

Supplementary Material B

Mining the in-use stock of energy-transition materials for closed-loop e-mobility

Viktoria Schuster¹, Luca Ciacci^{2, 3*}, Fabrizio Passarini^{2,3*}

¹Department of Economics, Alma Mater Studiorum – University of Bologna, 40136 Bologna, Italy

²Department of Industrial Chemistry “Toso Montanari”, Alma Mater Studiorum – University of Bologna, 40136 Bologna, Italy

³Interdepartmental Centre of Industrial Research “Renewable Resources, Environment, Sea and Energy”, Alma Mater Studiorum – University of Bologna, 47923 Rimini, Italy

Corresponding authors: luca.ciacci5@unibo.it (L.C), fabrizio.passarini@unibo.it (F.P.)

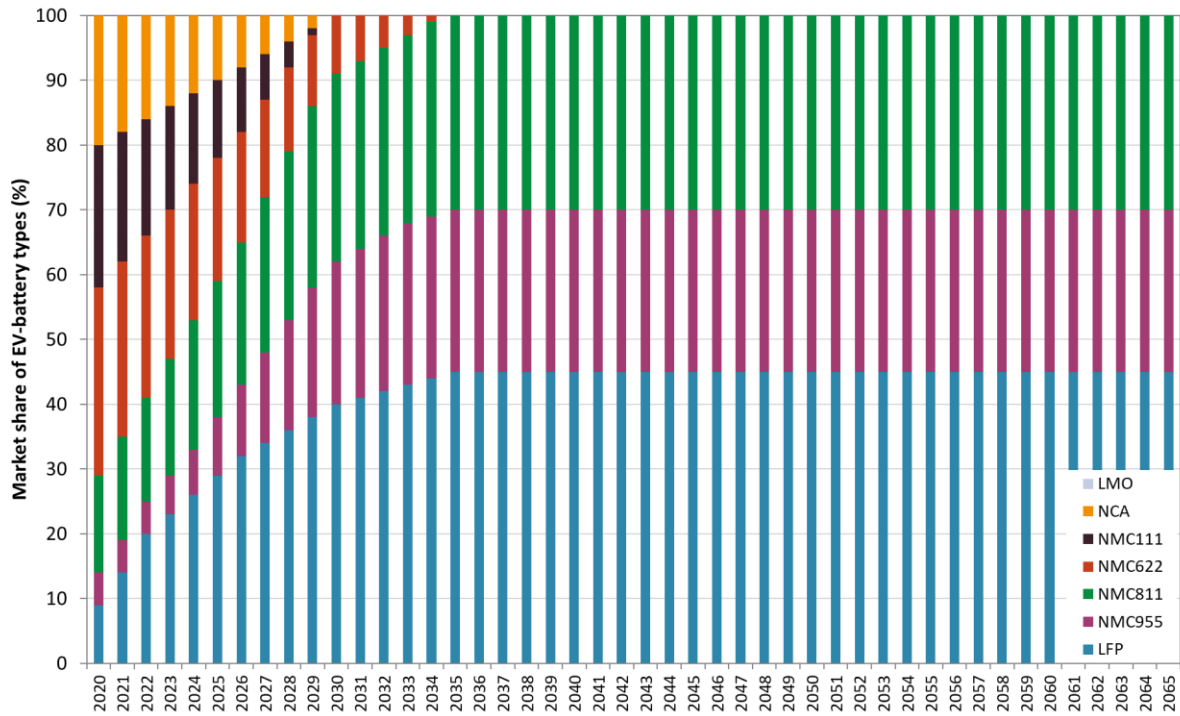


Figure S1: Time trend of market shares of battery types for EVs, in %

Table S1. Efficiencies of recycling processes for lithium (Li), nickel (Ni), cobalt (Co), manganese (Mn), and natural graphite (Graph). Own calculation based on Chen et. al., 2019 and Bernhart, 2019.

