

The Life Cycle of Copper, its Co-Products and By-Products

(Figures)

Robert U. Ayres, Leslie W. Ayres and Ingrid Råde

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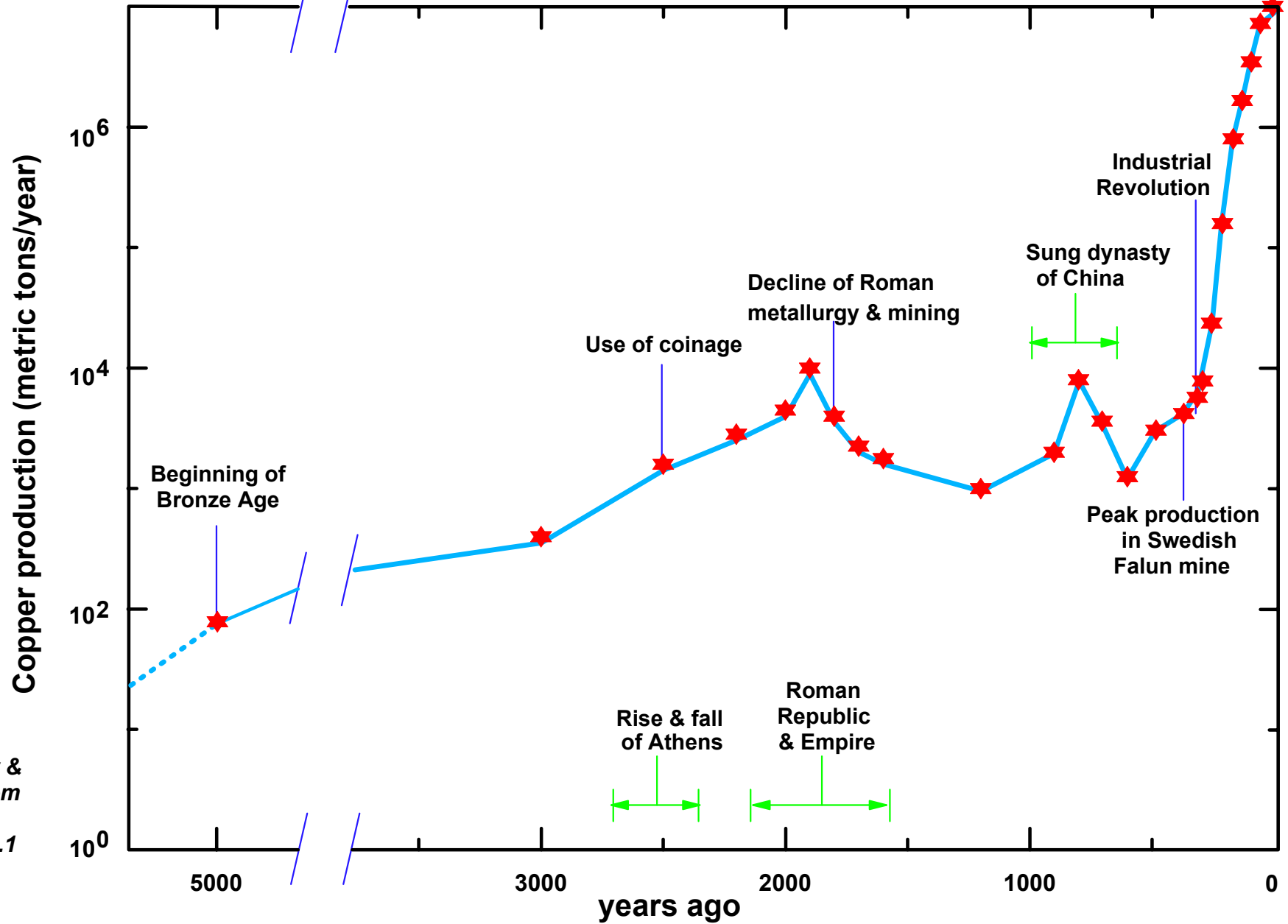


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Figure 1.1: Variations in the rate of copper extraction, past 5000 years



Source:
Landner &
Lindström
1999,
Figure 2.1

Figure 1.2: Copper production at the mine in Falun, Sweden

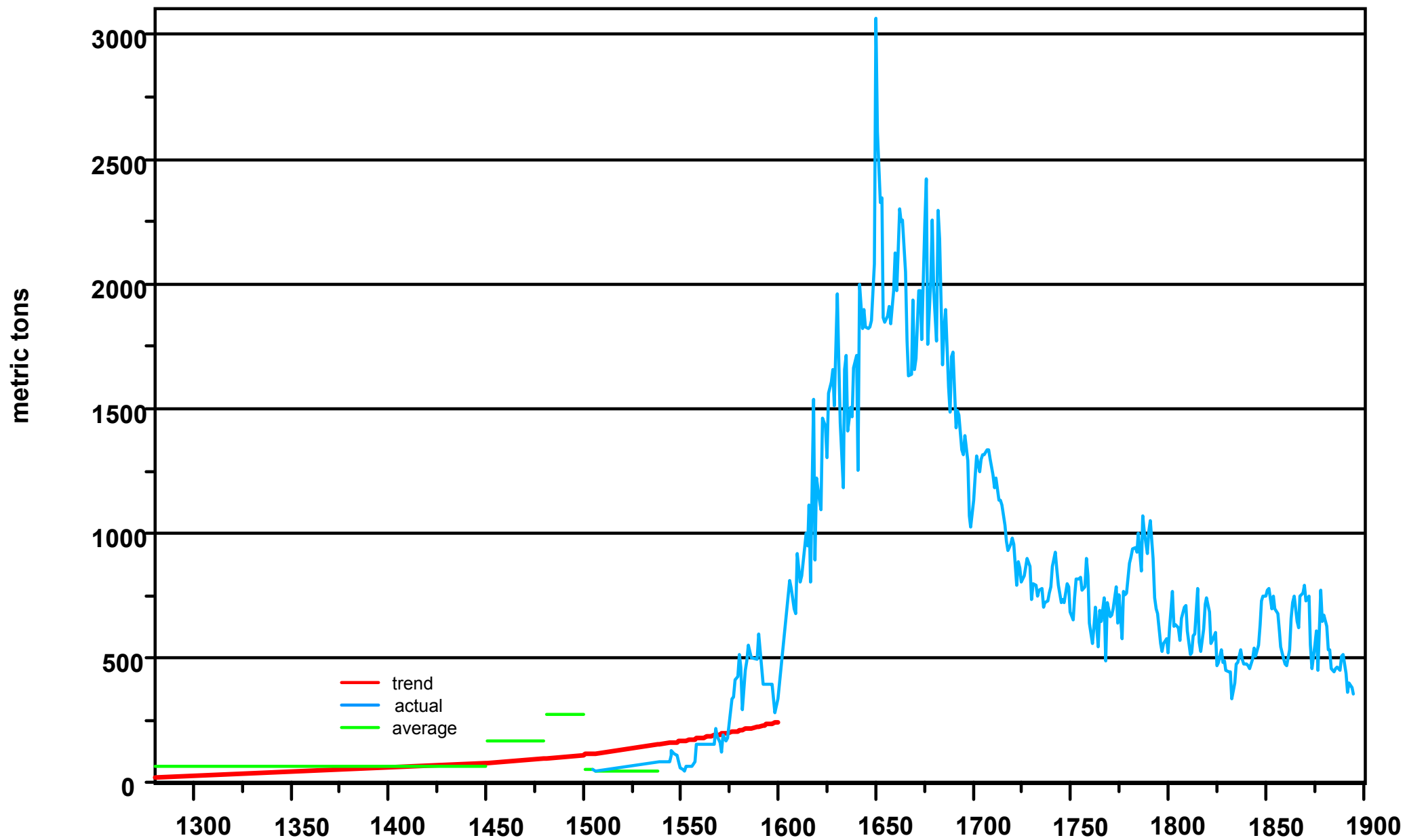
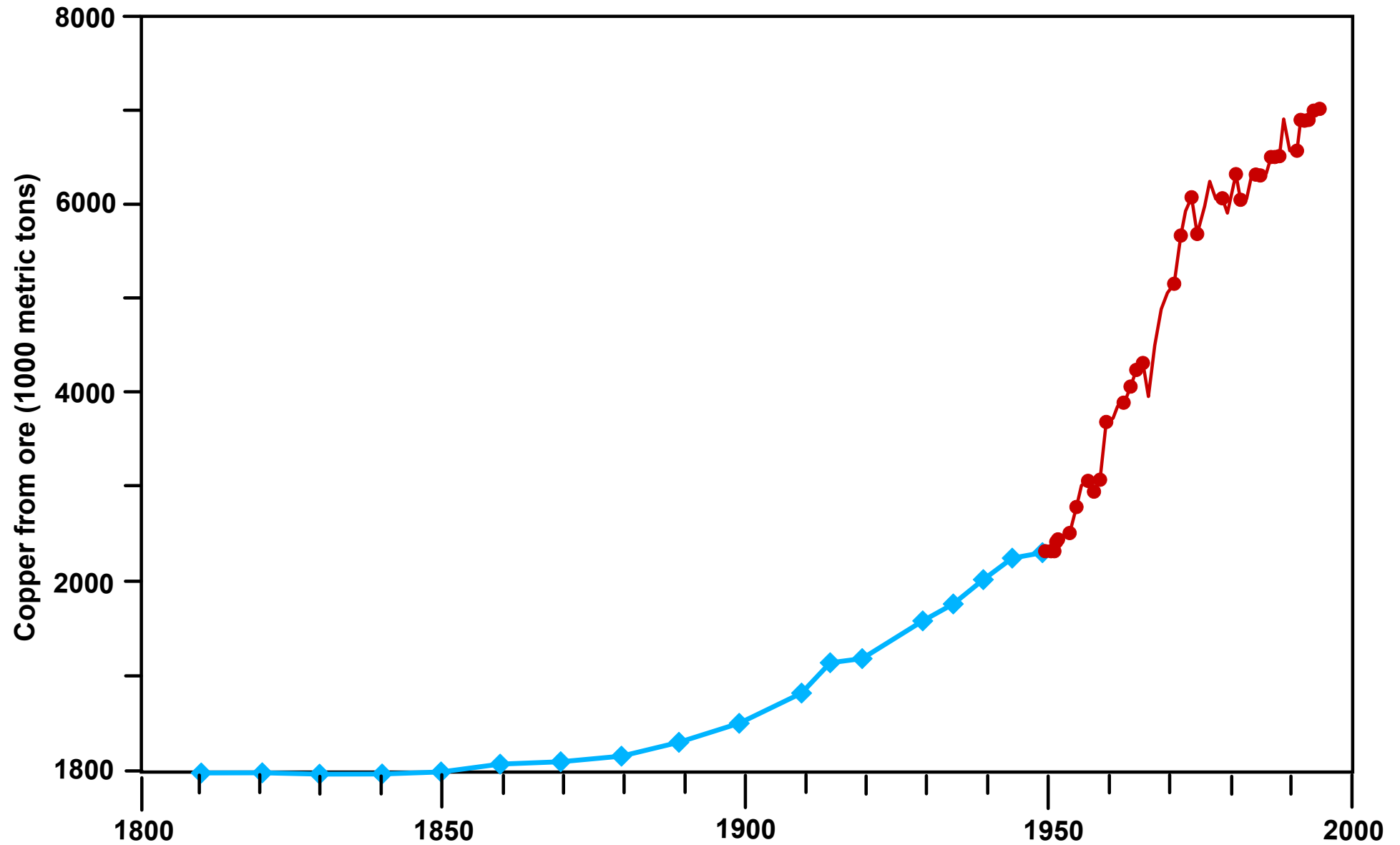
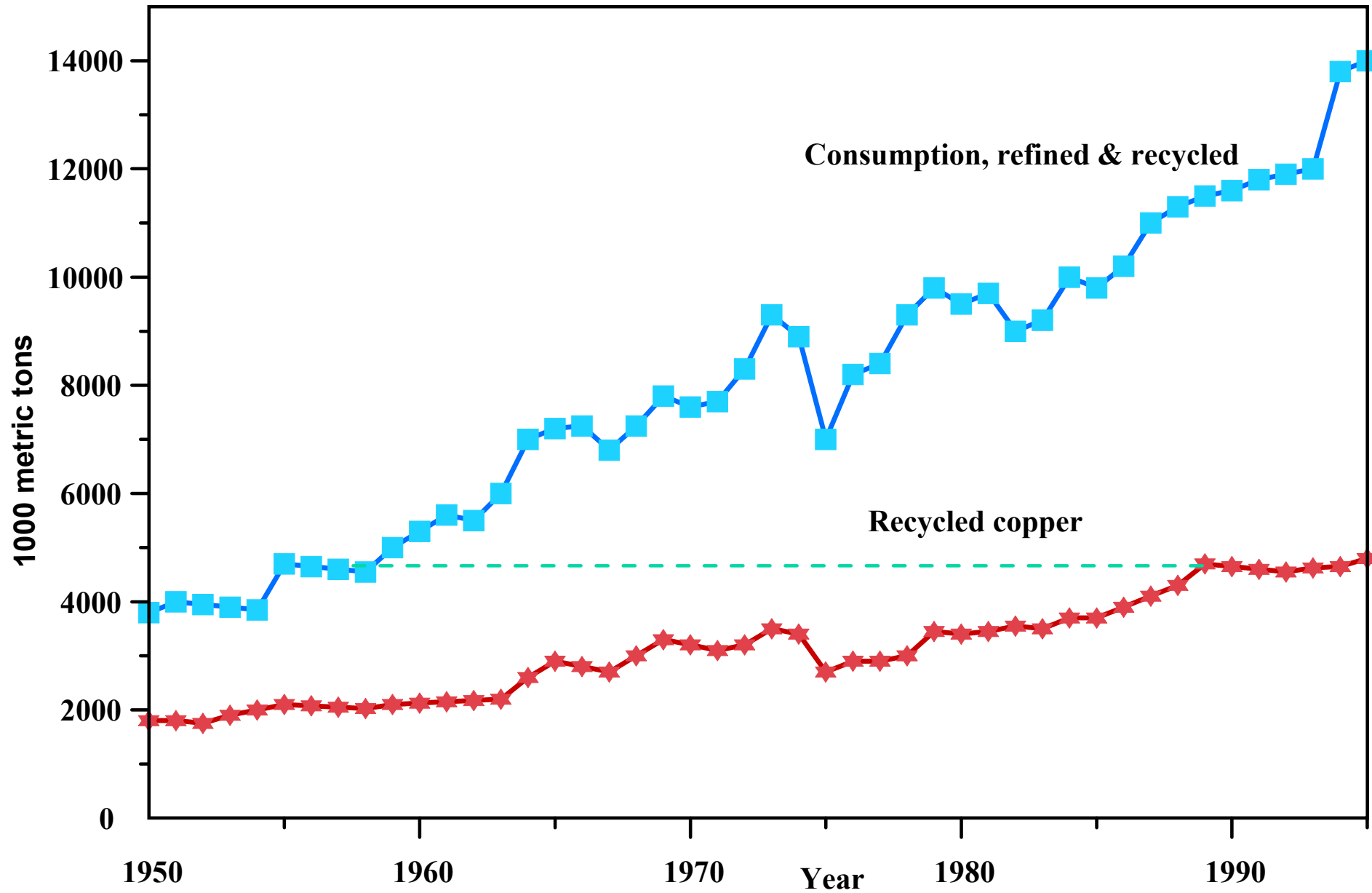


Figure 1.3: Total production of copper from ores in the "Western World", 1810 - 1995



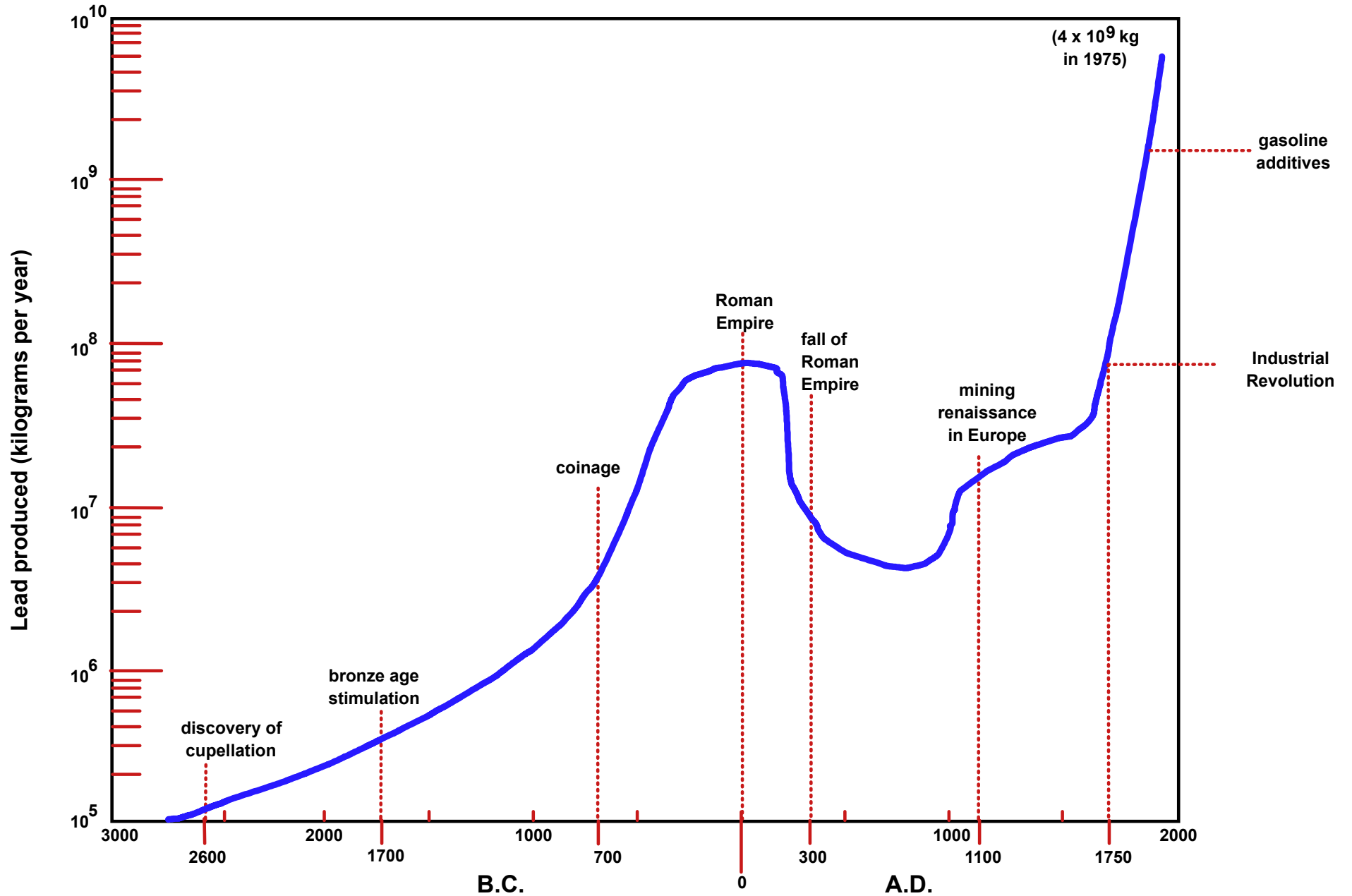
Source: Landner & Lindström 1999, Figure 4.1

Figure 1.4: Total consumption of copper in the "Western World", 1950-1995



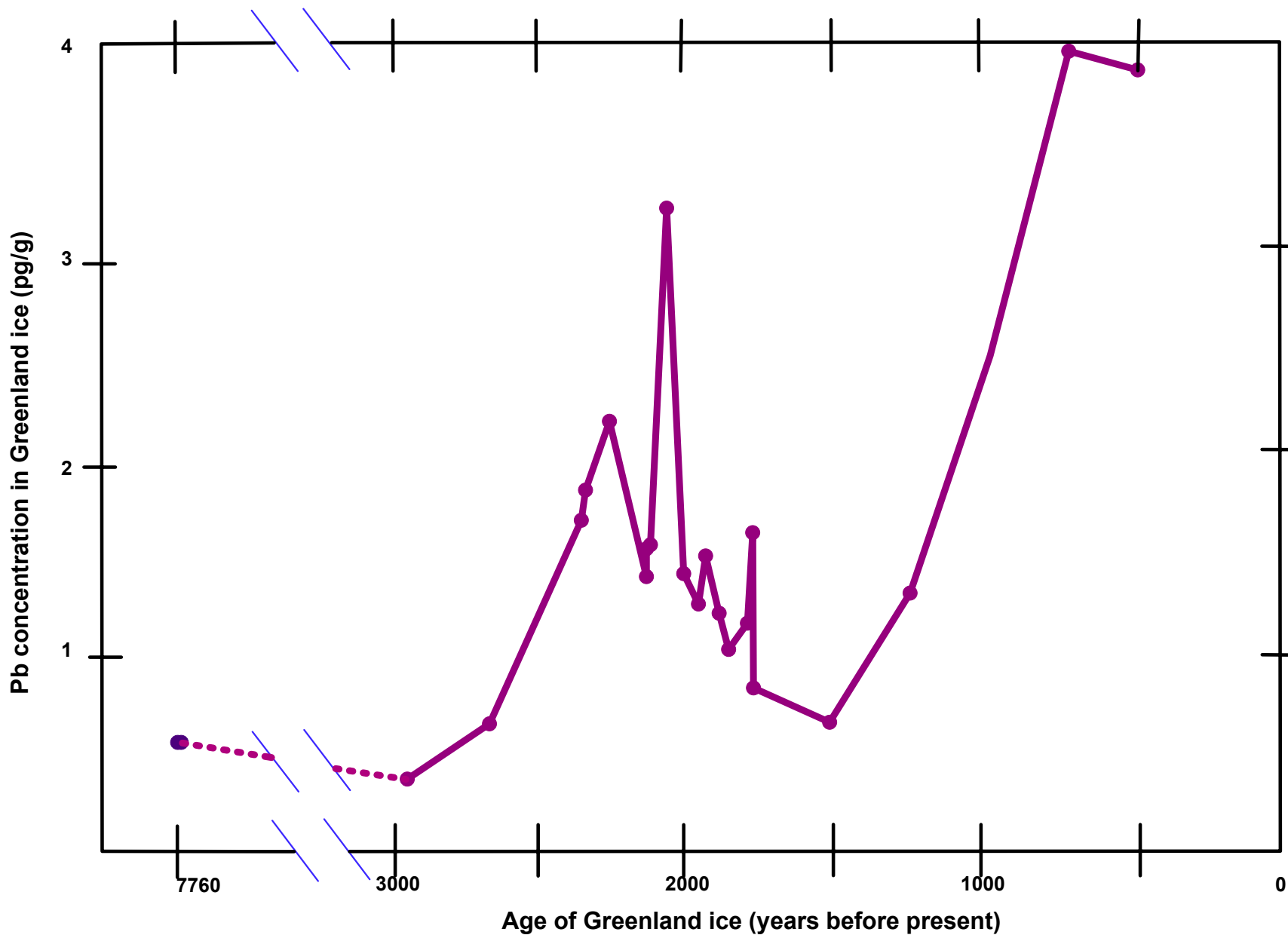
Source: Landner & Lindström 1999, Figure 4.2

Figure 1.5: Historical production of lead



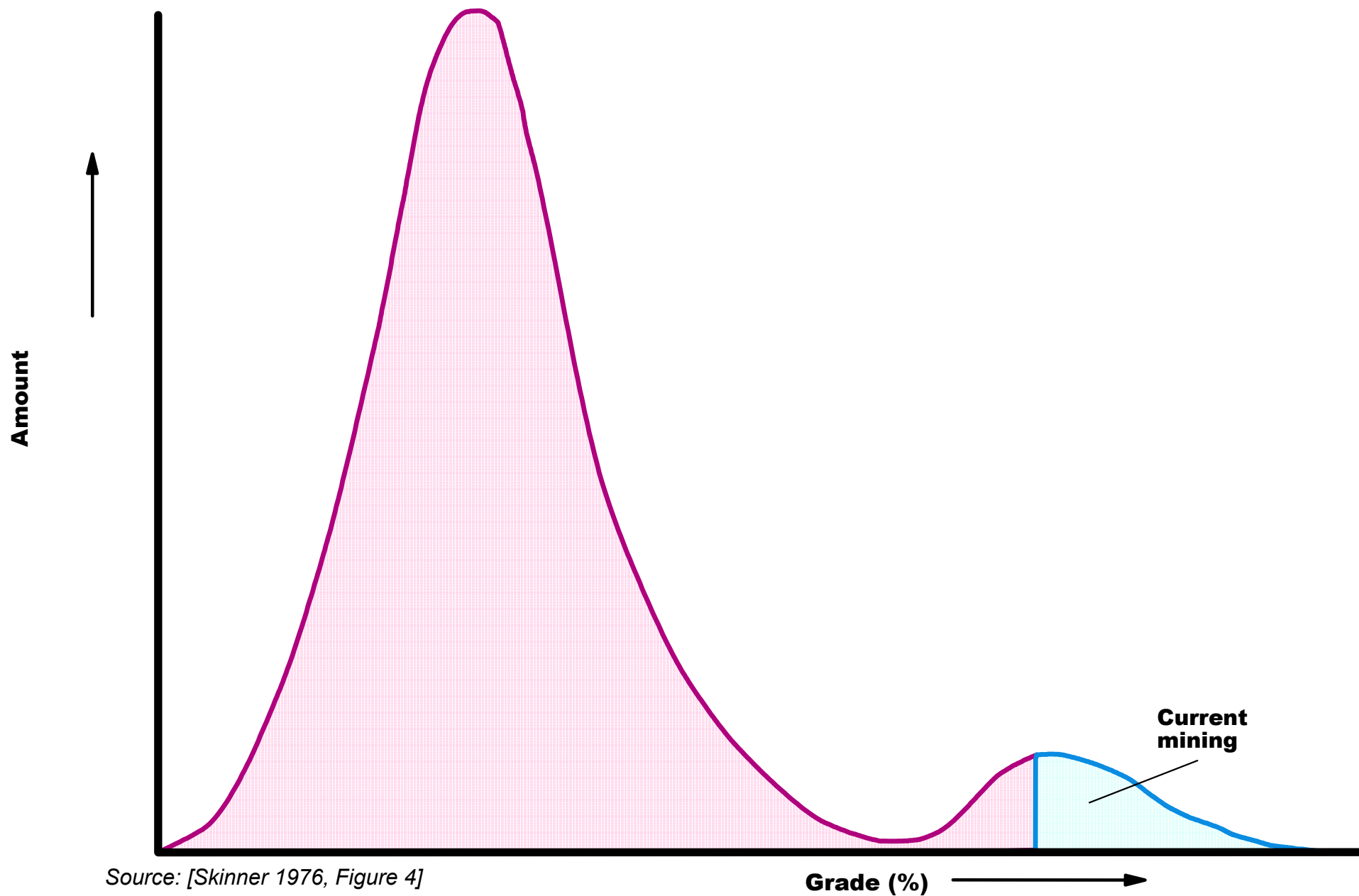
Source: adapted from Patterson et al. 1970

Figure 1.6: Greenland ice and lead production



Source: [Boutron 1998, p. 158]

Figure 1.7: Probable distribution of a geochemically scarce metal in the Earth's crust



Source: [Skinner 1976, Figure 4]

Figure 2.1: USA; copper foundry production, imports, exports & apparent consumption, 1913 - 1998 (3 year moving averages)

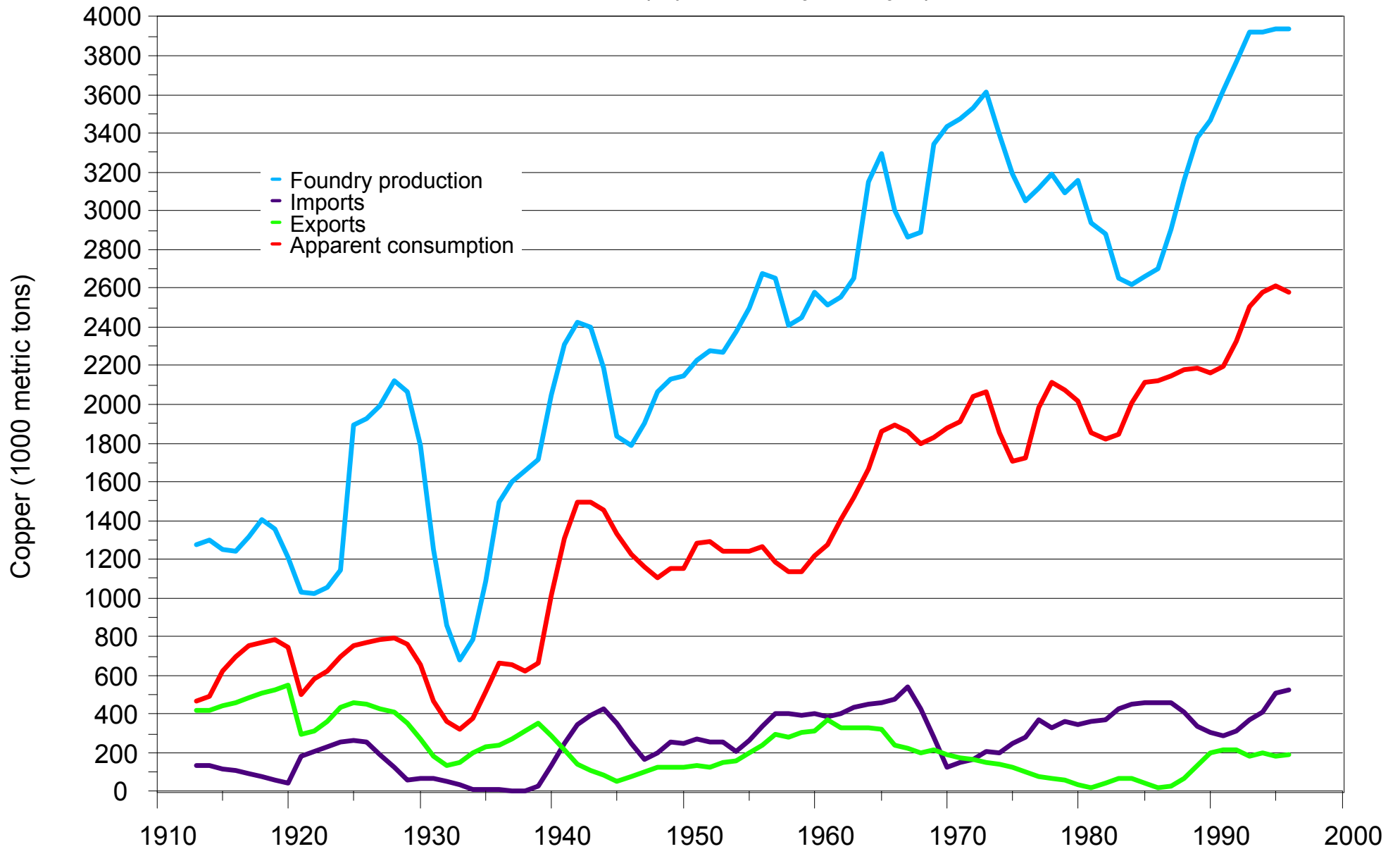


Figure 2.2: France; copper foundry production, imports, exports & apparent consumption, 1913 - 1998 (3 year moving averages)

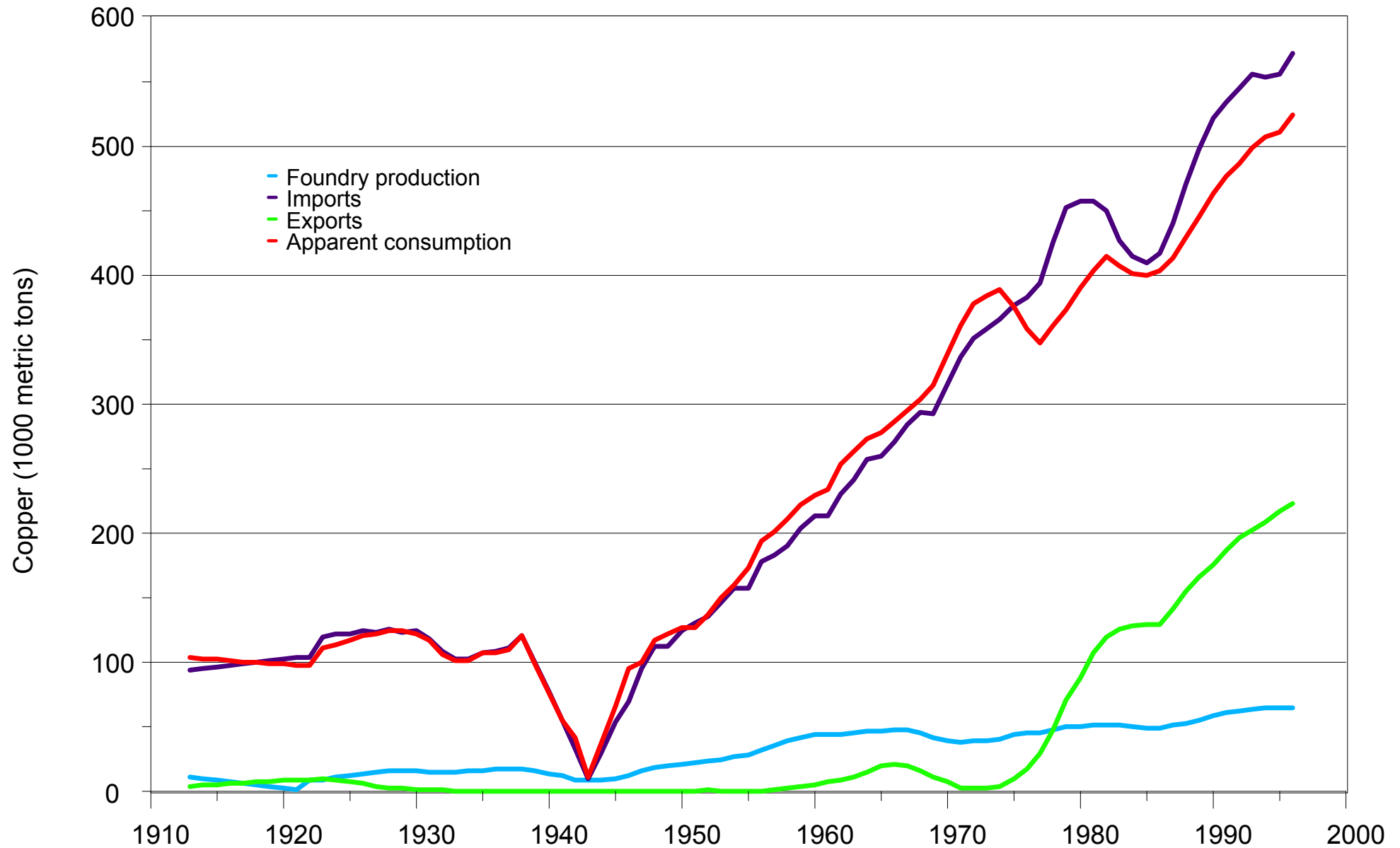


Figure 2.3: United Kingdom; copper foundry production, imports, exports & apparent consumption, 1913 - 1998 (3 year moving averages)

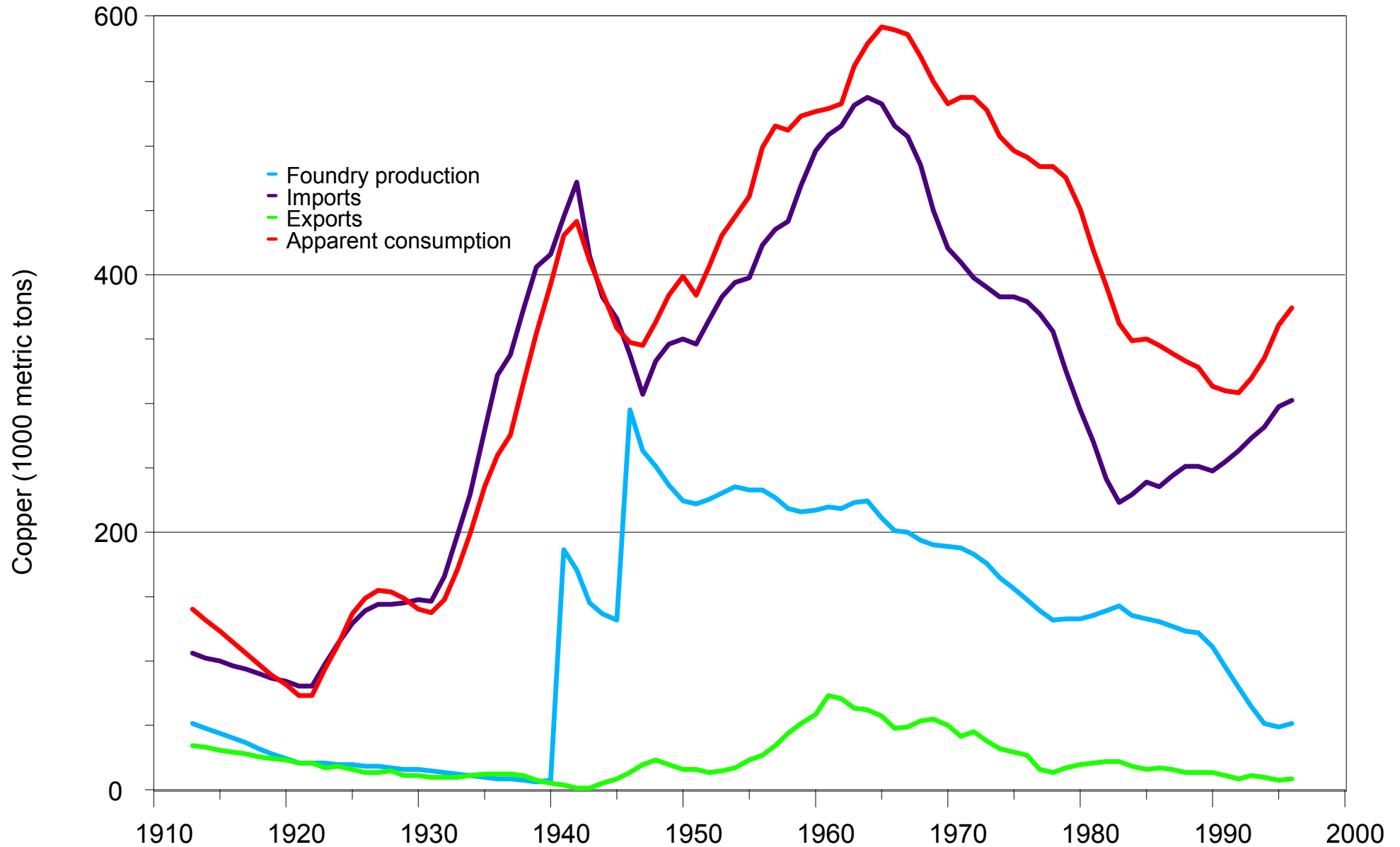


Figure 2.4: Germany; copper foundry production, imports, exports & apparent consumption, 1913 - 1998 (3 year moving averages)

