

# Overview of Life Cycle Cost Assessment: Case Study of LCA Alternatives Assessment of Lead-Free Cast Brass for the Potable Water Supply Components

WRCB Stakeholder Workgroup Meeting #3 to  
Support Development of Water Loss Performance Standards (SB555)

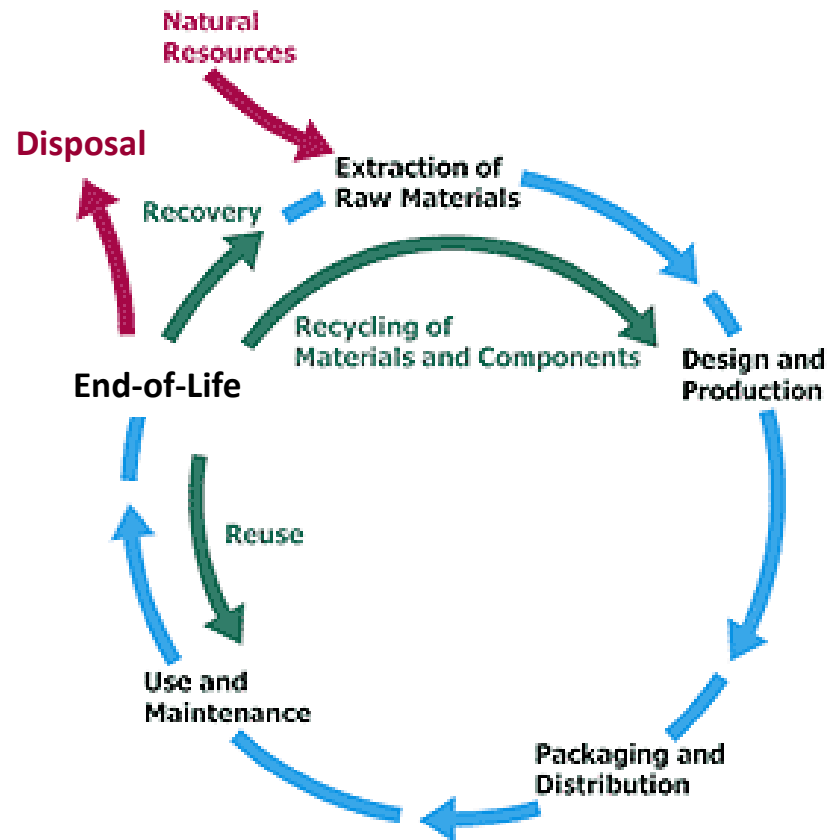
Metropolitan Water District  
September 17, 2018



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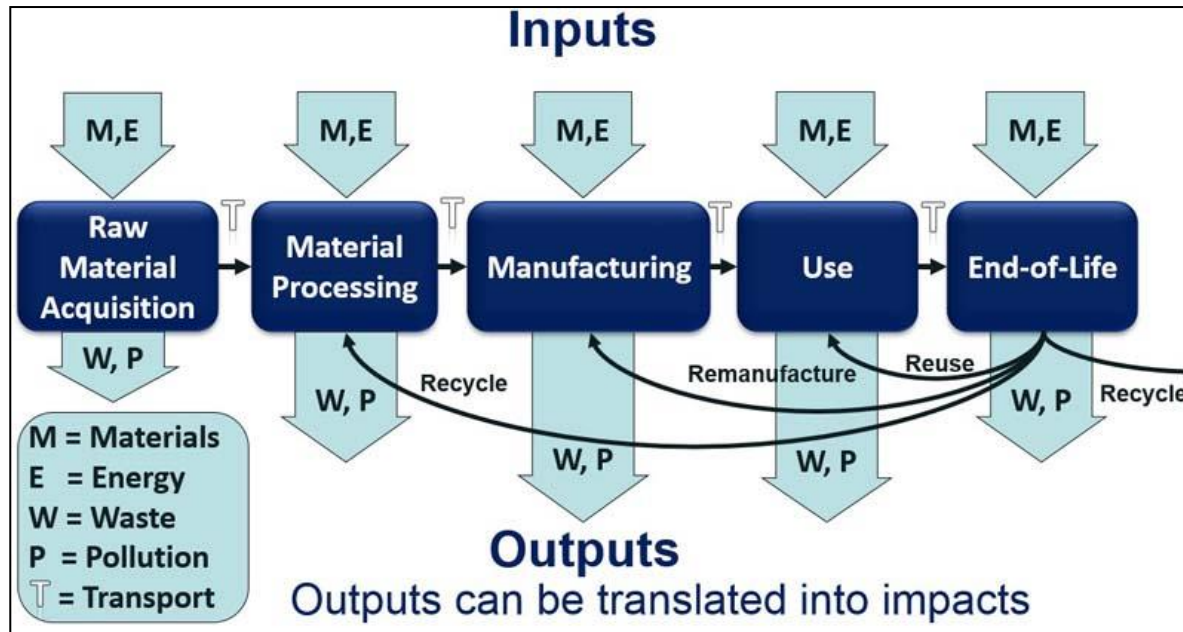
# What is a Product Life Cycle?

2



# What is a Life Cycle Assessment?

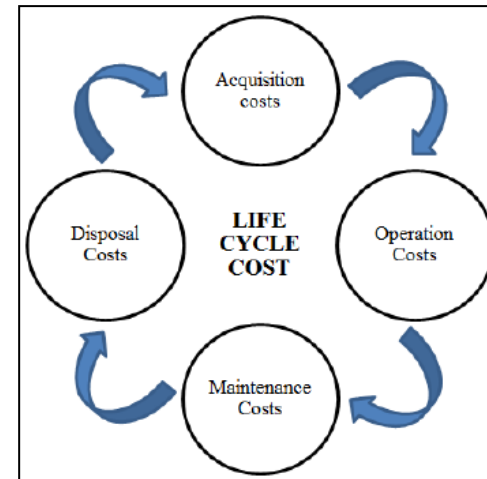
3



# What is a Life Cycle Cost (LCC) Assessment?

4

- Conventional LCC assessment



- Range of LCC assessments

	People (social impacts)	Planet (environmental impacts)	Profit/prosperity (monetary costs)
External costs (externalities)	<div style="border: 1px solid black; padding: 10px;"> <p><b>Societal LCC</b></p> <div style="border: 1px solid black; padding: 5px; margin: 5px 0;"> <p><b>Environmental LCC</b></p> <div style="border: 1px solid black; padding: 5px; margin: 5px 0;"> <p><b>Conventional LCC</b></p> </div> </div> </div>		
Internal (private) costs or benefits			

