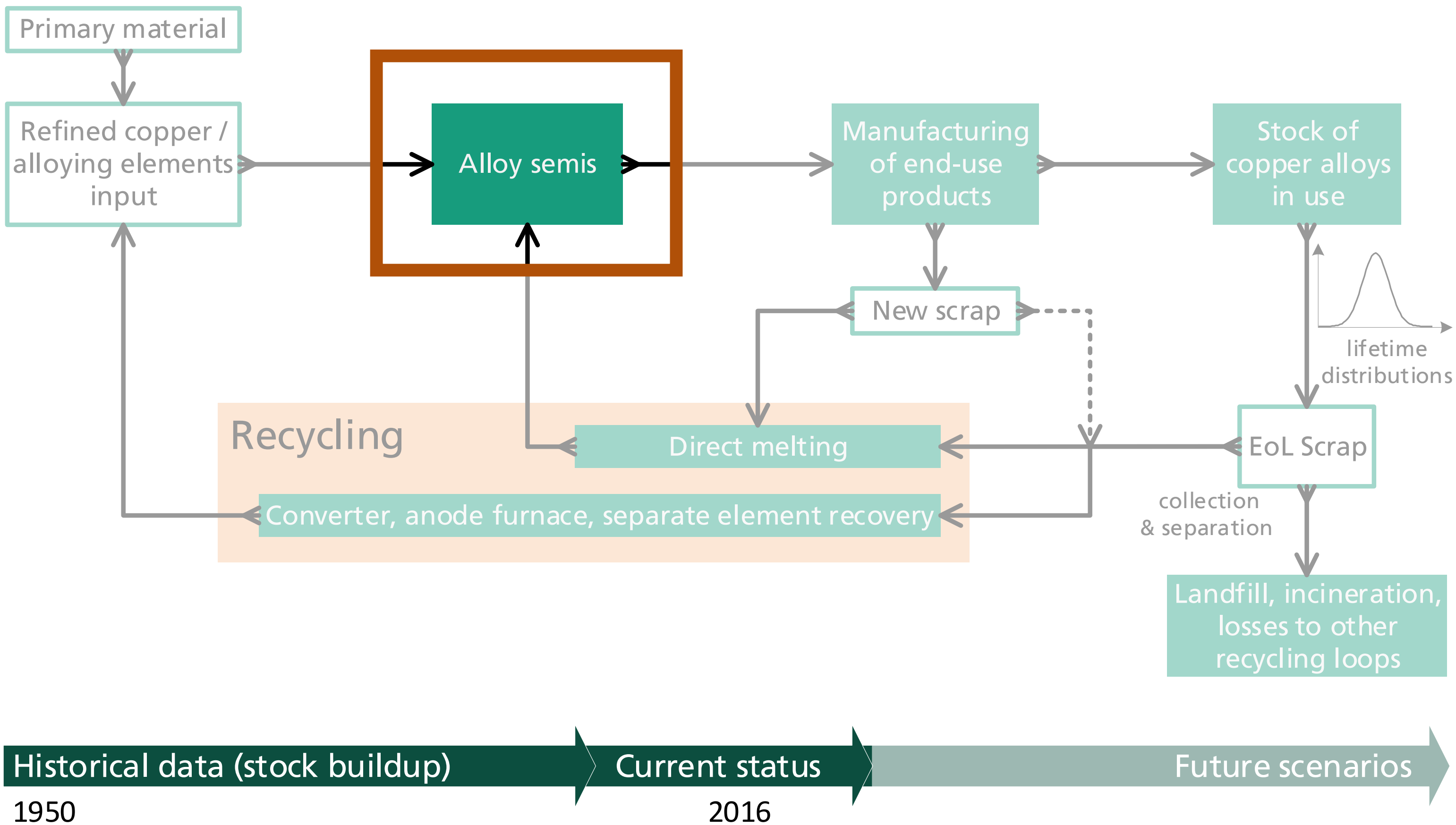
Average lead content of semi-finished goods from survey work with questionnaire based on the „lead content“ matrix:

												Diverse			
	Plumbing	Architecture	Electrical Power	Power Utility	Electrical Industrial	Non-Electrical Industrial	Automotive Electrical	Automotive Non-Electrical	Other Transport	Consumer & General Products	Electronic	Ammunition	Clothing	Coins	Other
Tube		3%		2%		2%		3%	3%			3%			3%
RBS		2%	3%	3%		2%		3%	3%	3%		3%	3%	3%	3%
PSS								1%		1%		1%		1%	2%
Mech.wire		3%				2%		3%		3%			3%		3%
Castings		4%				2%			5%			4%	3%	3%	4%