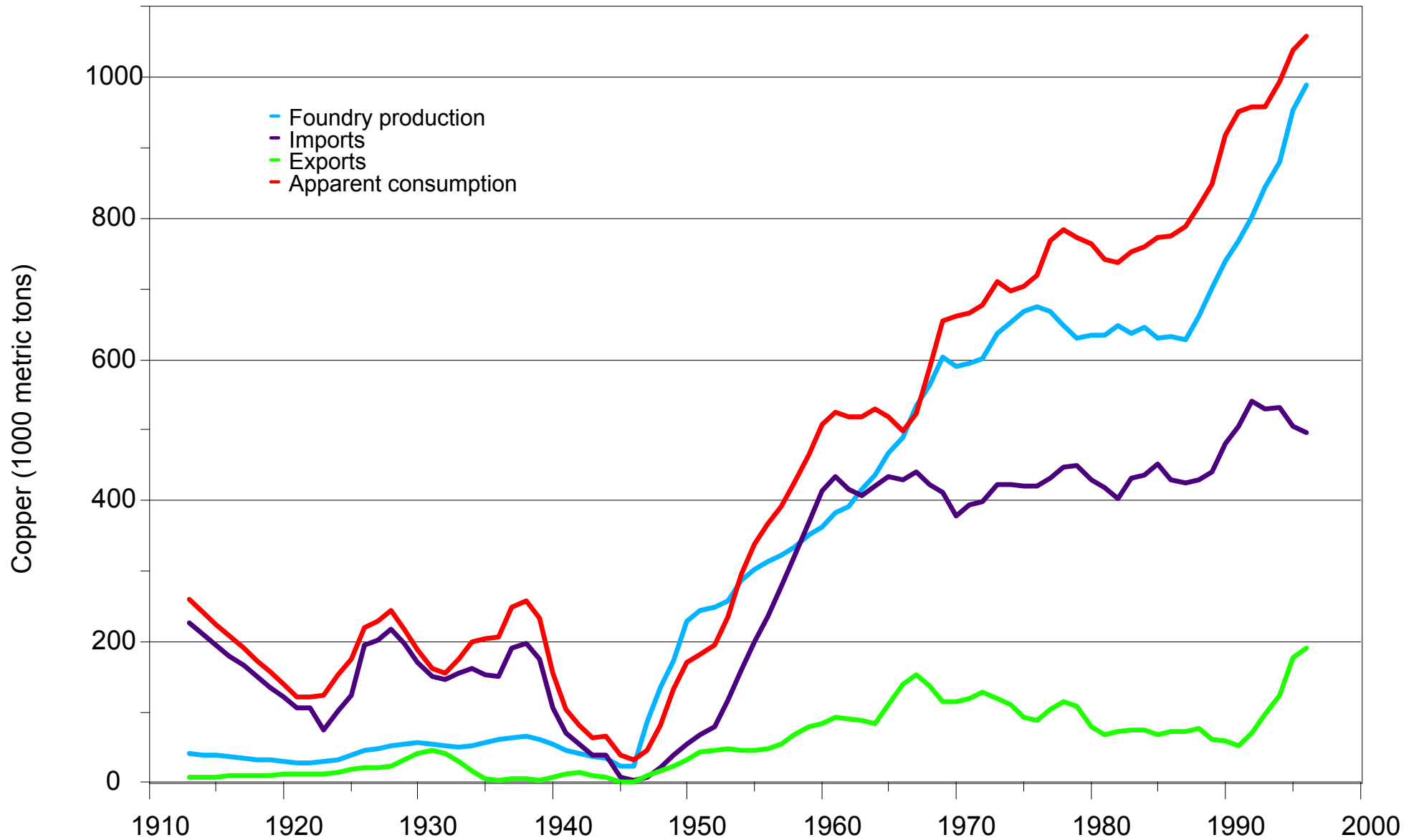


Figure 2.5: Sweden; copper foundry production, imports, exports & apparent consumption, 1913 - 1998 (3 year moving averages)

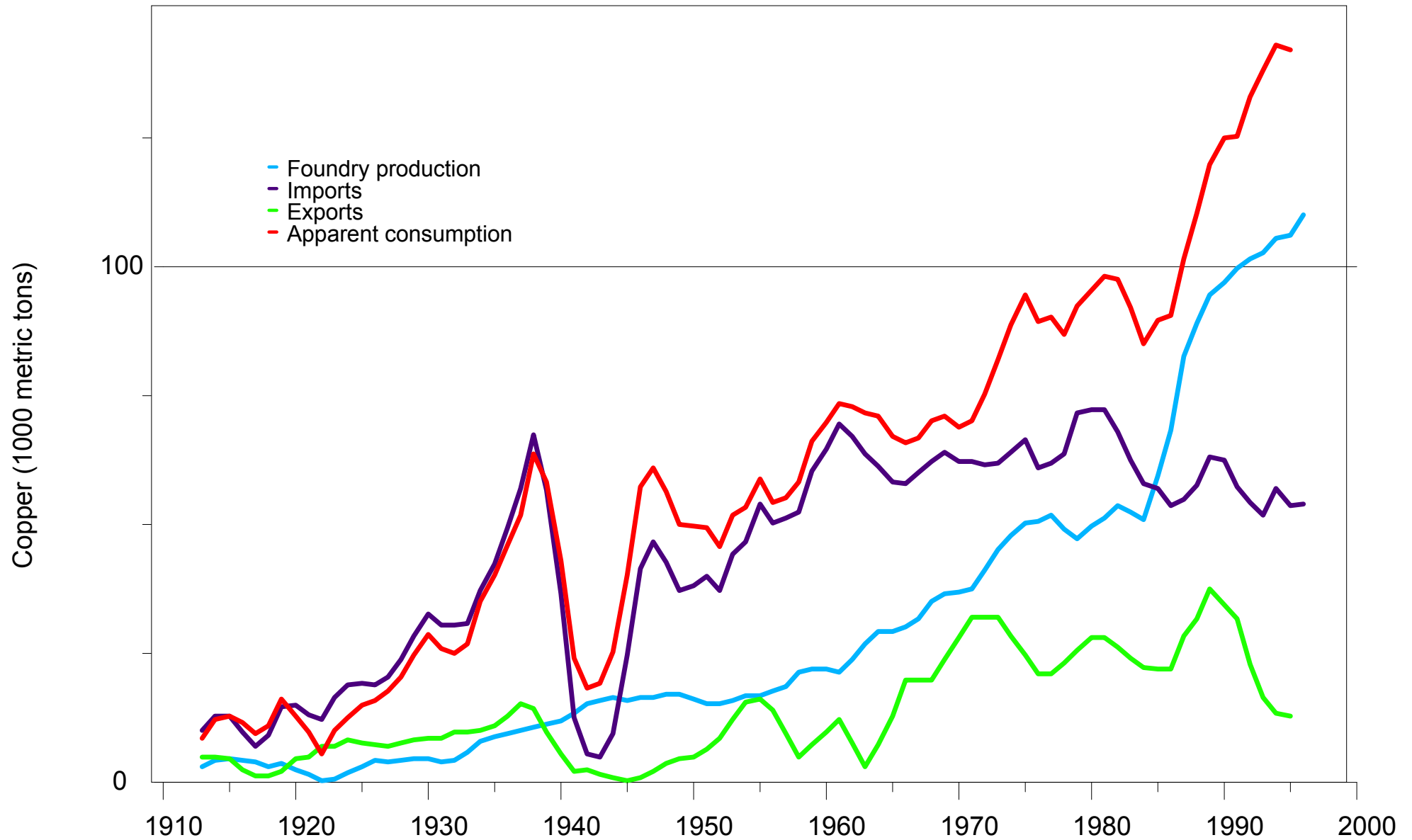


Figure 2.6: Japan; copper foundry production, imports, exports & apparent consumption, 1913 - 1998 (3 year moving averages)

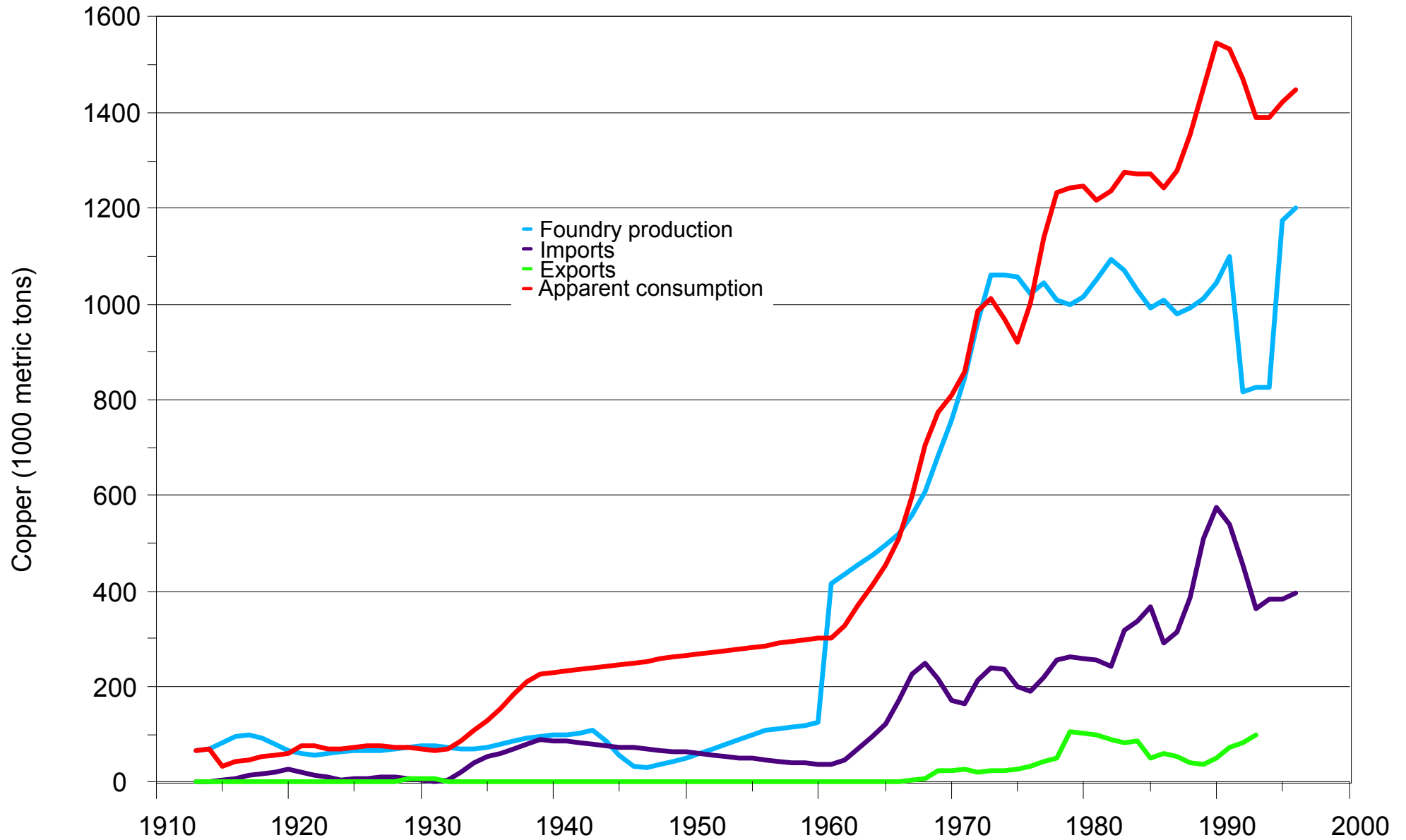


Figure 2.7: Mass flows (kg) in the production of 1 MT copper (simplified processes, typical material mixes)

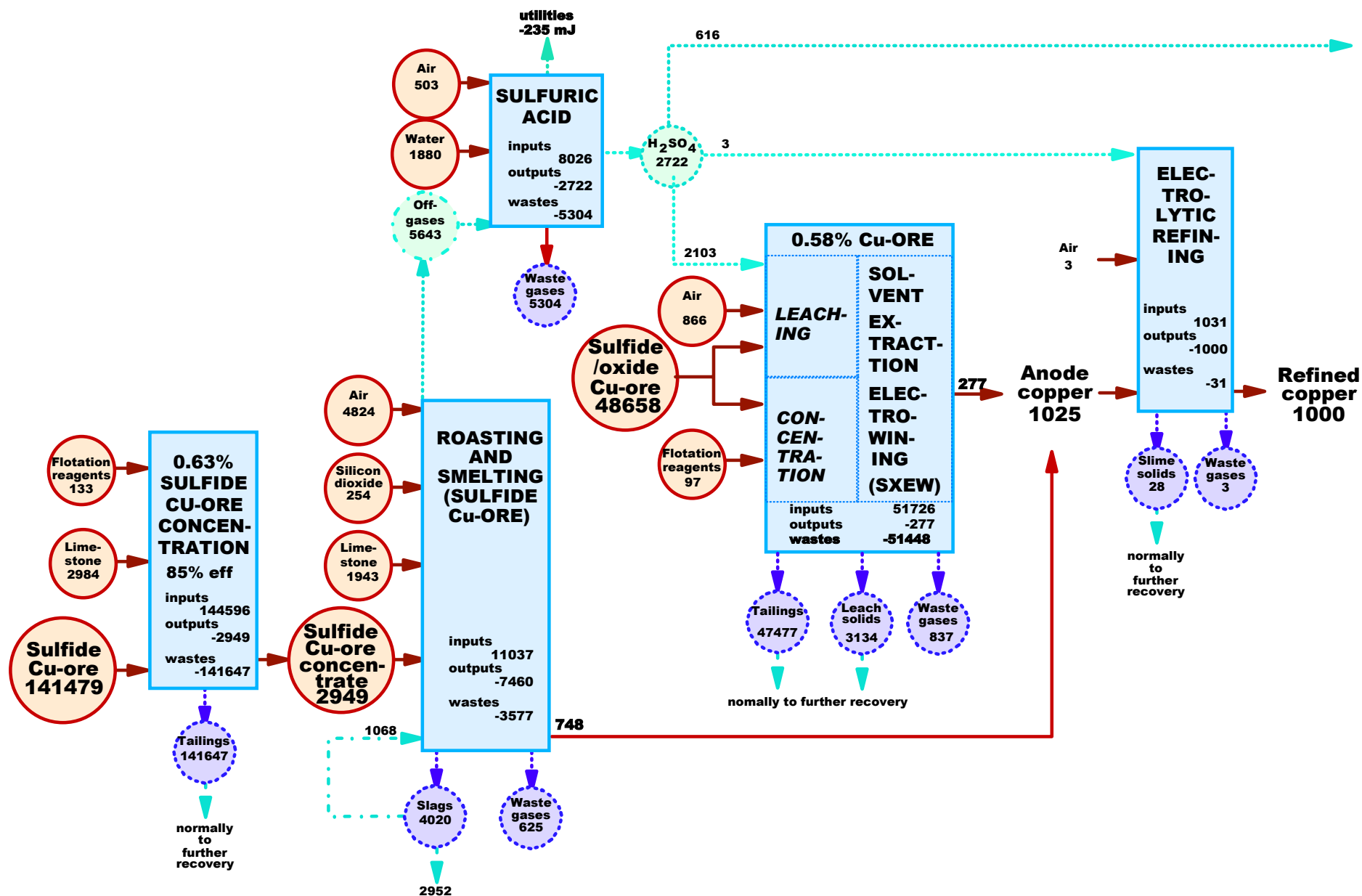


Figure 2.8: US copper ore grade percent, 1880-2000

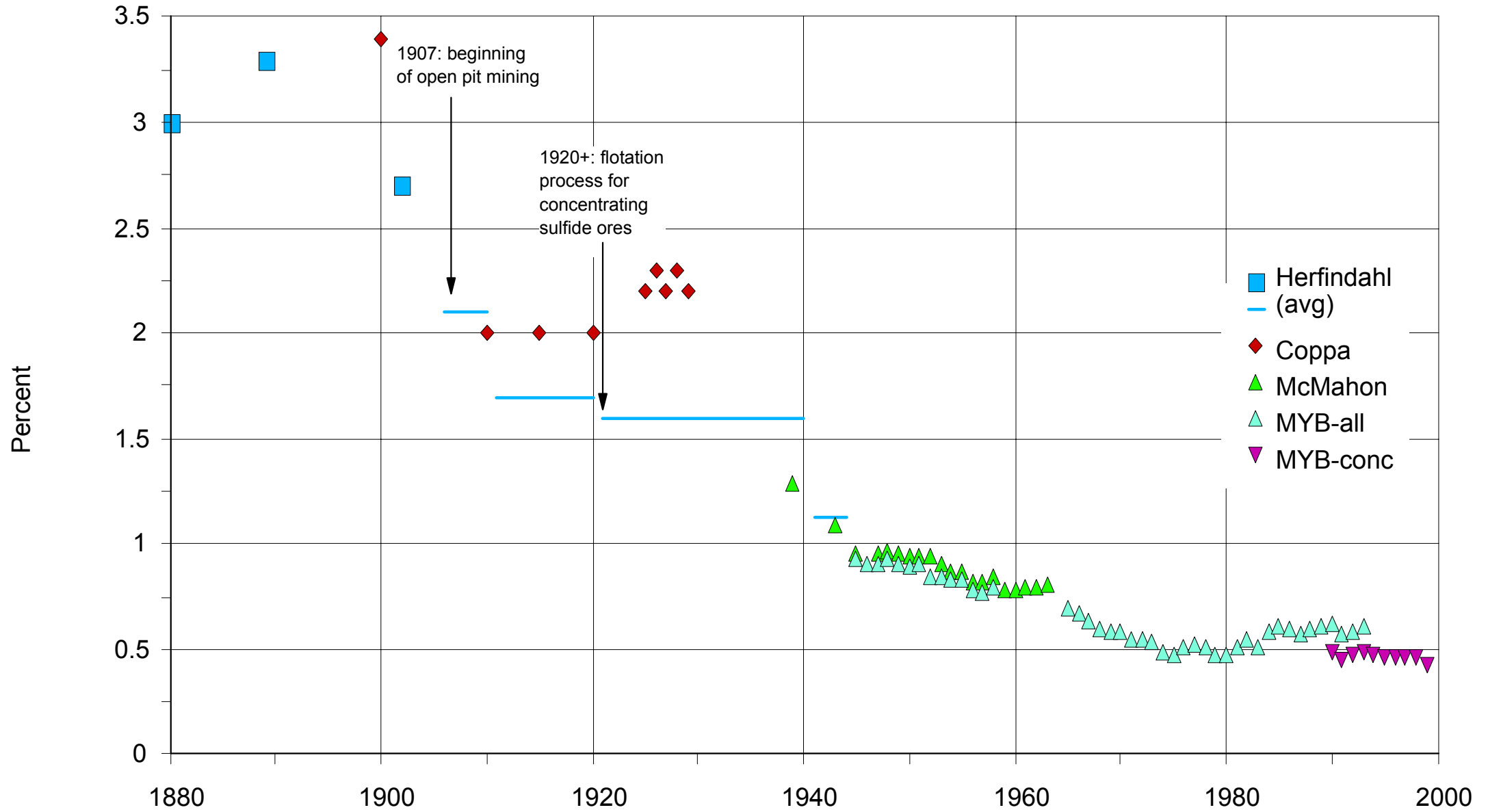


Figure 2.9: Exergy flows (mJ) in the production of 1 MT copper (simplified processes, typical material mixes)

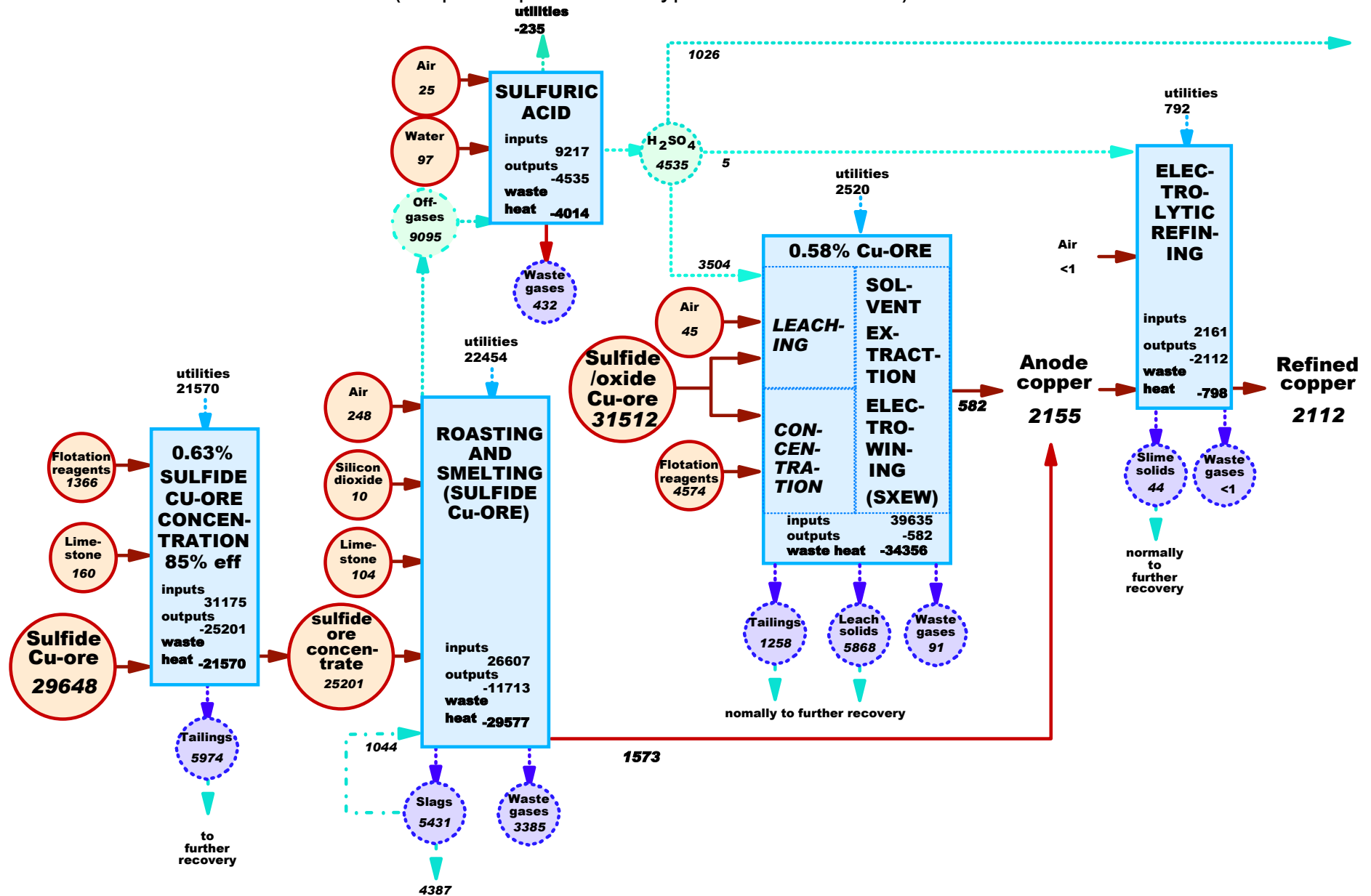


Figure 2.10: Primary copper mass and exergy flows per MT Cu

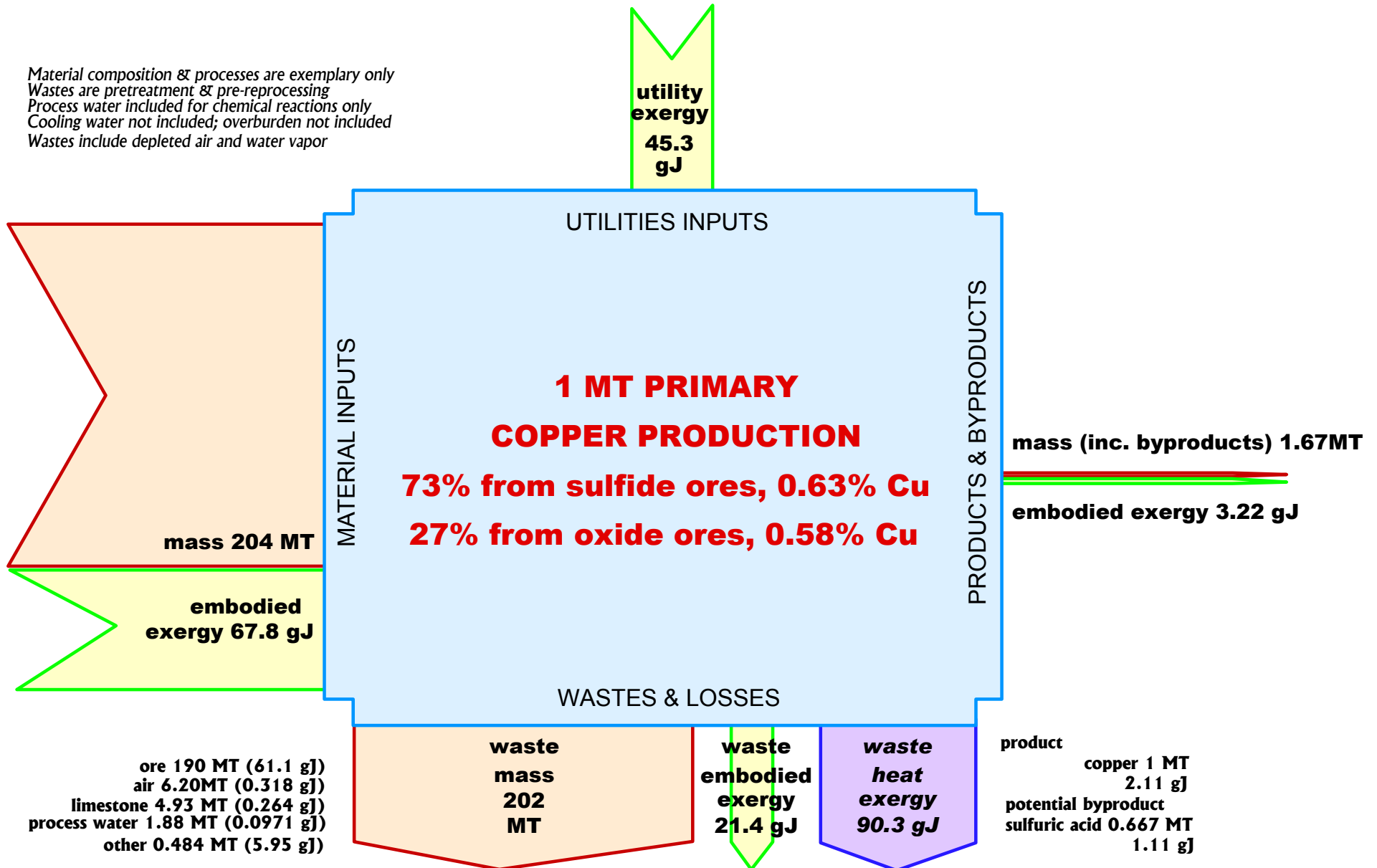


Figure 3.1: Electrical consumption of copper; US 1947 - 1993

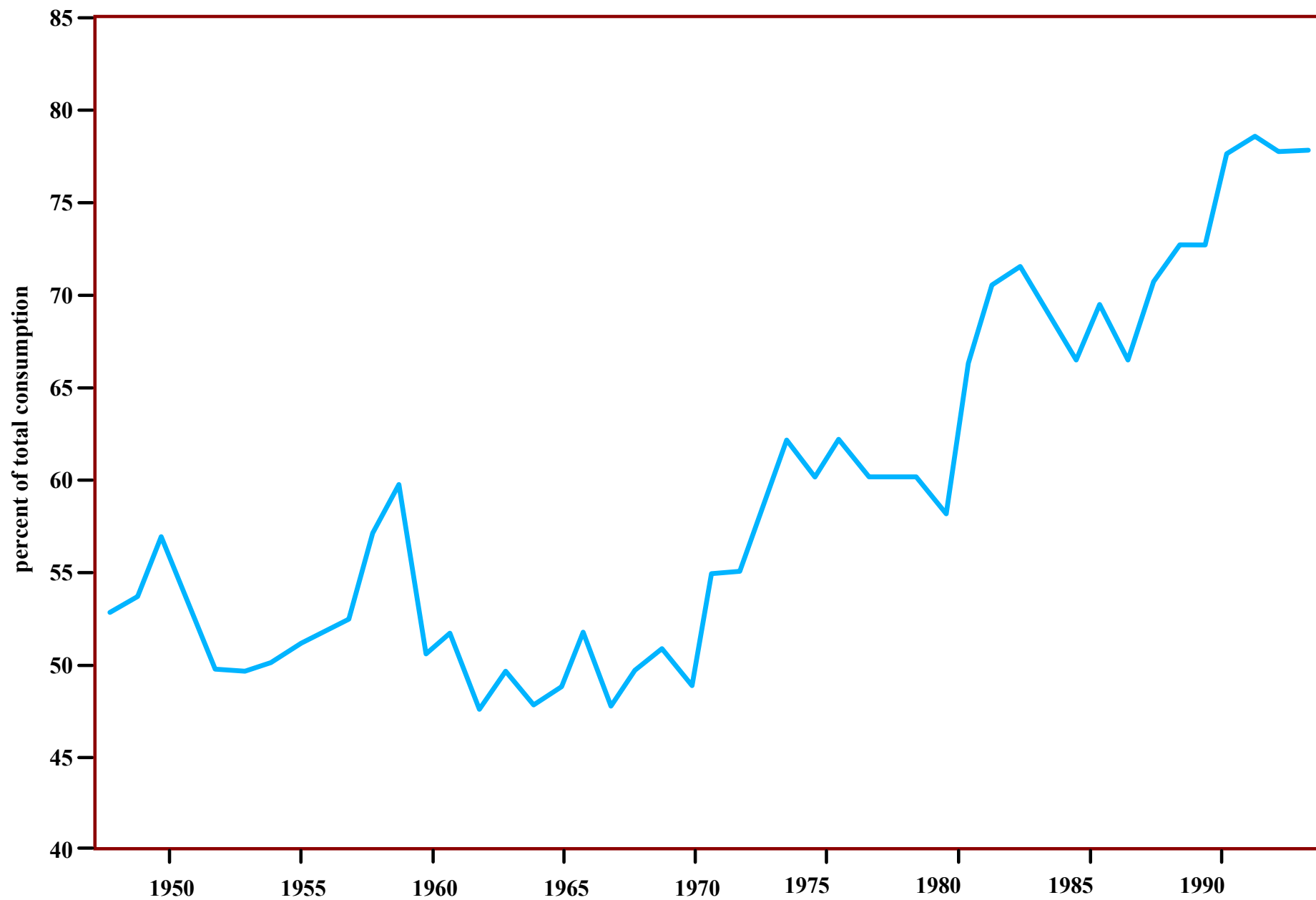
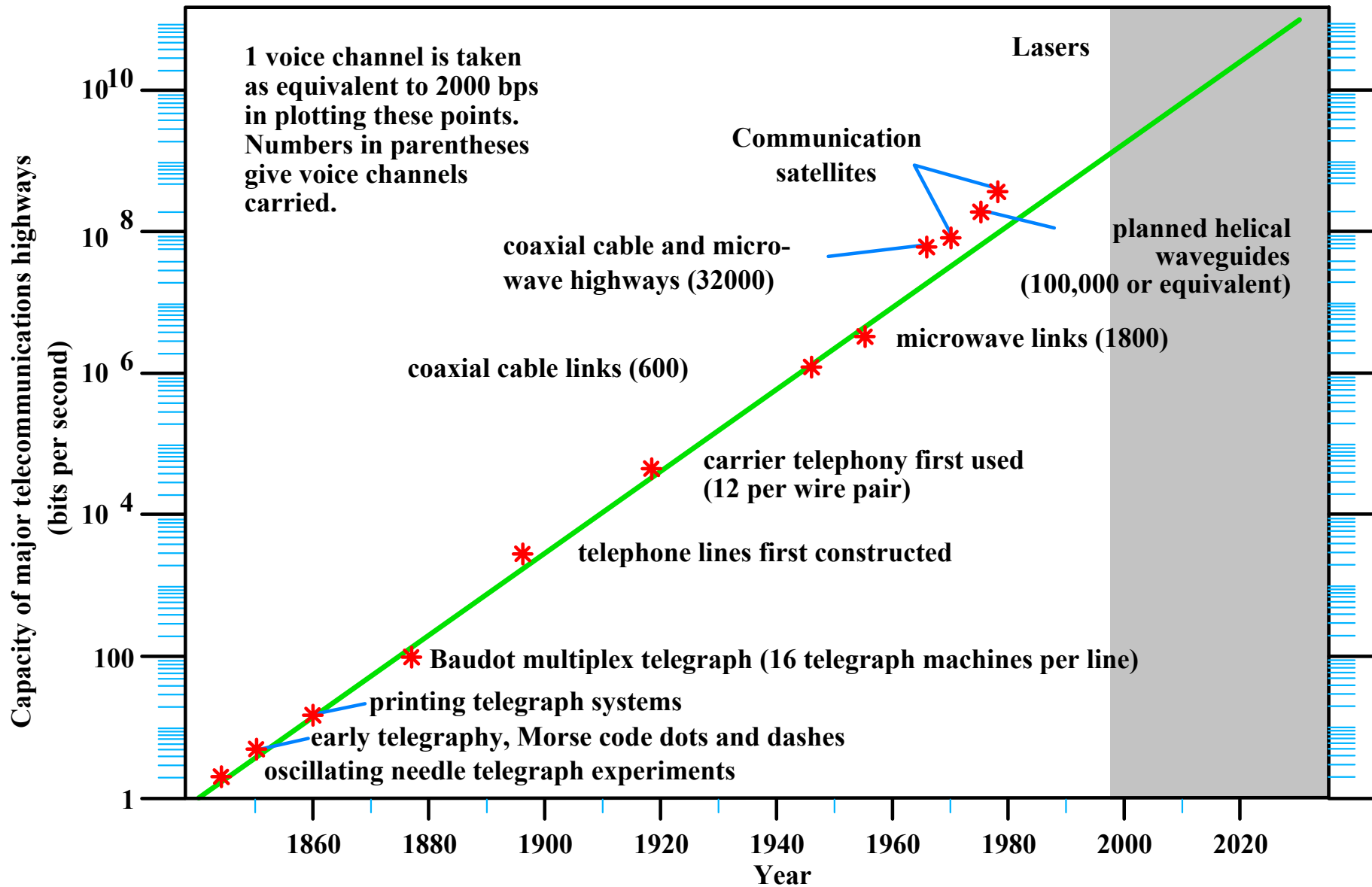