# Case Study: “Lifecycle-Based Alternatives Analysis of Lead-Free Brass Substitutes in the Potable Water Supply System”

5

- **Final Report:** June 9, 2017
- **Policy Context:** AB1953 (1996), Federal Reduction in Lead in Drinking Water Act (2011)
- **Subject of Interest:** Pb-Free Brass vs Pb-Bearing Brass for Potable Water Supply Cast Components

System Location	NSF/ANSI Standard	Device	
Transmission and Distribution	Standard 61, Section 8	Backflow preventers	Curb stops
		Pressure regulators	Water meters
		Compression fittings	Building valves
		Strainers	Pressure tanks
		Expansion tanks	Corporation stops
		Meter stops	Valves and fittings
		Check valves	Meter couplings
		Service saddles	
End Use	Standard 61, Section 9	Single and double handled faucets	Bubblers and water coolers
		Hot and cold water dispensers	Residential refrigerator ice makers
		Drinking fountains	Supply stops and endpoint control valves

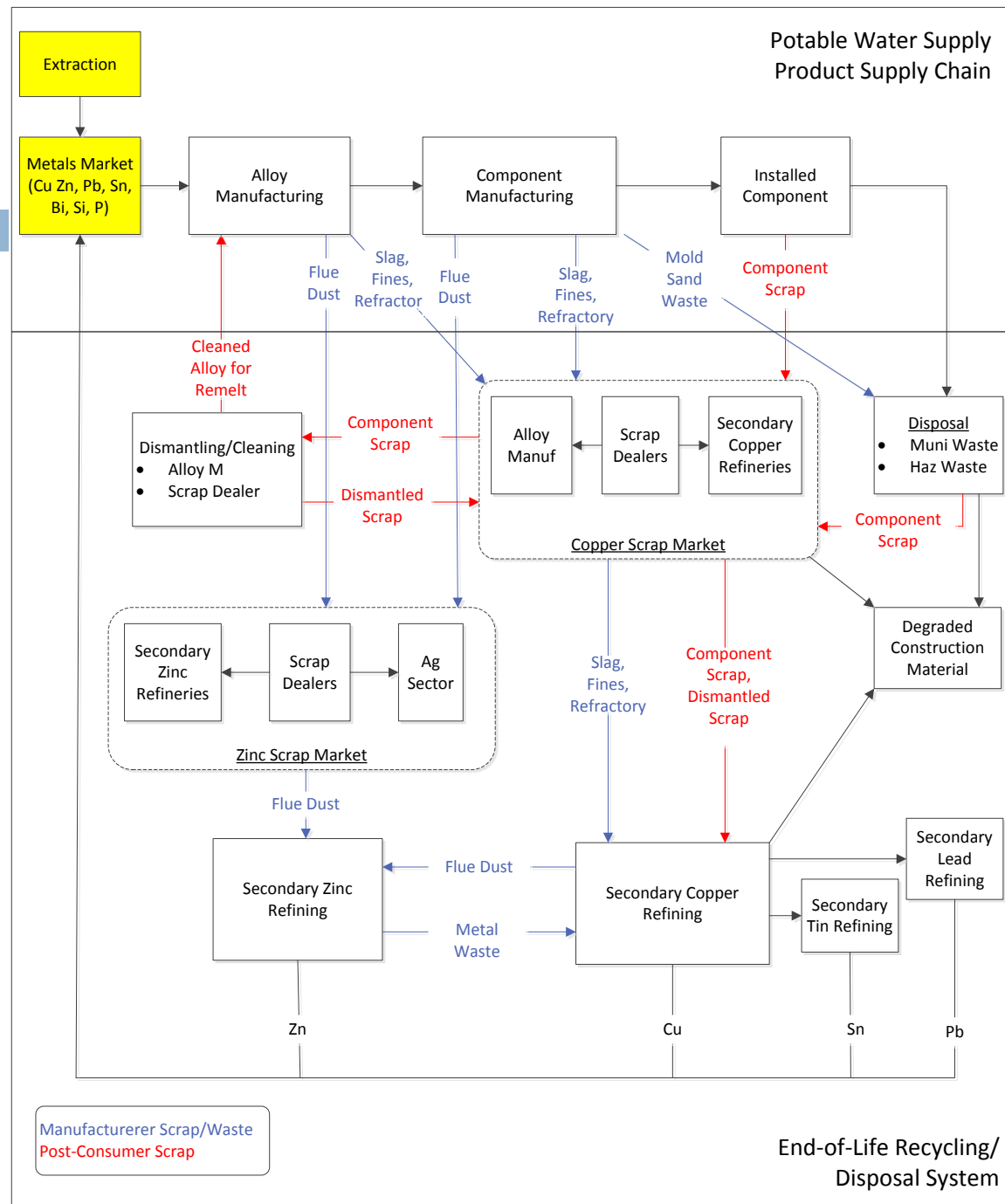
- **Research Team:** UCLA and Virginia Tech
- **Research Approach:** Lifecycle-Base Alternatives Analysis

# Lifecycle-Based Alternatives Analysis Framework

Life Cycle Stage	Impact Criteria	Sub-Criteria	Pb Brass C83600	Bi Brass C89833/36	Si Brass C87850	Si Brass C87600/01
Beginning-of-Life	Economic	Cost extracting/processing elements	Baseline			
	Environmental	Availability; energy; CO <sub>2</sub> emissions	Baseline			
	Health	Exposure	Baseline			
Materials Manufacturing	Economic	Alloy cost; waste recycling/disposal	Baseline			
	Performance	Yield; metal loss	Baseline			
	Environmental	Energy; CO <sub>2</sub> emissions	Baseline			
	Health	Exposure	Baseline			
Component Manufacturing	Economic	Component cost; waste recycling/disposal	Baseline			
	Performance	Applicability; yield; metal loss; machining	Baseline			
	Environmental	Energy, CO <sub>2</sub> emissions, hazardous waste	Baseline			
	Health	Exposure	Baseline			
Use	Economic	Amortized cost if different useful life; reuse/recycling/disposal	Baseline			
	Performance	Useful life of component	Baseline			
	Environmental	Env. impacts if difference in useful life	Baseline			
	Health	Toxicity metal leaching	Baseline			
End-of-Life	Economic	Reuse of components and recycling components & manufacture waste	Baseline			
	Performance	Reuse/recycle/disposal of components & manufacturer waste	Baseline			
	Environmental	Energy, CO <sub>2</sub> emissions	Baseline			
	Health	Exposure	Baseline			