ICA/IWCC Global 2017 Semis End-Use Dataset with own additions

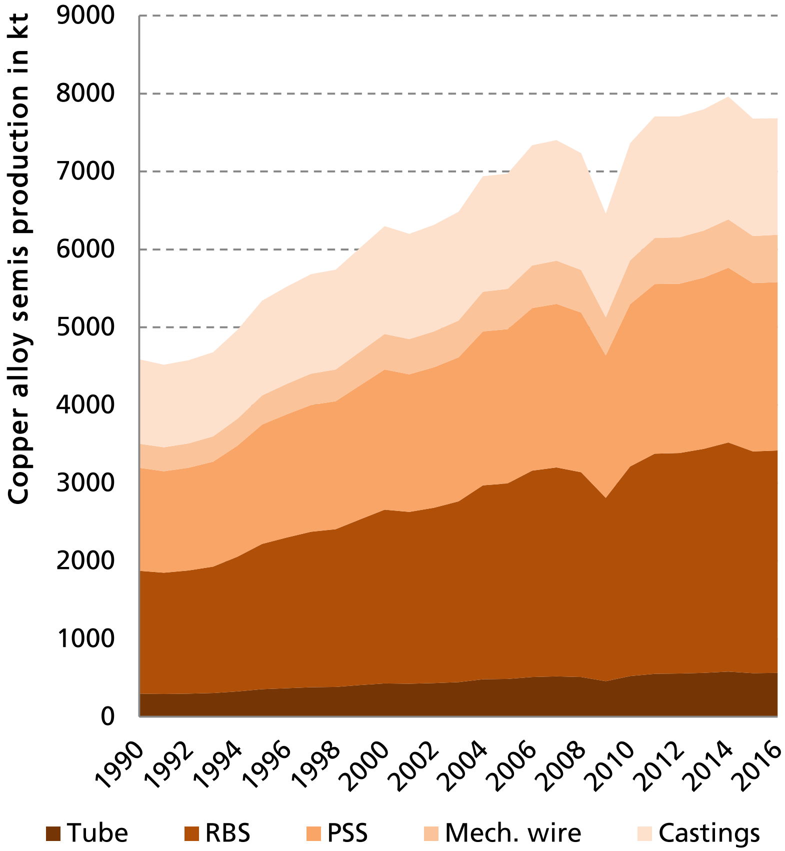
Fraunhofer ISI

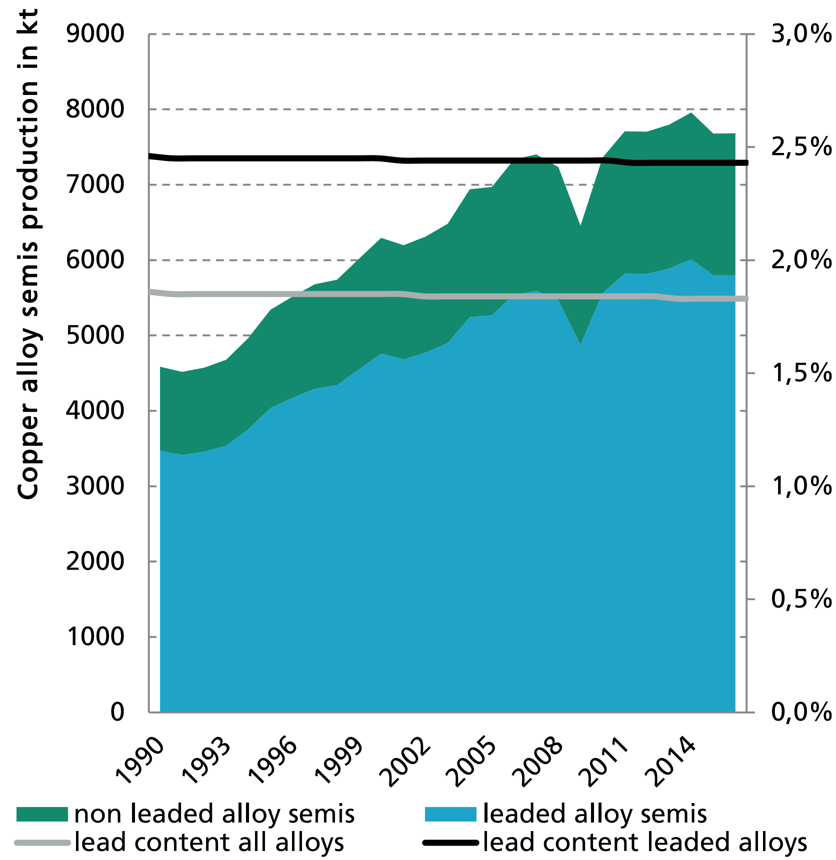
Data on brass semis production



Fraunhofer ISI

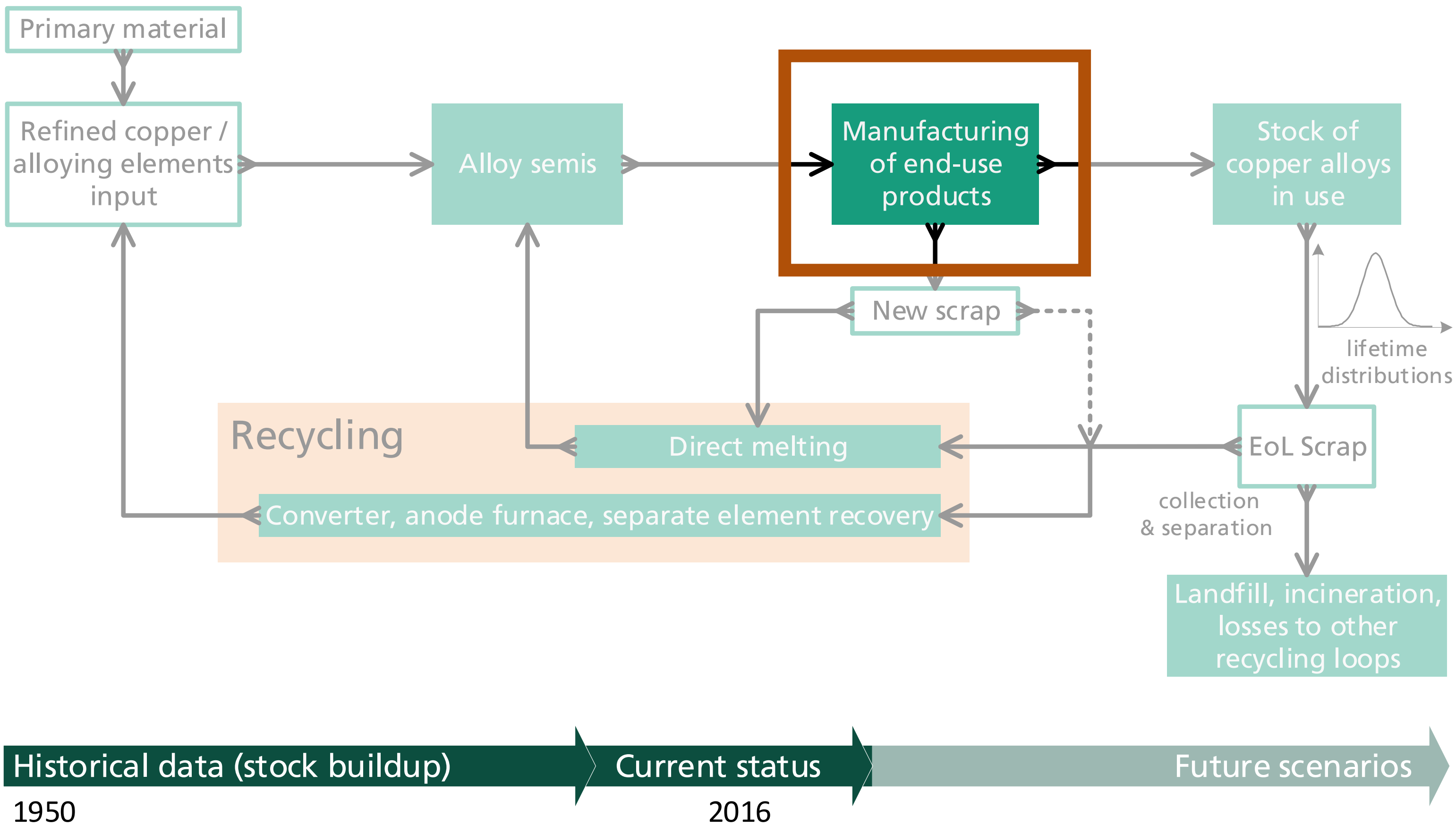
Global production of semi-finished goods in brass mills