Figure 3.2: Telecommunications capacity



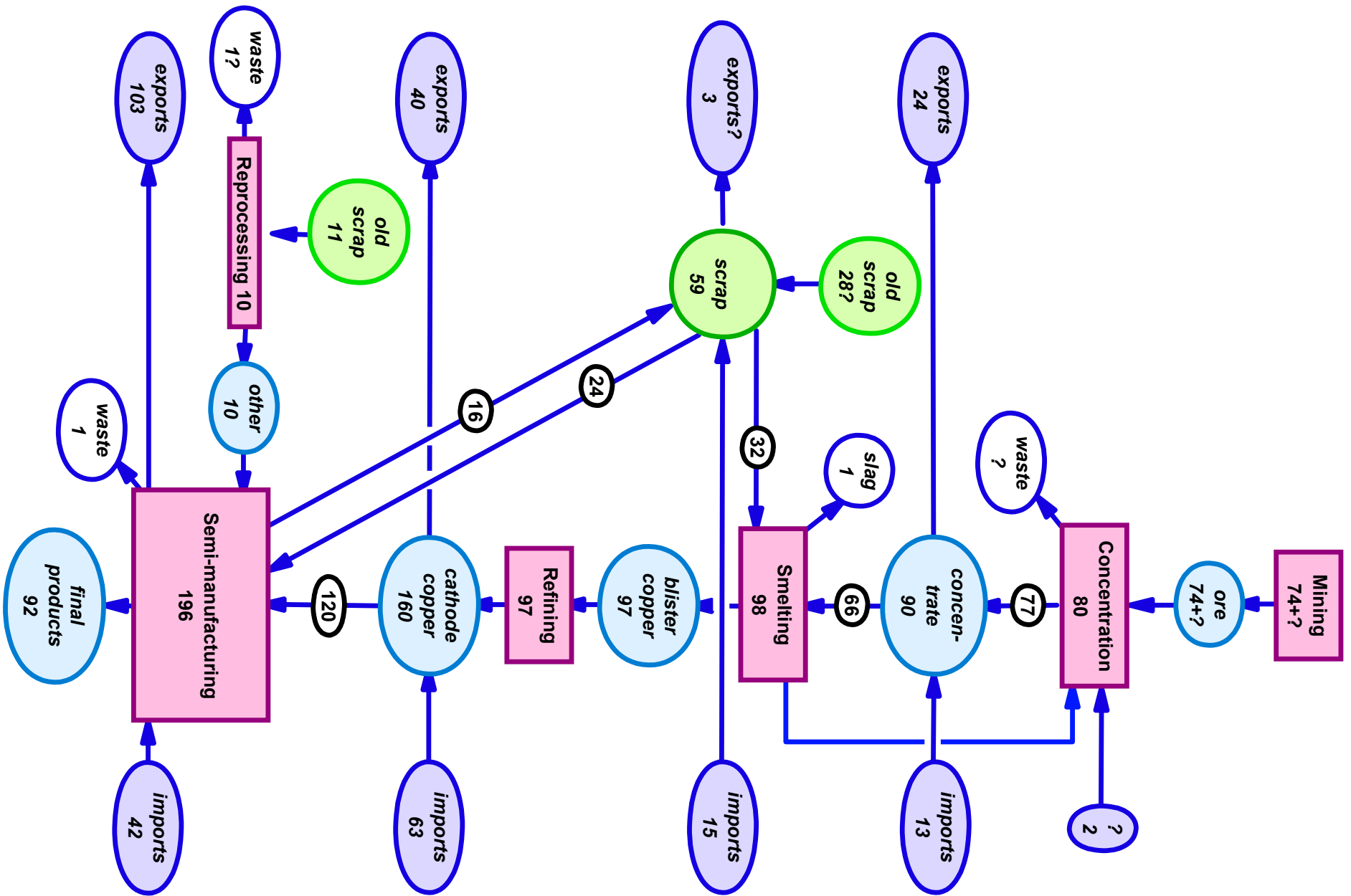
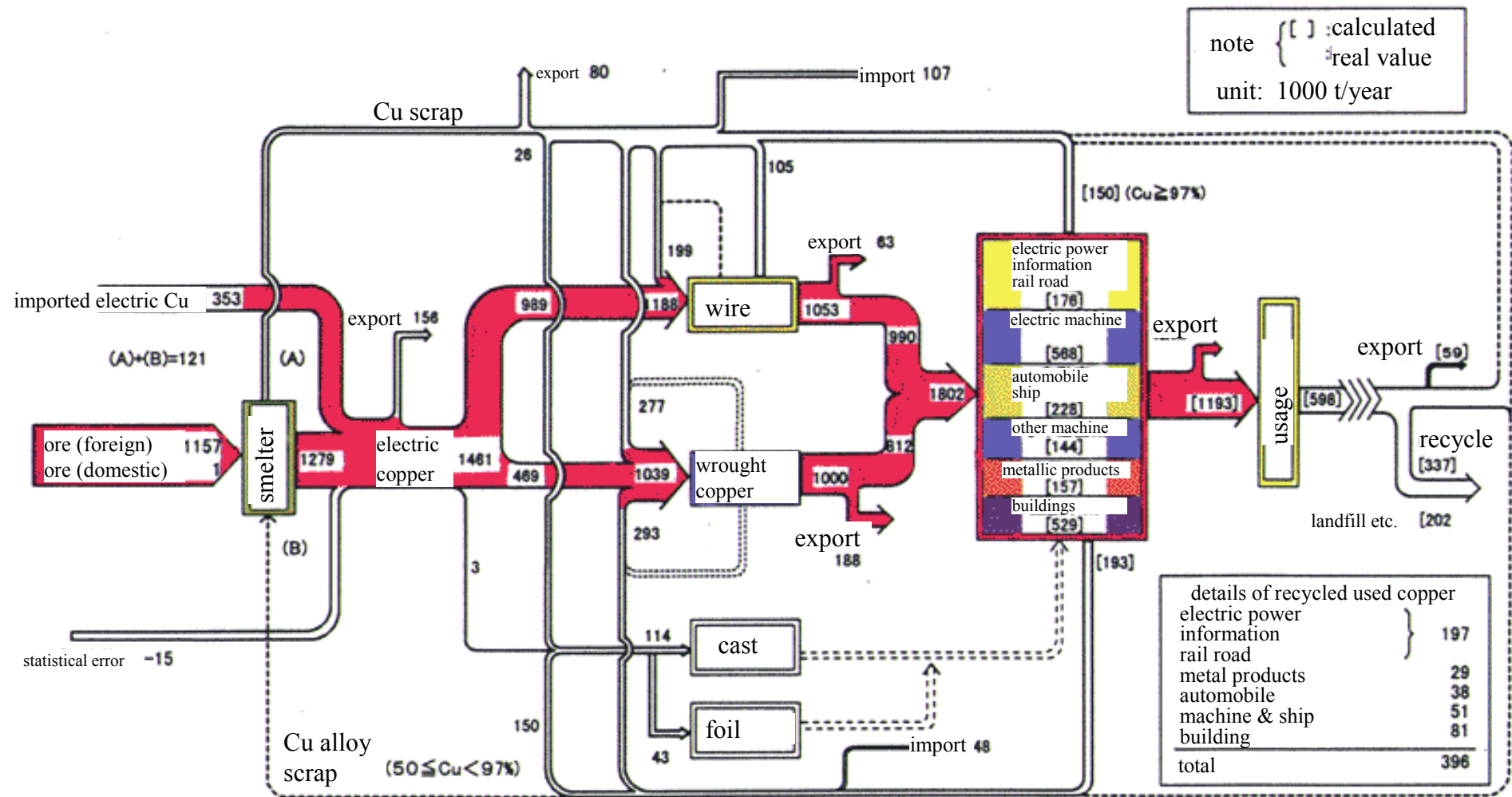


Figure 3.3: A tentative copper bala

Figure 3.4: Copper balance for Japan 1997 (kMT/year)



flow data were estimated by Metal Keizai Kenkyusho

Halada's comment

dependency ratio on natural Cu ore = $(1157+1+353-156)/(1802-193-150+83+188)=78.3\%$
 contribution of total scrap = $100-78.3 = 21.7\%$ and that of used scrap = $337 / (1802-193-150+83+188)= 18.4\%$
 , while scrap ratio in Cu production = $(121+ 199+277+293+114+43+80+59)/(1053+1000+114+43+156)=50\%$

Figure 3.5: Price of copper on the New York market, 1870 - 2000
(cents per pound in current and constant 1987 US dollars)

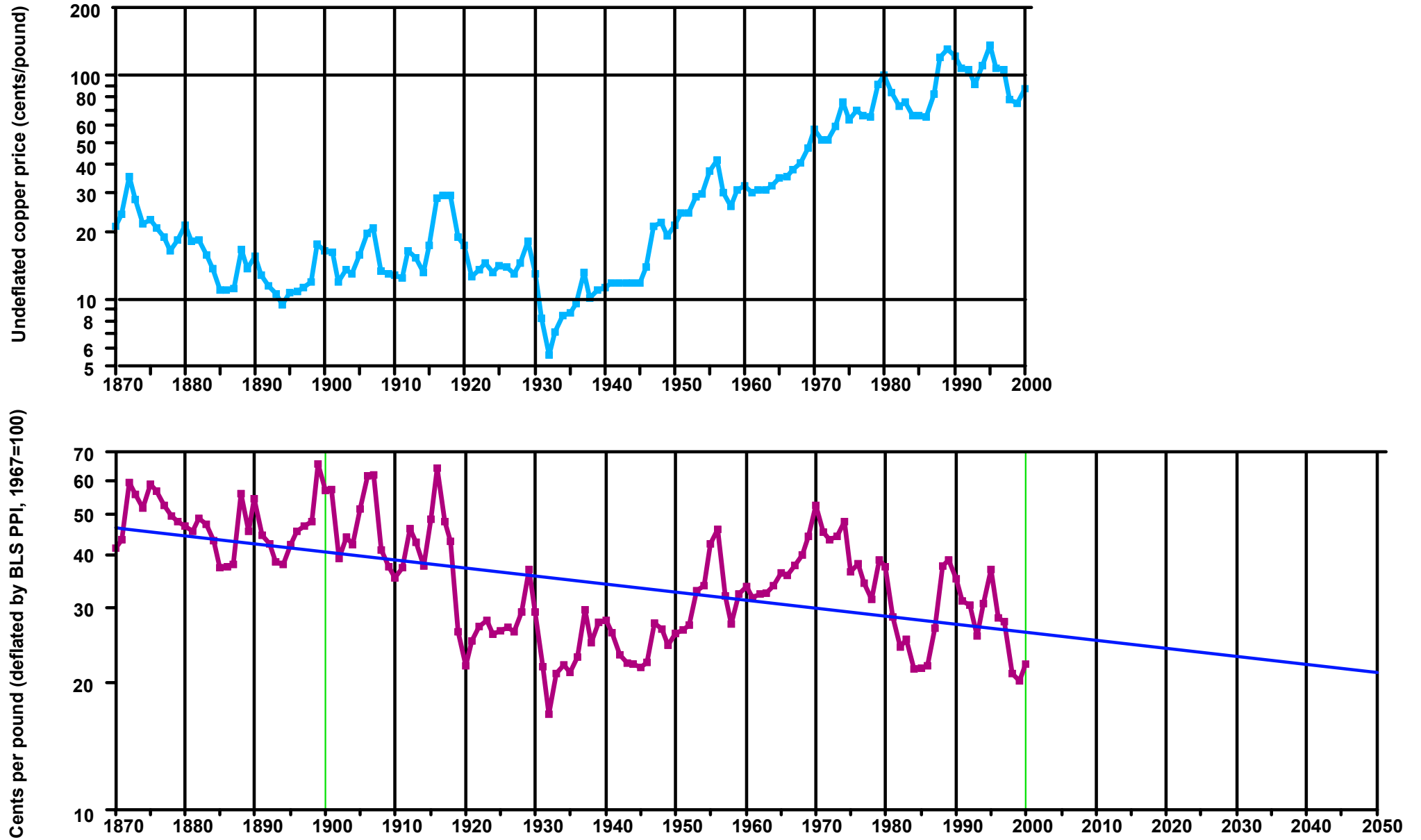
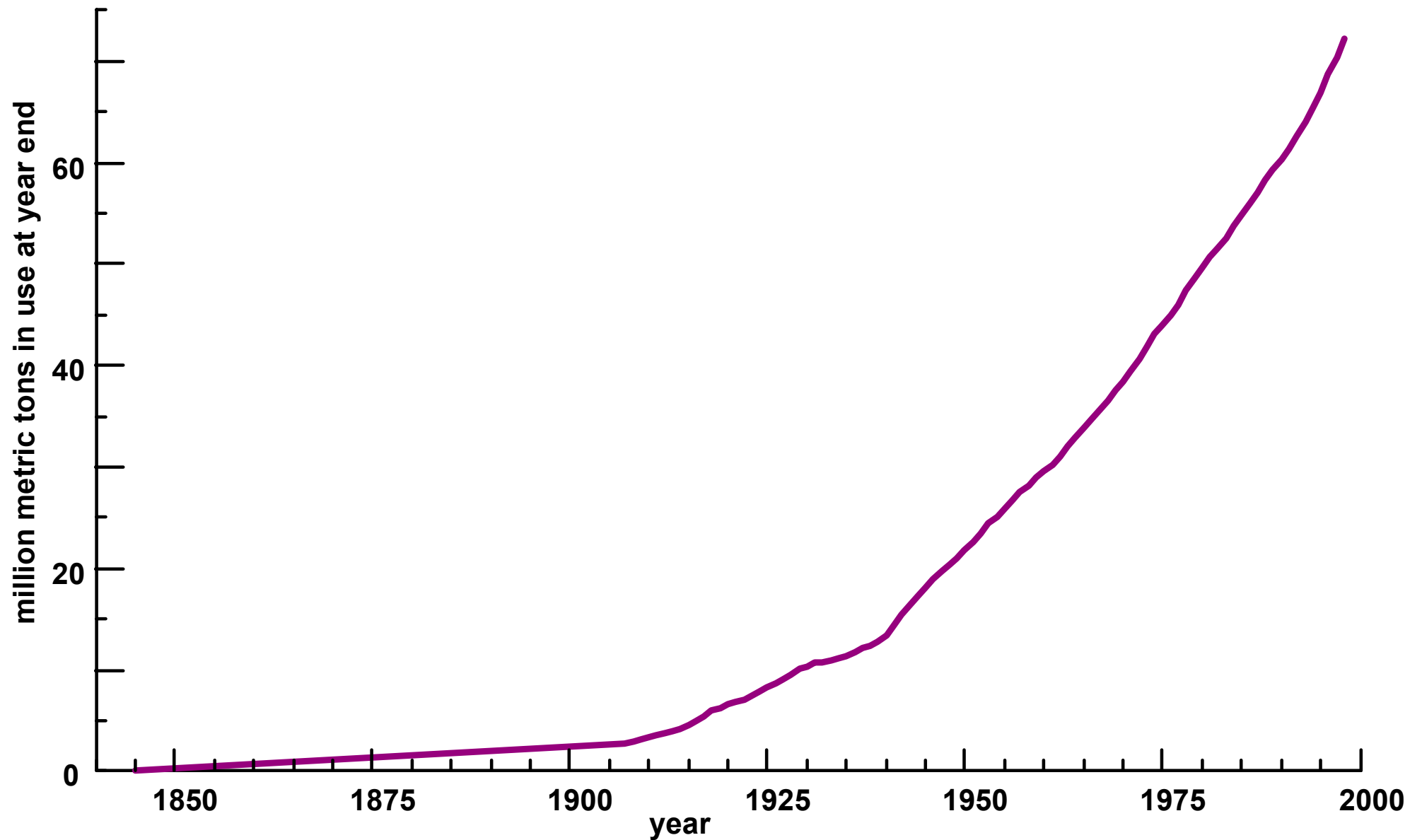
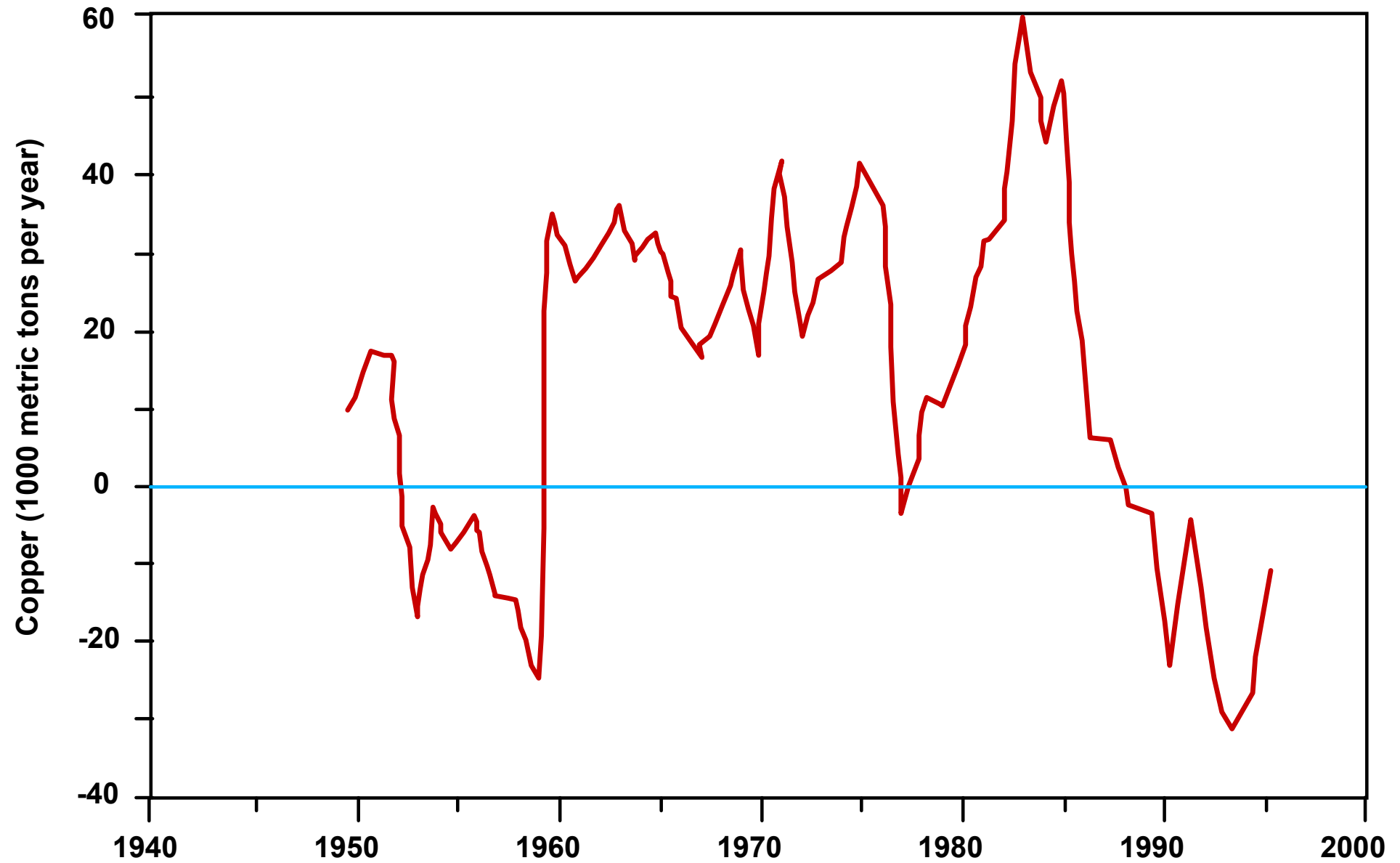


Figure 3.6: Estimated accumulation of copper-in-use in USA, 1845 - 1998



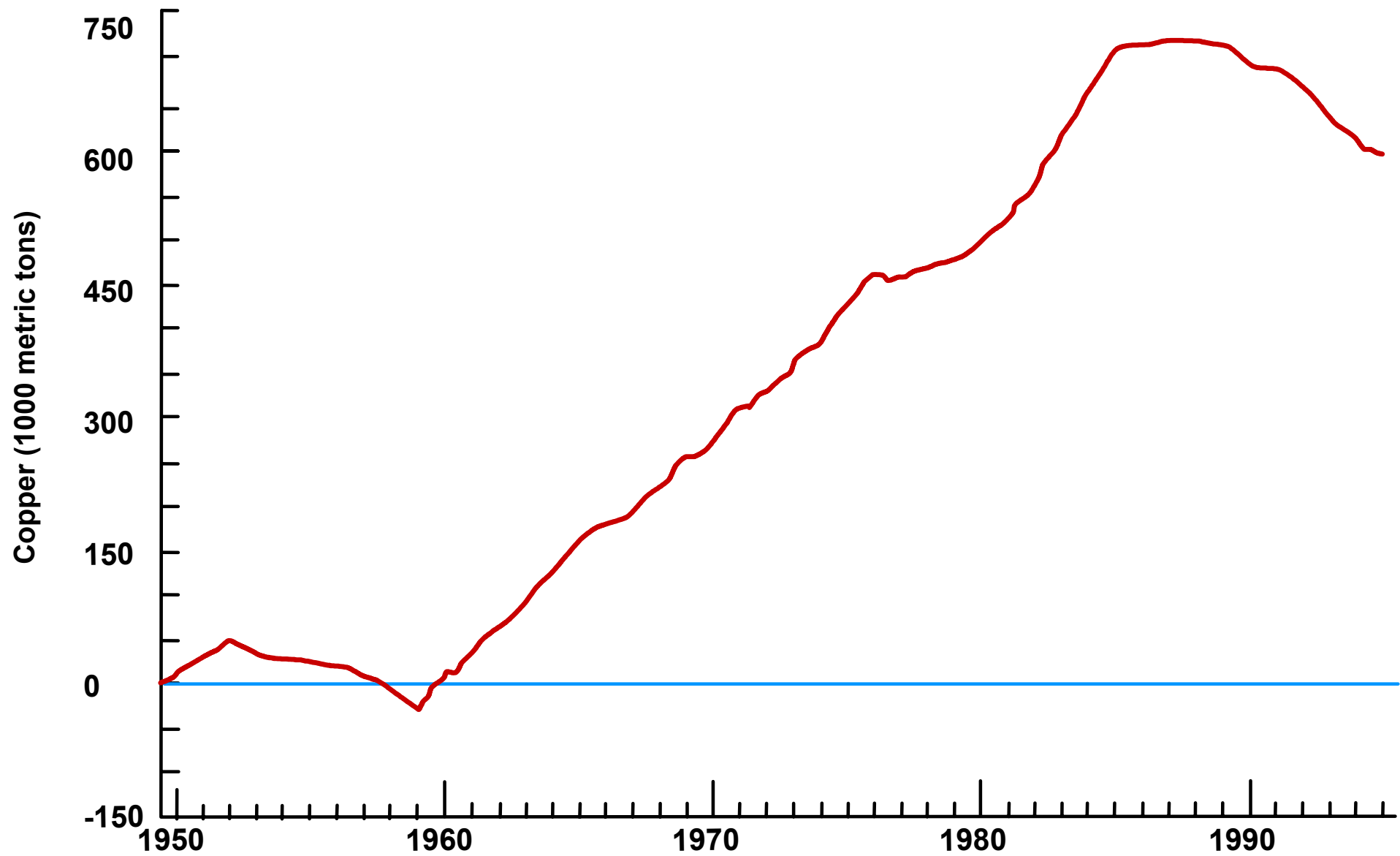
Sources: McMahon 1964, Historical Statistics, and Minerals Yearbooks

Figure 3.7: Annual change in the copper store in the Swedish technosphere: 1950 - 1995



Source: Landner & Lindström 1999, Figure 5.6

Figure 3.8: Cumulative evolution of the copper reservoir in the Swedish technosphere (1950 base)



Source: Landner & Lindström 1999, Figure 4.6

Figure 3.9: World copper production and the US manufacturing production index, 1880 - 1998 with projections to 2050

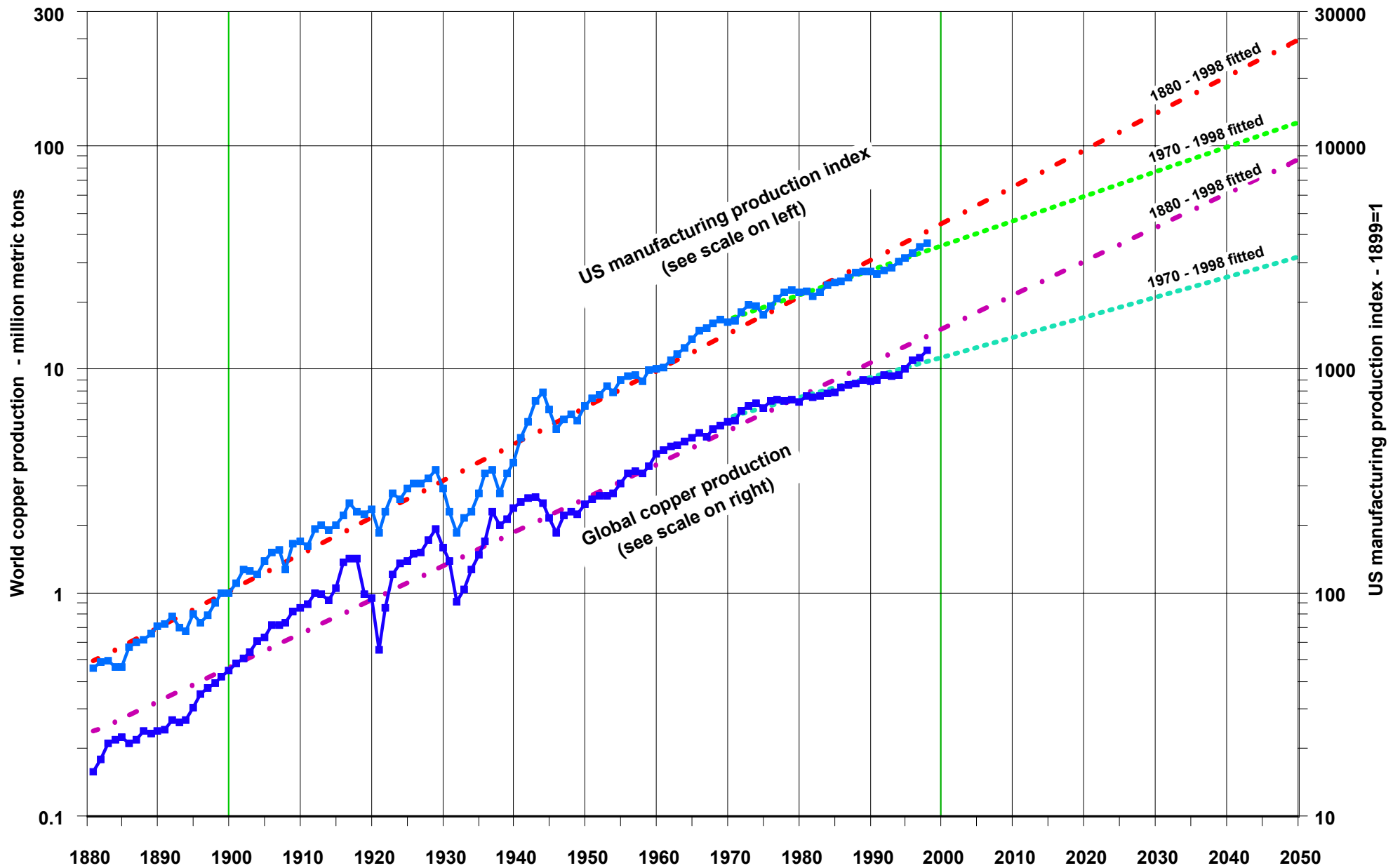


Figure 3.10: Historical and modeled Intensity of Use (consumption of refined copper) as a function of GDP/capita in 1960-1997

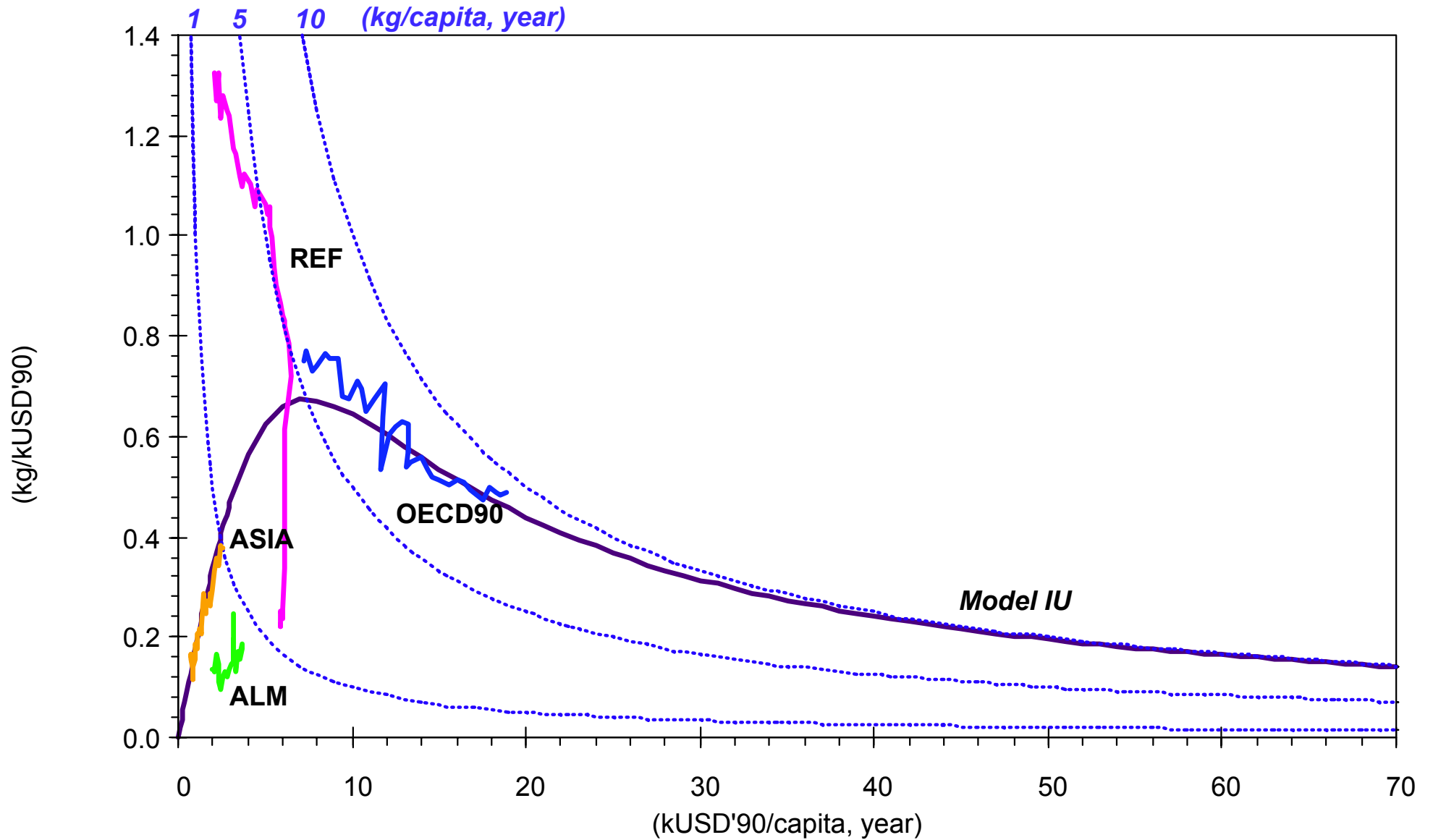


Figure 3.11: Model of the global copper system

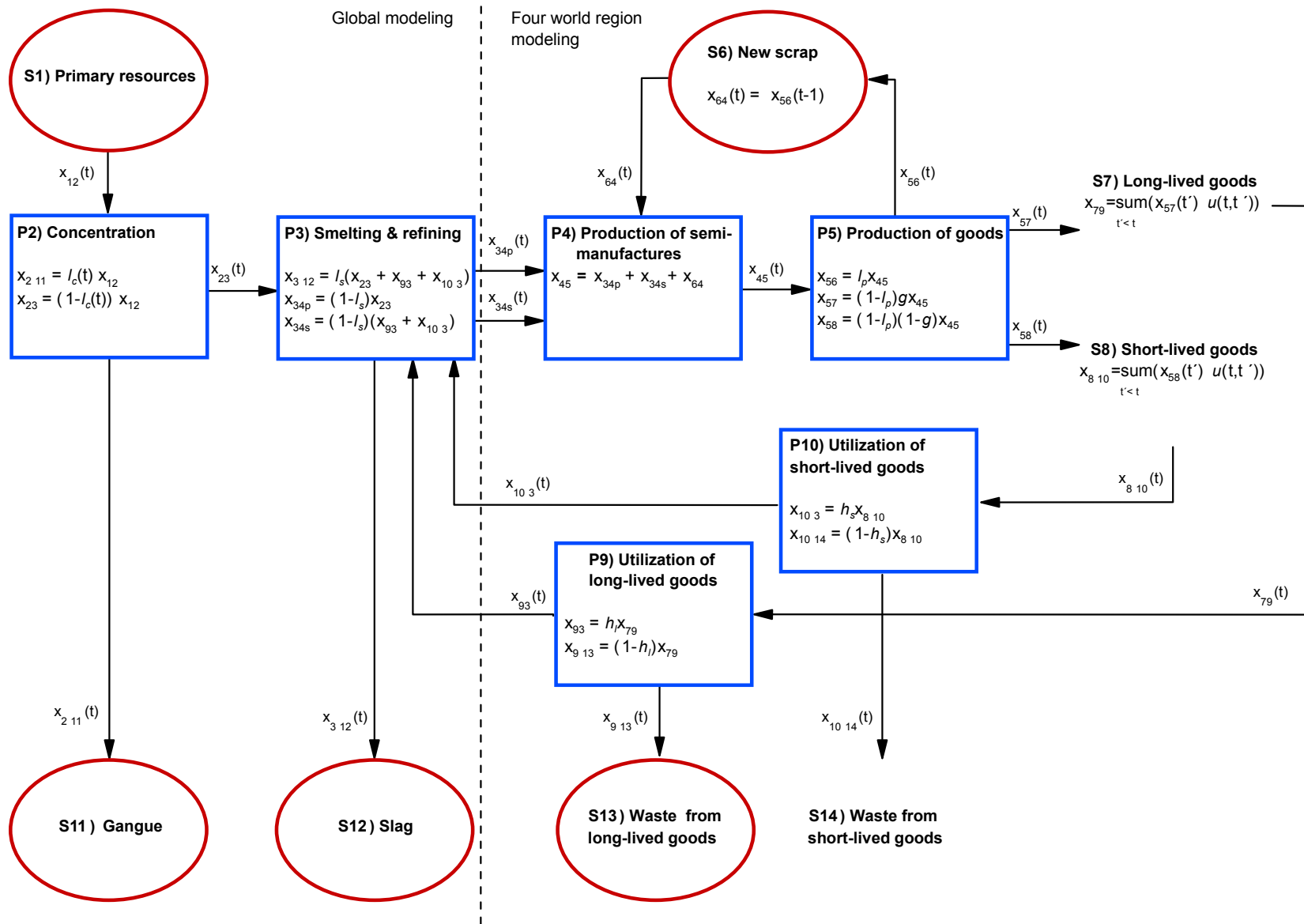


Figure 3.12: Global copper recycling (separation) efficiency
8 scenarios

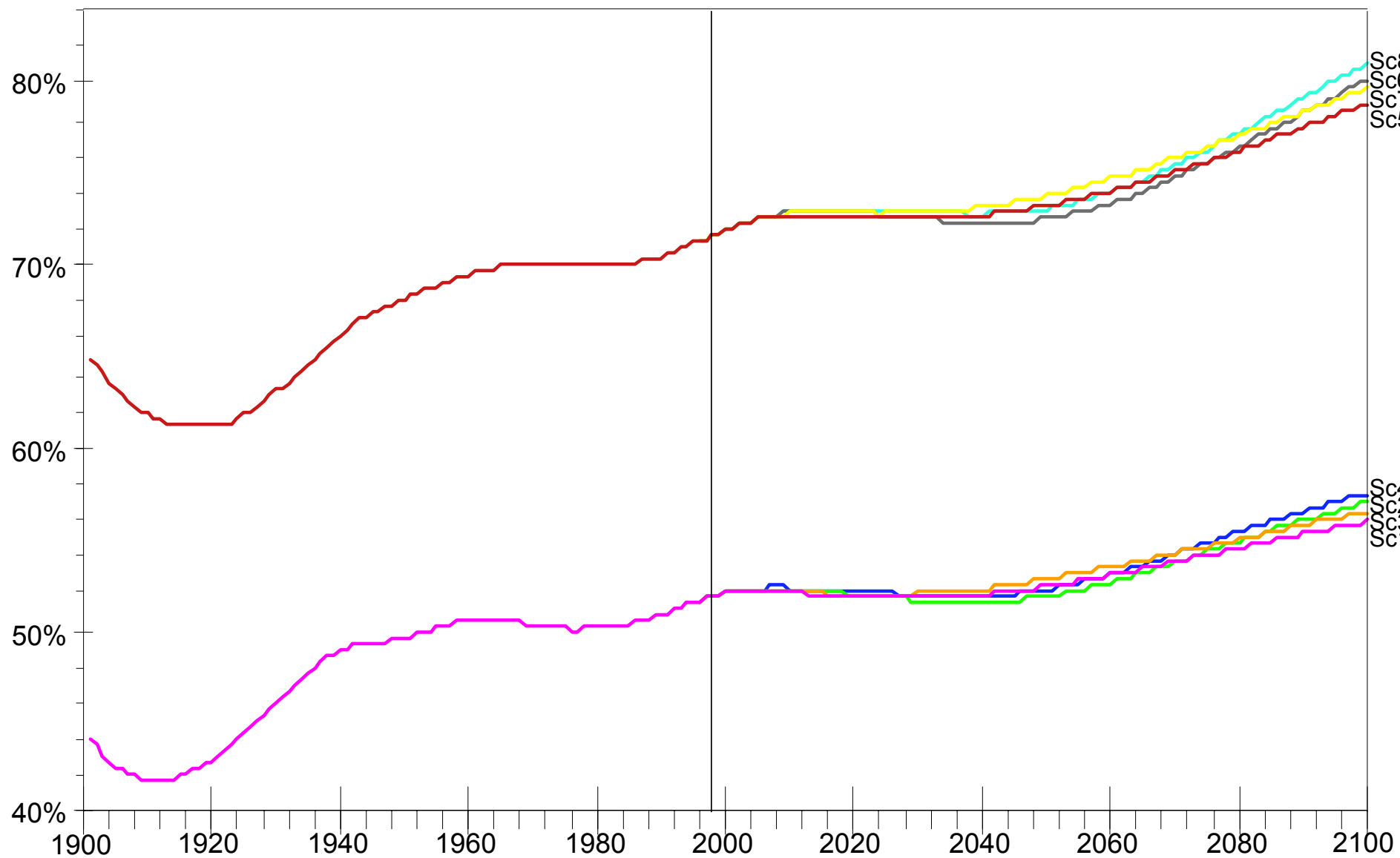


Figure 3.13: Global copper recycling rate

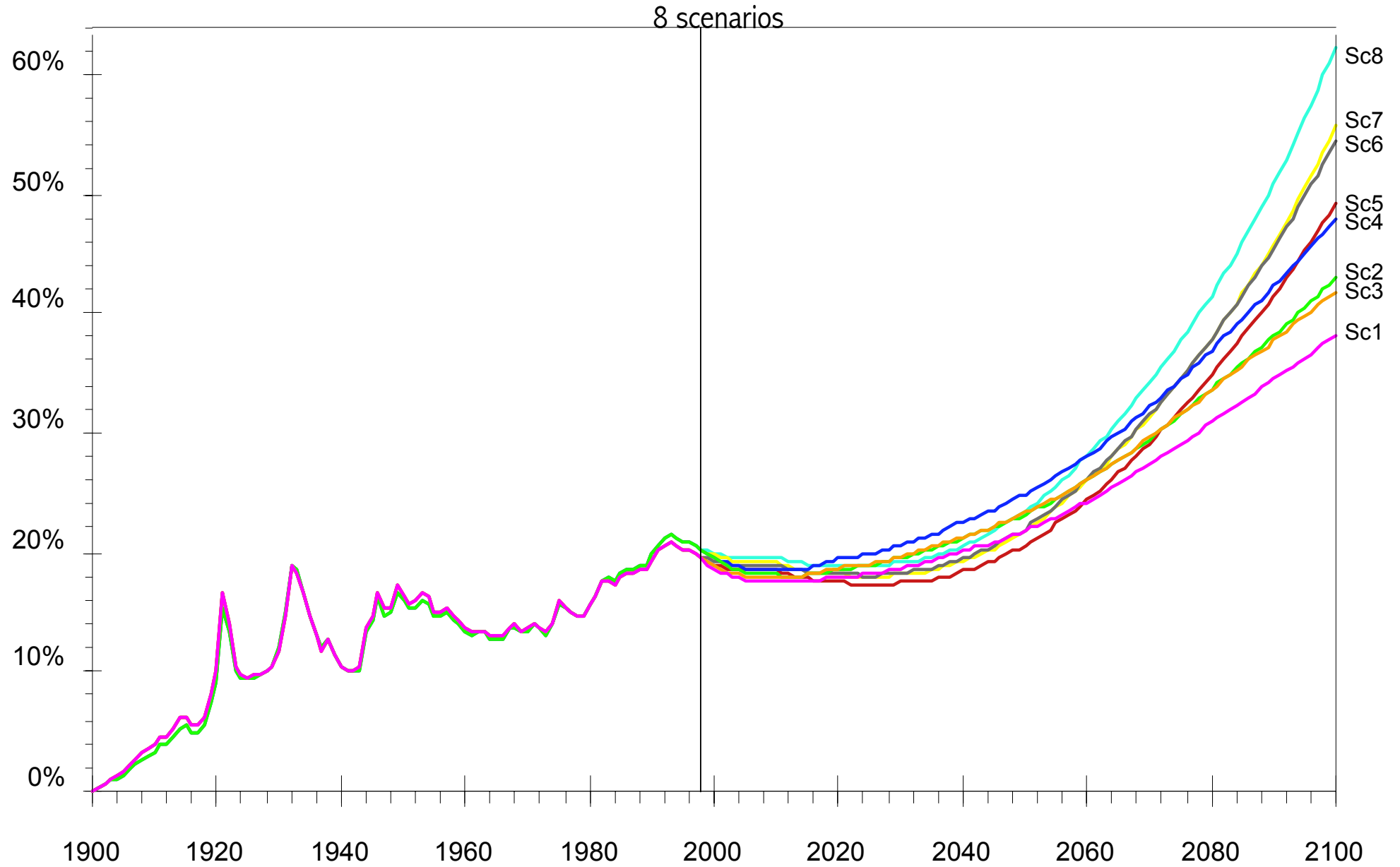


Figure 3.14: Global consumption of refined copper, scenarios 1 through 4 (low recycling efficiency)