# Beginning-of-Life Phase

7



# Figure 3.11: Cost for Primary-Sourced Elements Per 100 Kg Metal Input into Alloy Manufacturing

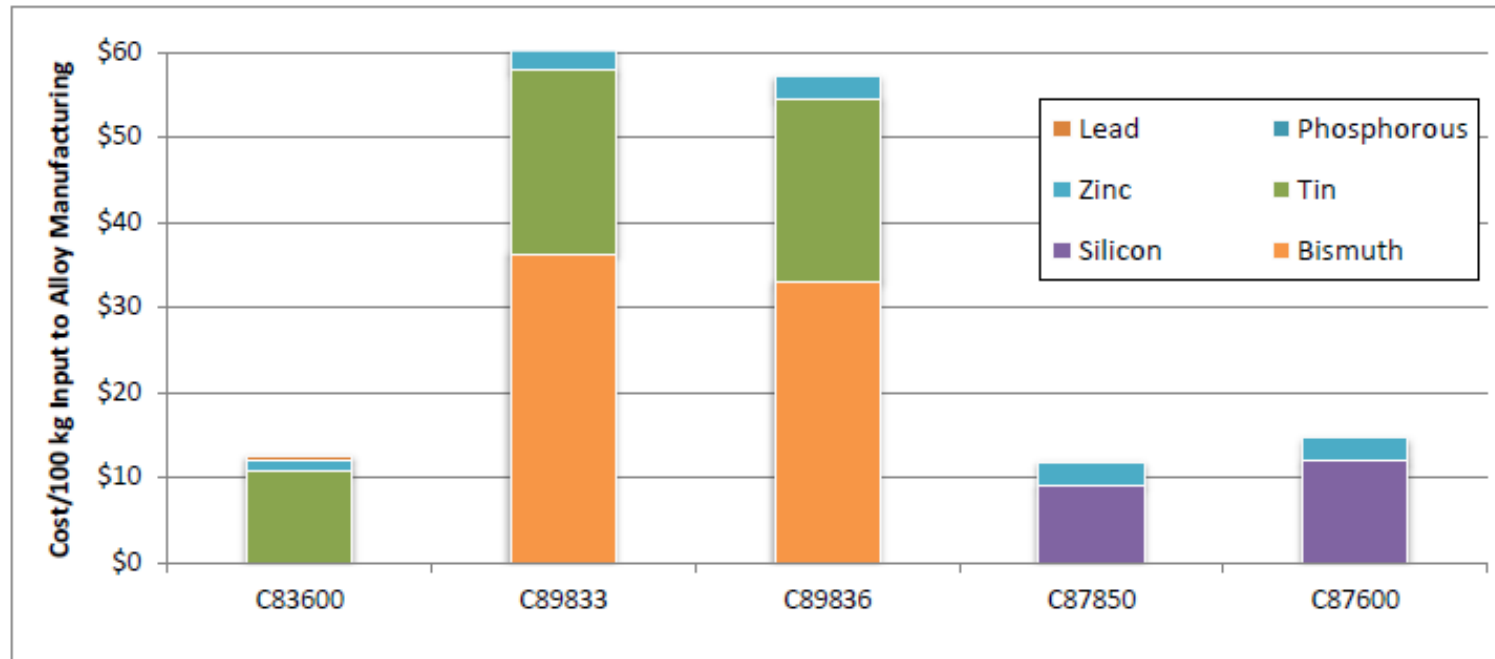
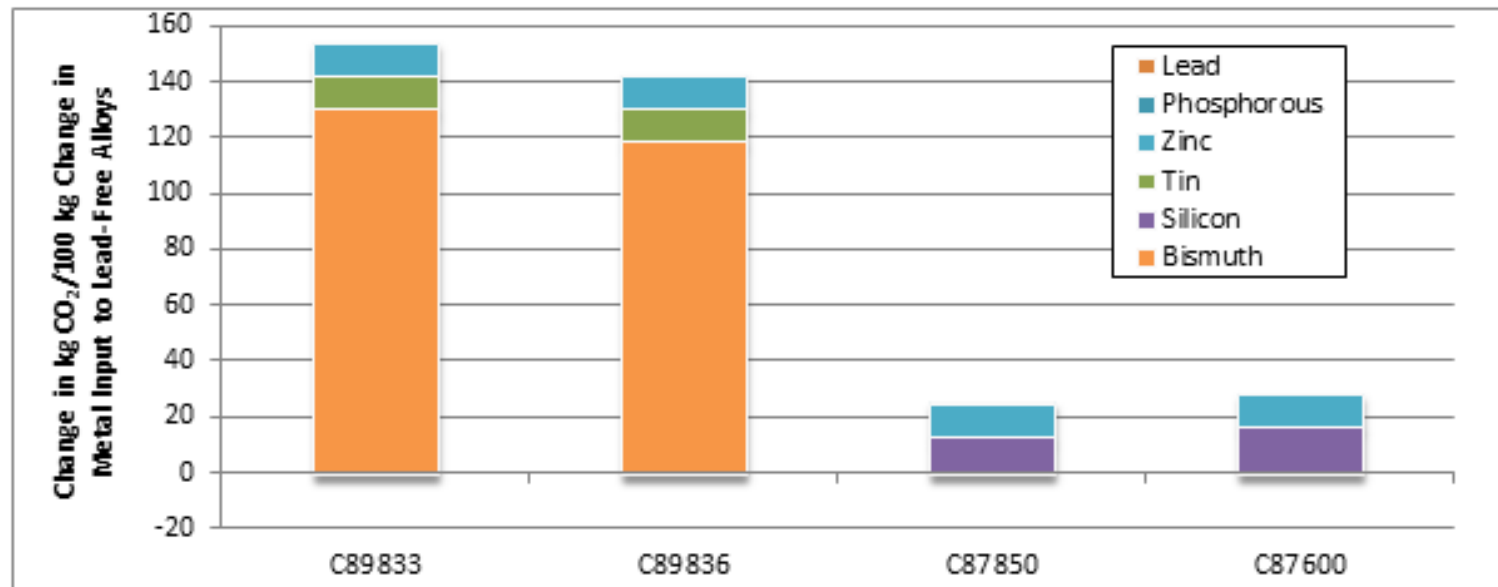