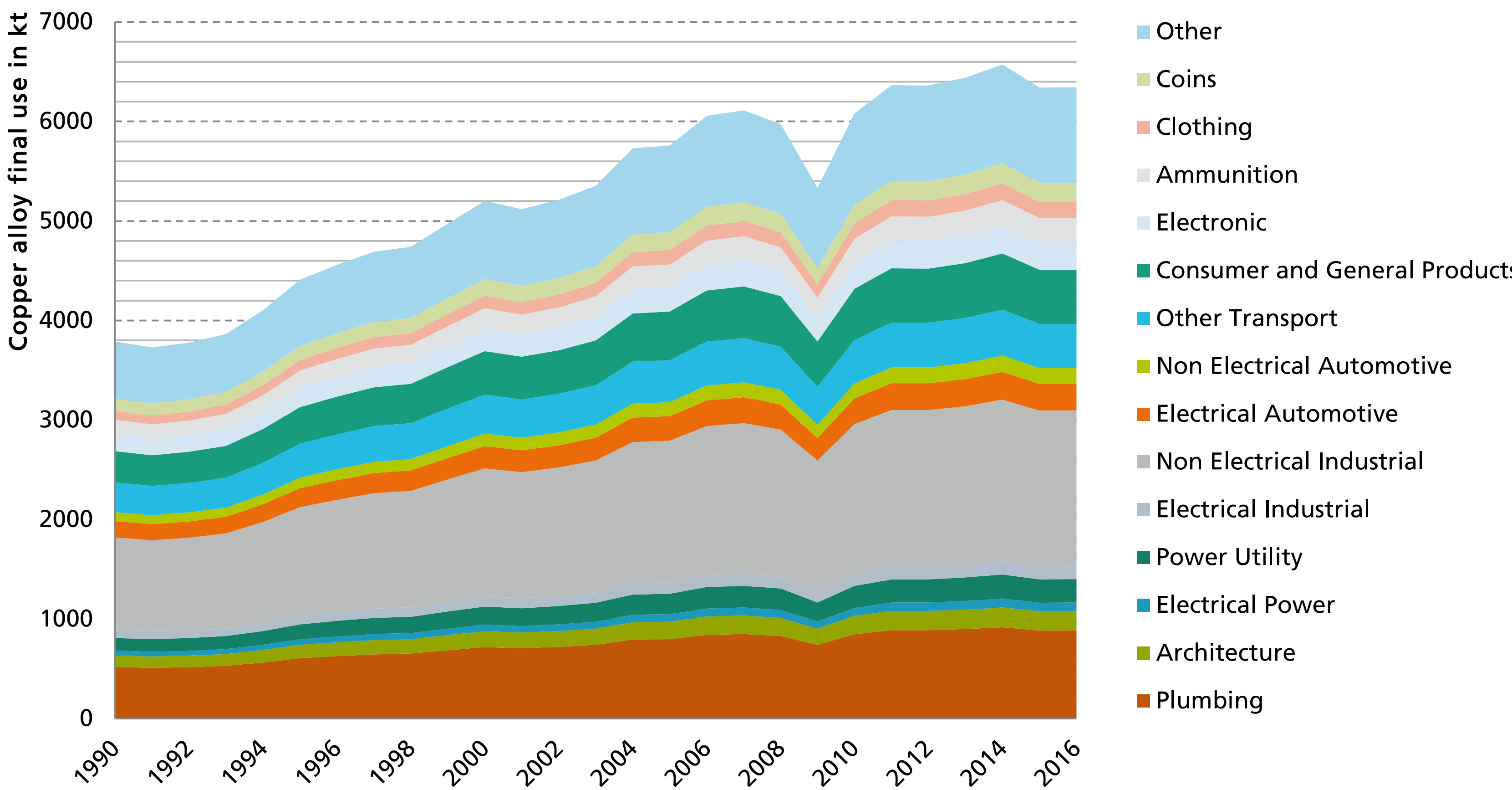
ICA/IWCC Global 2017 Semis End-Use Dataset with own additions