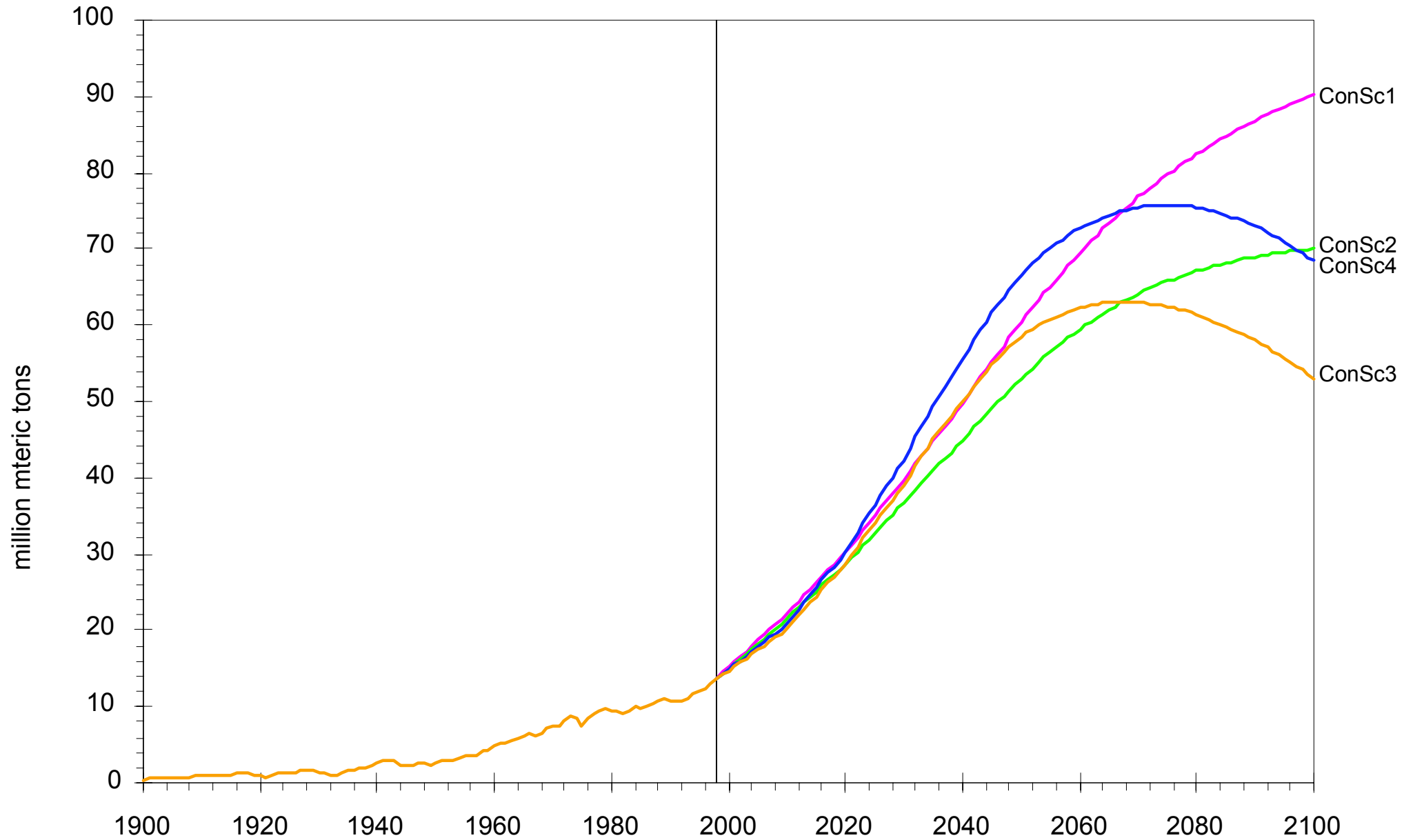


Figure 3.15: Regional consumption of refined copper; scenarios 1 and 5

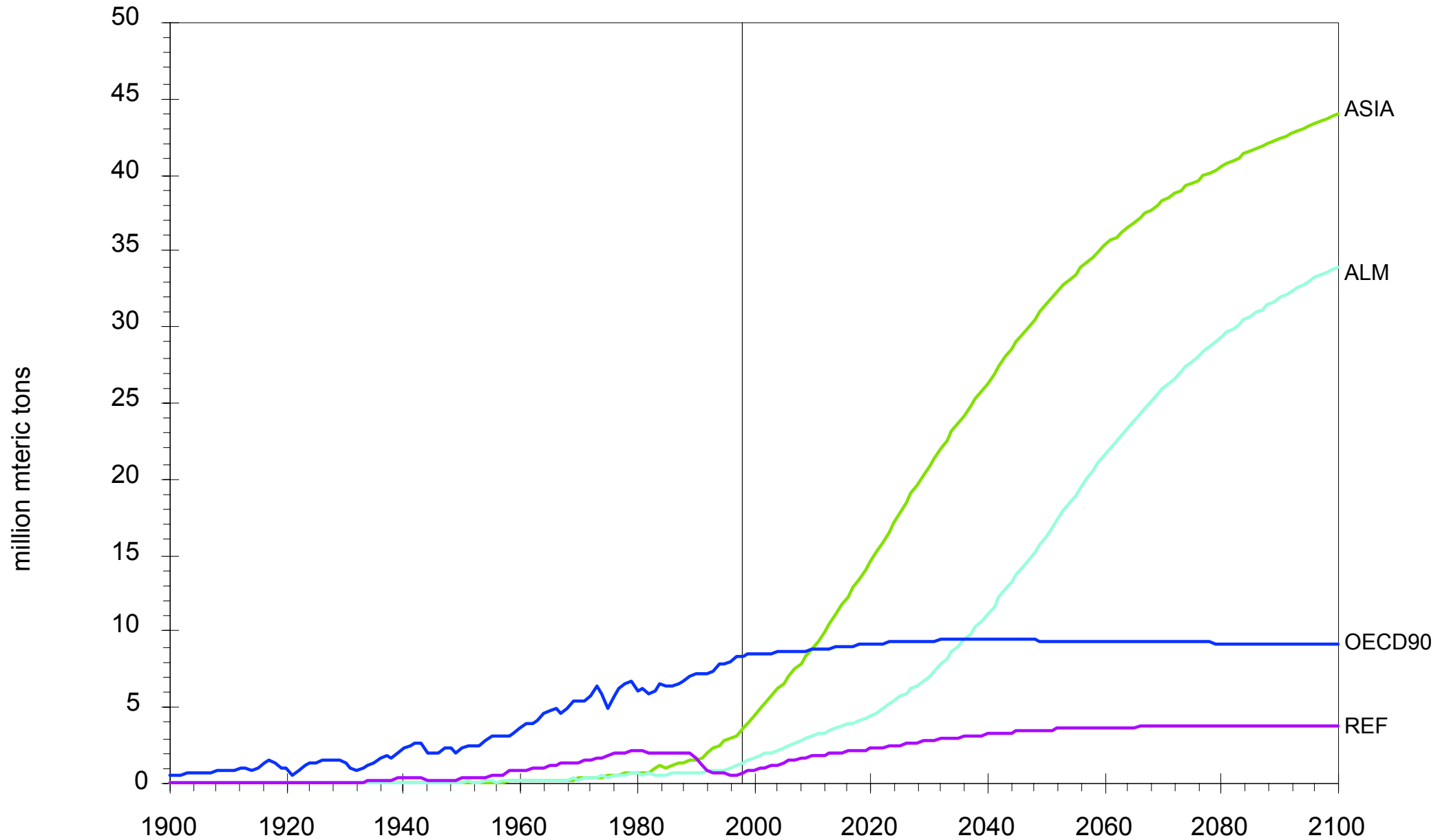


Figure 3.16: Regional consumption of refined copper; scenarios 3 and 7

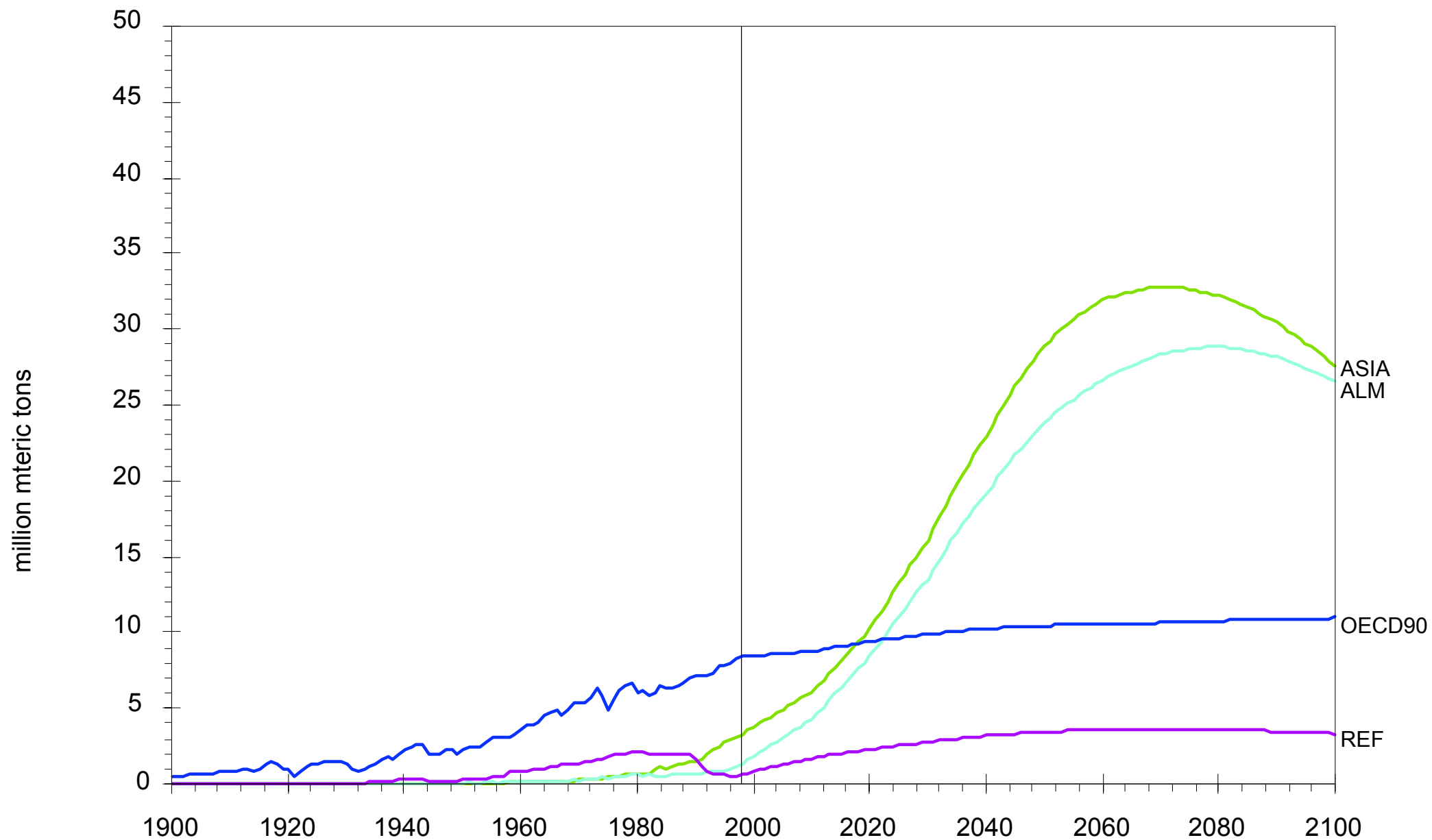


Figure 3.17: Regional consumption of refined copper; scenarios 2 and 6

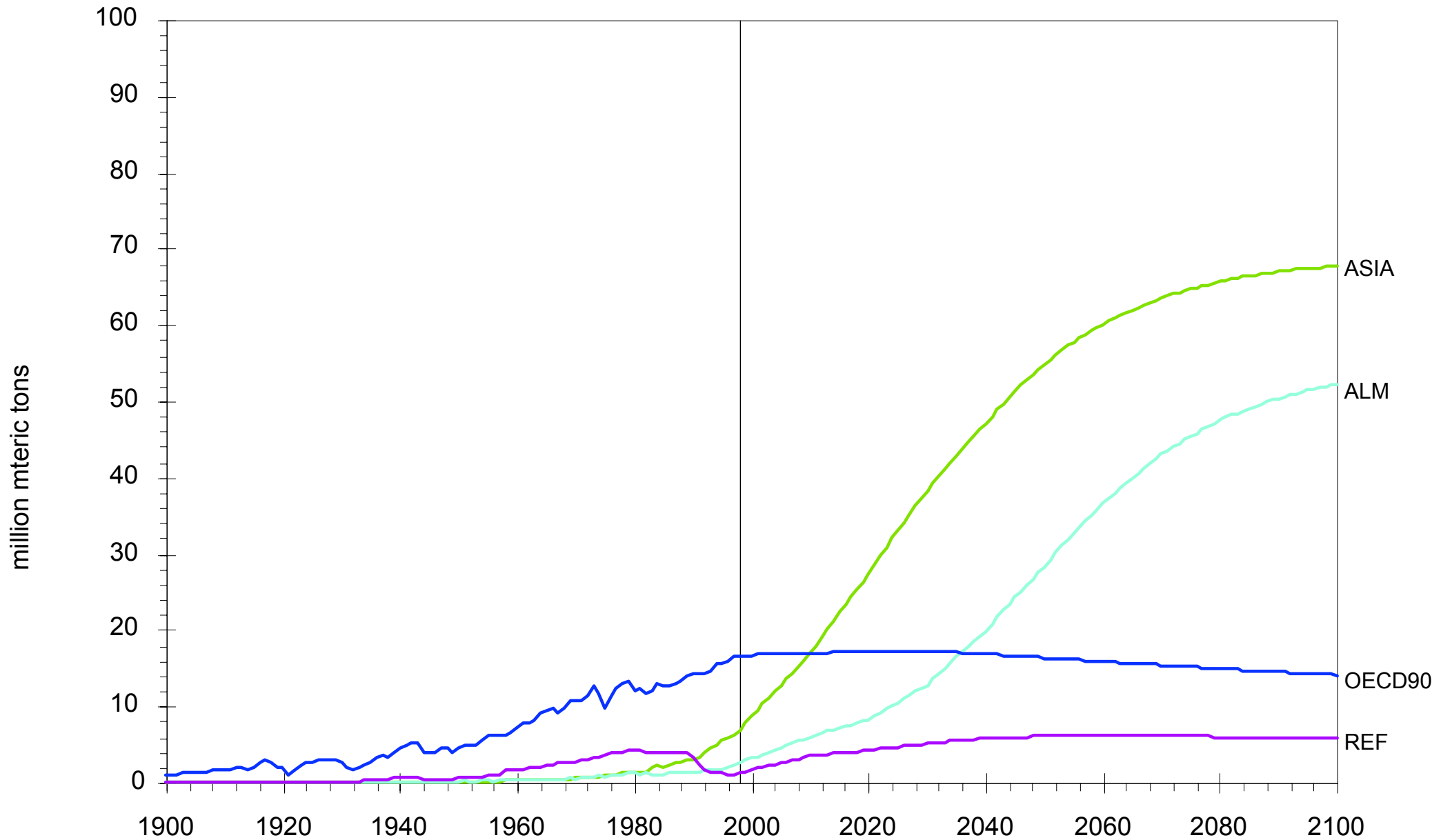


Figure 3.18: Regional consumption of refined copper; scenarios 4 and 8

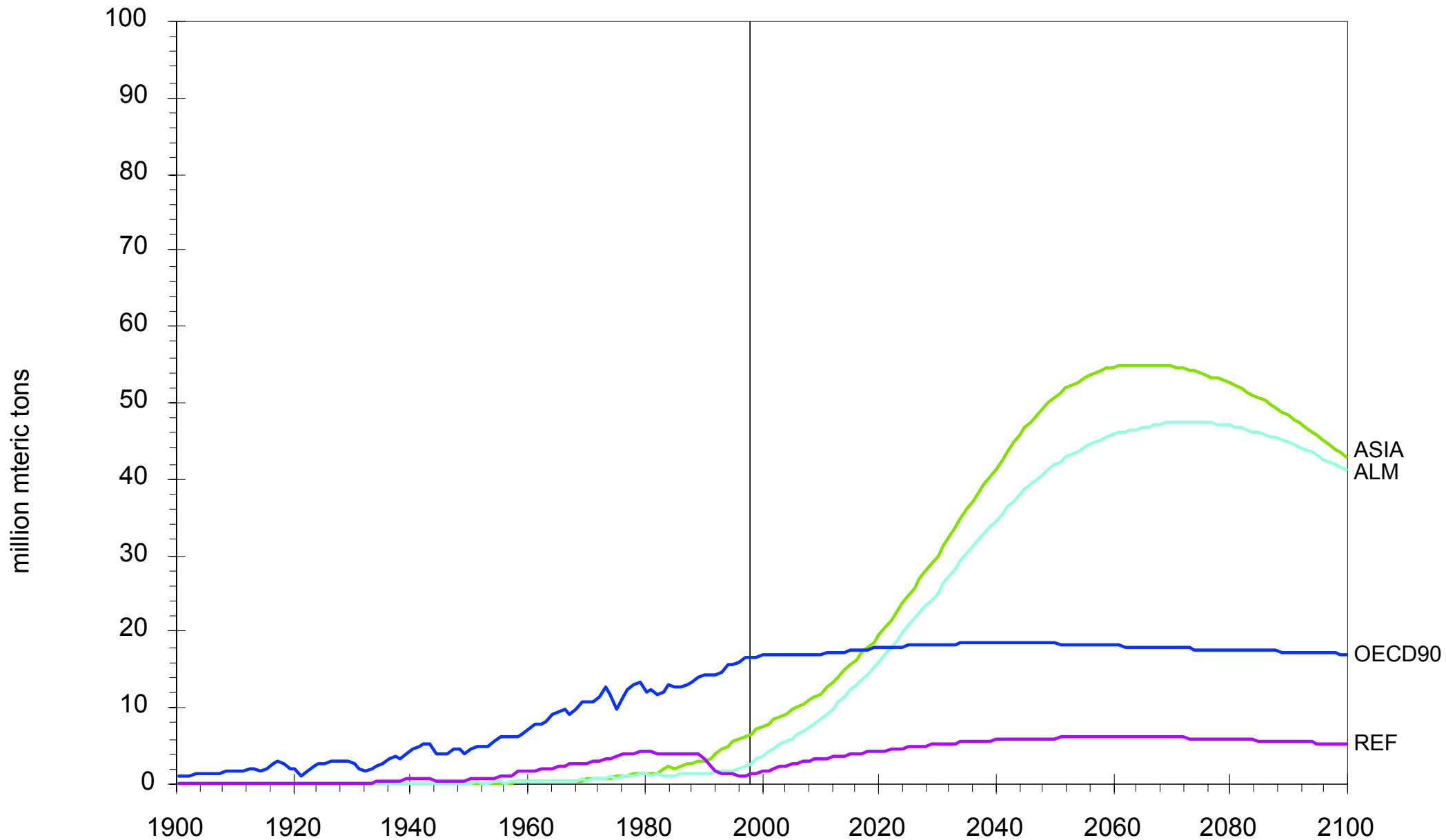


Figure 3.19: Global mine production of copper, 1900 - 1998, MMT
8 scenarios

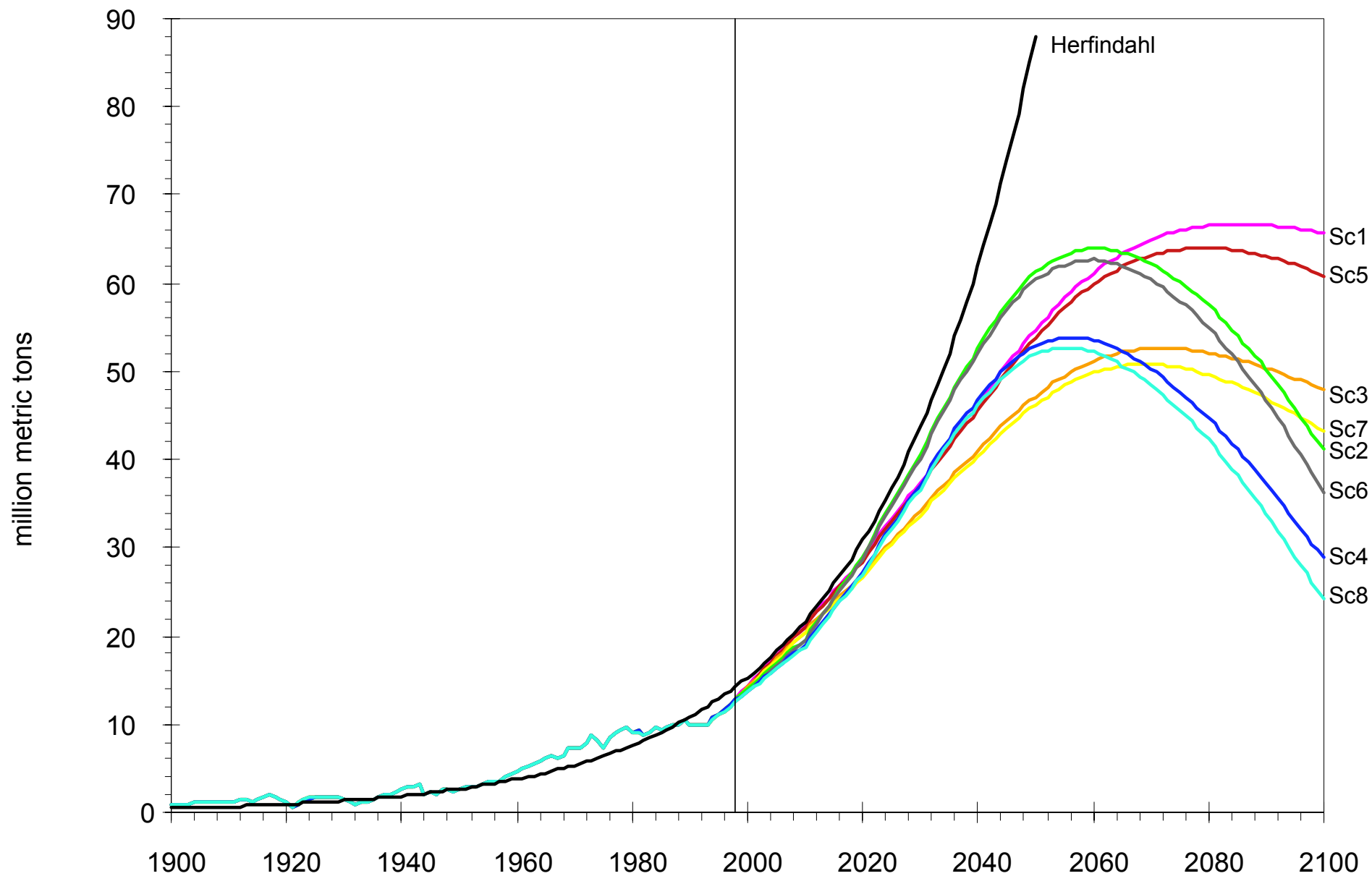


Figure 3.20: Cumulative global mine production of copper, 1900 - 1998, MMT

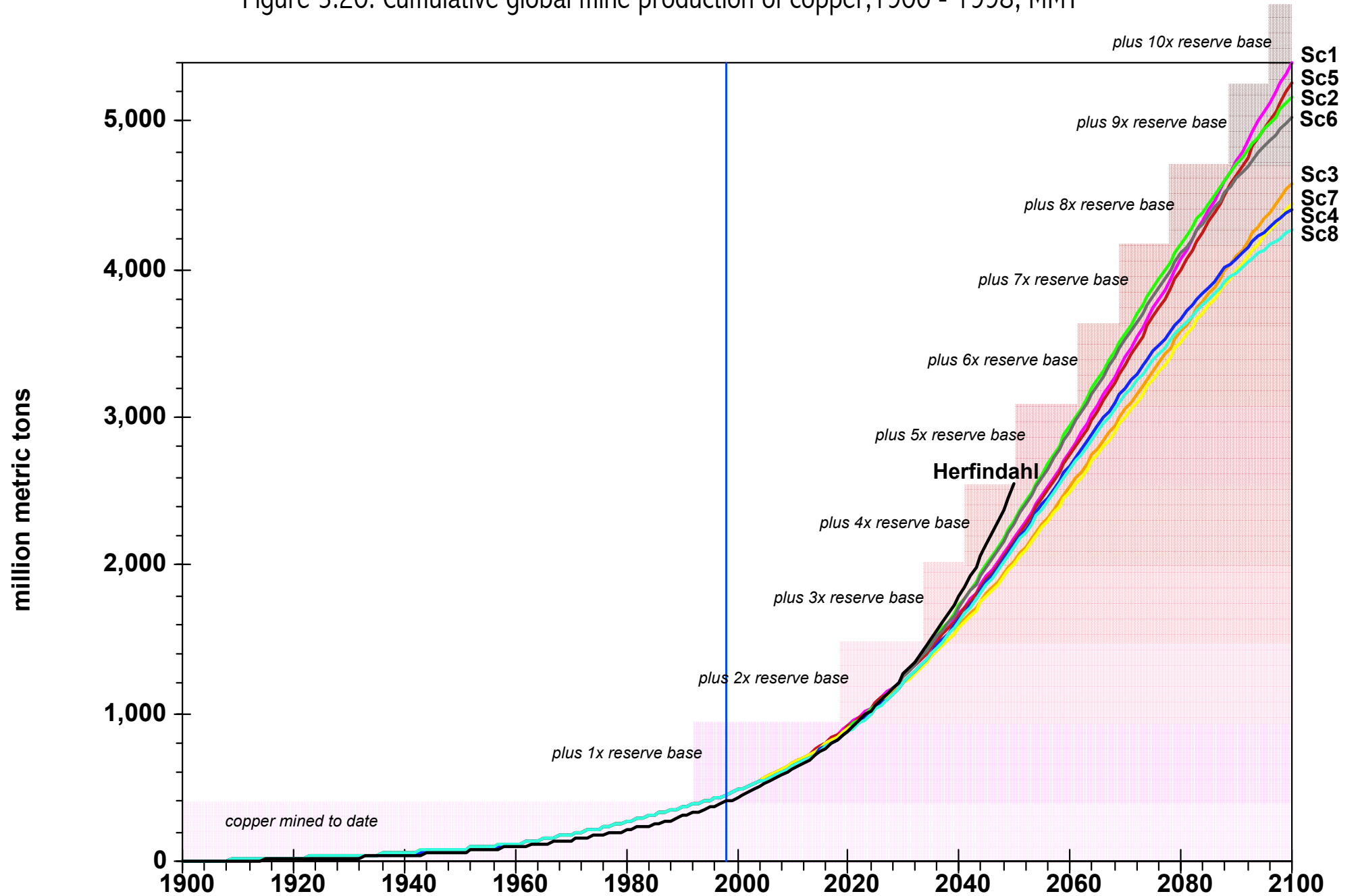


Figure 3.21: Global stock of waste copper, 1900 - 1998, MMT
8 scenarios

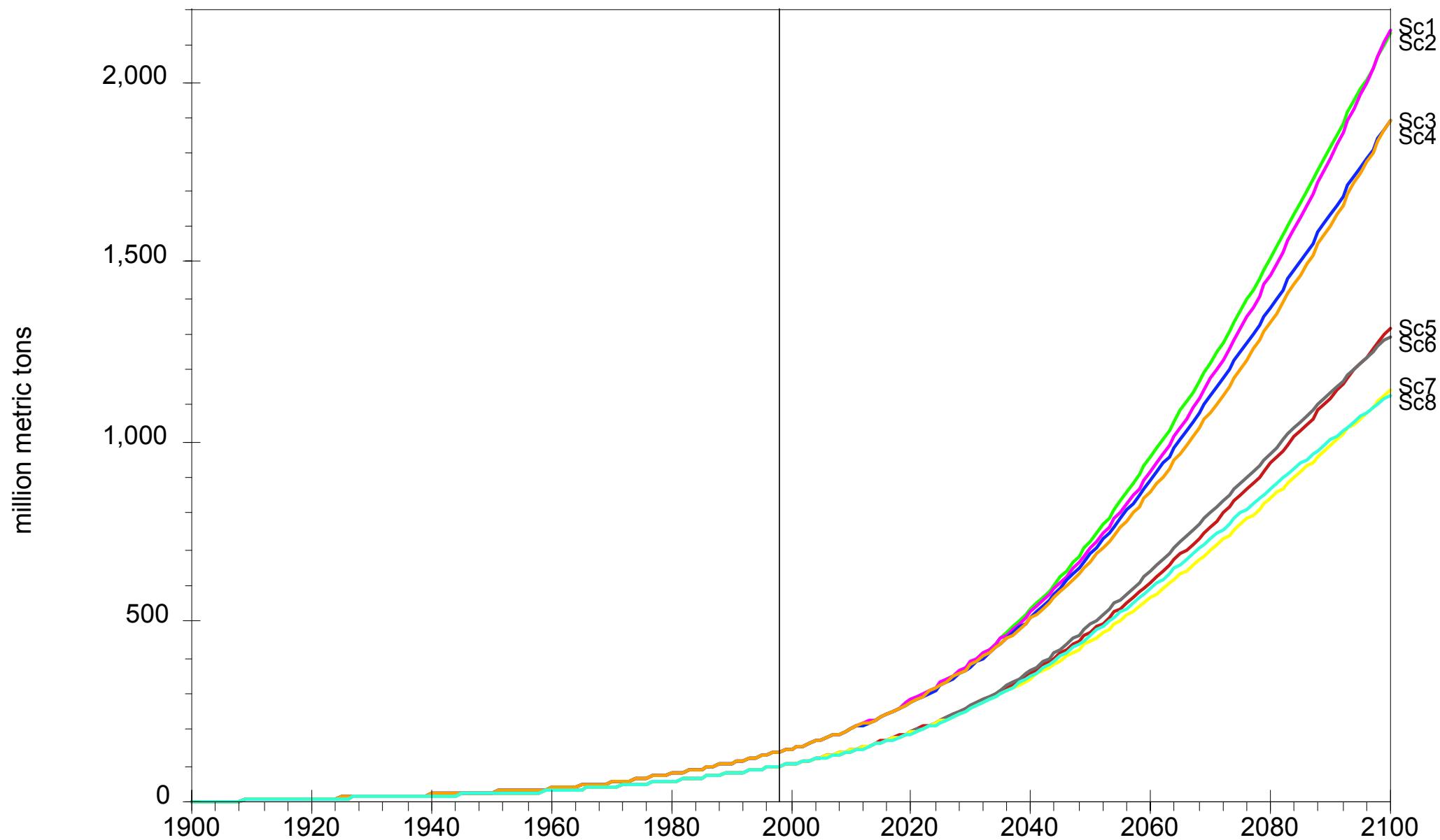


Figure 3.22: Global stock of long-lived copper products, 1900 - 1998, MMT
8 scenarios

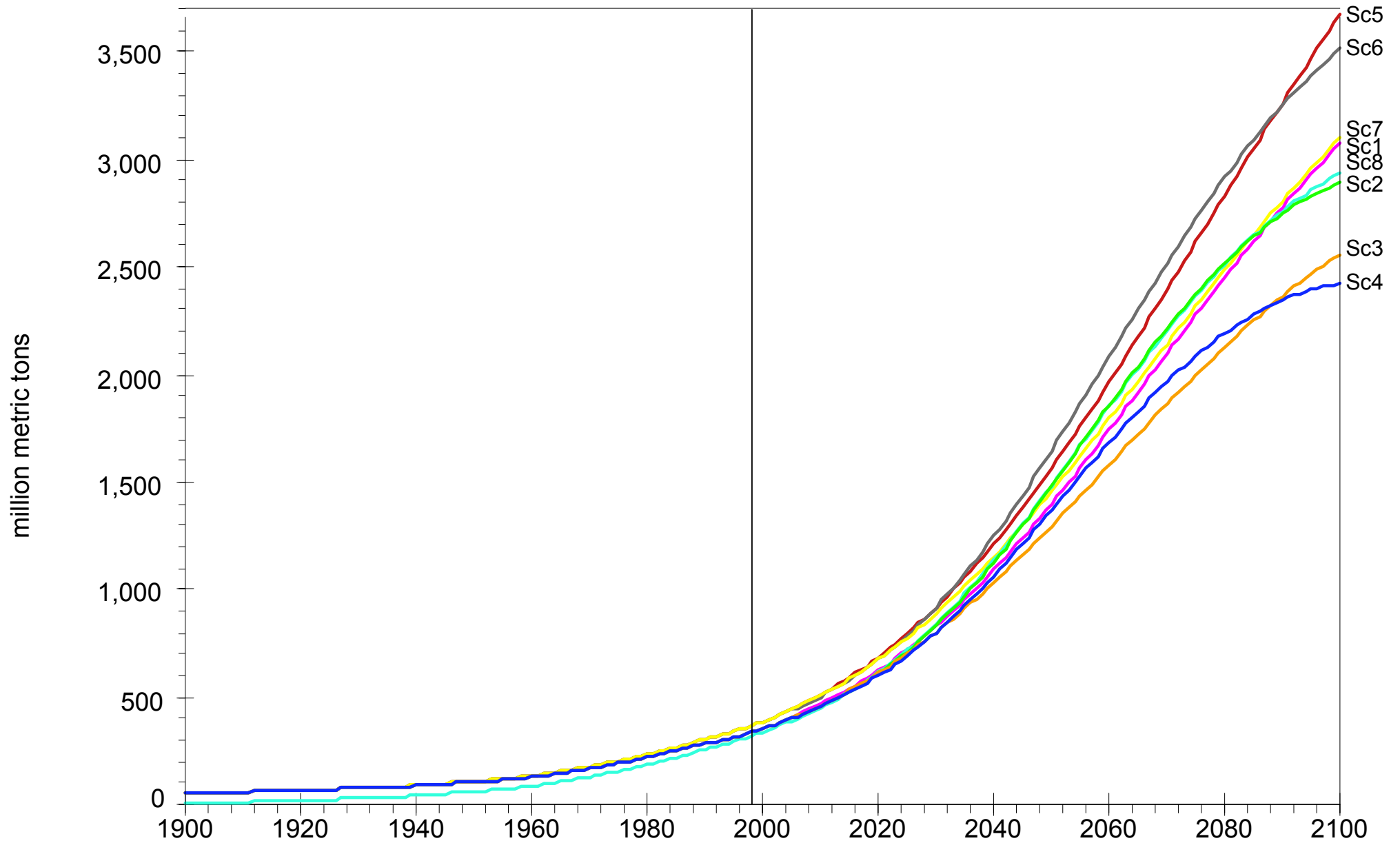


Figure 3.23: Global stock of short-lived copper products, 1900 - 1998, MMT
8 scenarios