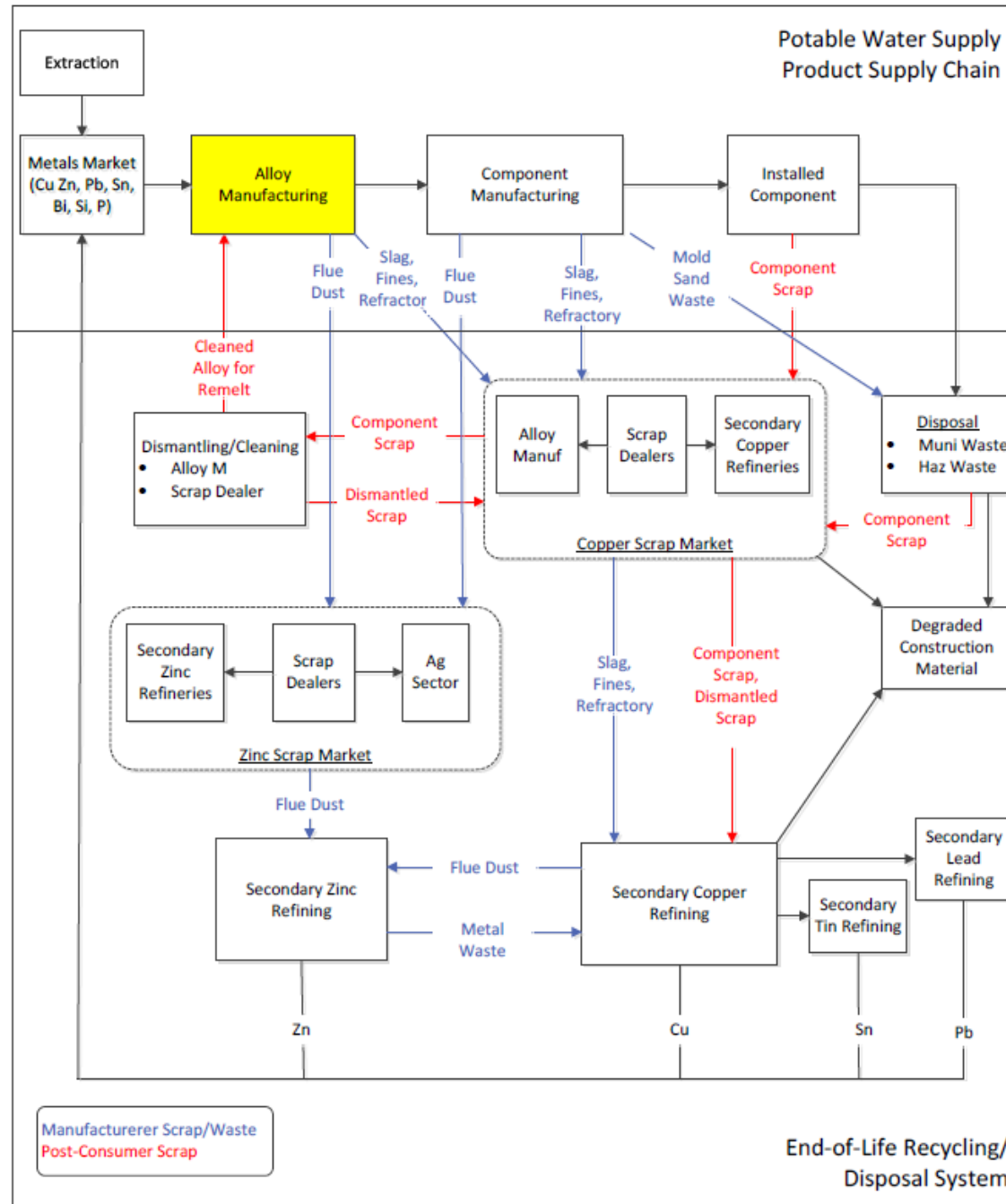


Figure 3.8: CO<sub>2</sub> Emissions Attributed to Mining and Refining Elements Per 100 Kg Metal Input into Alloy Manufacturing