Brass in manufacturing of end-use products



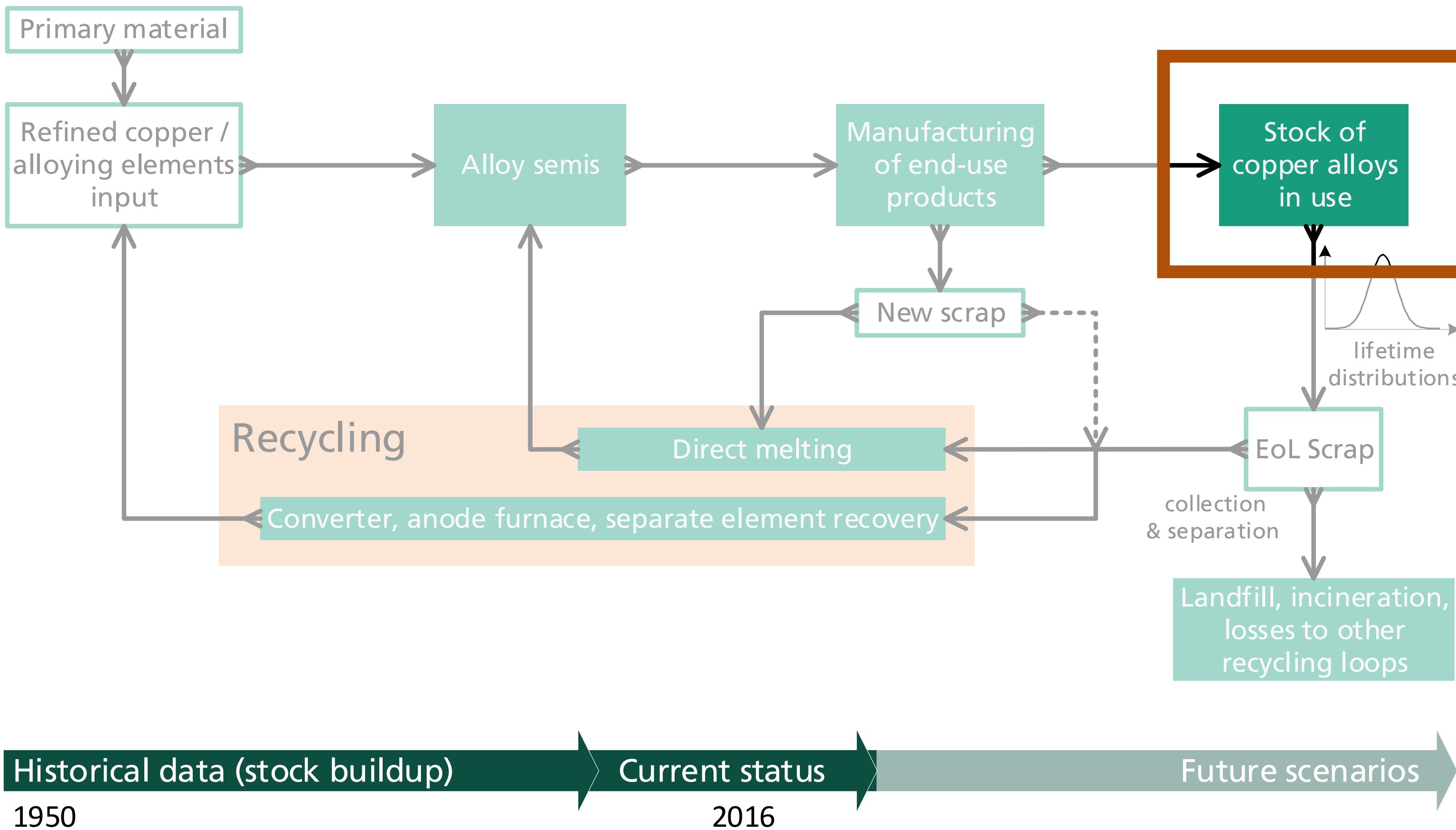
Fraunhofer ISI

Copper alloys by final use