Recovery Rates						
		Li	Ni	Co	Mn	Graphite
(Chen et al, 2019)						
Pyrometallurgical Processes	1	94.9%	99.3%	99.8%	79.9%	
	2	97.5%				
	3	98.9%		95.7%		91.1%
	4	99.7%				
	5	91.3%			95.1%	
	6	84.7%	99.0%	99.0%	99.0%	
mean		94.5%	99.2%	98.2%	91.3%	91.1%
Hydrometallurgical Processes	leaching	99.0%	97.7%	88.4%		
	solvent extraction	99.9%	99.7%	98.0%	92.0%	
	precipitation	96.0%		99.0%	99.0%	
	sol-gel	98.4%	98.5%	99.5%		
mean		98.3%	98.6%	96.2%	95.5%	0.0%
(Bernhart, 2019)						
Pyrolysis-Hydrometallurgical		50-60%	> 95%	> 95%		0%
Mechanical-Hydrometallurgical		>90%	>99%	>99%		0%
Model		95%	95%	95%	95%	90%

Table S2. Comparison of our model results with selected references from the relevant literature.

	Annual sales [M unit/year]	Lithium inflow [kt/year]	Nickel inflow [kt/year]	Cobalt inflow [kt/year]	Manganese inflow [kt/year]	Graphite inflow [kt/year]
This study (STEPoS)	64 (2040)	327	1137	323	98	3473
	113 (2050)	574	1996	567	173	6098
	148 (2065)	754	2620	745	228	8008
This study (APoS)	98 (2040)	499	1734	493	150	5299
	129 (2050)	657	2284	649	198	6979
	136 (2065)	690	2399	682	208	7331
This study (NZEoS)	104 (2040)	529	1838	522	160	5616
	109 (2050)	553	1922	547	167	5875
	109 (2065)	554	1927	548	167	5889
Dunn et al., 2021	40-73 (2040) [†]	361-664	1672-3079	403-742	388-714	3176-5846
Xu et al., 2020	~110-210 (2050) [†]	620-1570	1500-7630	250-1460	160-810	4160-12840
Ziemann et al., 2018		850				

[†]Annual sales of EVs.

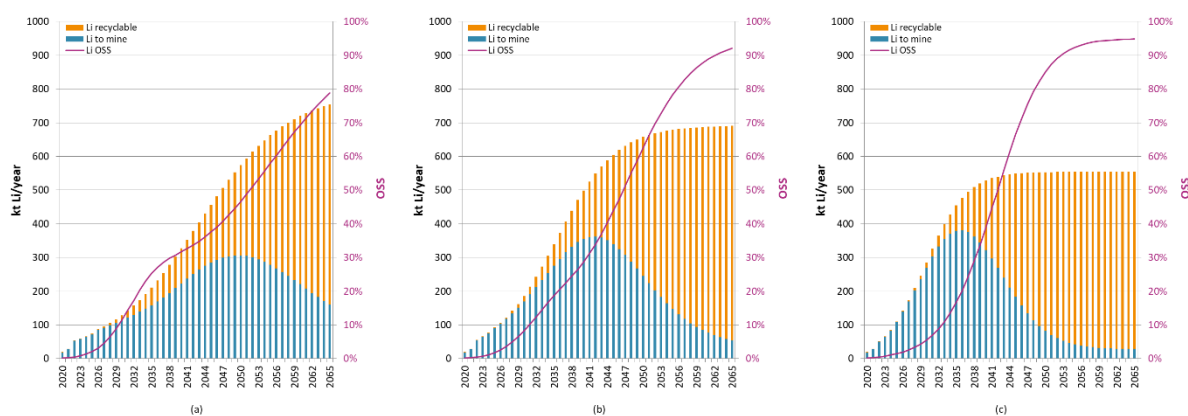


Figure S2. The required lithium amounts from mining (blue bars) and those potentially supplied from recycling (orange bars) estimated for STEPoS (a), APoS (b), and NZEoS (c). Old scrap supply ratio (OSS) for 2020-2065 is plotted on the second y-axis.