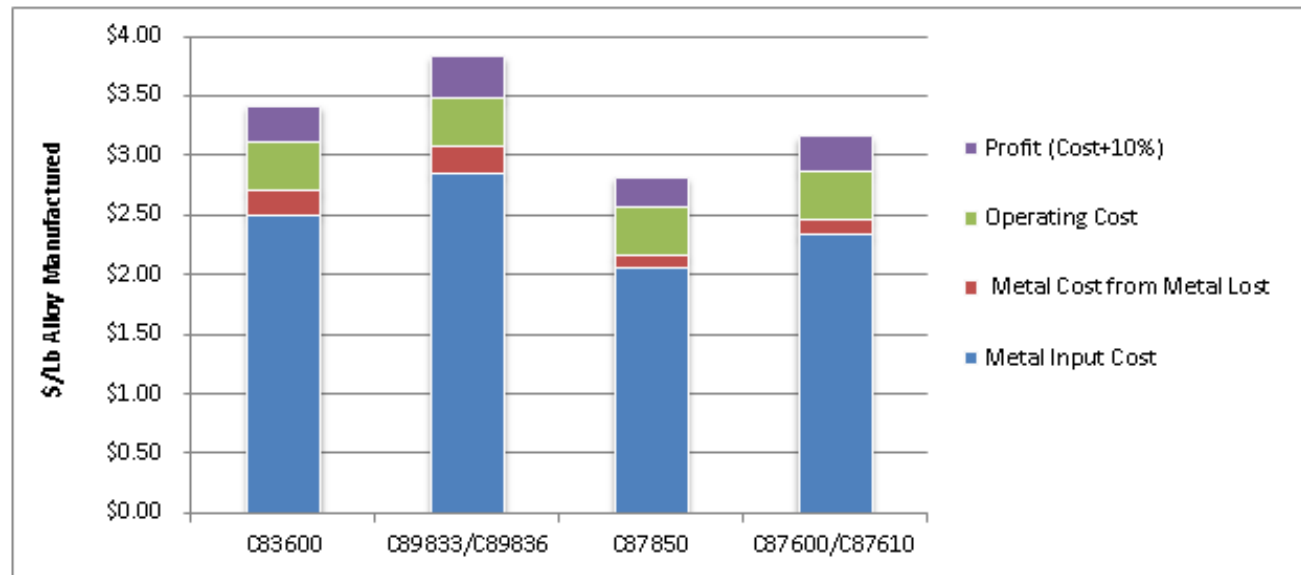


# Alloy Man. Phase

10



# Figure 4.4: Total Alloy Cost and Estimated Price



# Manufacturer Waste

12

Slag

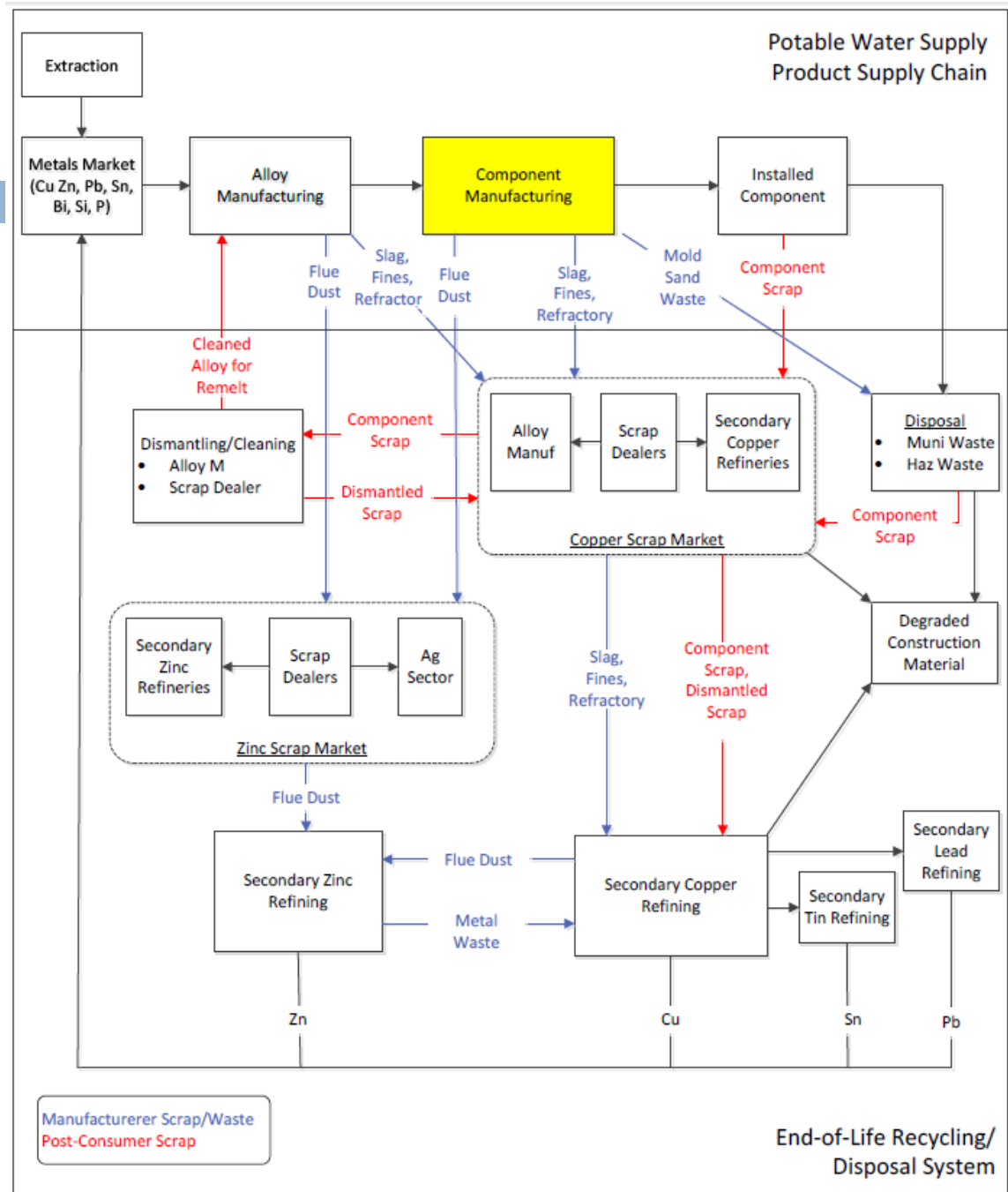


Flue Dust



# Component Man. Phase

13



# Table 5.8: Alternatives Assessment of Component Manufacturing – Qualitative Evaluation of Findings

Process	Main Criteria	Sub-Criteria	C83600	C89833/ C89836	C87850	C87600/ C87610
Molding	Technical Performance	Range of components	Baseline	≈	≈	≈
		Pattern optimization	Baseline	≈	≈	≈
Casting	Technical Performance	Alloy density	Baseline	≈	+	+
		Cast dimension	Baseline	≈	+	≈
		Pour temperature	Baseline	-	++	+
		Melt loss	Baseline	≈	++	++
		Yield	Baseline	+	+	+
		Shake out time	Baseline	-	+	≈
		Furnace maintenance	Baseline	≈	+	+
		Casting defect rate	Baseline	≈	≈	≈
	Environmental Impact	Energy use	Baseline	≈	+	+
		Slag recovery and reuse	Baseline	≈	≈	≈
		Mold sand reduce	Baseline	≈	+	+
		Recyclability of elements	Baseline	-	≈	≈
		Hazardous waste generation	Baseline	+	+	+
	Human Health Impacts	Fume emissions	Baseline	≈	+	+
		Lead exposure	Baseline	≈	≈	≈
		Silica exposure	Baseline	≈	+	+
	Economic Impacts	Alloy input cost	Baseline	-	++	+
		Operating cost	Baseline	≈	+	+
		Total cost		-	++	+
	Machining	Technical Performance	Tooling	Baseline	≈	≈
Tool life			Baseline	≈	++	-
Machine time			Baseline	≈	++	-
Throughput time			Baseline	≈	++	-
Environmental Impact		Energy use	Baseline	-	++	-
		Hazardous coolant disposal	Baseline	≈	≈	≈
		Coolant volume generated	Baseline	≈	+	-
		Recyclability of borings	Baseline	≈	≈	≈
Human Health Impacts		Lead exposure	Baseline	+	+	+
Economic Impacts		Labor cost	Baseline	≈	++	-
		Machine operating cost	Baseline	-	+	-
		Total cost	Baseline	-	++	-
Component Testing		Technical Performance	Component failure rate	Baseline	≈	≈