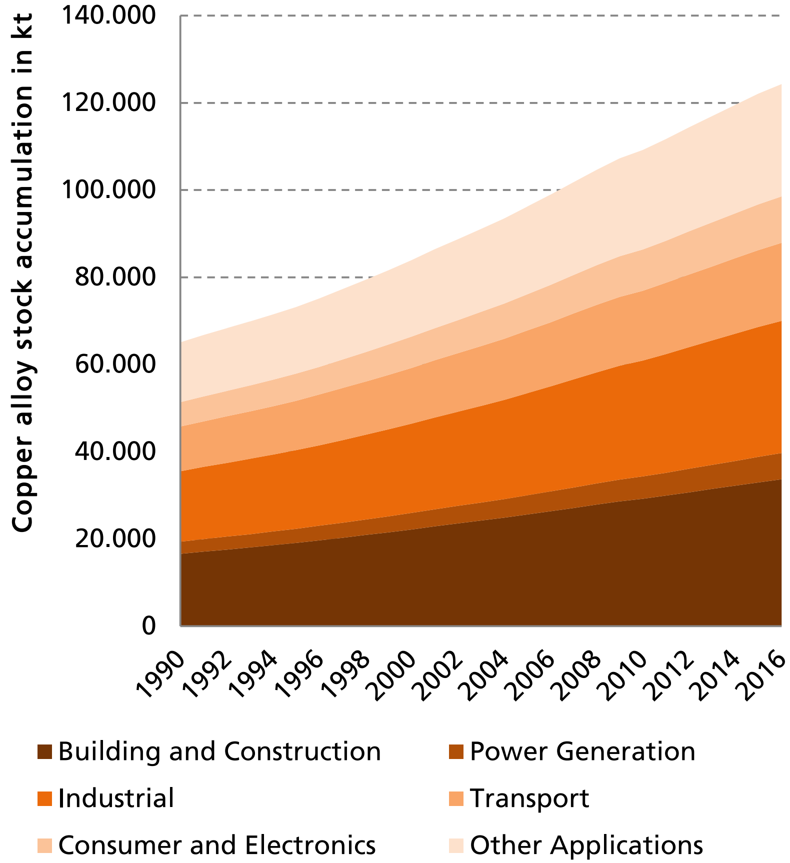


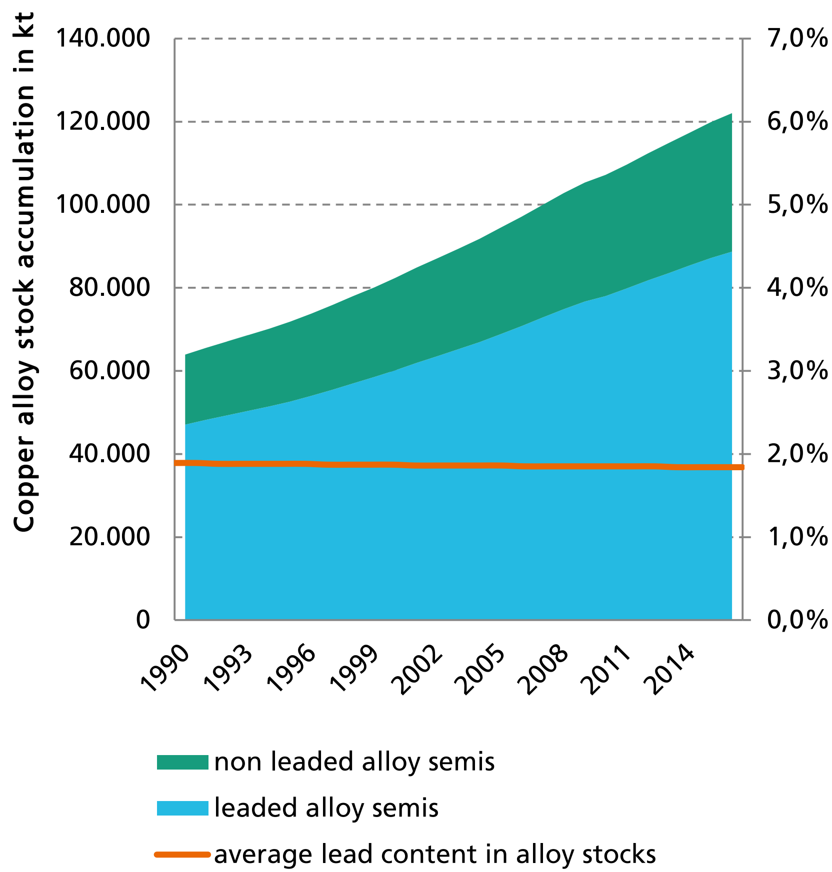
ICA/IWCC Global 2017 Semis End-Use Dataset with own additions