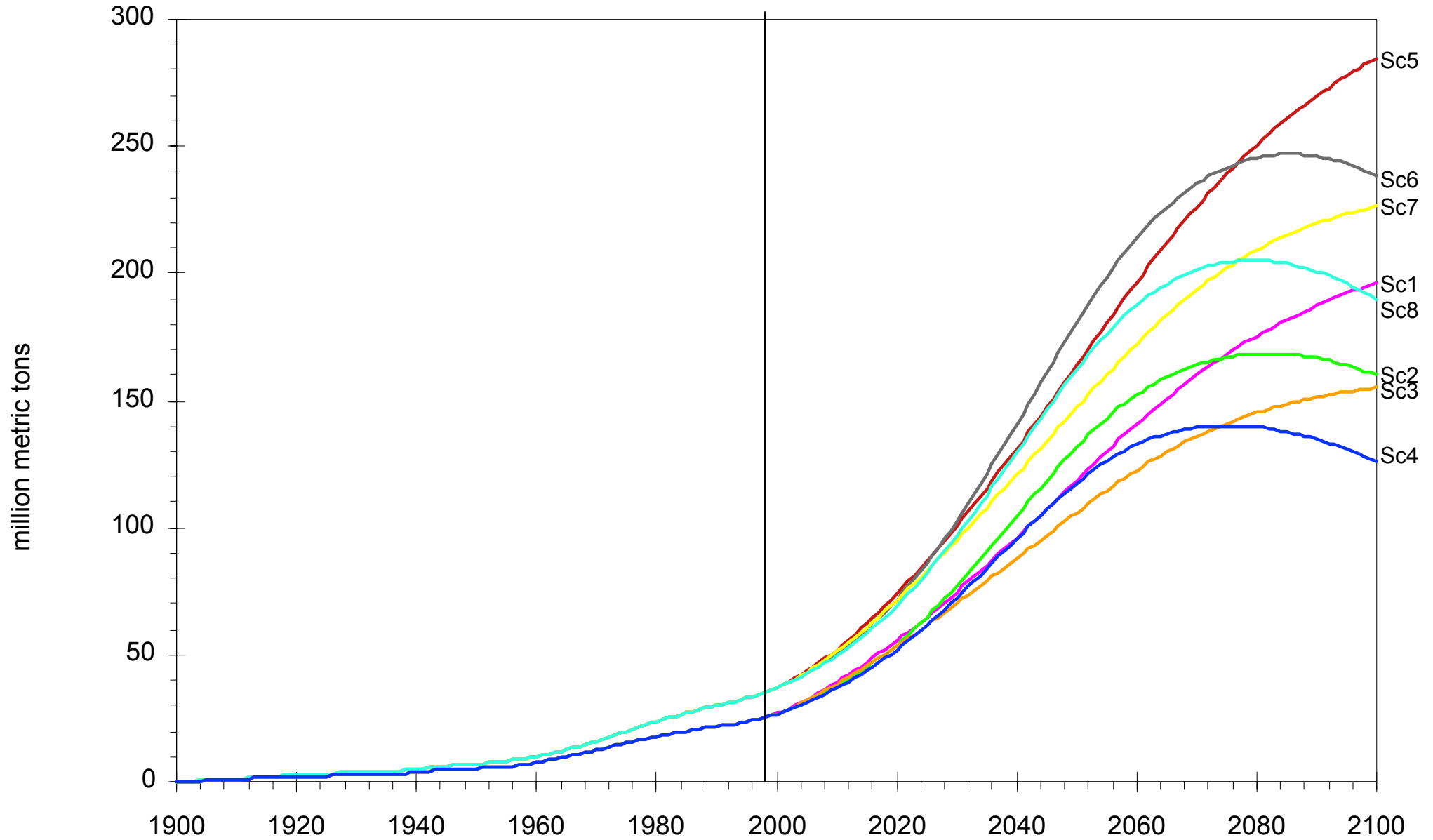
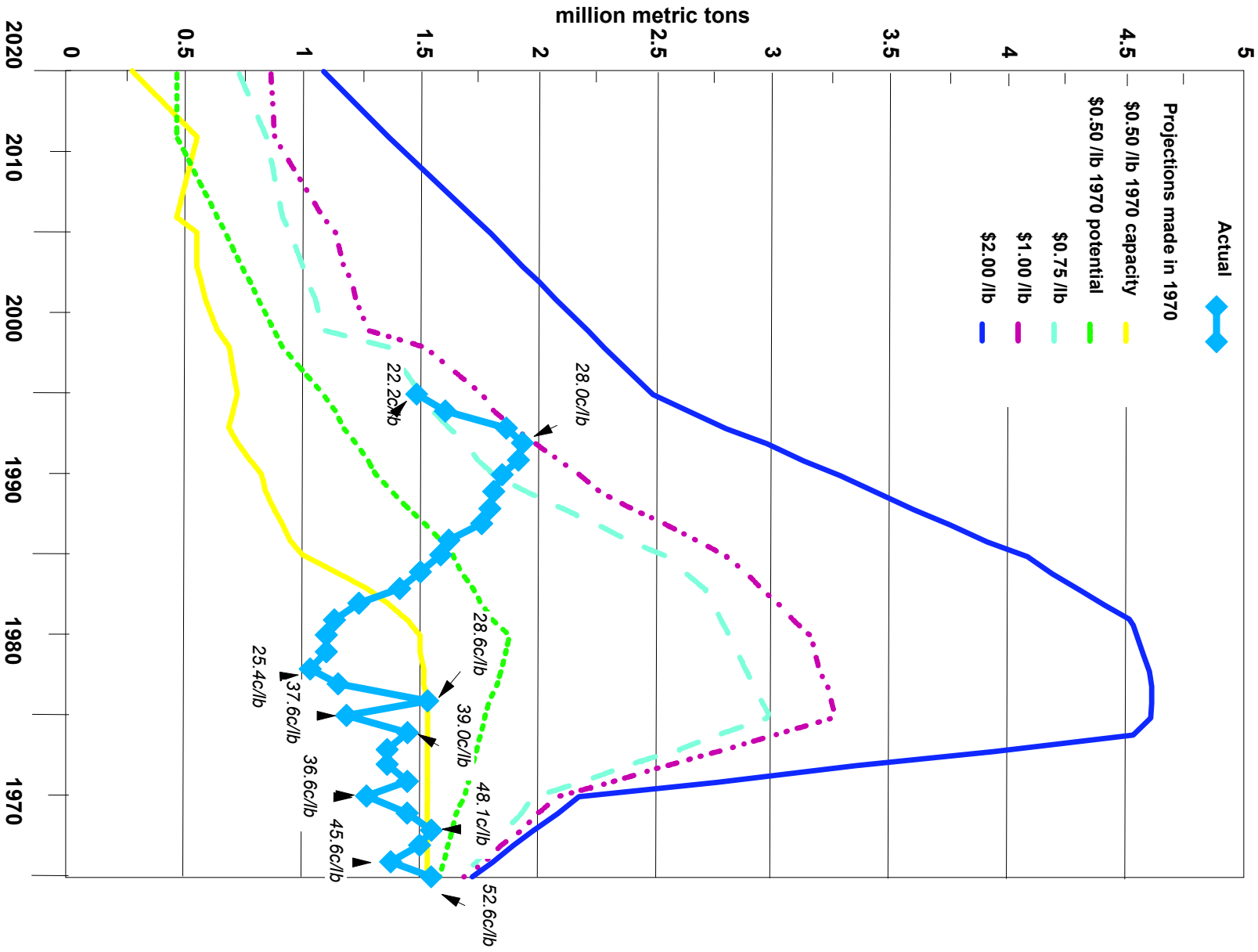


Figure 3.24: Actual and projected mine of copper for the US 1970 -2020



Sources: Actual [USGS Minerals Yearbooks]; Projections [COMRATE 1975]
Dollar values in constant 1967 dollars

Figure 4.1: Mass flows (kg) in the production of 1 MT lead (simplified processes, typical material mixes)

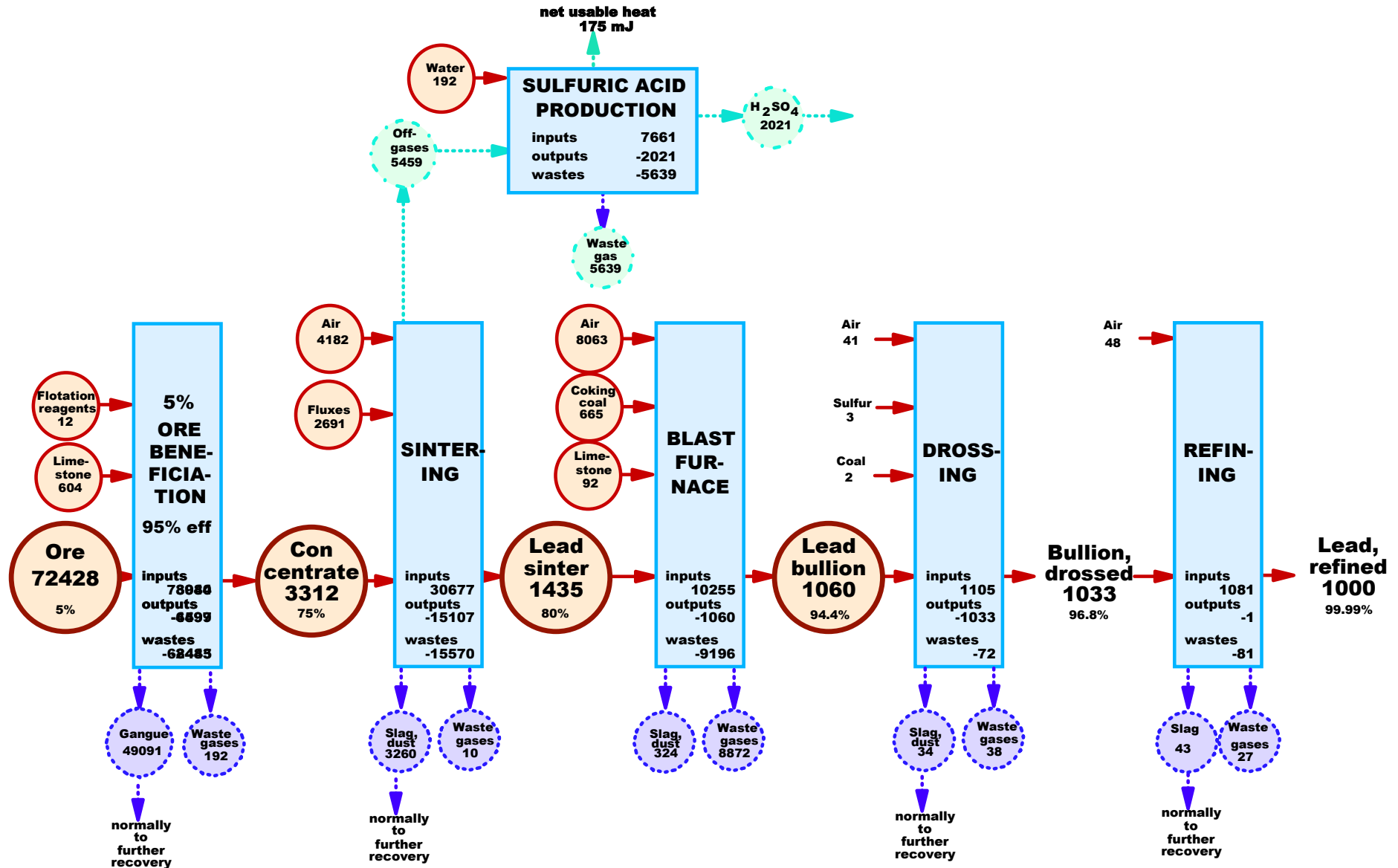


Figure 4.2: Exergy flows (mJ) in the production of 1 MT lead (simplified processes, typical material mixes)

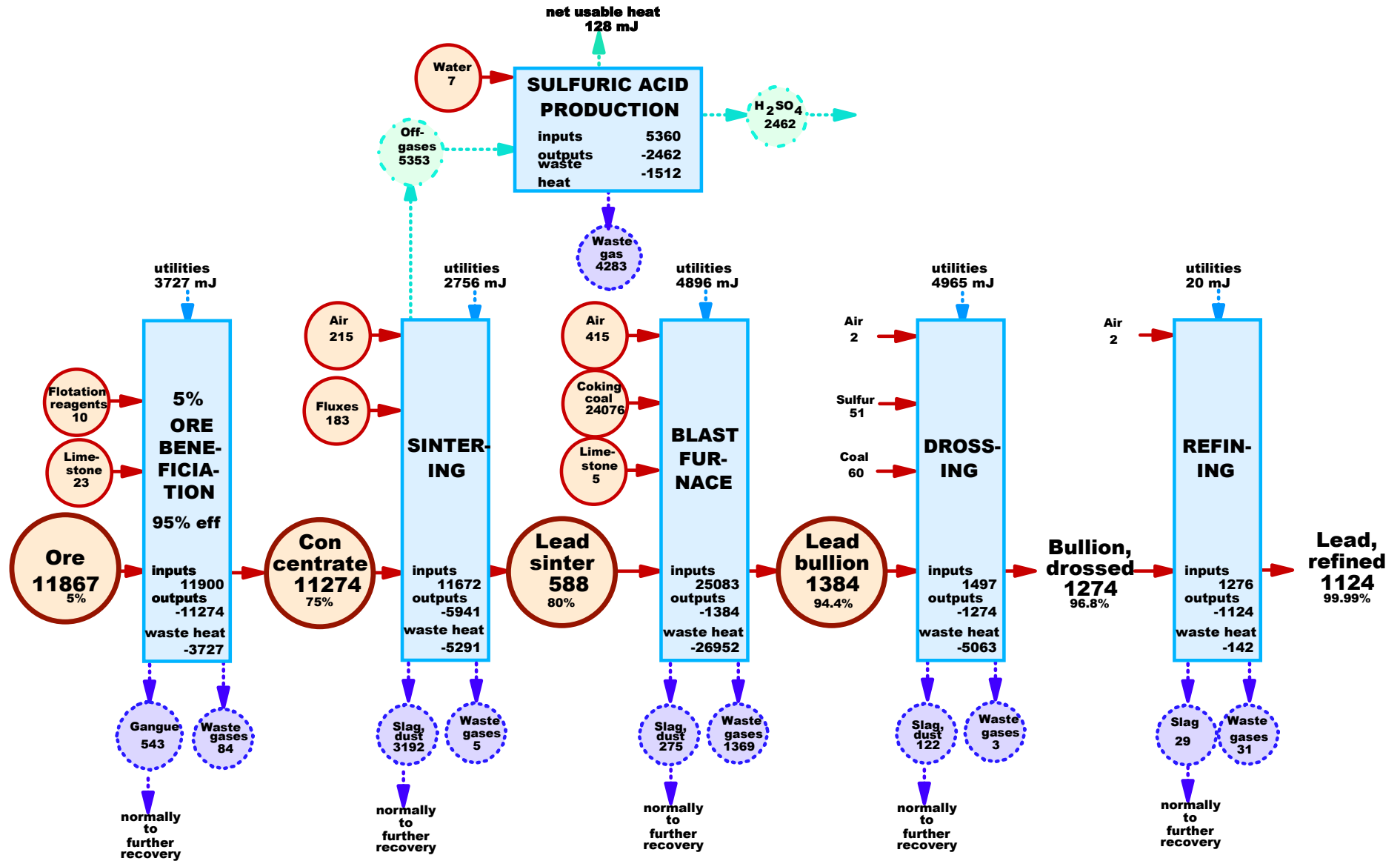


Figure 4.3: Primary lead unit mass and exergy flows

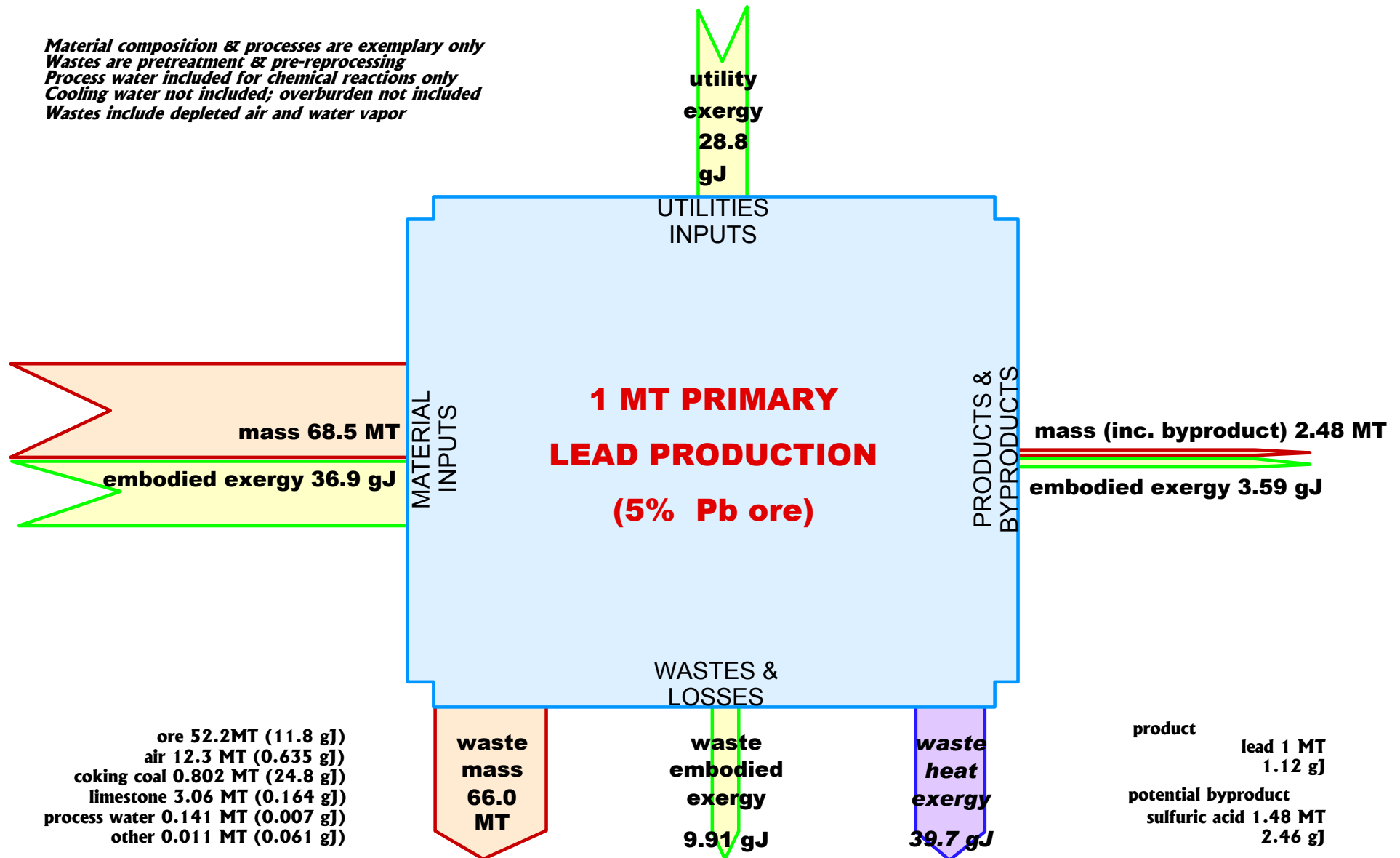


Figure 4.4: Mass flows (kg) in the production of 1 MT zinc (simplified processes, typical material mixes)

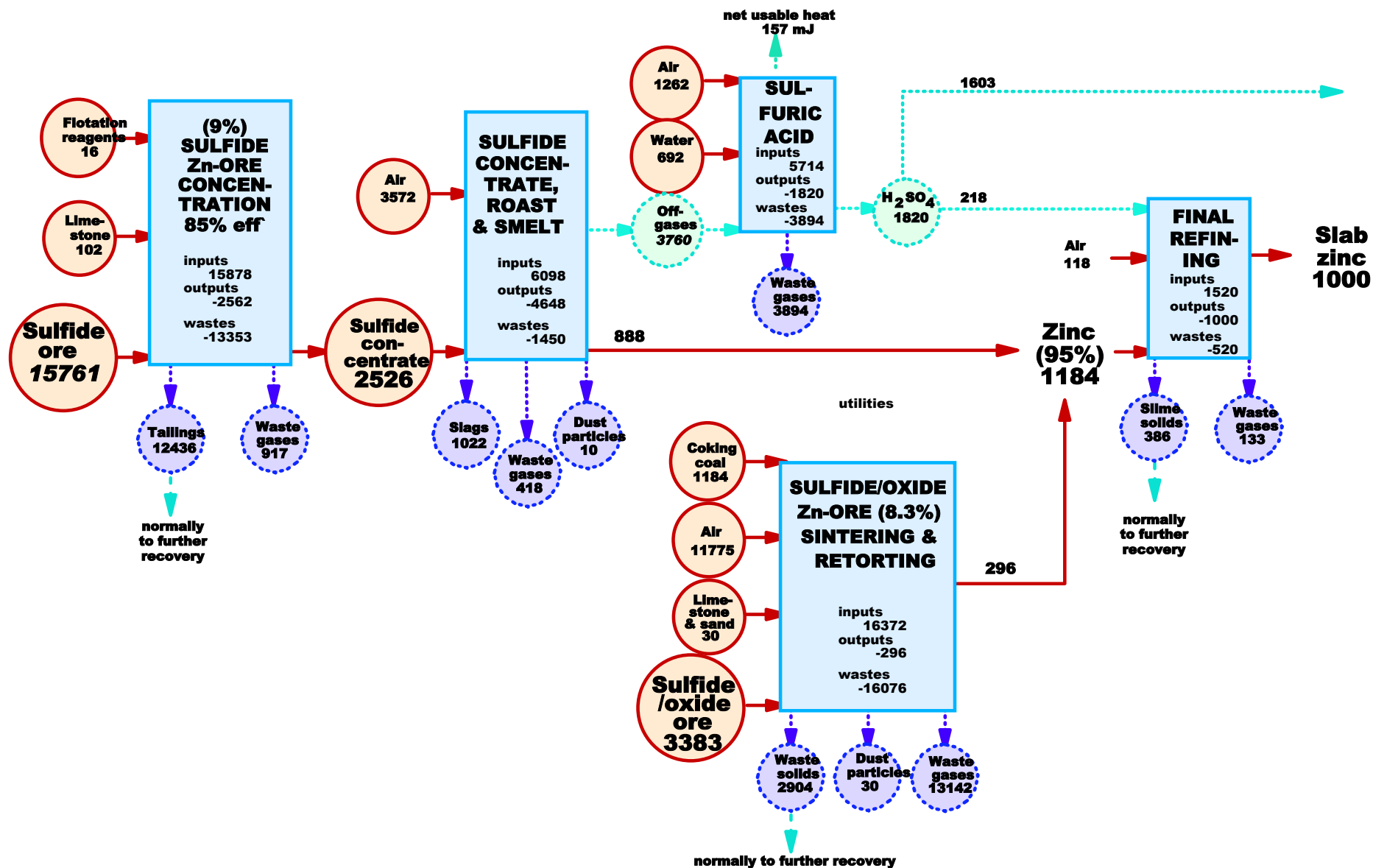


Figure 4.5: Exergy flows (mJ) in the production of 1 MT zinc (simplified processes, typical material mixes)

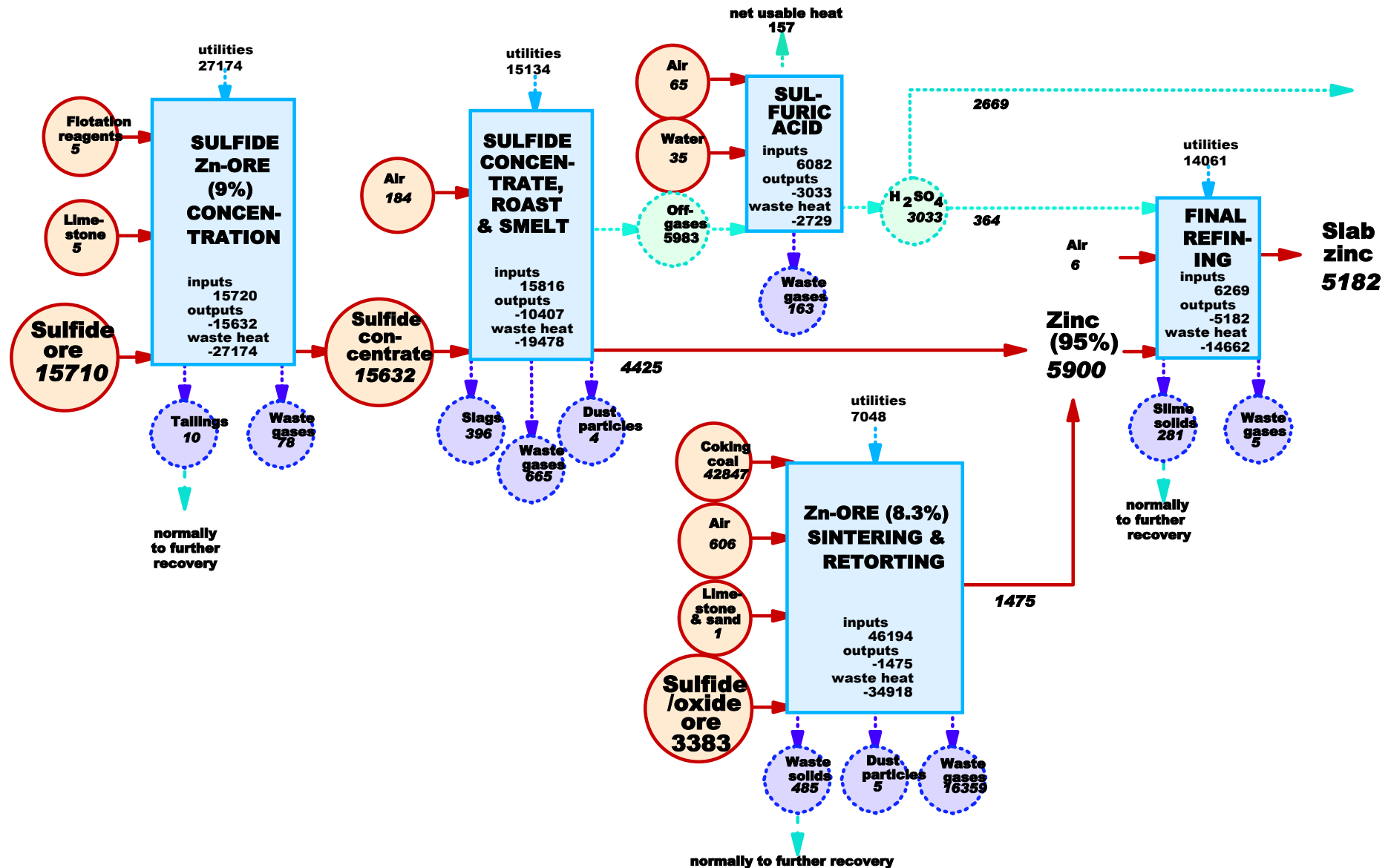


Figure 4.6 Overall unit zinc mass and exergy flows

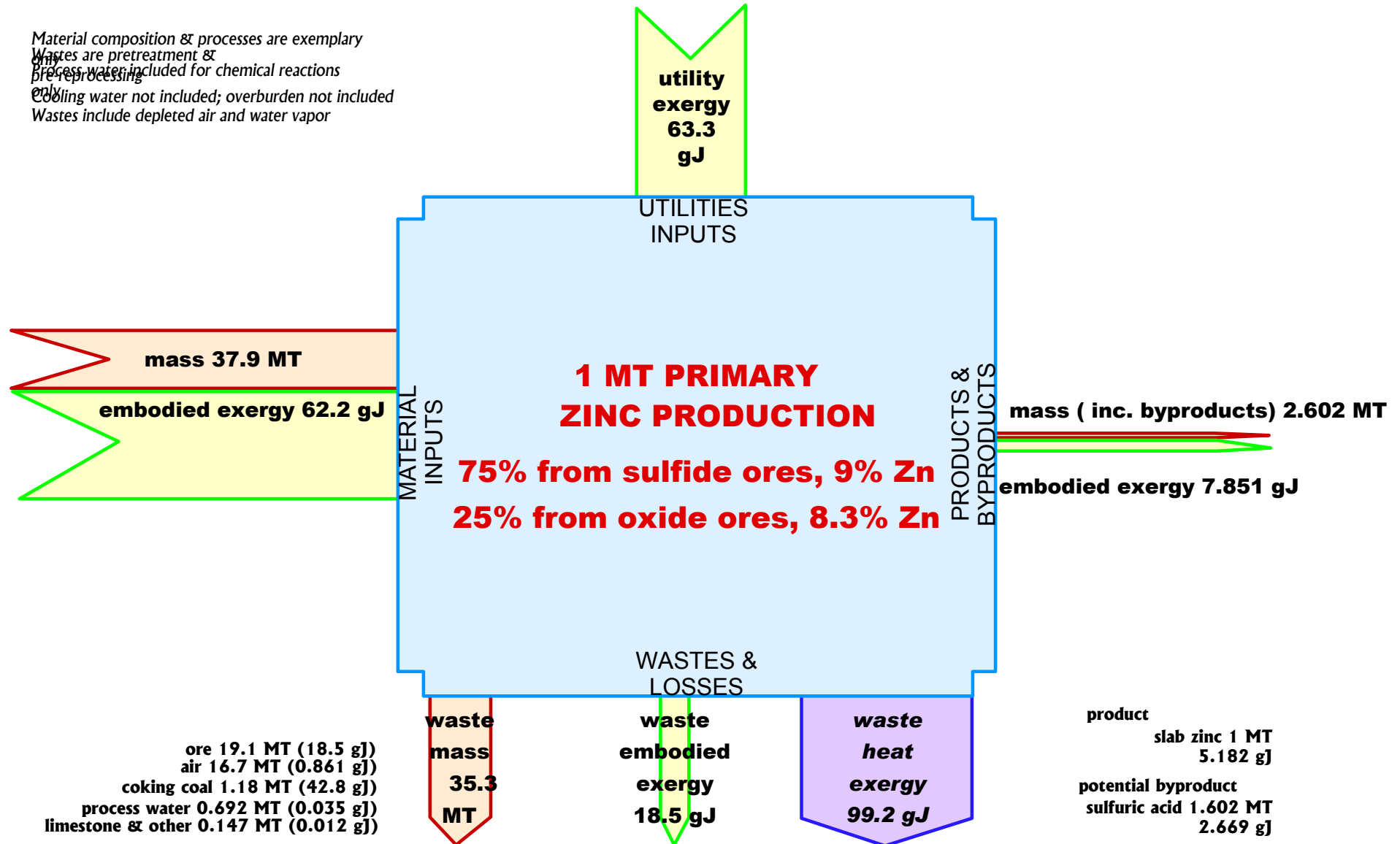
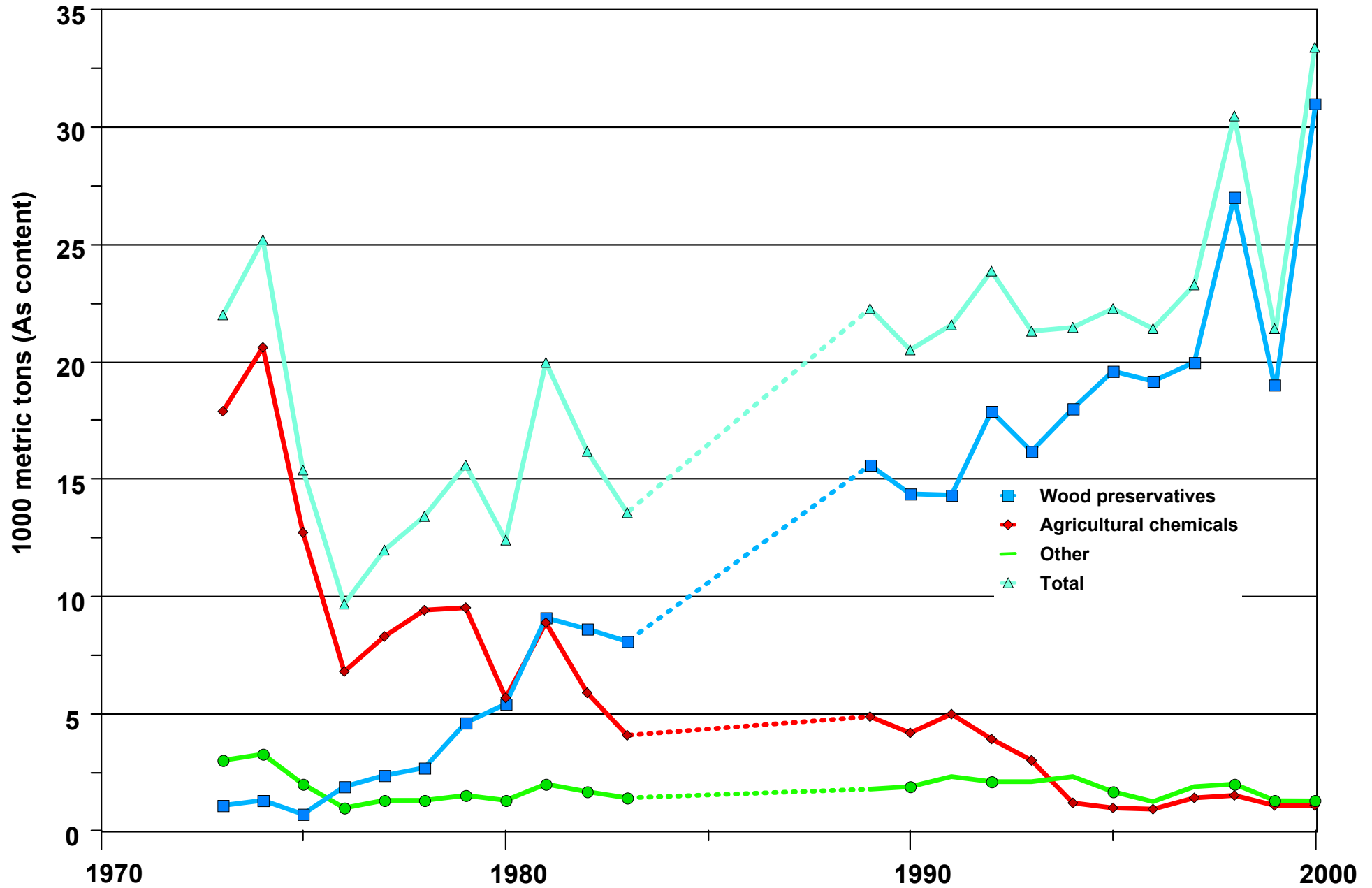


Figure 4.7: Arsenic demand patterns in the United States, 1973 - 2000 (kMT)