# Use Phase

15

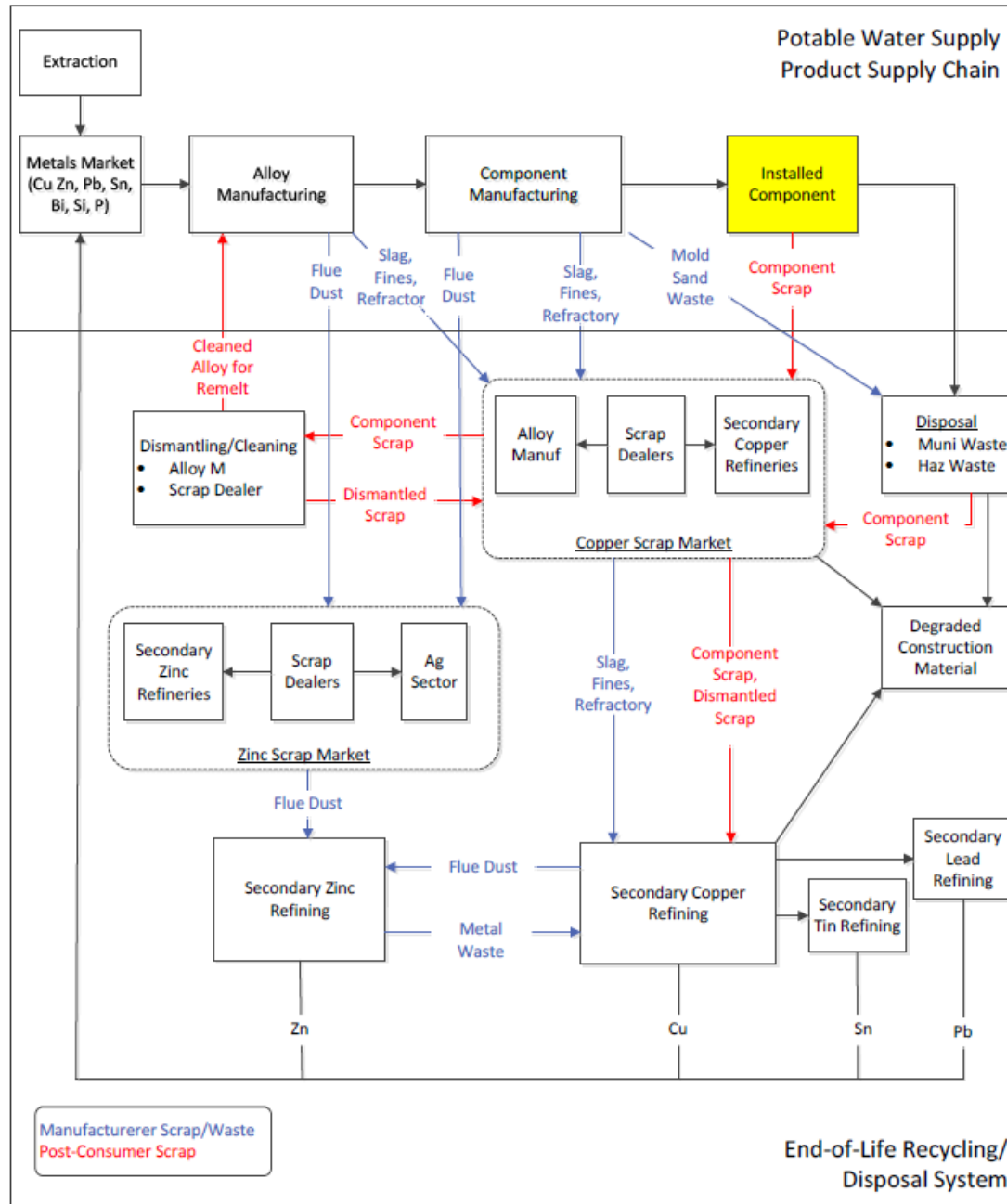


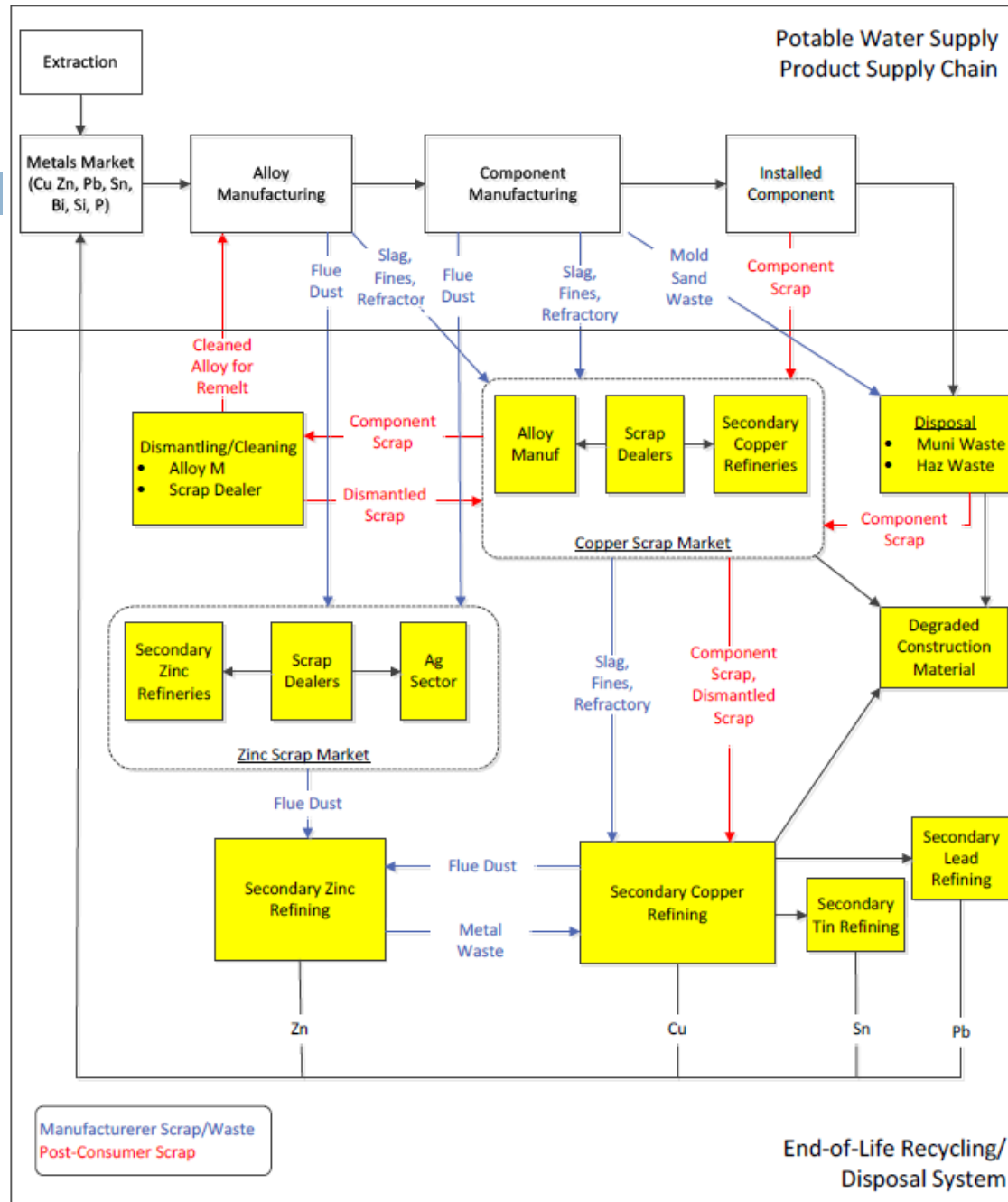
Table 6.16: Qualitative Alternatives Assessment Use-Phase – Qualitative Evaluation of Findings