Build-up of in-use stock



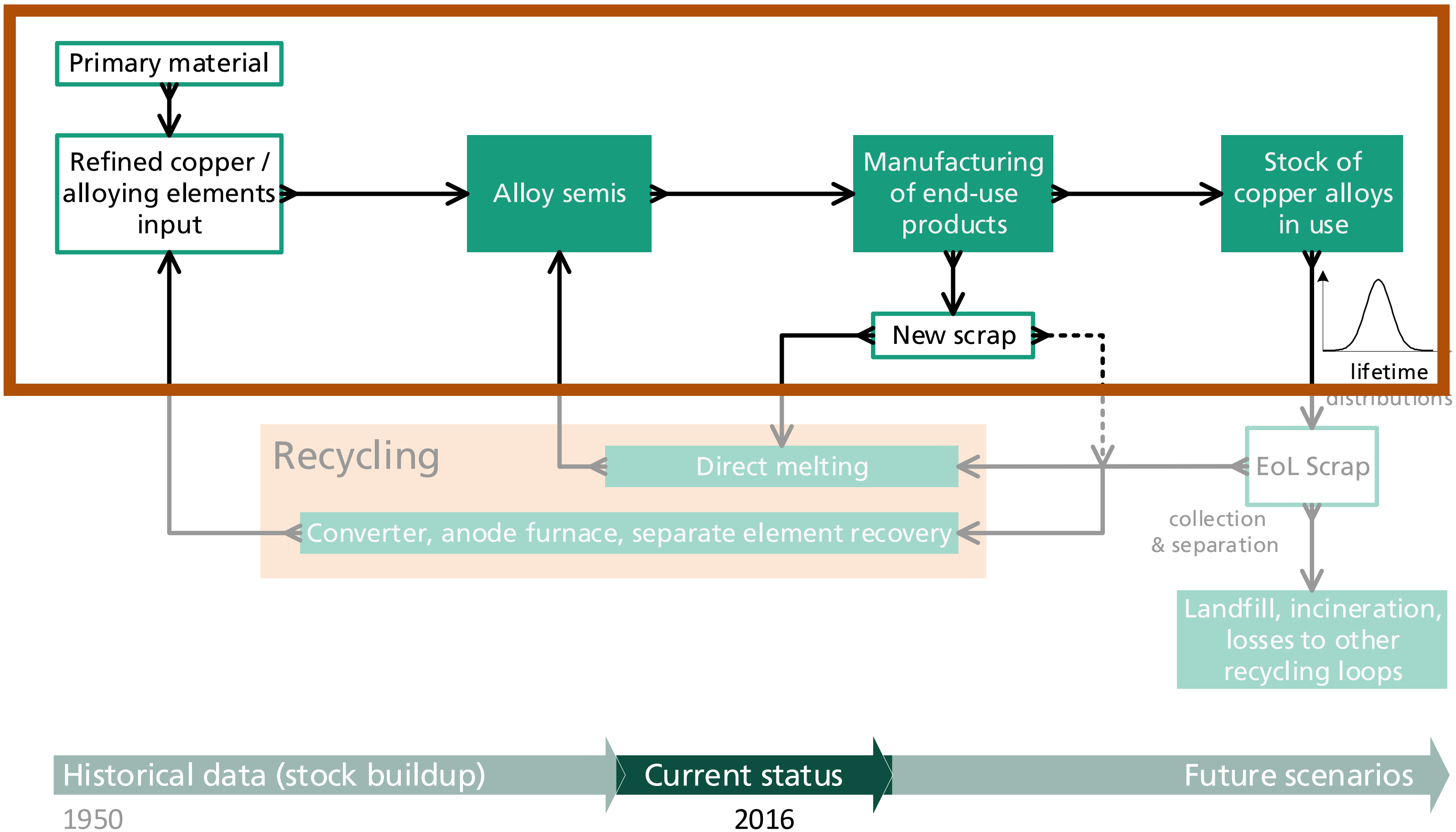
Build-up of stocks in use



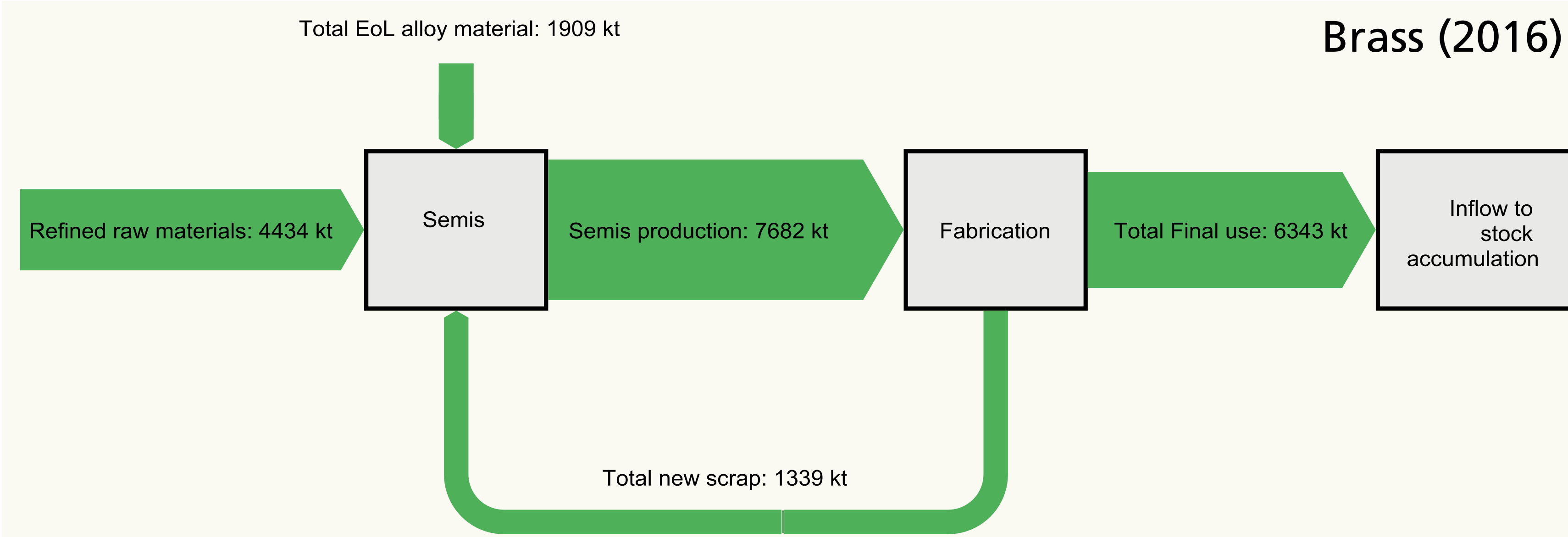


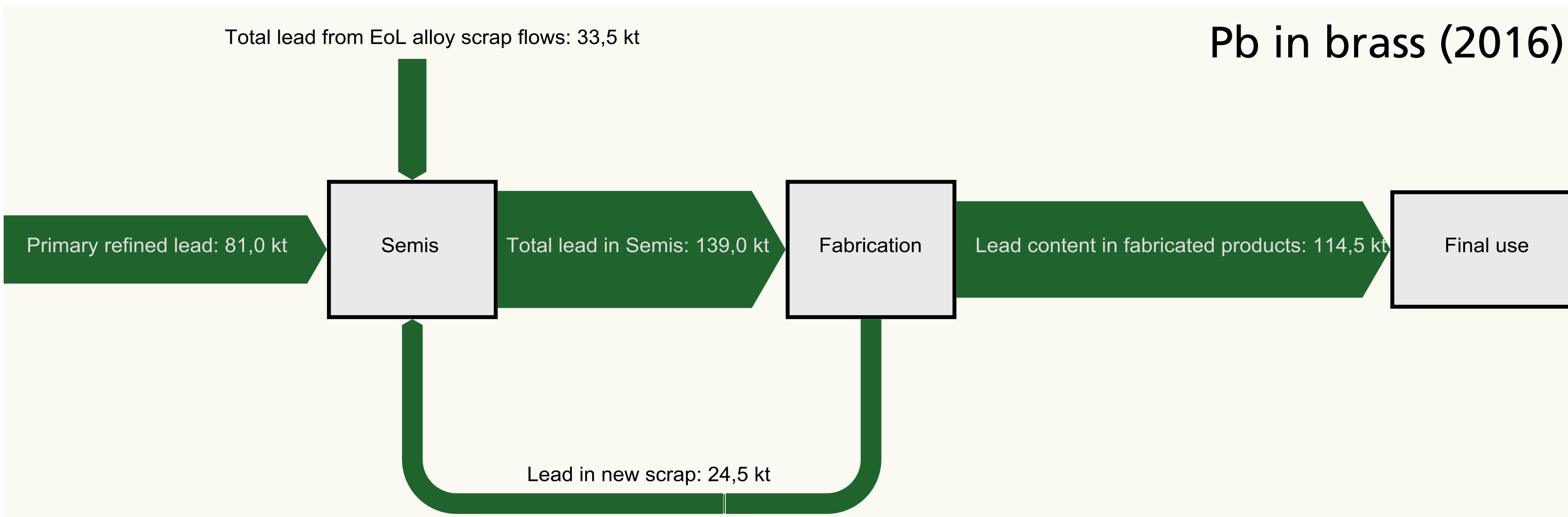
Fraunhofer ISI

Decompose into brass & Pb in brass for 2016

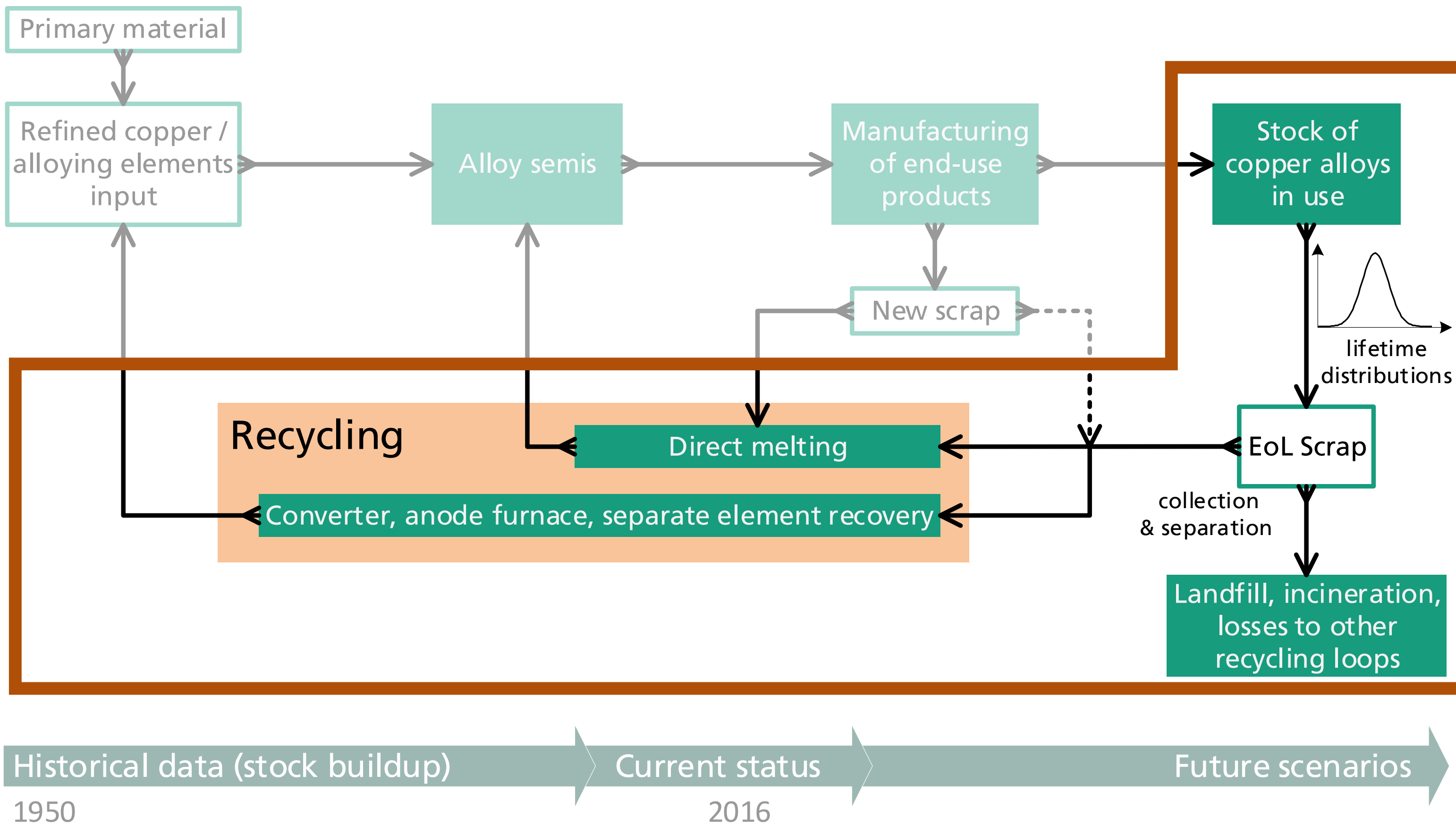


Fraunhofer ISI

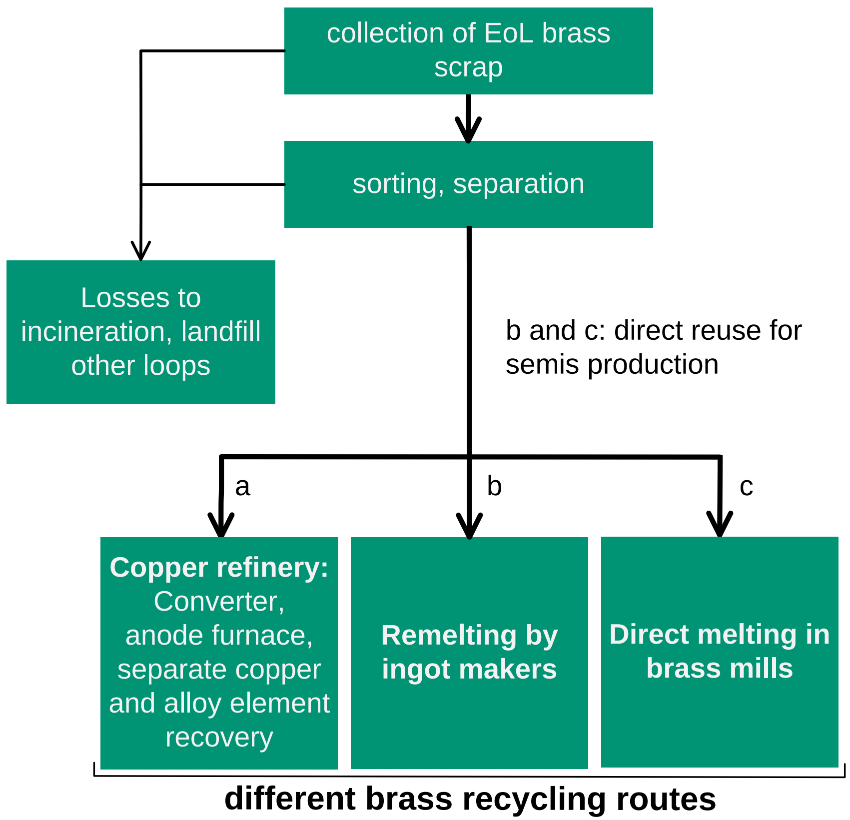

Brass (2016)
Total EoL alloy material: 1909 kt
Refined raw materials: 4434 kt
Semis
Semis production: 7682 kt
Fabrication
Total Final use: 6343 kt
Inflow to stock accumulation
Total new scrap: 1339 kt

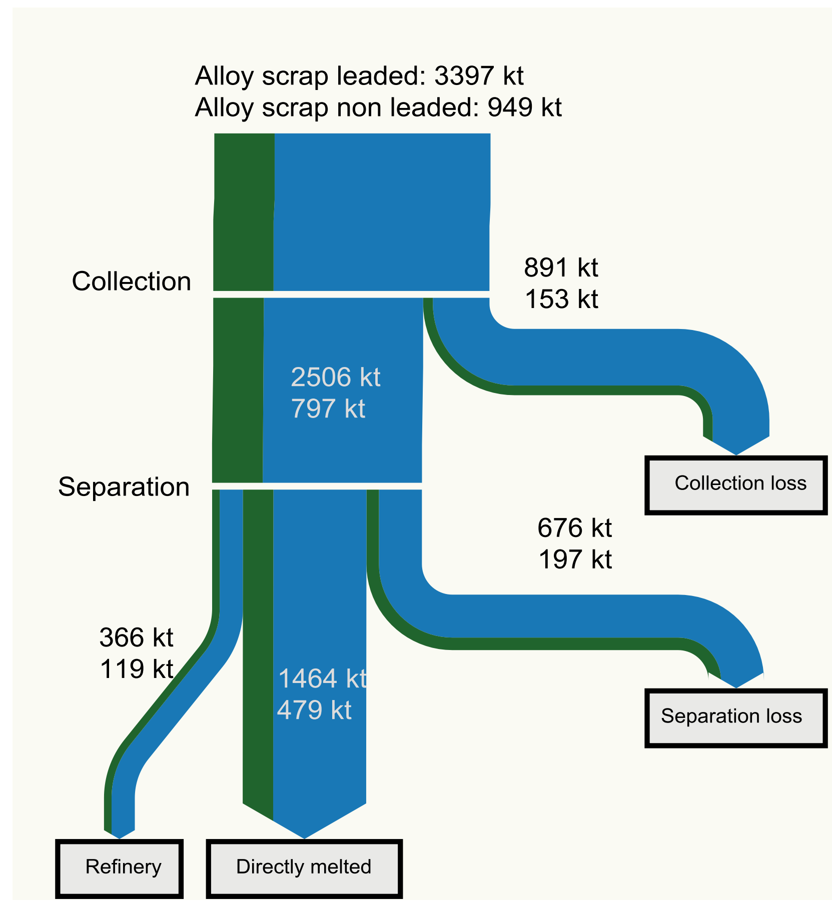

Pb in brass (2016)
Total lead from EoL alloy scrap flows: 33,5 kt
Primary refined lead: 81,0 kt
Semis
Total lead in Semis: 139,0 kt
Fabrication