Source: USBM, USGS. Minerals Yearbooks, various years, "Arsenic" Table 1

Figure Annex 1 (1.2): Copper production at the mine in Falun, Sweden

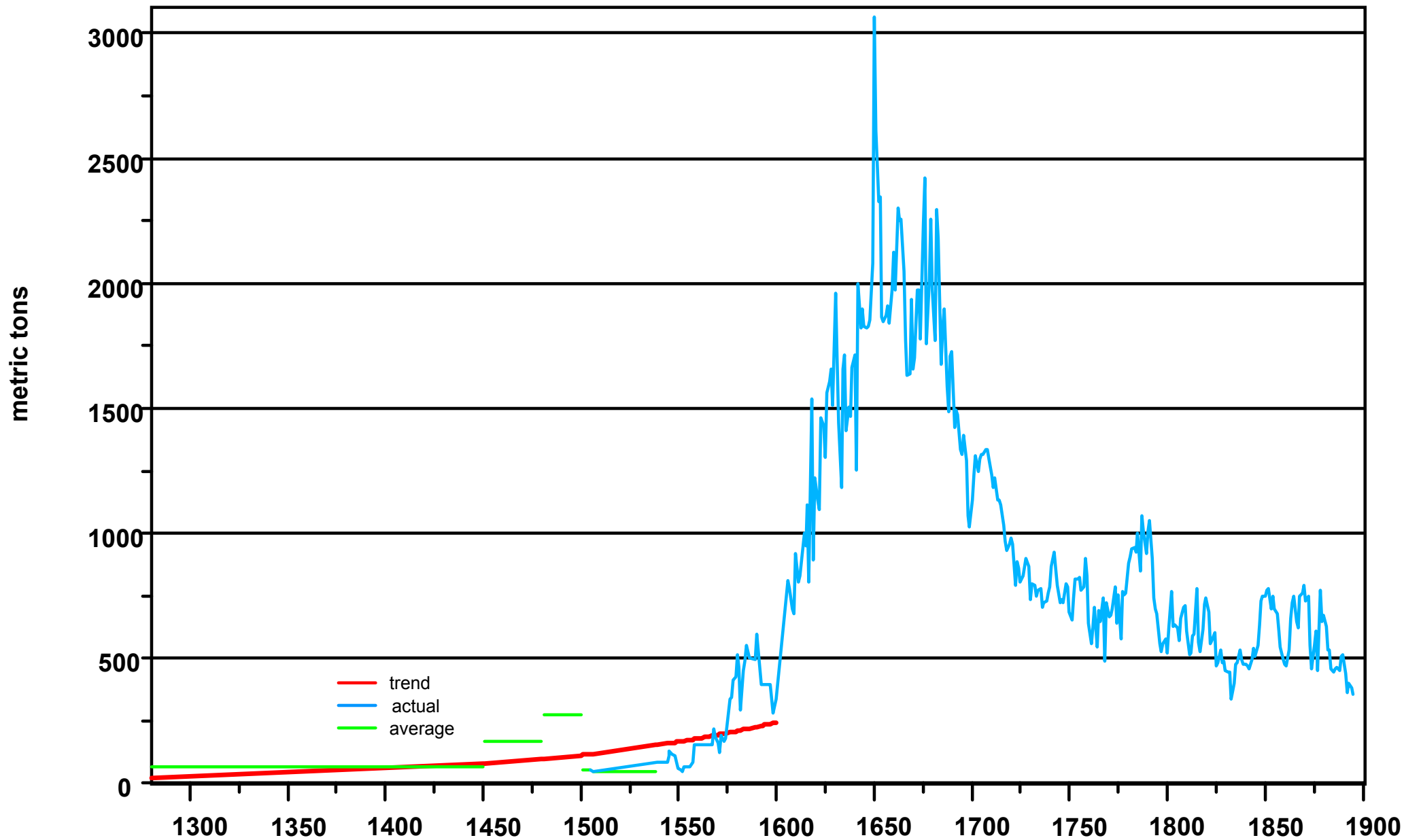


Figure B1 (3.11): Model of the global copper system

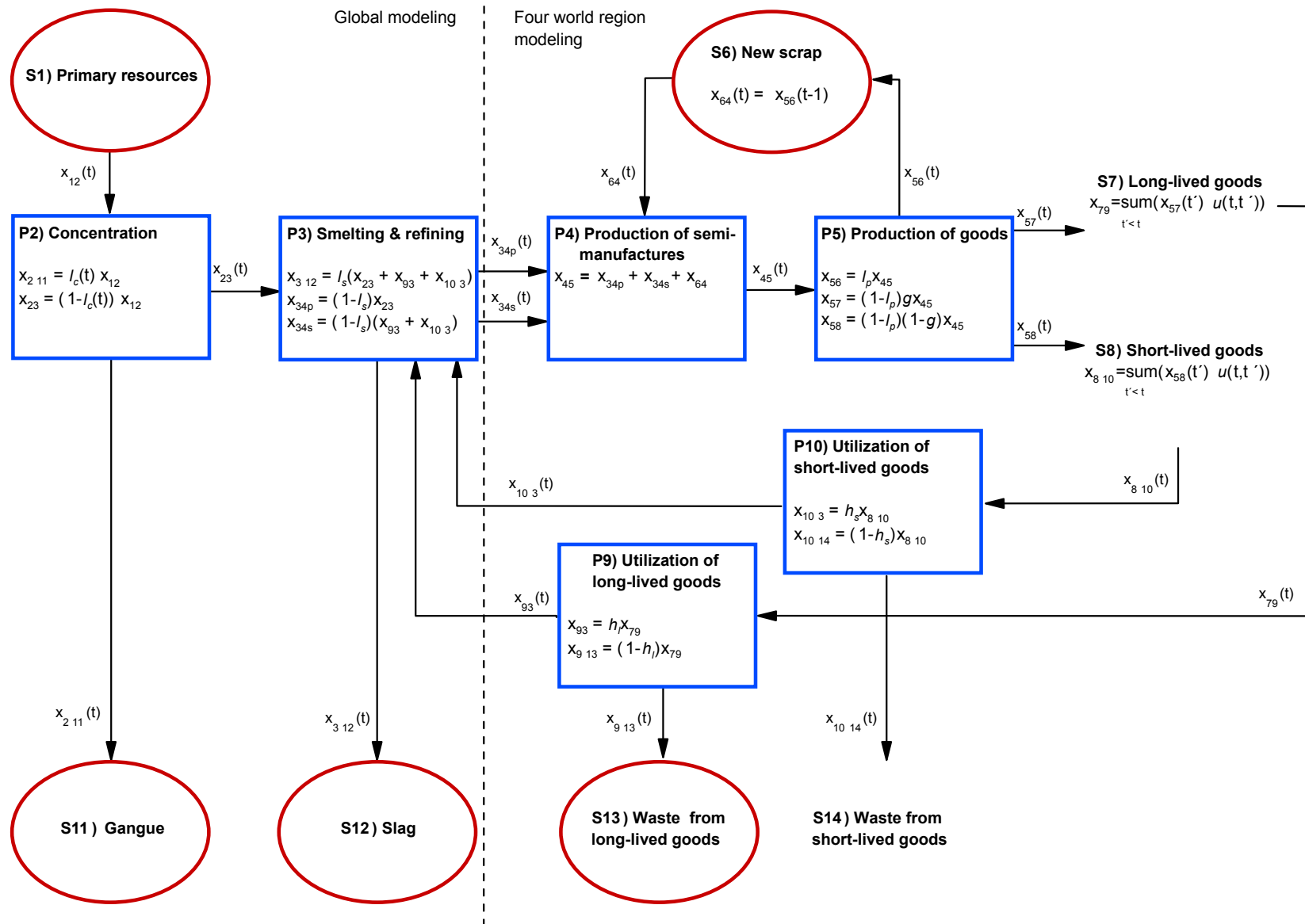


Figure B2: Recovery of copper in new and old scrap in OECD90, 1958–1997;
 scrap as a percentage of consumption

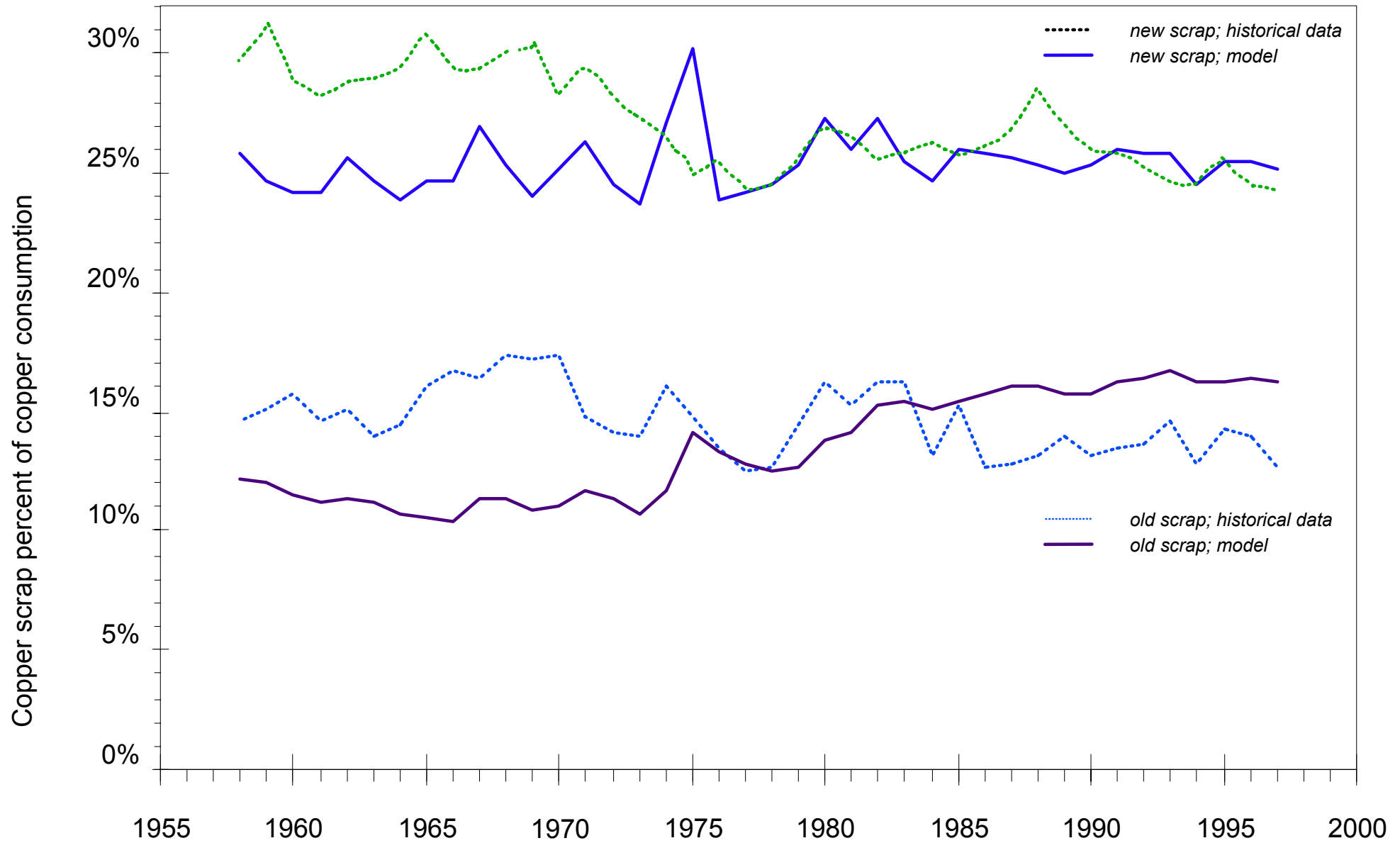


Figure B3: Recovery of copper in new and old scrap in OECD90, 1958–1997

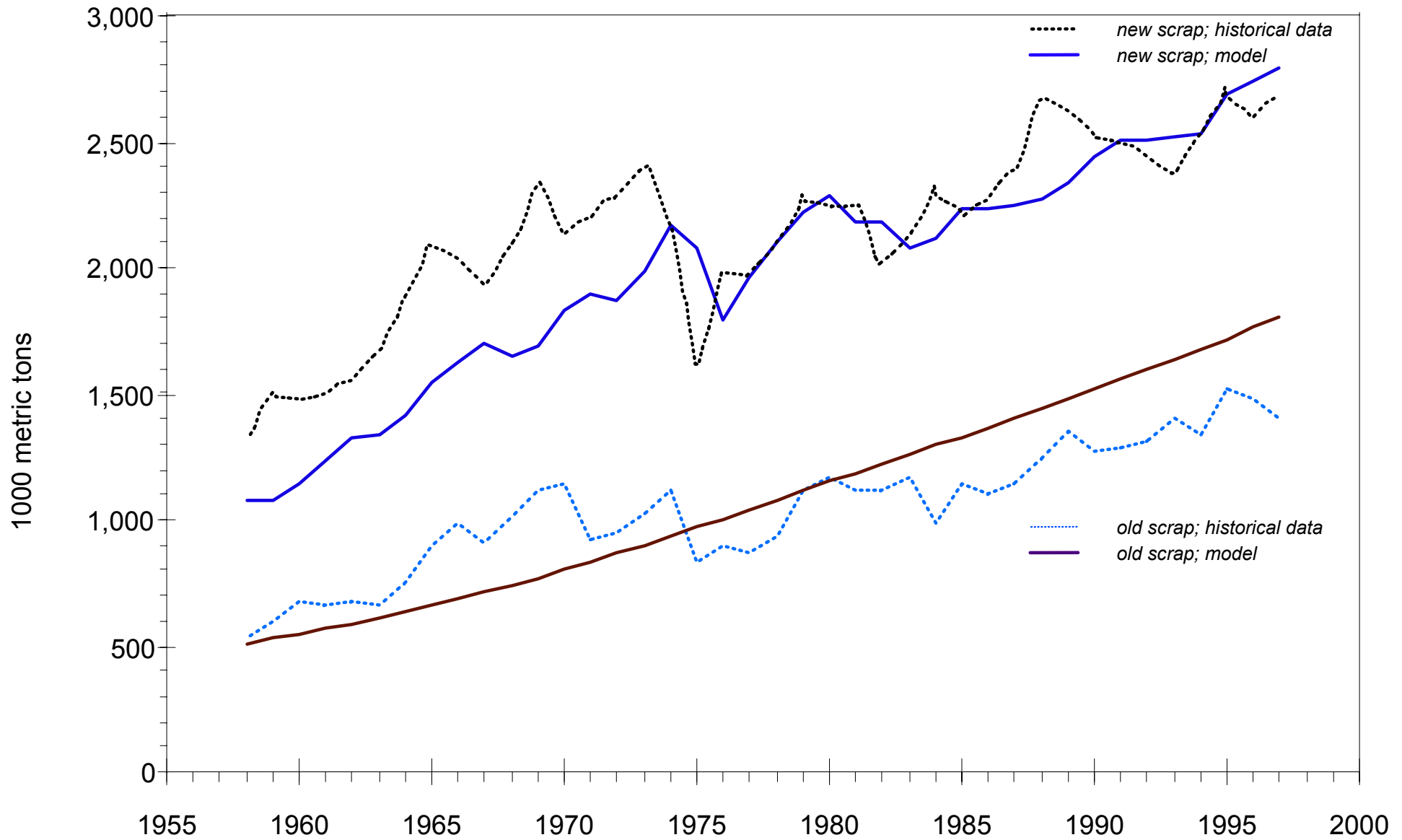
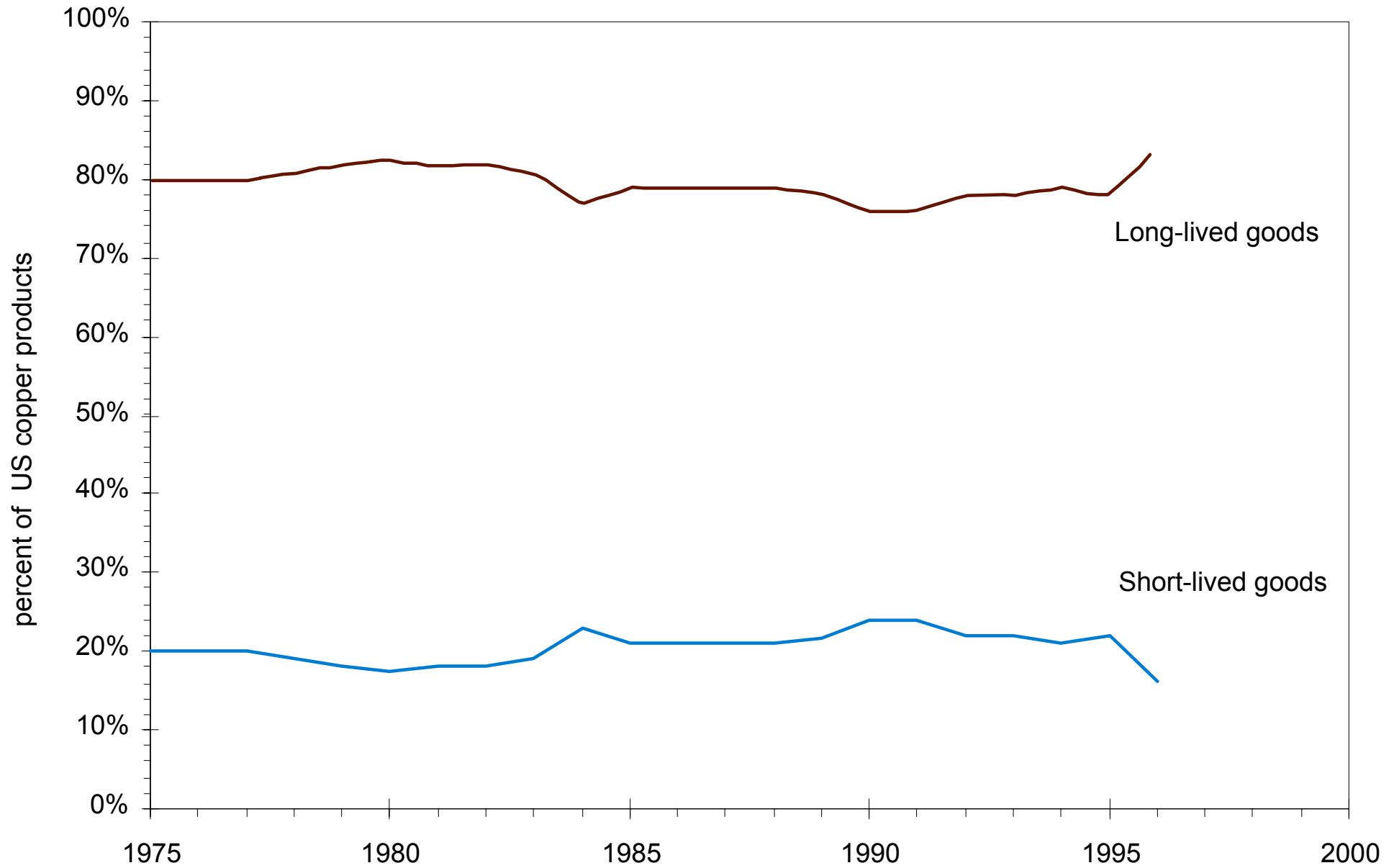


Figure B4: US production of long- and short- lived copper products; 1975 - 1996



Long-lived products: building/construction, electric/electronic, industrial machinery/equipment.
Short-lived products: transportation equipment, consumer products

Figure B5: Global smelter production of copper from ore; 1900-1998

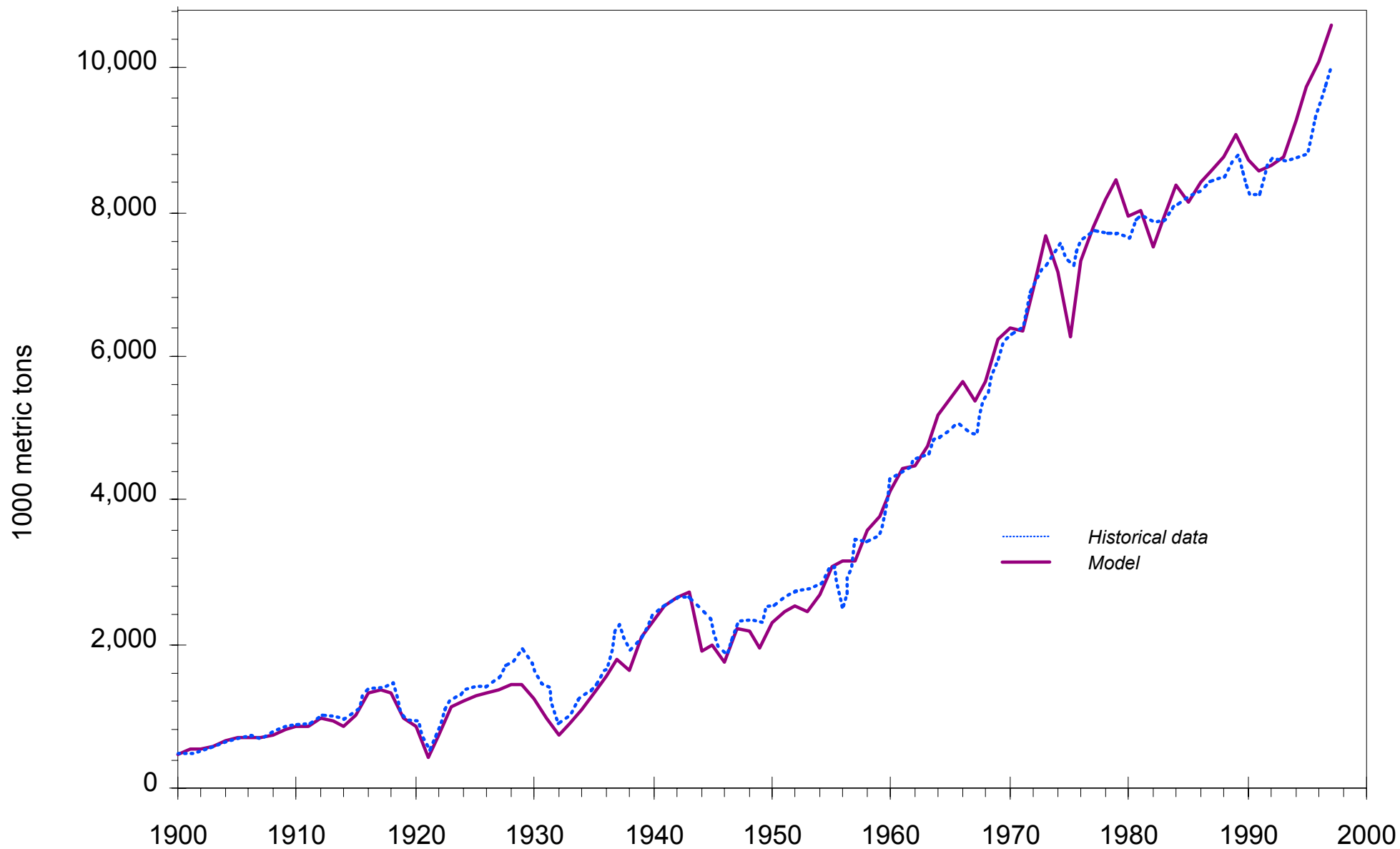


Figure B6: Cumulative global smelter production of copper from ore; 1900-1998

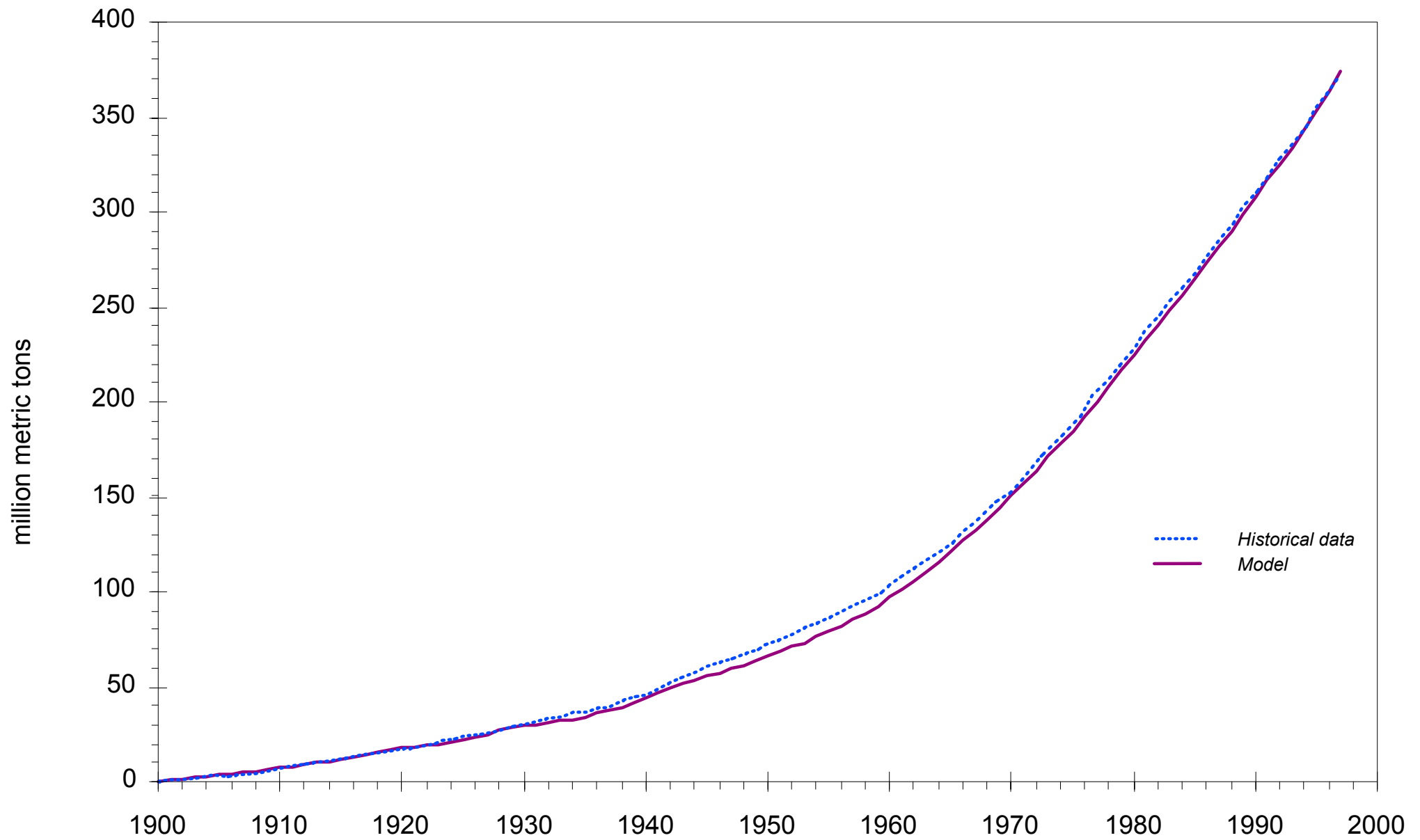


Figure B7 (2.7): Historical and modeled Intensity of Use (consumption of refined copper) as a function of GDP/capita in 1960-1997

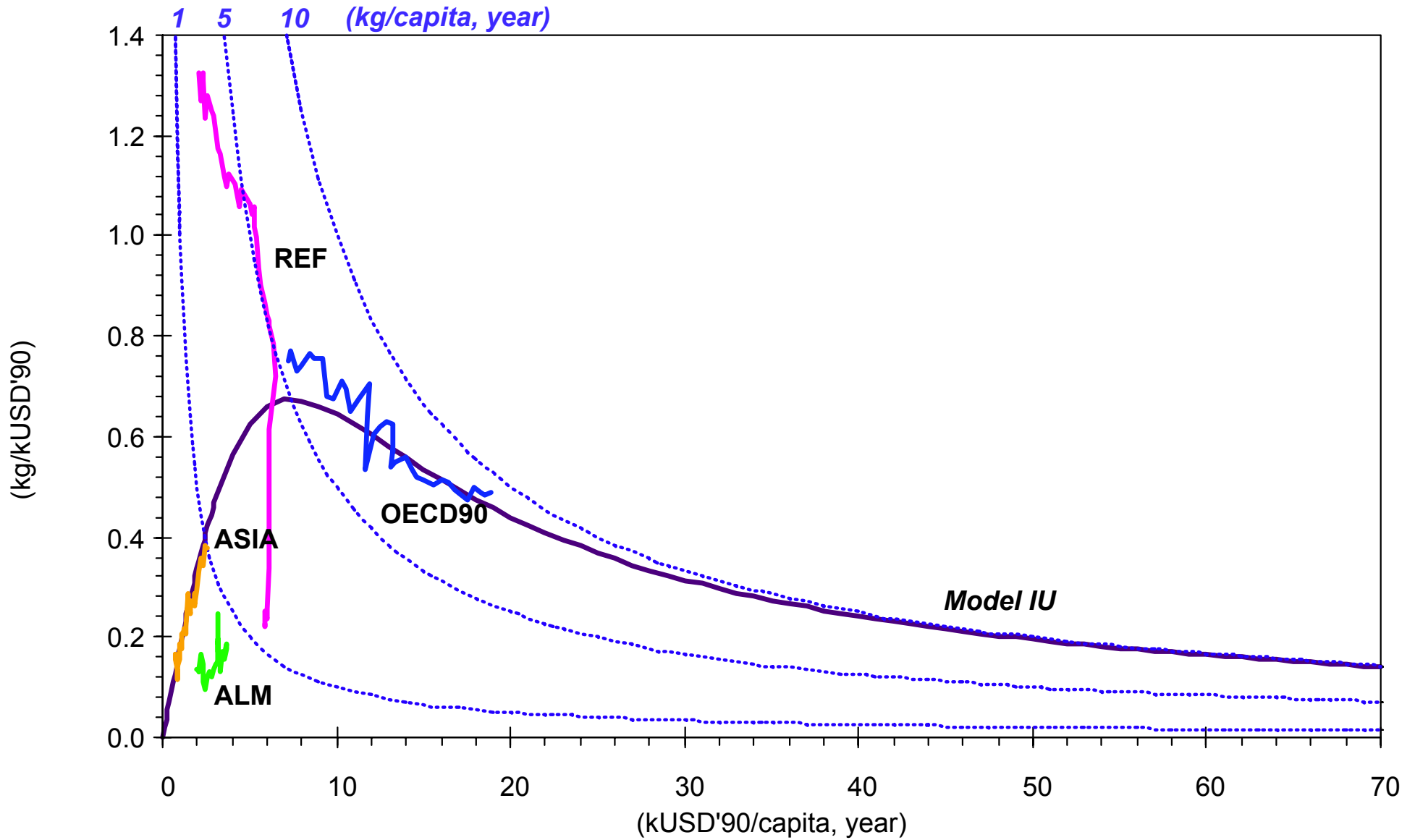


Figure B8. IPCC scenario B1 and B2 of population and GDP/capita in 1990–2100.
 Historical data in 1960–90. GDP in PPP

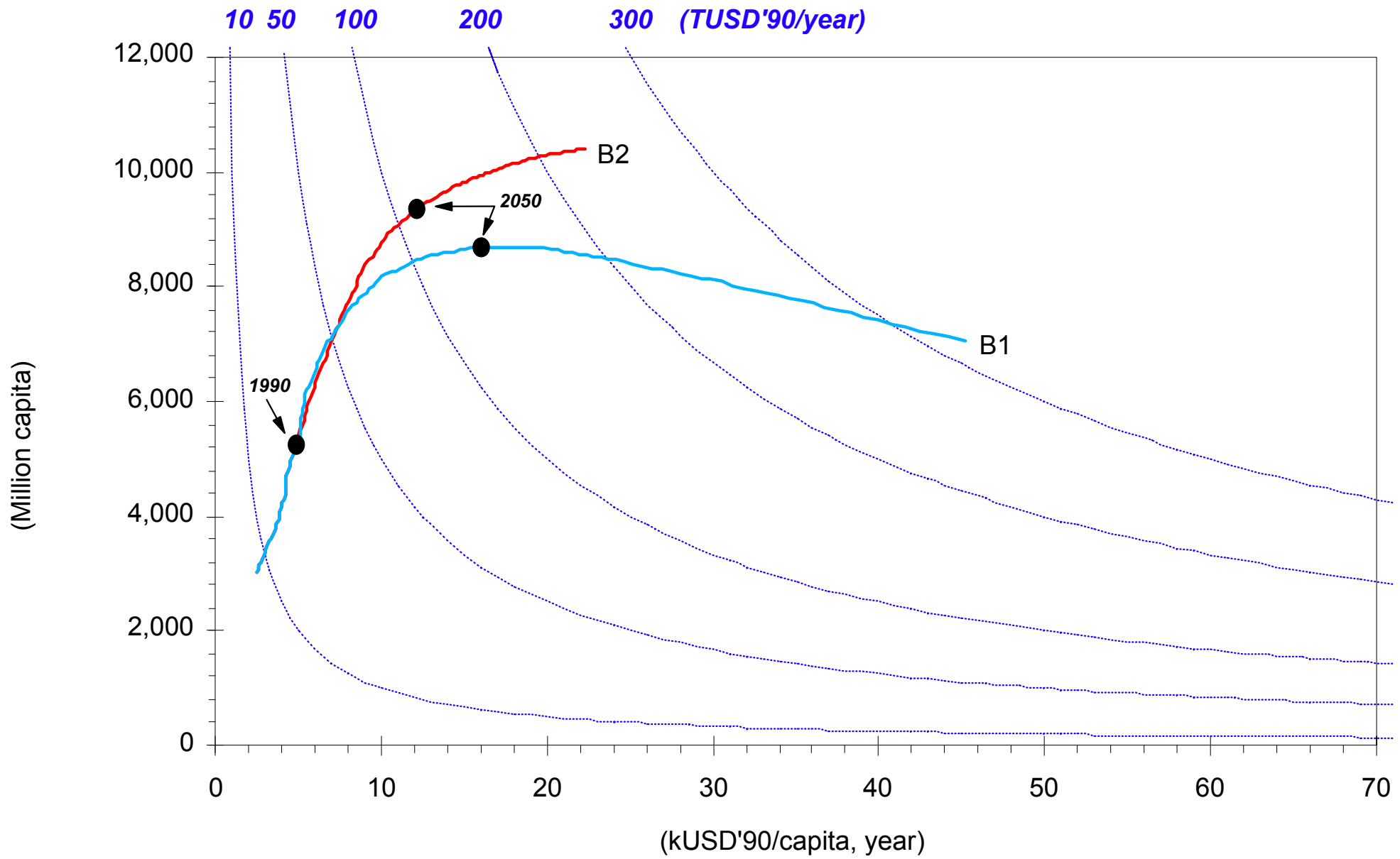


Figure B9: IPCC scenario B1 of population and GDP/capita in 1990–2100.
 Historical data in 1960–90. GDP in PPP

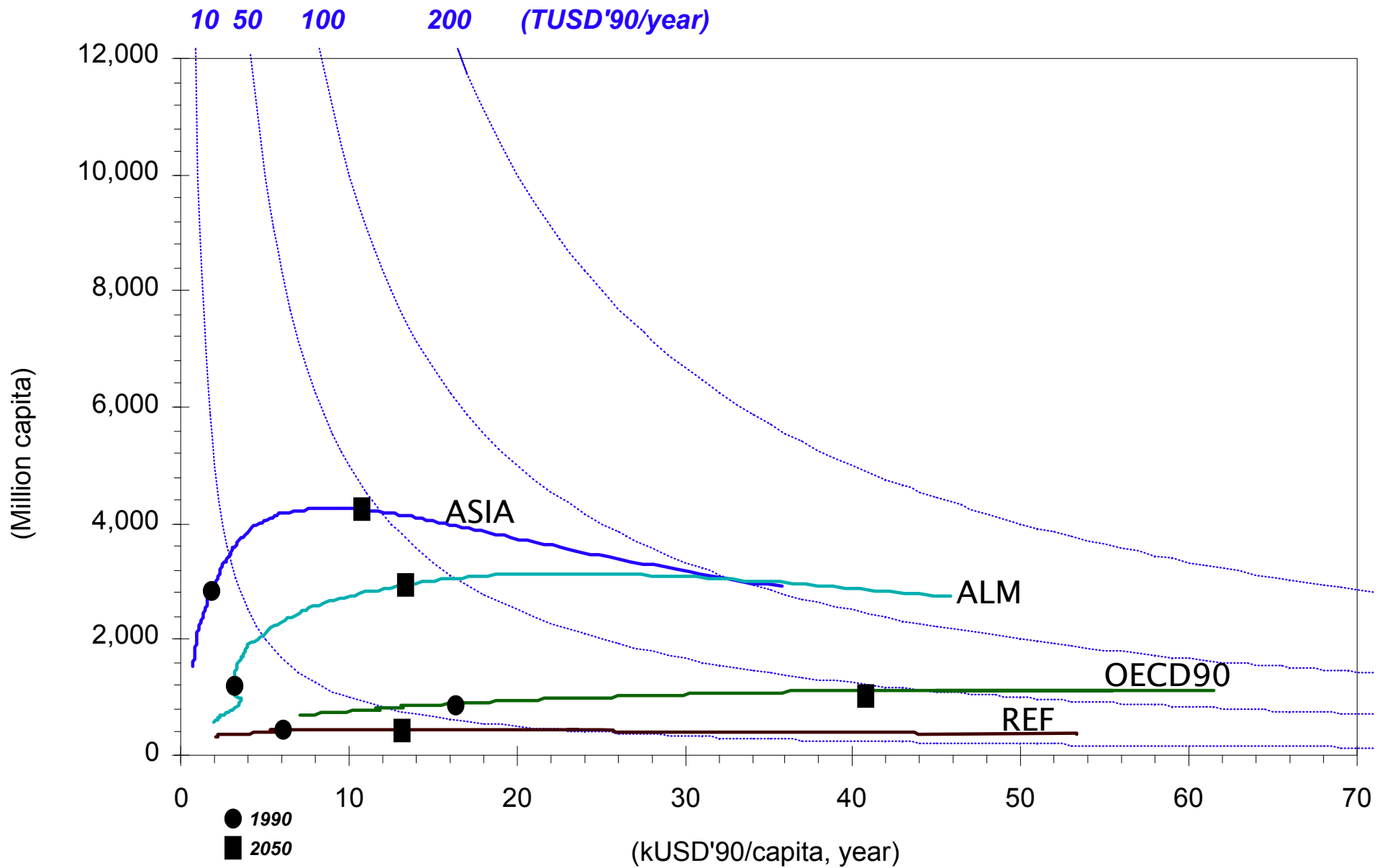


Figure B10. IPCC scenario B2 of population and GDP/capita in 1990–2100.
 Historical data in 1960–90. GDP in PPP