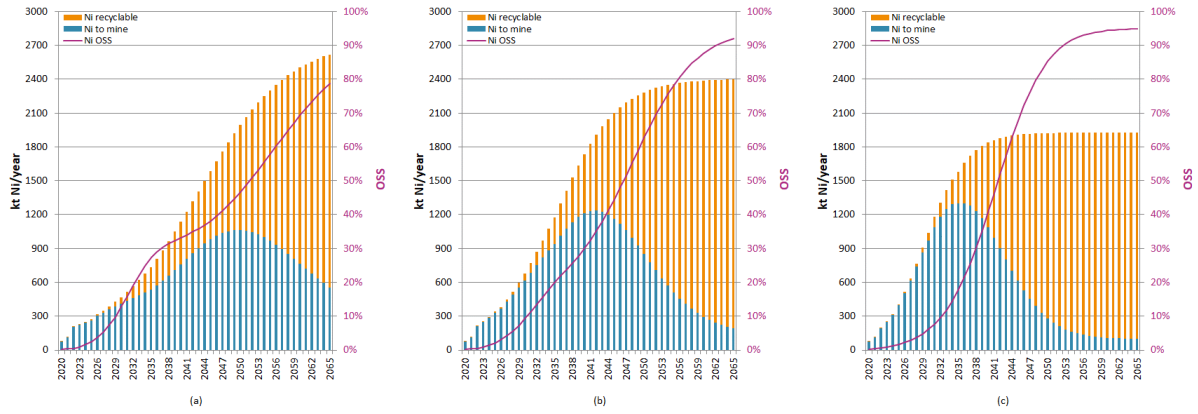


Figure S3. The required nickel amounts from mining (blue bars) and those potentially supplied from recycling (orange bars) estimated for STEPoS (a), APoS (b), and NZEoS (c). Old scrap supply ratio (OSS) for 2020-2065 is plotted on the second y-axis.

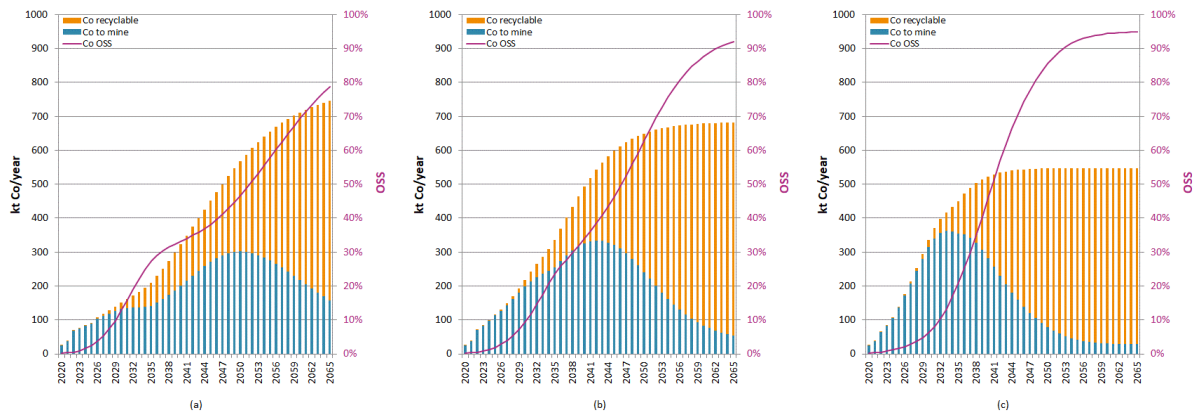


Figure S4. The required cobalt amounts from mining (blue bars) and those potentially supplied from recycling (orange bars) estimated for STEPoS (a), APoS (b), and NZEoS (c). Old scrap supply ratio (OSS) for 2020-2065 is plotted on the second y-axis.