Main Criteria	Sub-Criteria	Sub-Criteria	Pb Brass C83600	Bi Brass C89833/ C89836	Si Brass C87850	Si Brass C87600/ C87610
Technical Performance	Range of Components	Temperature sensitivity	Standard	-	=	=
	Installation	Soldering quality	Standard	=	+	+
		External forces	Standard	-	=	+
	Component Life Expectancy	Dezincification	Standard	=	=	=
		High redux water test	Standard	=	=	=
		Low redux water test	Standard	=	=	=
		Stress corrosion cracking	Standard	=	=	=
Human Health Impact	Metal Toxicity in Water		Standard	++	++	++
	Leaching		Standard	++	++	++
Environmental Impacts	Resource Impacts		Standard	=	=	=
	End-of-Life Recyclability		Standard	--	=	=
Economic Impacts <sup>25</sup>	Component Price		Standard	-	+	+
	Component Life Cost Impact		Standard	=	=	=
	Scrap Value		Standard	--	=	=



# End-of-Life Phase

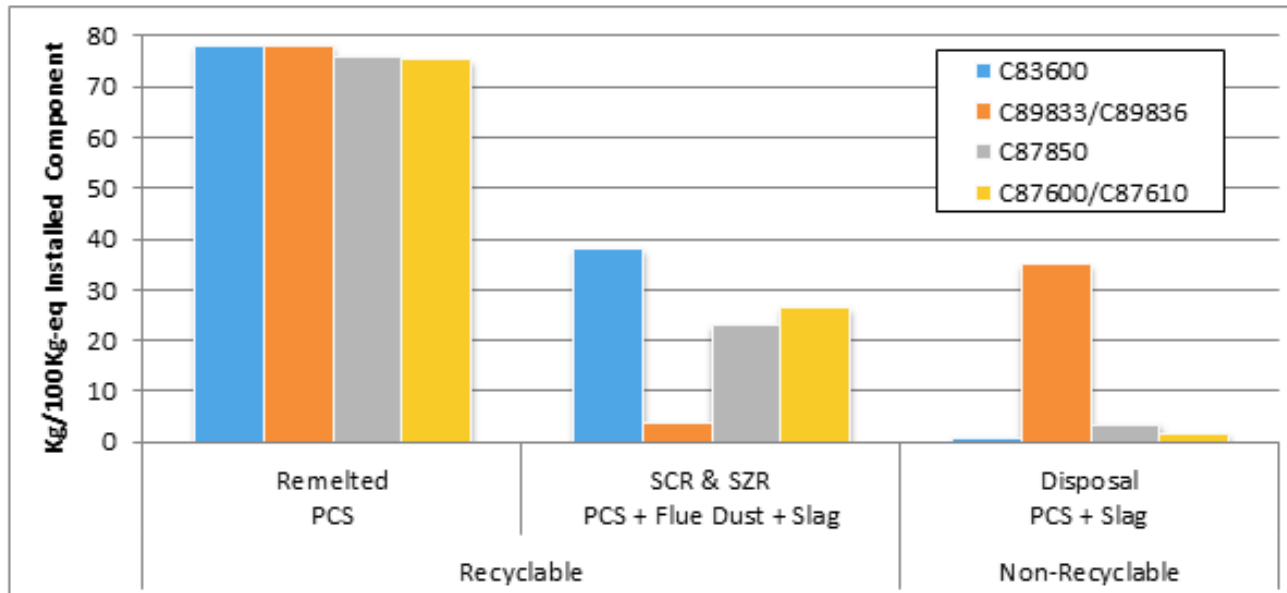
17



# Table 7.7: Restriction/Penalties on Metal Contaminants to Secondary Copper Refining, Metallo Case Study

<u>Fines for materials containing Cu</u>			
<b>Elements</b>	<b>Tolerance</b>	<b>Refused</b>	<b>Deduction of</b>
As	0.0 %	1.0 %	0.2 unit Cu for 0.1 unit As
Bi	0.0 %	0.2 %	1.0 unit Cu for 0.1 unit Bi
Cd	0.0 %	0.5 %	0.5 unit Cu for 0.1 unit Cd
Cl	0.5 %	2.5 %	0.2 unit Cu for 0.1 unit Cl
Ni	0.5 %	3.0 %	0.2 unit Cu for 0.1 unit Ni
S	0.5 %	1.5 %	0.3 unit Cu for 0.1 unit S
Sb	0.5 %	1.0 %	0.5 unit Cu for 0.1 unit Sb
Be	0.0 %	always	
Cr	0.0 %	0.5 %	0.2 unit Cu for 0.1 unit Cr
F	0.0 %	2.0 %	0.3 unit Cu for 0.1 unit F

# Figure 7.8: Scrap Recovery/Disposal Rate per 100 Kg-eq Cast Brass Potable Water Supply Components



# Figure 7.19: Relative End-of-Life Avoided/Unavoidable Cost Rate per 100 Kg-eq Cast Brass Potable Water Supply Components