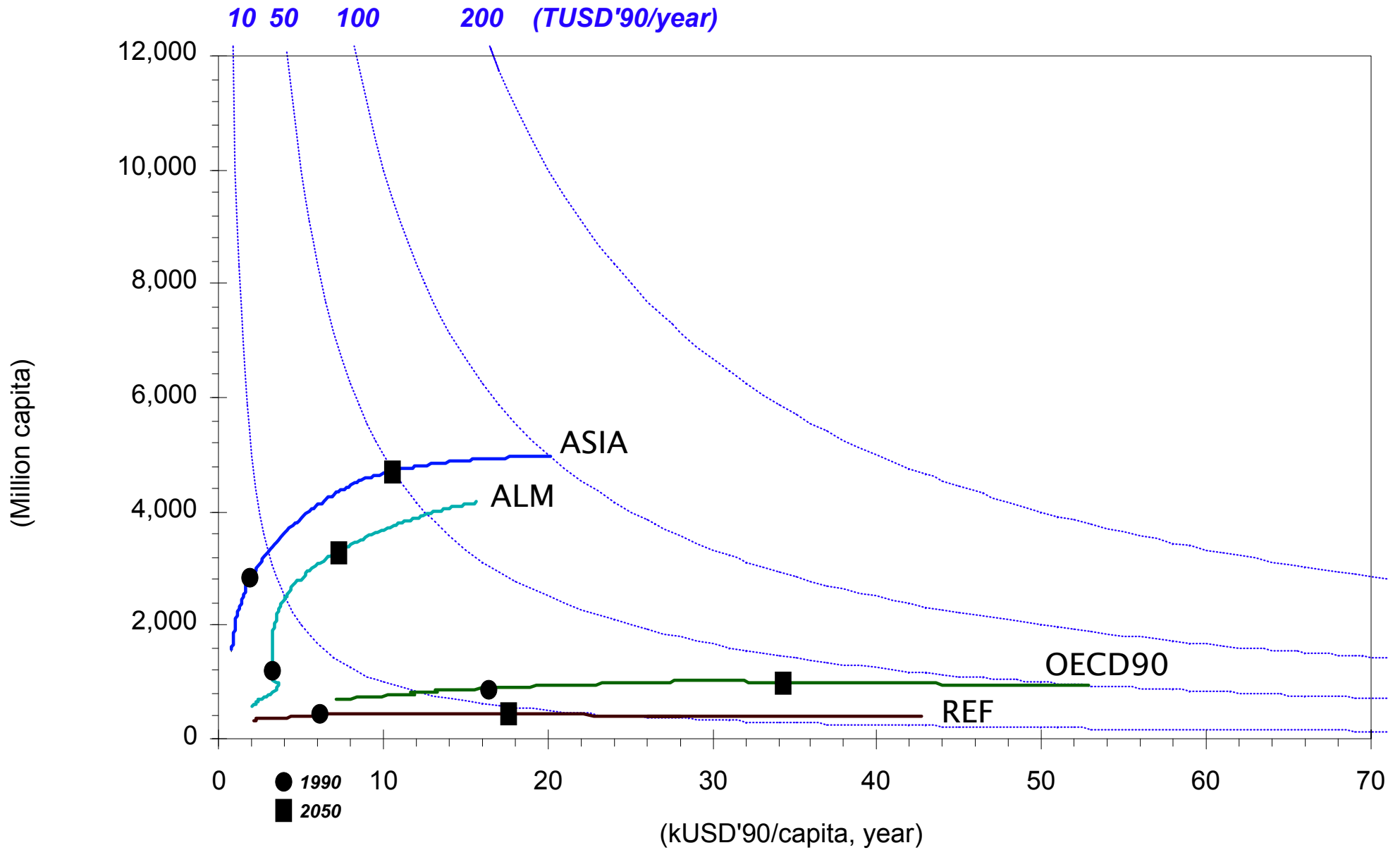


Figure B11 (3.14): Global consumption of refined copper, scenarios 1 through 4

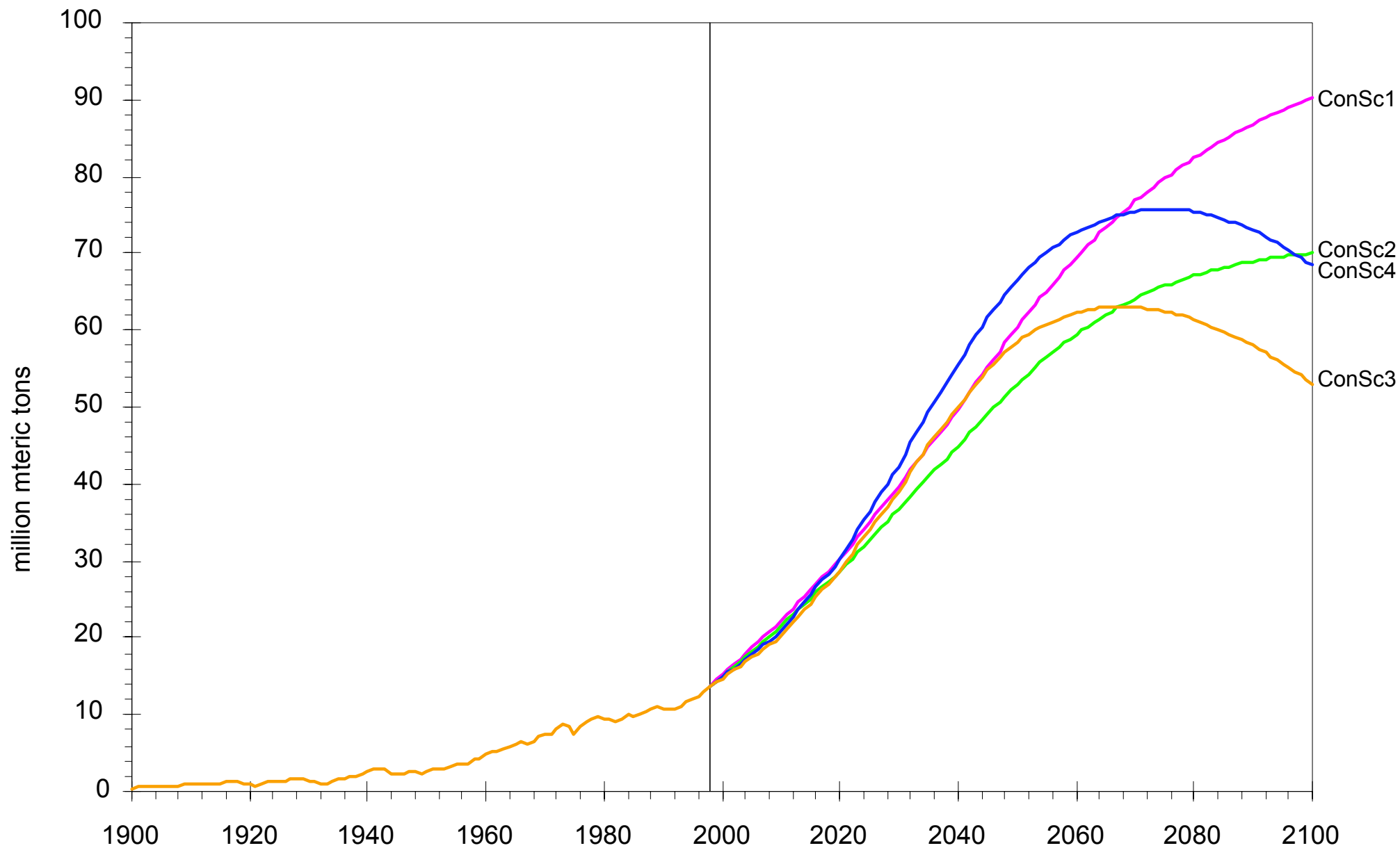


Figure B12(3.15): Regional consumption of refined copper; scenarios 1 and 5

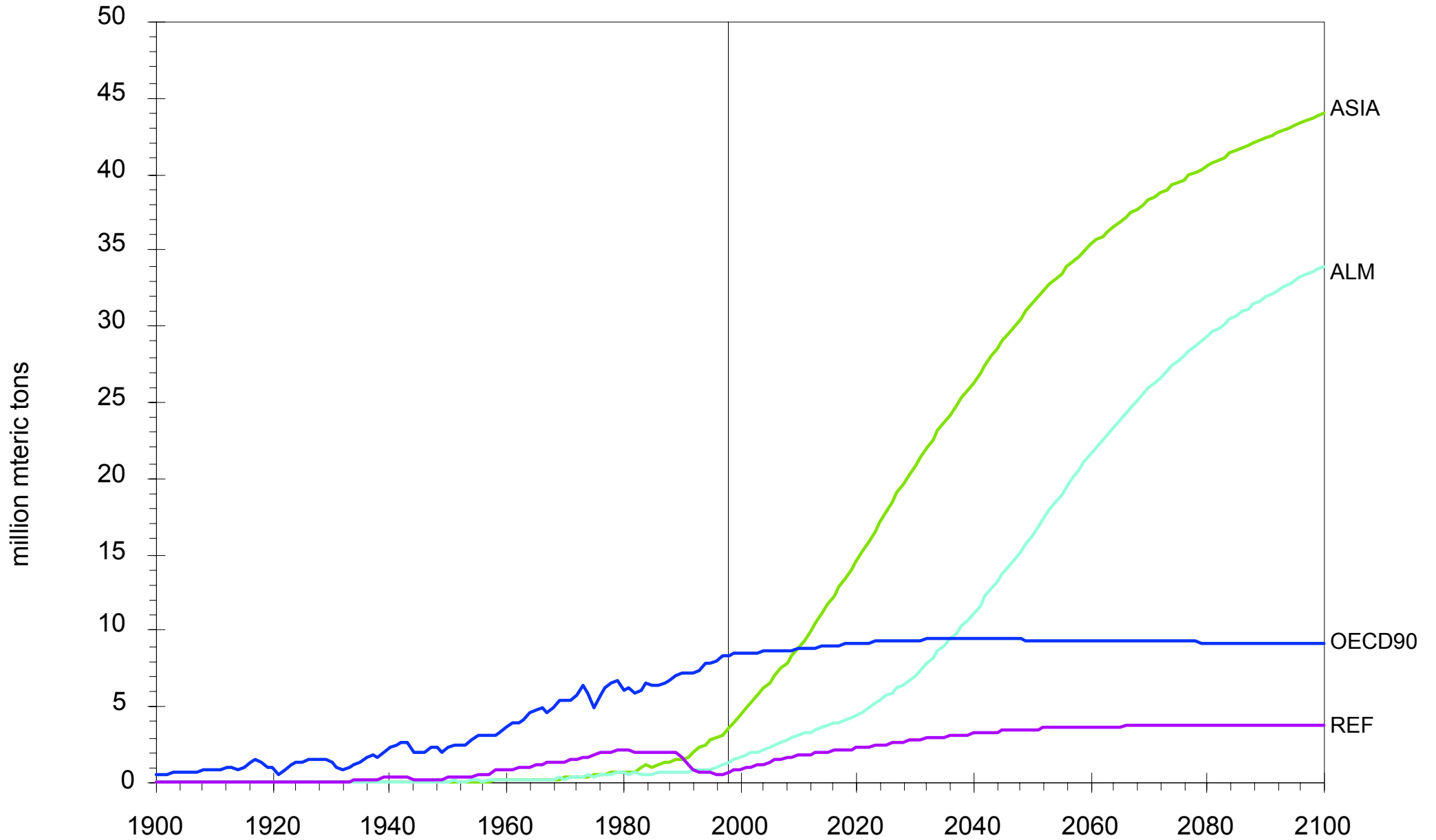


Figure B13 (3.16): Regional consumption of refined copper; scenarios 3 and 7

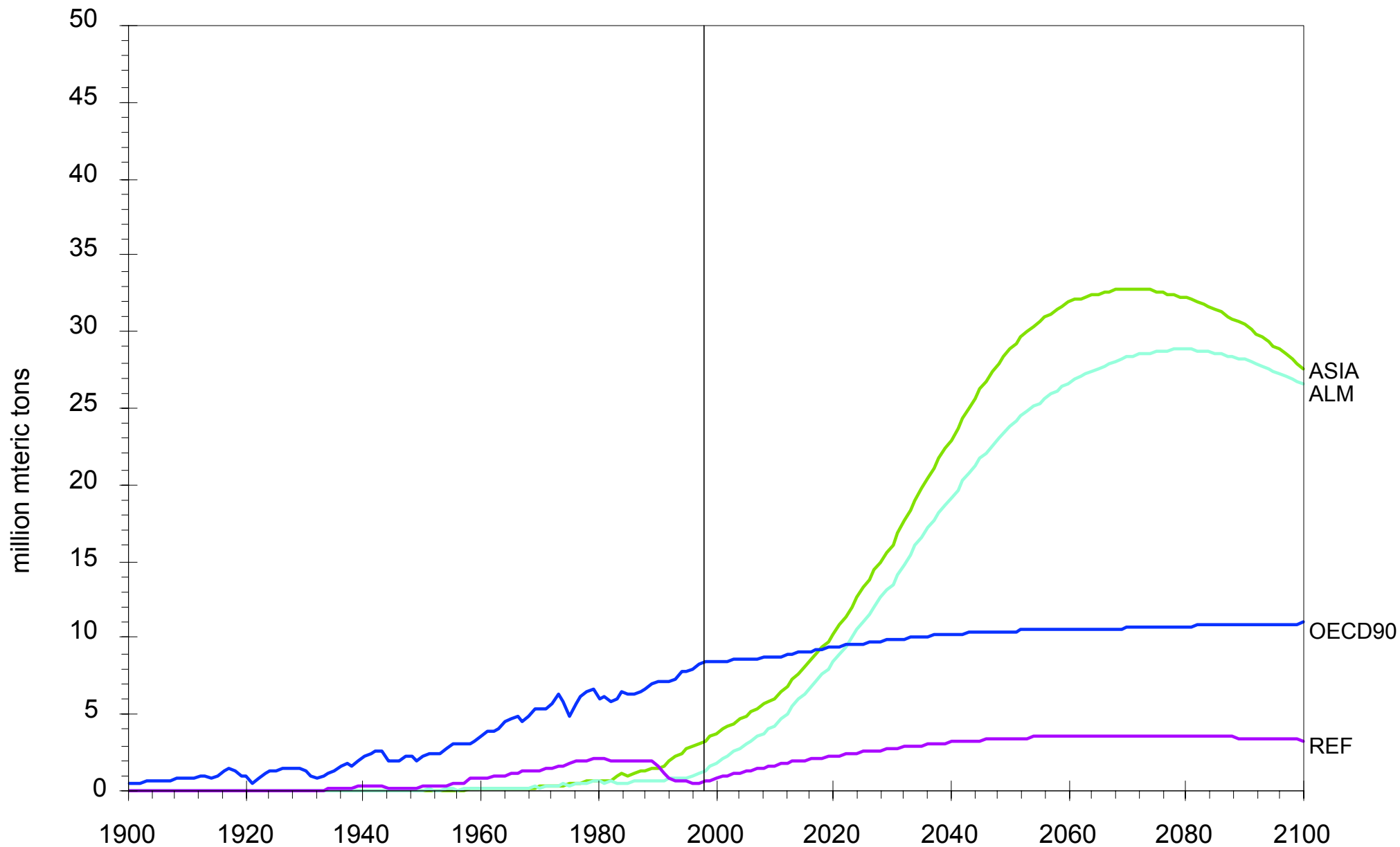


Figure B14 (3.17): Regional consumption of refined copper; scenarios 2 and 6

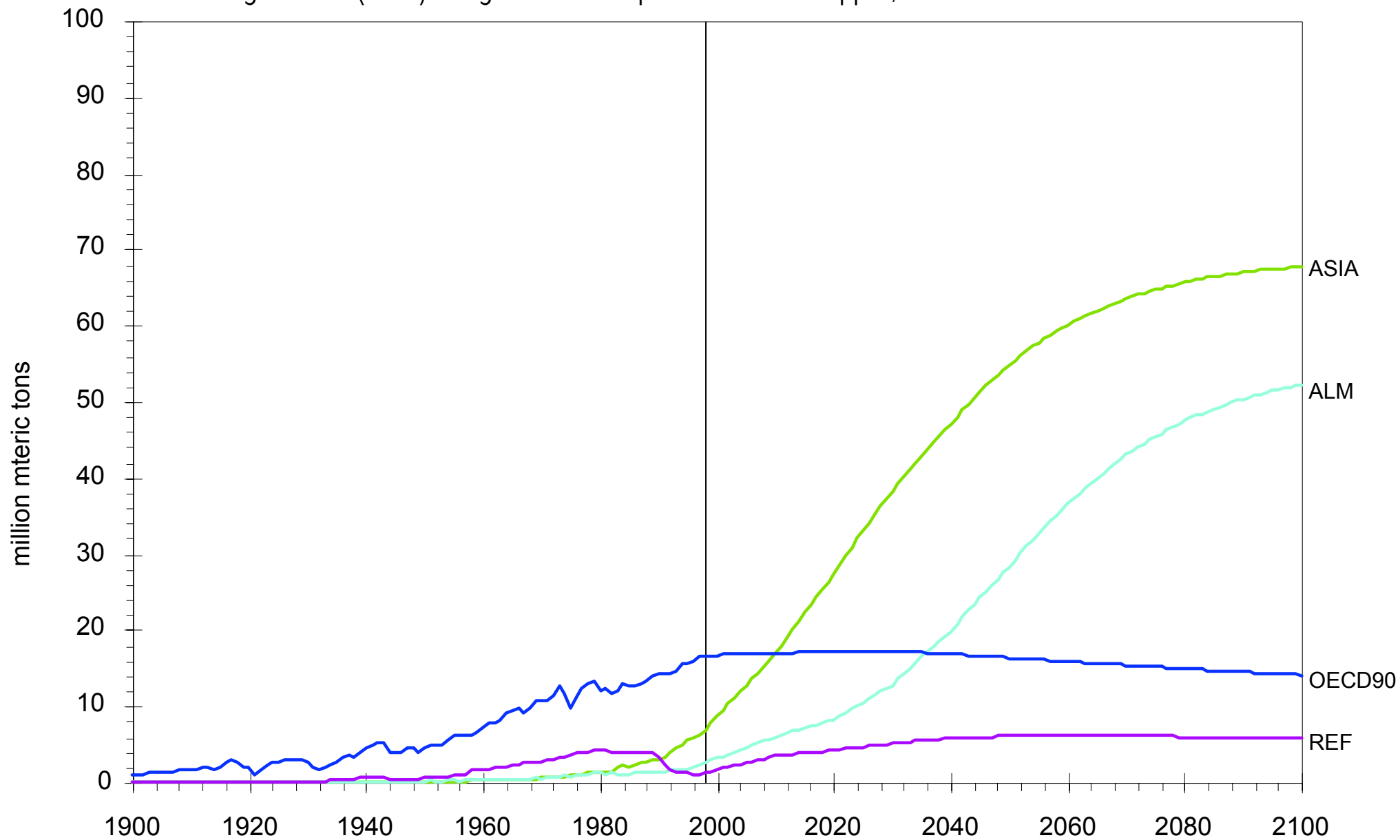


Figure B15 (3.18): Regional consumption of refined copper; scenarios 4 and 8

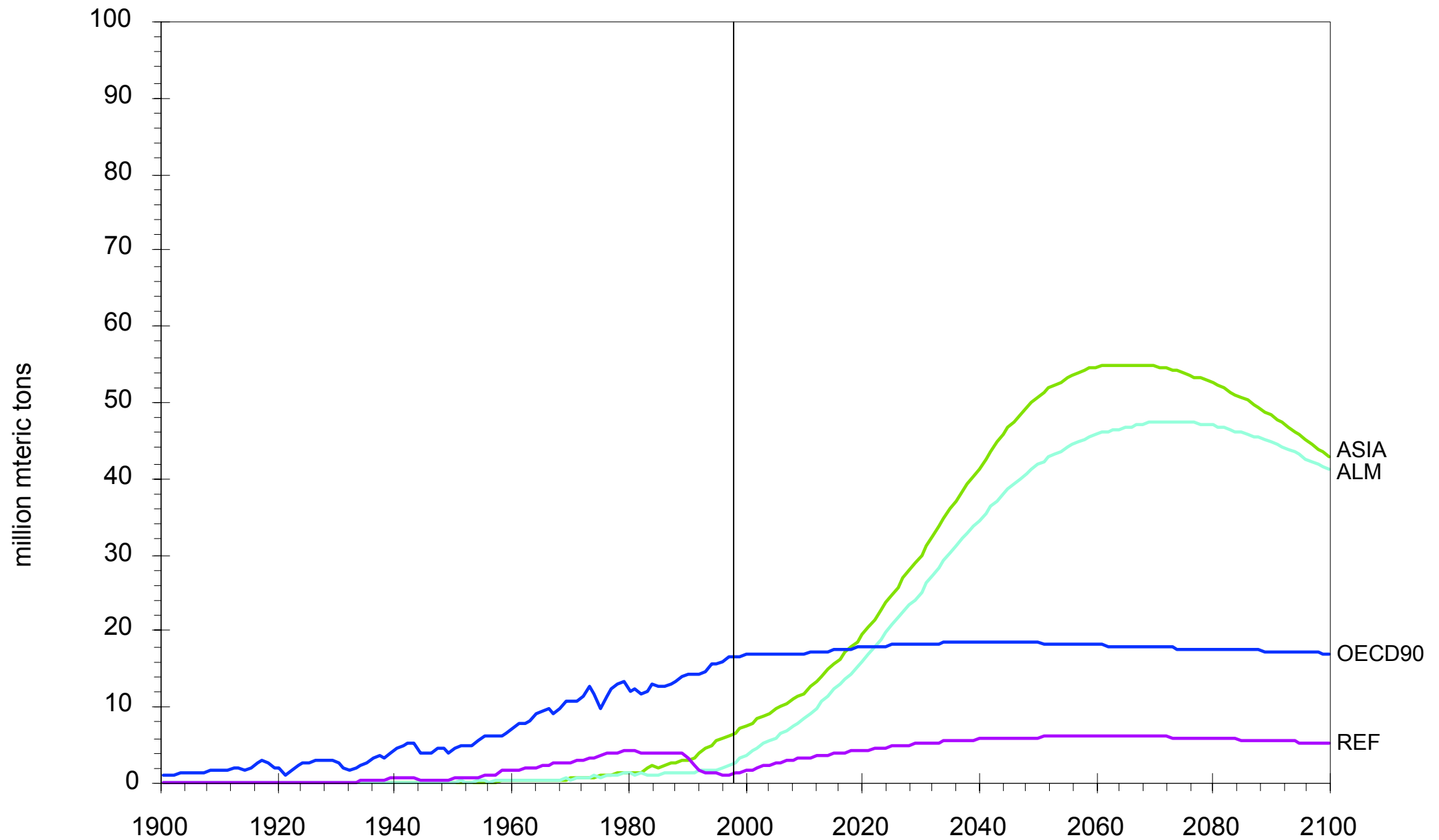


Figure B16: Global per capita consumption of refined copper, ConSc1–ConSc4.

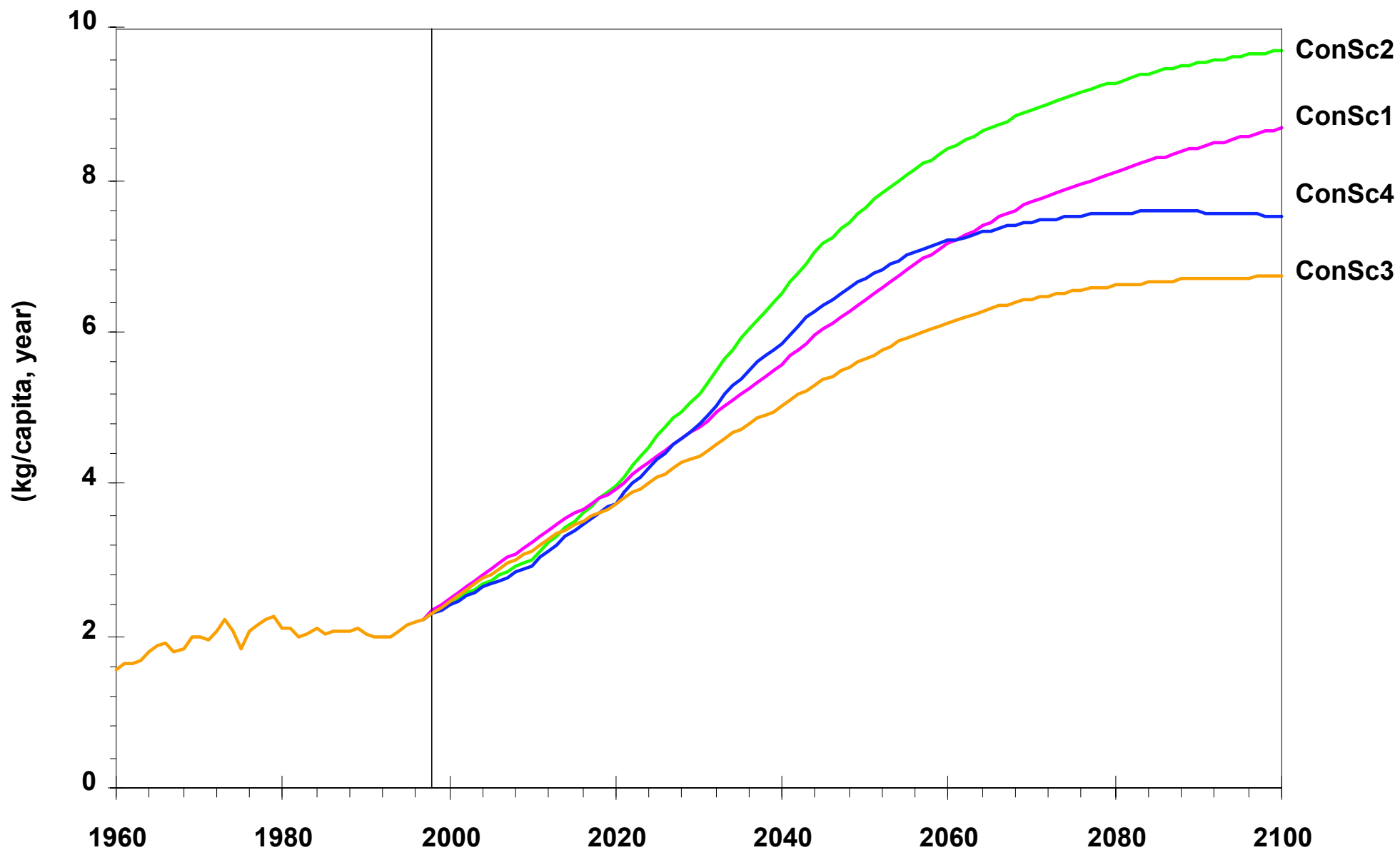


Figure B17: Regional per capita consumption of refined copper with IPCC scenario B2 and high IU, ConSc1. Input to Sc1 and Sc5.

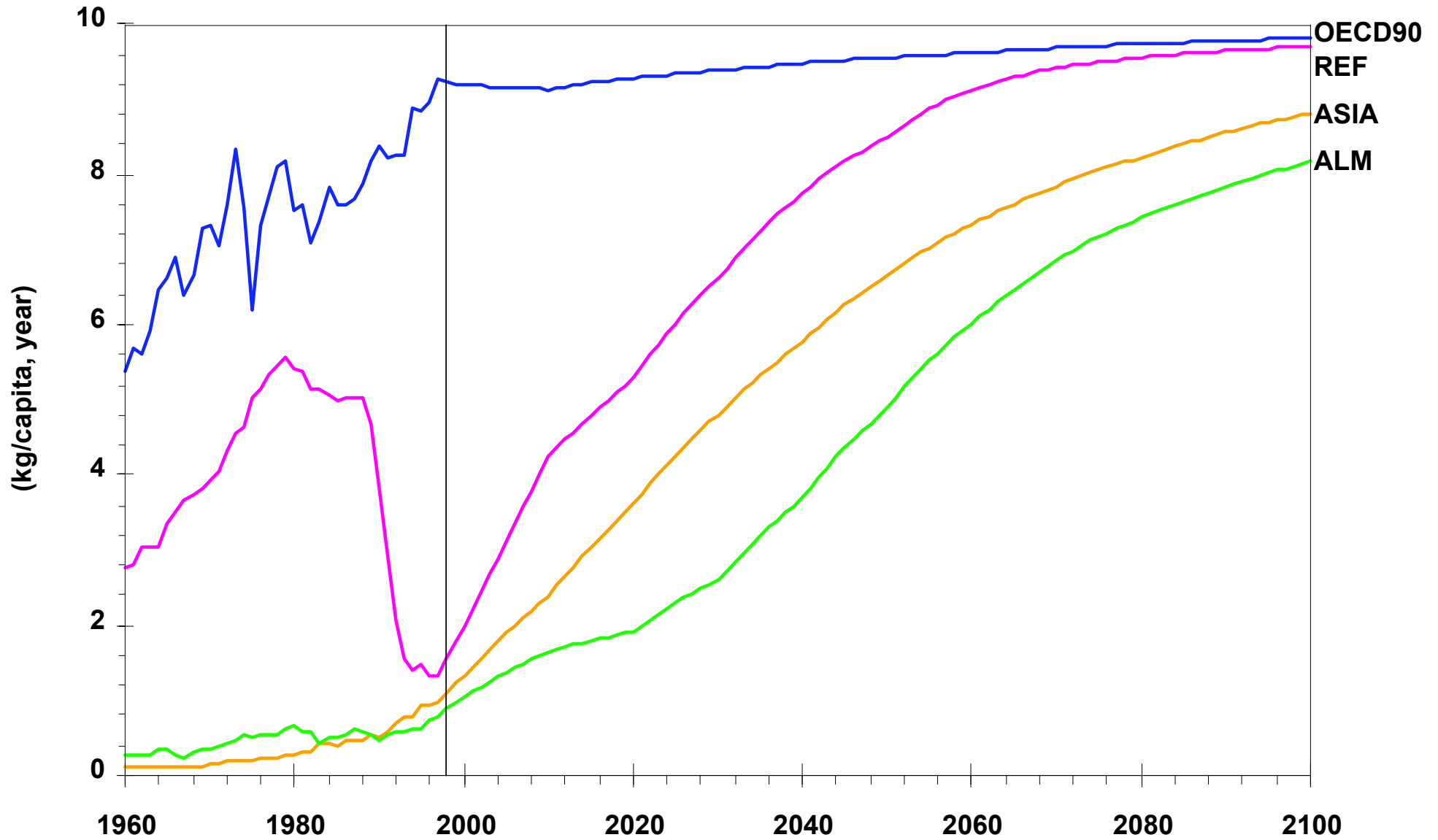


Figure B18: Regional per capita consumption of refined copper with IPCC scenario B1 and high IU, ConSc2. Input to Sc2 and Sc6

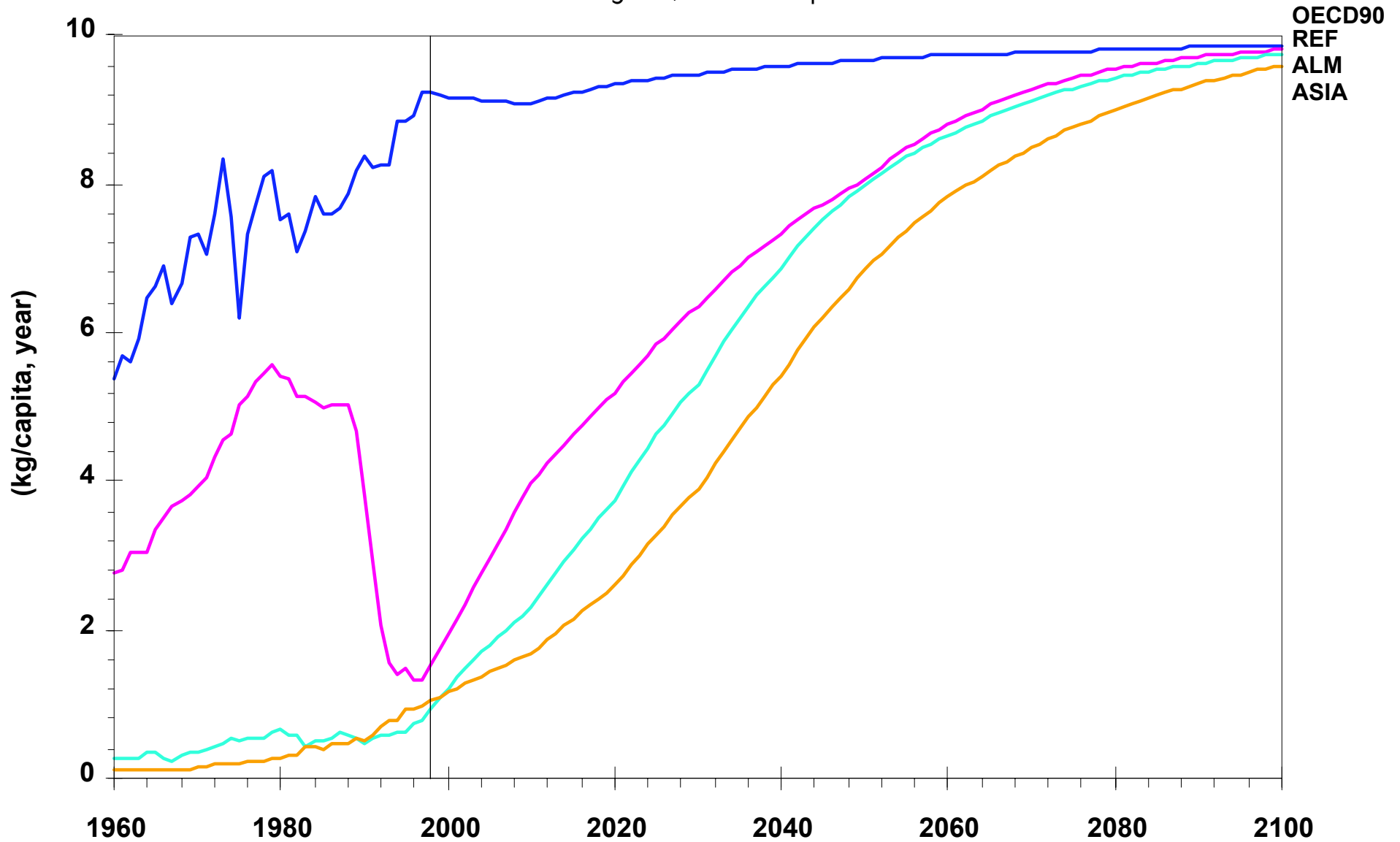


Figure B19: Regional per capita consumption of refined copper with IPCC scenario B2 and low IU, ConSc3. Input to Sc3 and Sc7

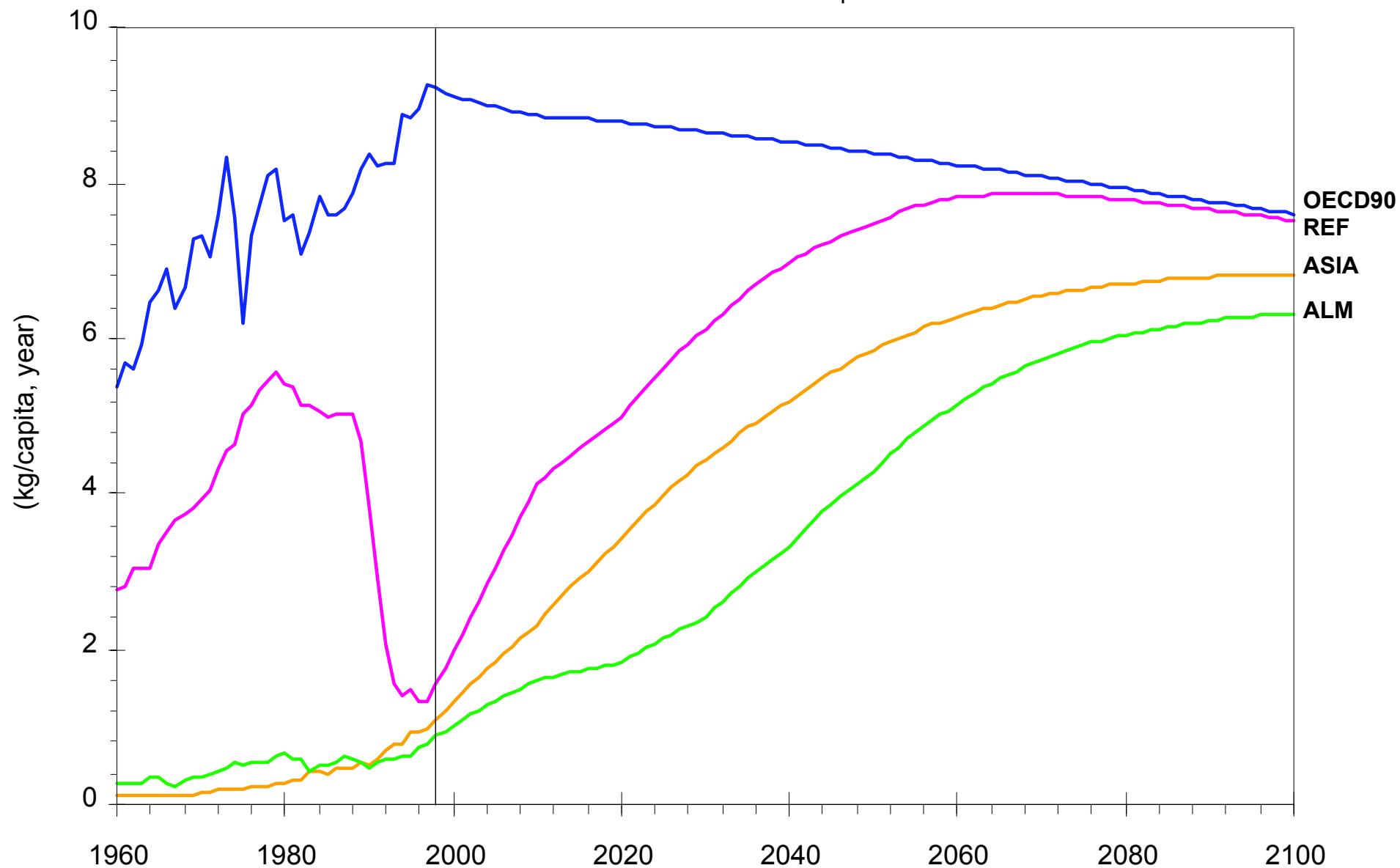


Figure B20: Regional per capita consumption of refined copper with IPCC scenario B1 and low IU, ConSc4. Input to Sc4 and Sc8.