Lead content in fabricated products: 114,5 kt
Final use
Lead in new scrap: 24,5 kt

EoL waste management flows in 2016



EoL waste management flows in 2016





Important factors in Pb dilution scenarios

- Overall demand for Cu-alloys in the future
- Ability to meet specifications (provide function) with reduced Pb content
- Possible dilution through:
  1. Reduction of primary input (primary Pb into Cu-alloys)
  2. Share of EoL scrap going to direct re-melting vs. smelting/refining (current options) or removal of Pb from directly re-melted brass (lab scale research)
- Time scale for dilution and shape of change curve (constant rate, accelerating/decelerating rate of reduction, step changes, etc.)

Summary and key conclusions

- The model delivers:
  - Increased transparency of lead flows in copper alloys at a global level
  - It is possible to derive timeframes for dilution of lead content provided plausible scenarios are agreed upon
- Most lead contained in copper alloys is introduced to the alloy as primary material
- Extent to which recycling pathways would change depends on the desired level of dilution

A GLOBAL STOCK-AND-FLOW MODEL FOR LEAD IN COPPER ALLOYS

Dr. Luis TERCERO ESPINOZA
April 2018

Dr. Luis A. TERCERO ESPINOZA

Head of Business Unit Systemic Risks &
Coordinator for Materials and Raw Materials

Fraunhofer Institute for
Systems and Innovation Research ISI
Breslauer Str. 48 | 76139 Karlsruhe | Germany

luis.tercero@isi.fraunhofer.de
www.isi.fraunhofer.de/rawmaterials

Fraunhofer
ISI