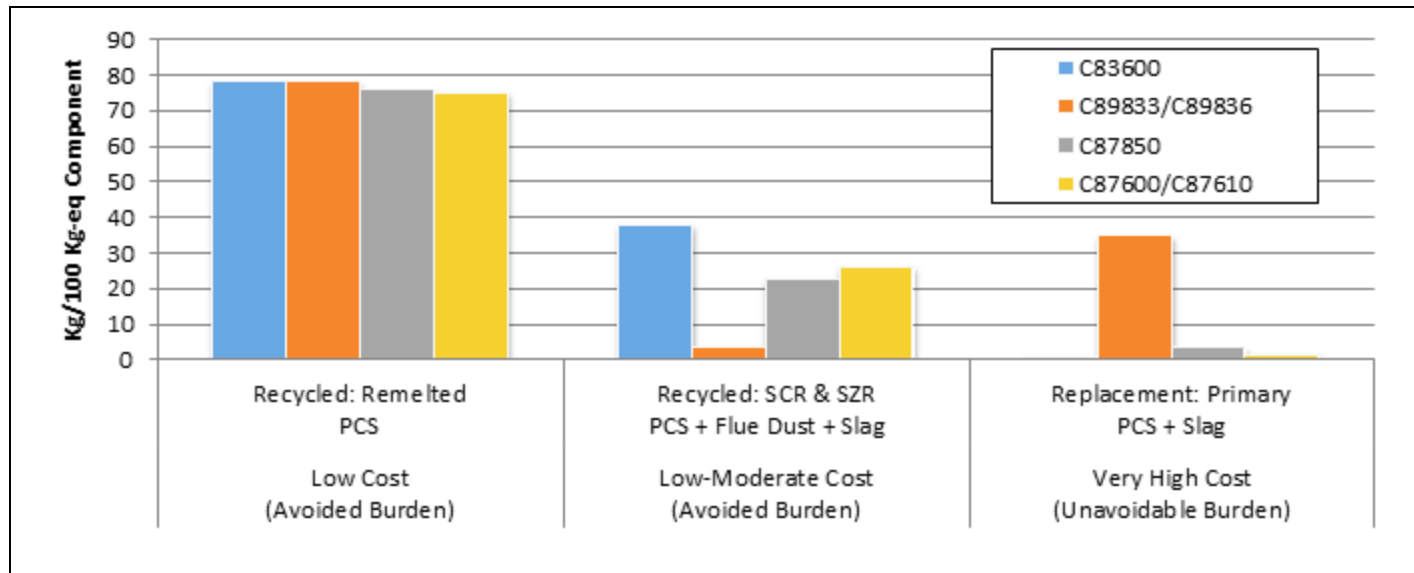
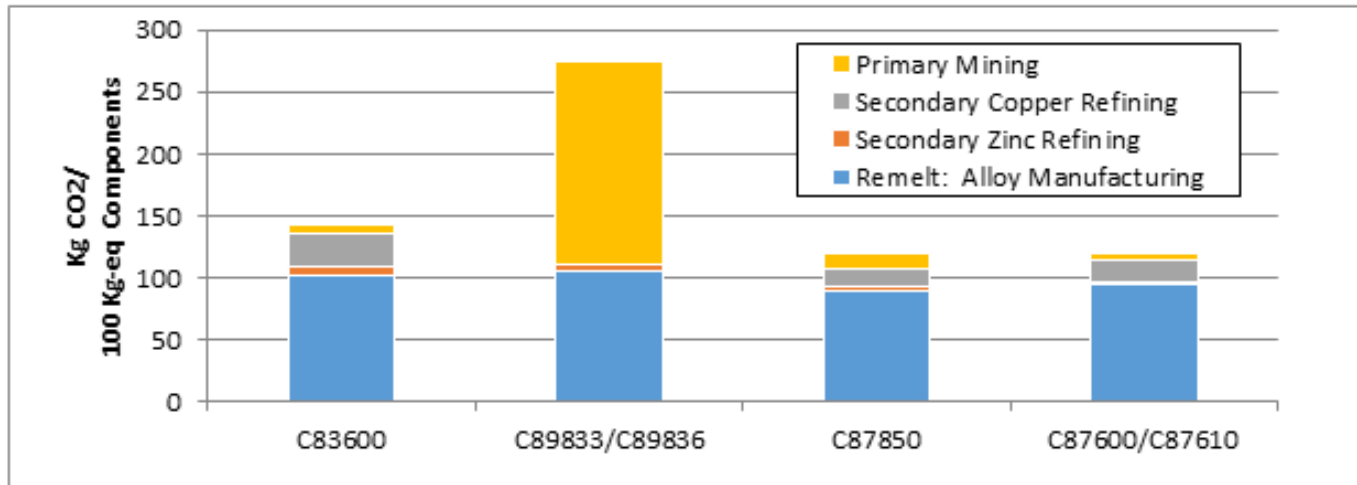


Figure 7.16: CO<sub>2</sub> Emissions per 100 kg-eq Cast Brass Potable Water Supply Components



# Table 9.1: Summary Alternatives Assessment Matrix of Leaded Brass to Lead-Free Substitutes by Life Cycle Stage and Major Impact Criteria

		<b>Pb Brass C83600</b>	<b>Bi Brass C89833/ C89836</b>	<b>Si Brass C87850</b>	<b>Si Brass C87600/ C87610</b>
<i>Beginning-of-Life</i>	Environmental Impact	Benchmark	--	=	=
	Health Impact	Benchmark	=	=	=
	Economic Impact	Benchmark	--	=	=
<i>Alloy Manufacturing</i>	Technical Performance	Benchmark	=	+	+
	Environmental Impact	Benchmark	=	+	+
	Health Impact	Benchmark	+	+	+
	Economic Impact	Benchmark	-	+	+
<i>Component Manufacturing</i>	Technical Performance	Benchmark	-	+	--
	Environmental Impact	Benchmark	+	++	++
	Health Impact	Benchmark	+	++	++
	Economic Impact	Benchmark	-	+	-
<i>Use</i>	Technical Performance	Benchmark	-	=	=
	Environmental Impact	Benchmark	=	=	=
	Health Impact	Benchmark	++	++	++
	Economic Impact	Benchmark	-	+	-
<i>End-of-Life</i>	Technical Performance	Benchmark	--	=	=
	Environmental Impact	Benchmark	--	=	=
	Health Impact	Benchmark	+	+	+
	Economic Impact	Benchmark	--	=	=
<i>Cumulative</i>	Environmental Impact	Benchmark	--	+	+

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23

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