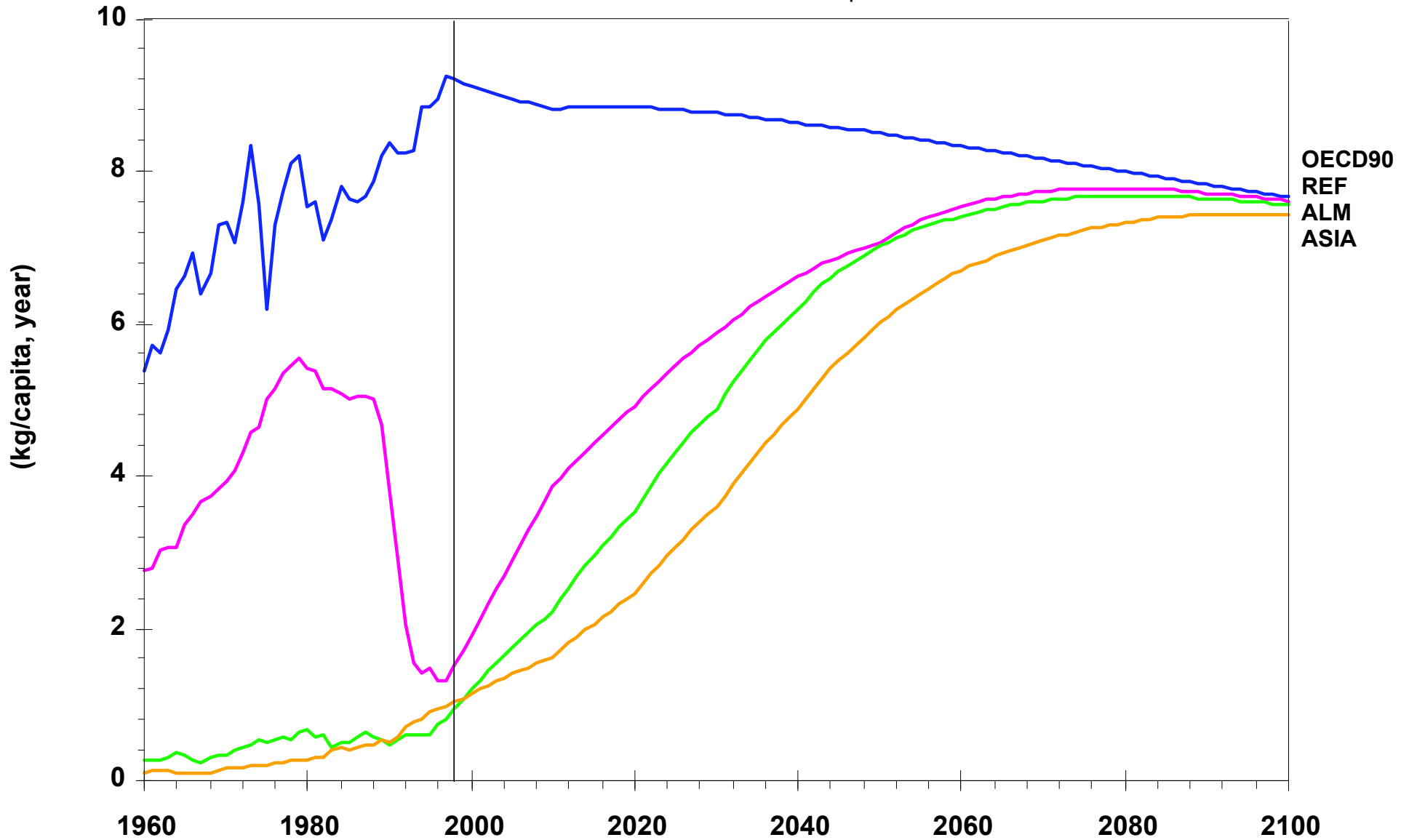


Figure B21(3.19): Global mine production of copper, 1900 - 1998, MMT

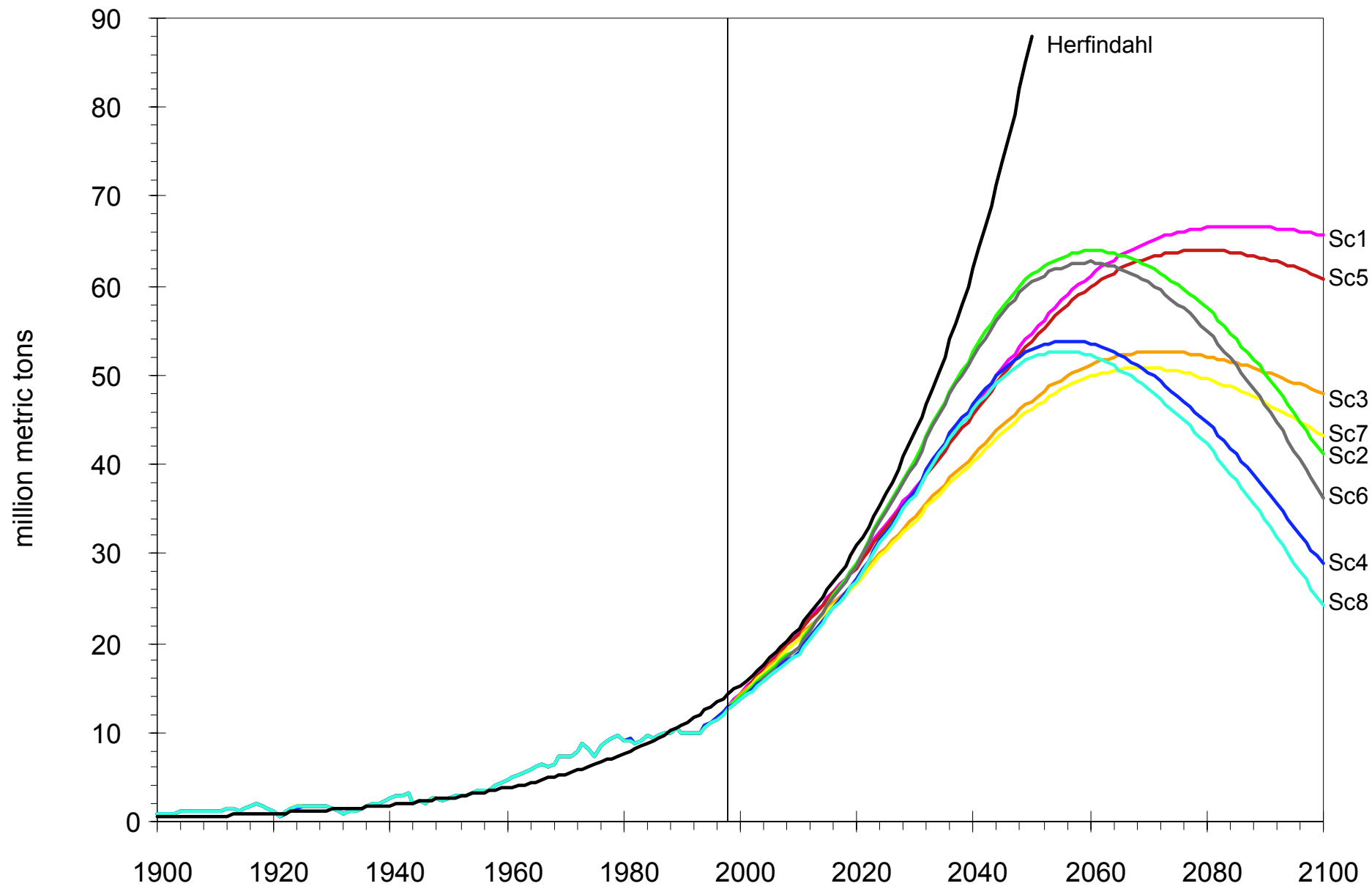


Figure B23(3.20): Cumulative global mine production of copper, 1900 - 1998, MMT

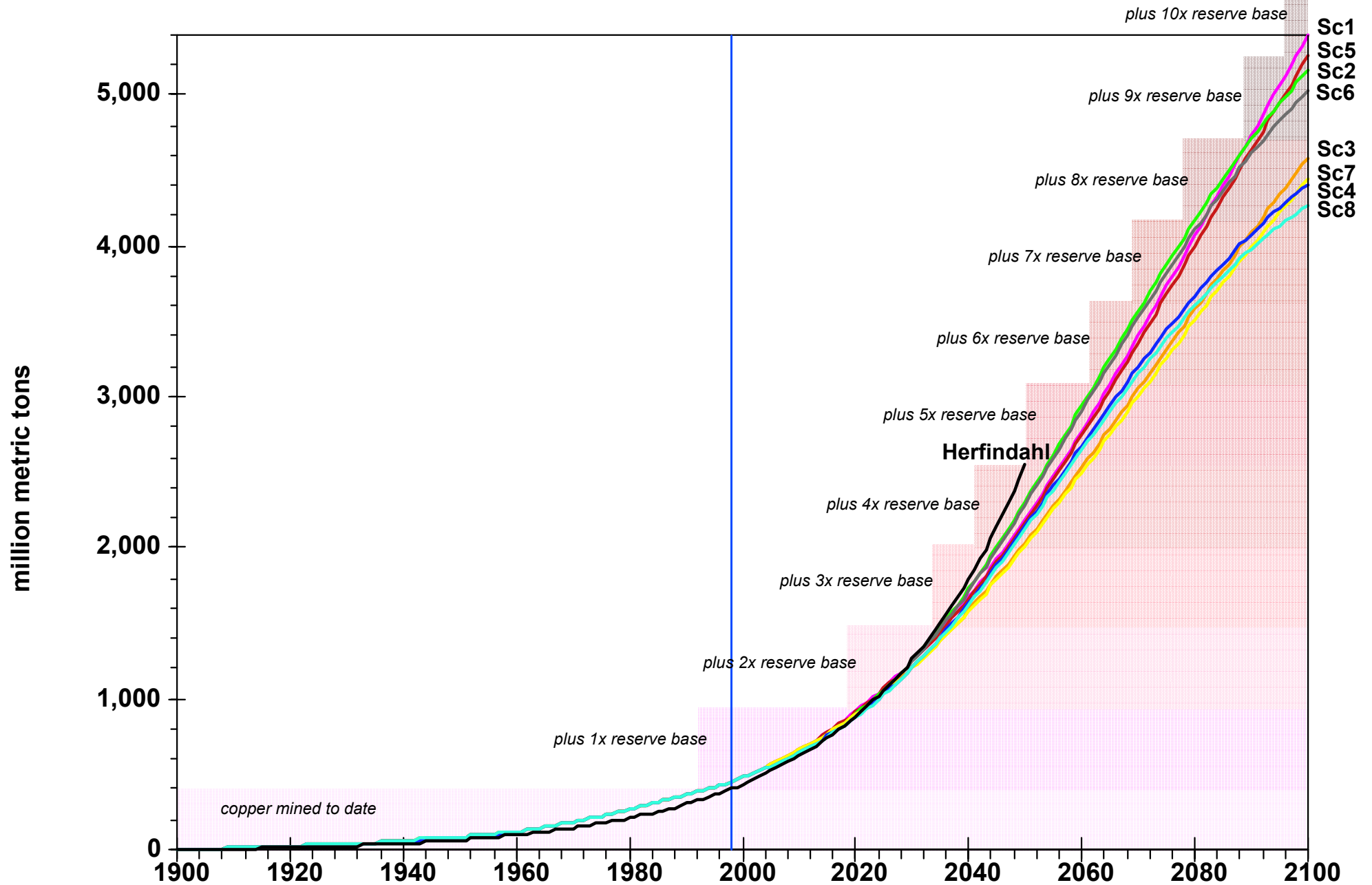


Figure B24: Comparison of copper system scenarios Sc1–8.
Global cumulative per capita mine production.

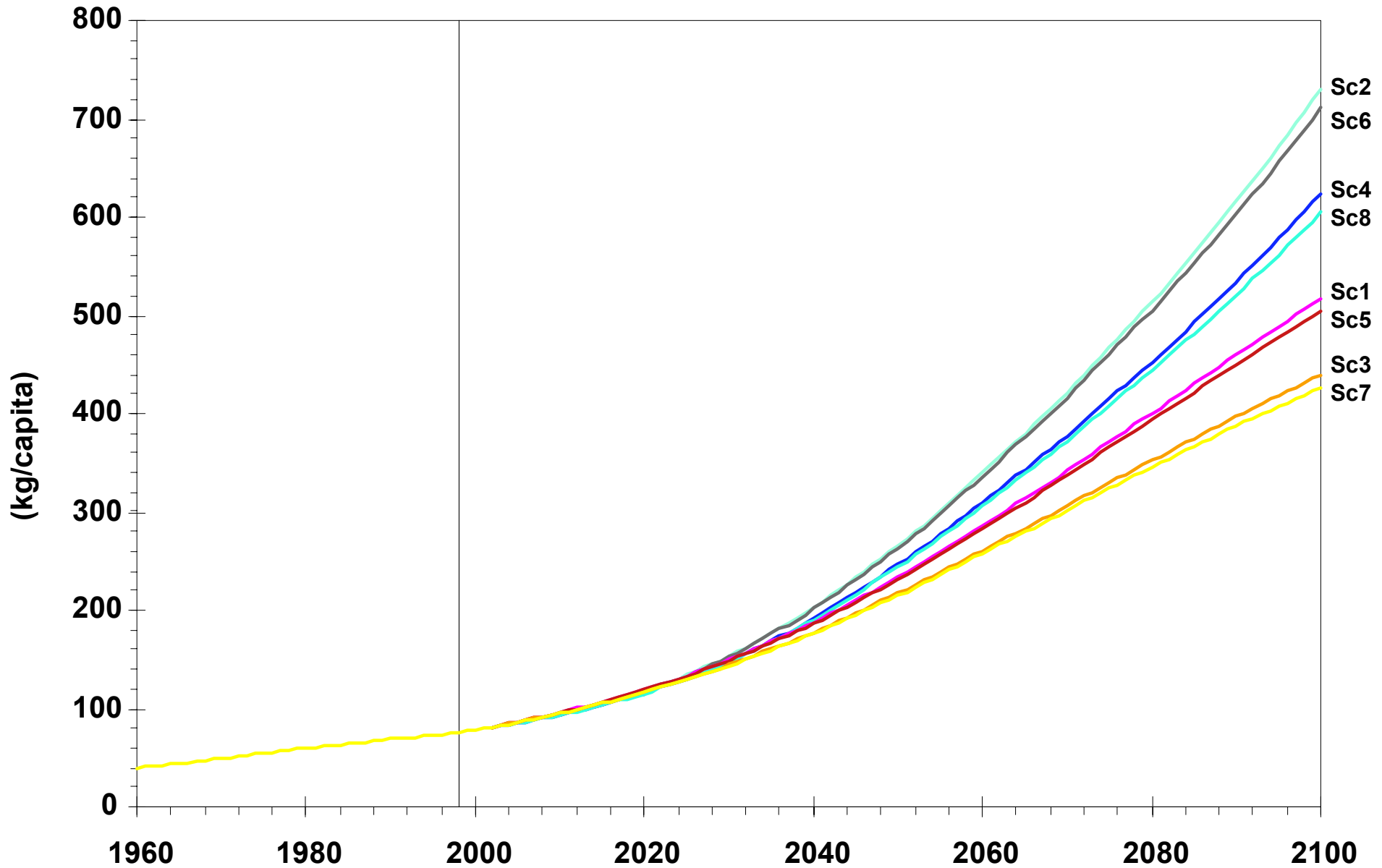


Figure B25 (3.21): Global stock of waste copper, 1900 - 1998, MMT

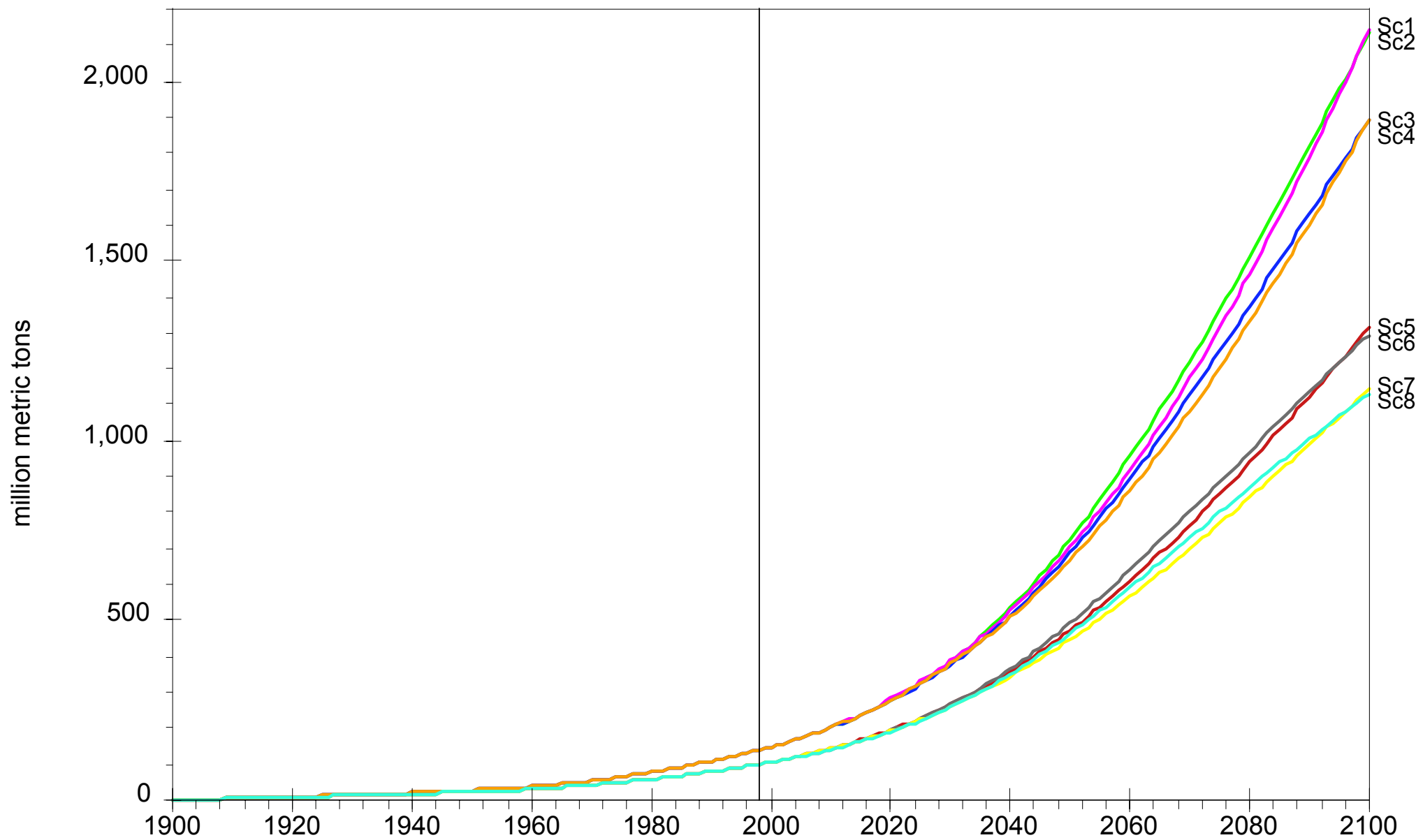


Figure B26: Comparison of copper system scenarios Sc1–8.
Global per capita stock of waste.

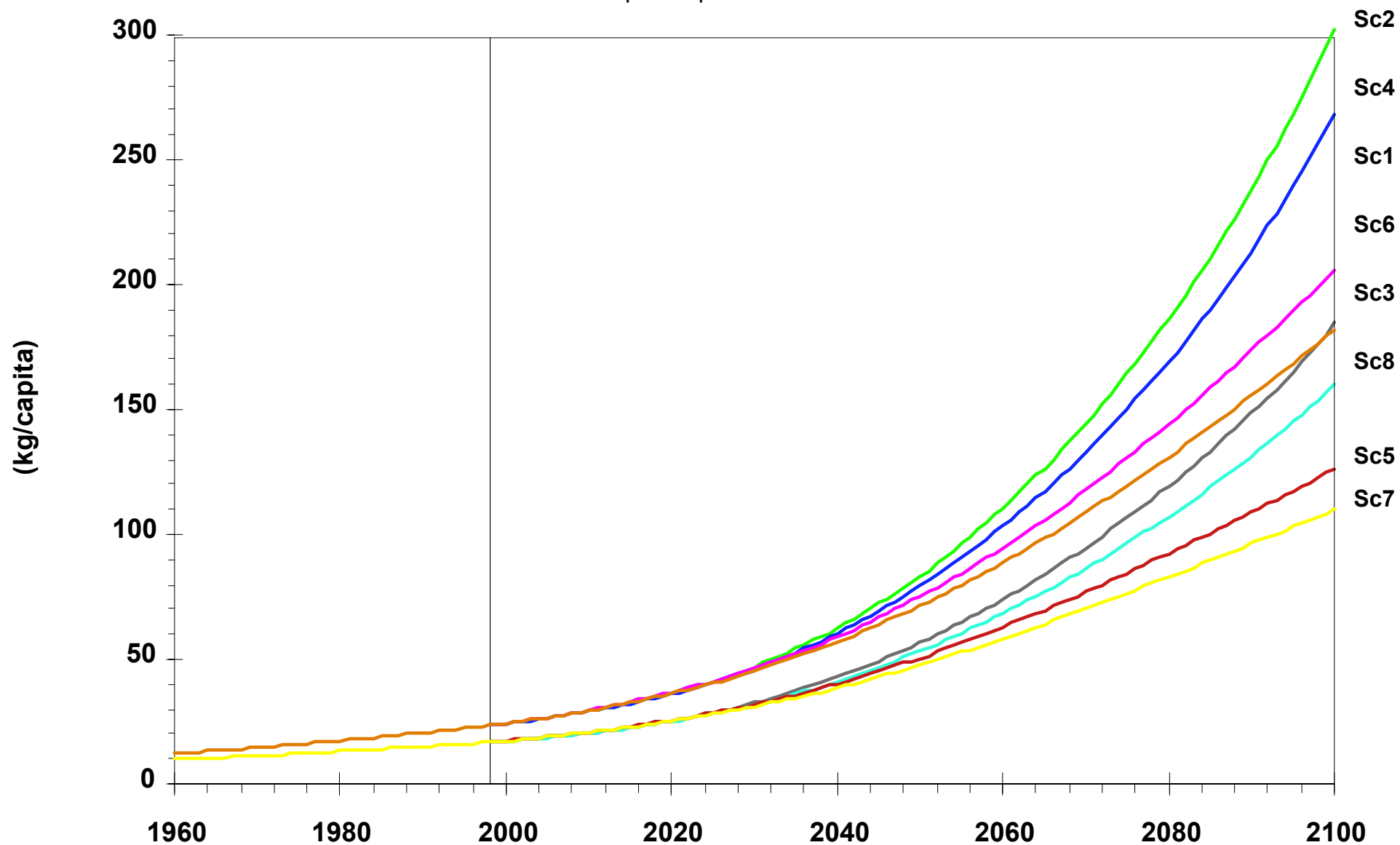


Figure B27 (2.31): Global stock of long-lived copper products, 1900 - 1998, MMT

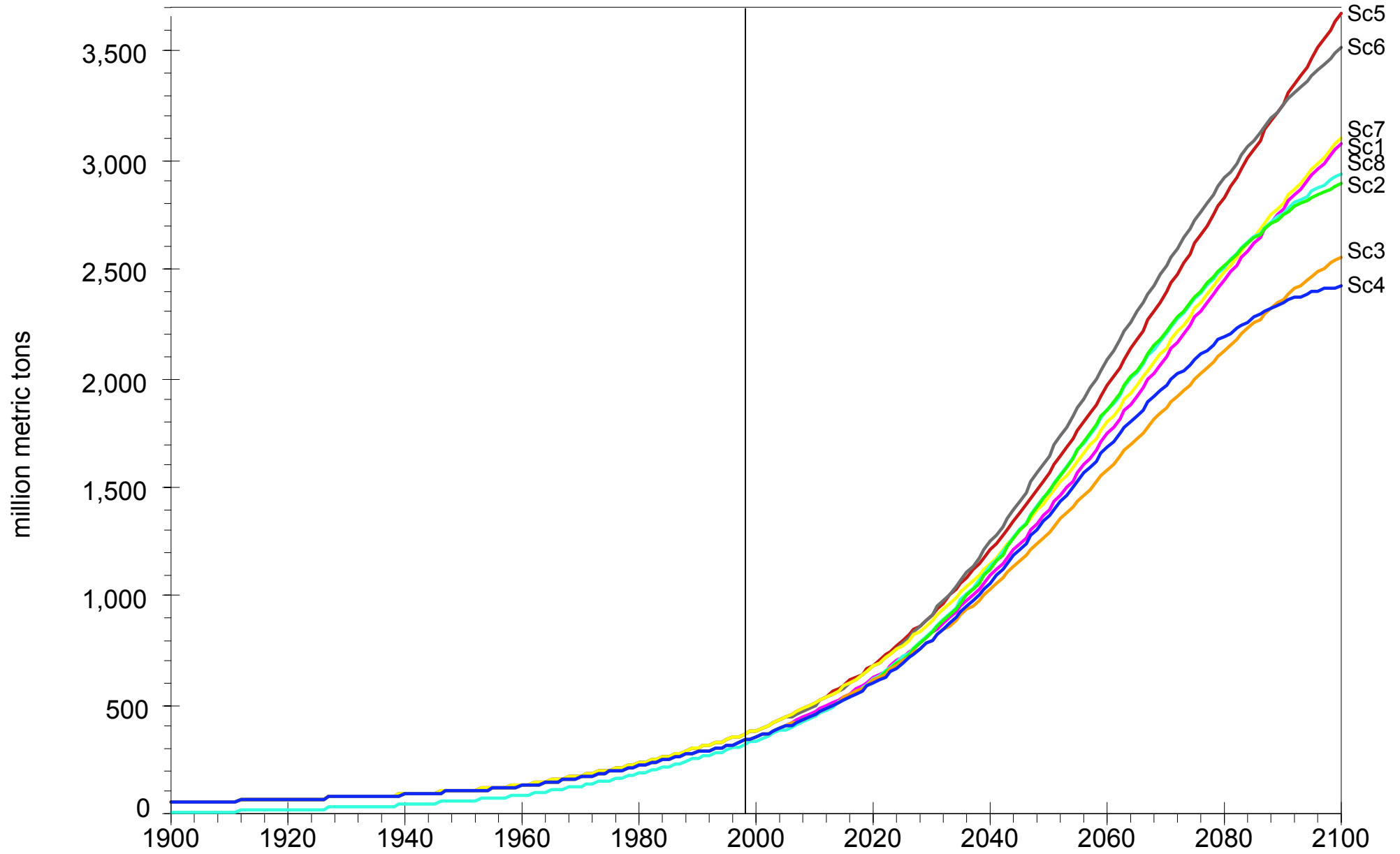


Figure B28: Comparison of copper system scenarios Sc1–8.
Global per capita stock of long-lived products

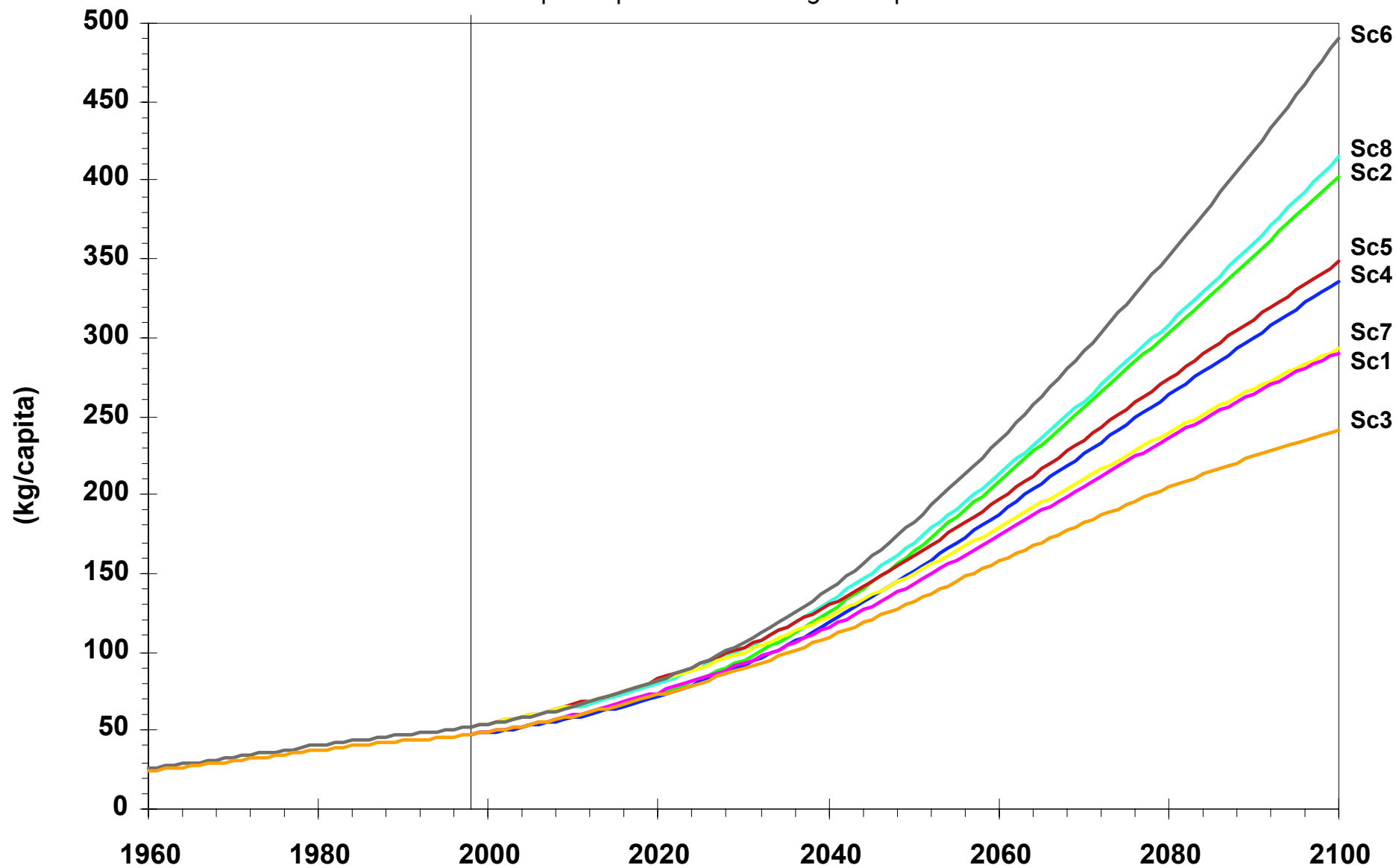


Figure B29 (3.23): Global stock of short-lived copper products, 1900 - 1998, MMT

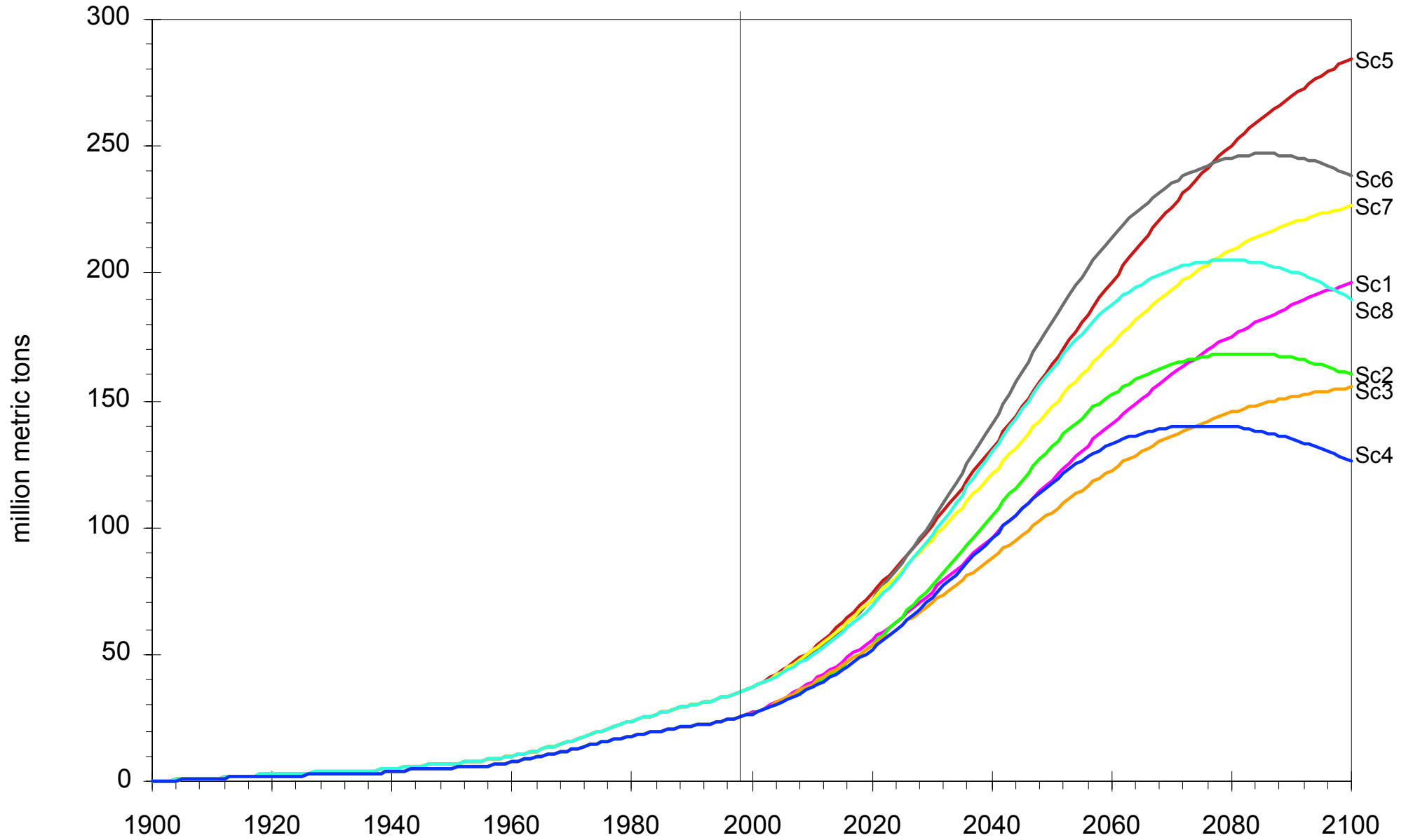


Figure B30: Comparison of copper system scenarios Sc1–8.
Global per capita stock of short-lived products

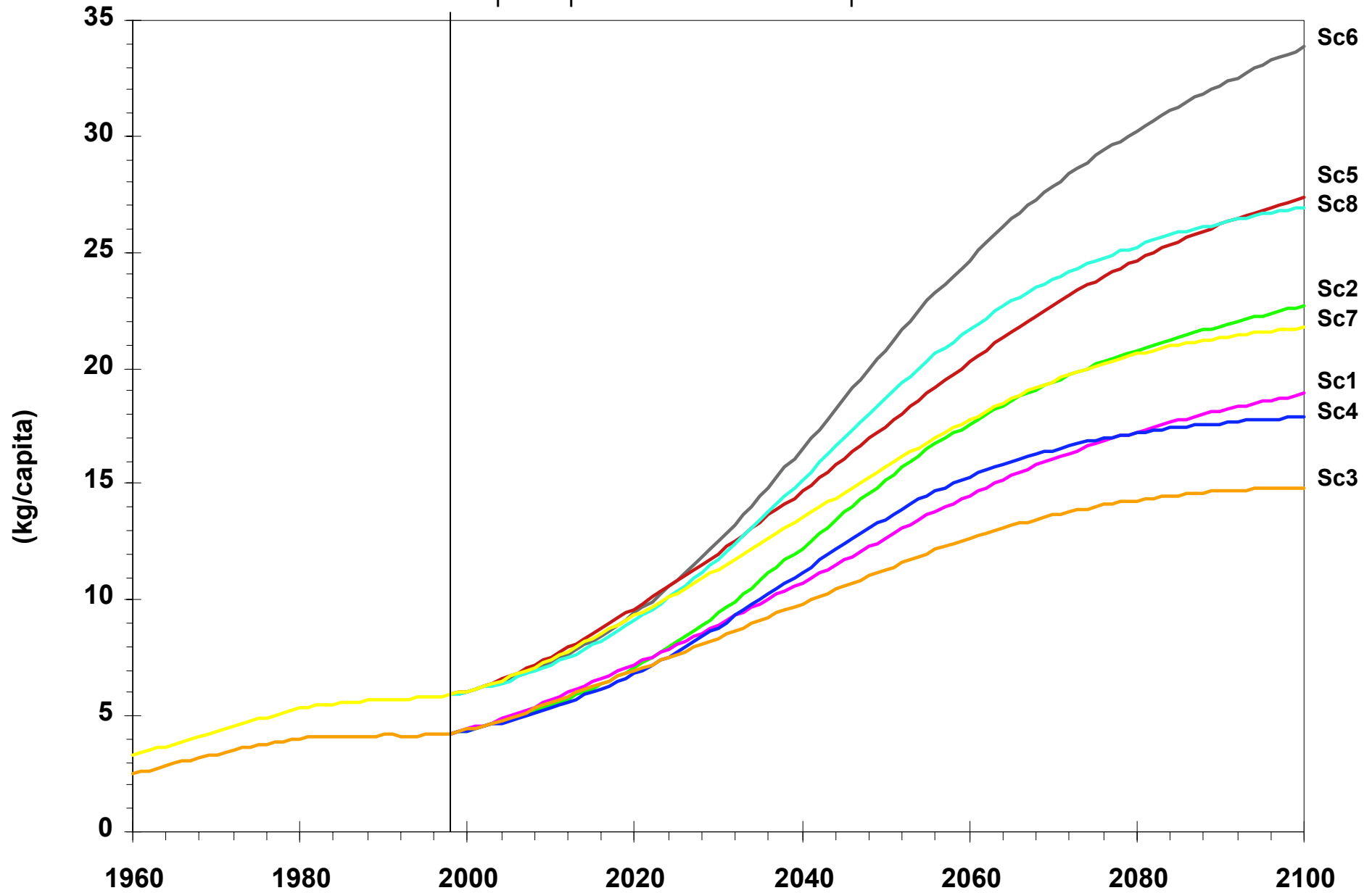


Figure B33 (3.12): Global copper recycling (separation) efficiency