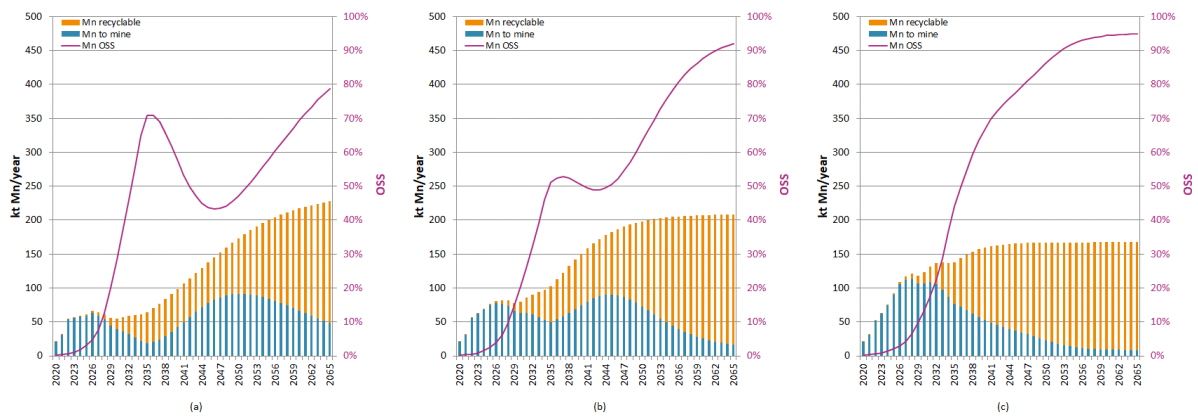


Figure S4. The required manganese amounts from mining (blue bars) and those potentially supplied from recycling (orange bars) estimated for STEPoS (a), APoS (b), and NZEoS (c). Old scrap supply ratio (OSS) for 2020-2065 is plotted on the second y-axis.

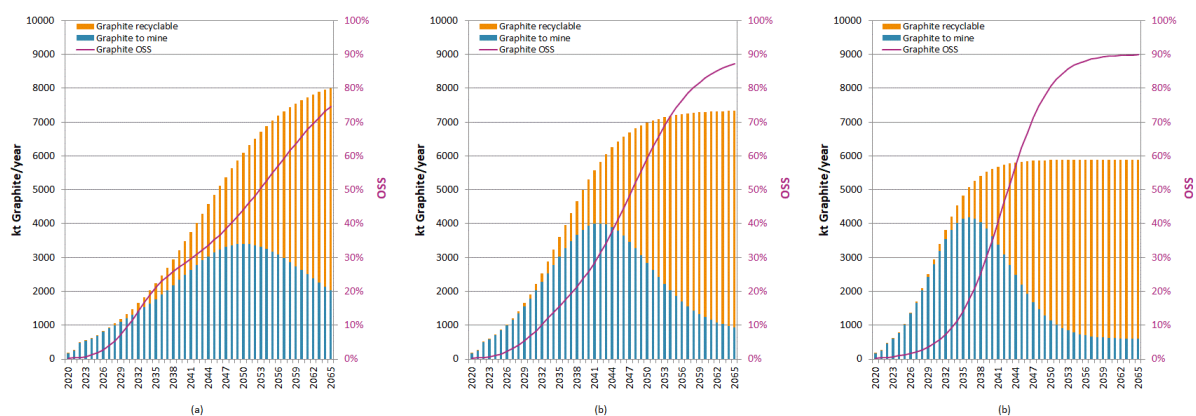


Figure S5. The required graphite amounts from mining (blue bars) and those potentially supplied from recycling (orange bars) estimated for STEPoS (a), APoS (b), and NZEoS (c). Old scrap supply ratio (OSS) for 2020-2065 is plotted on the second y-axis.

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