Politecnico di Torino

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Material flow and economic analyses of Lithium-ion batteries recycling processes in Europe

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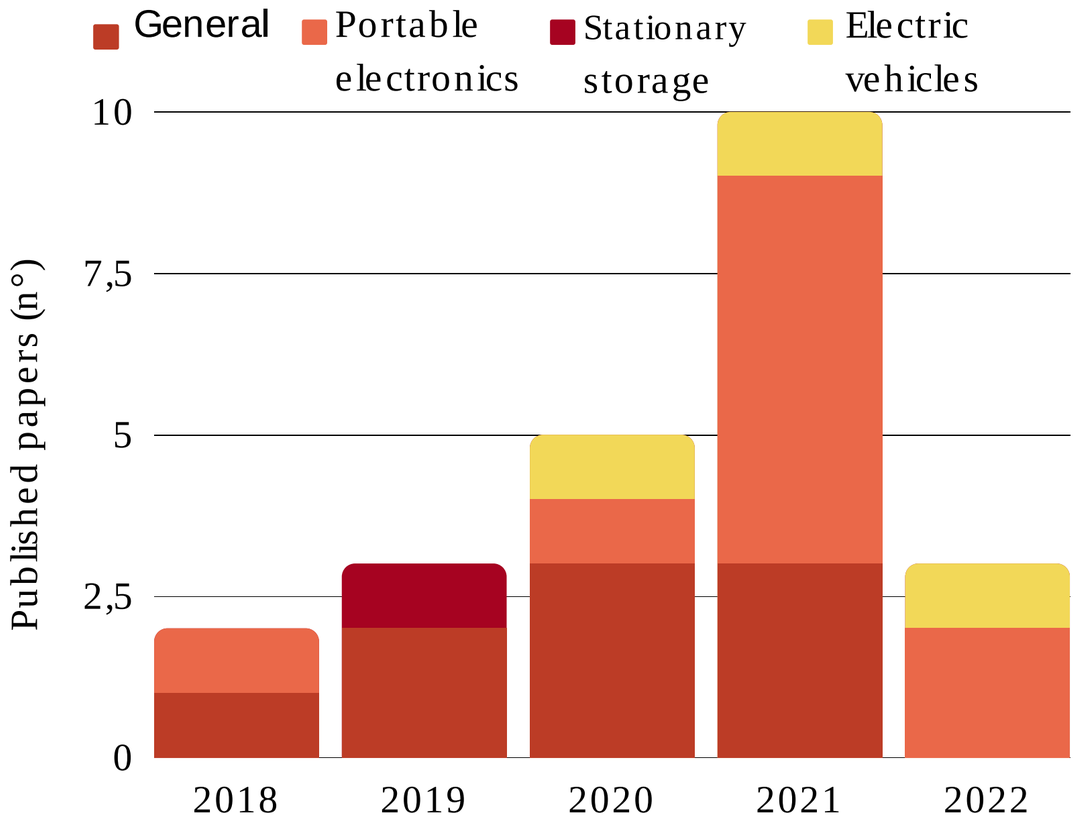
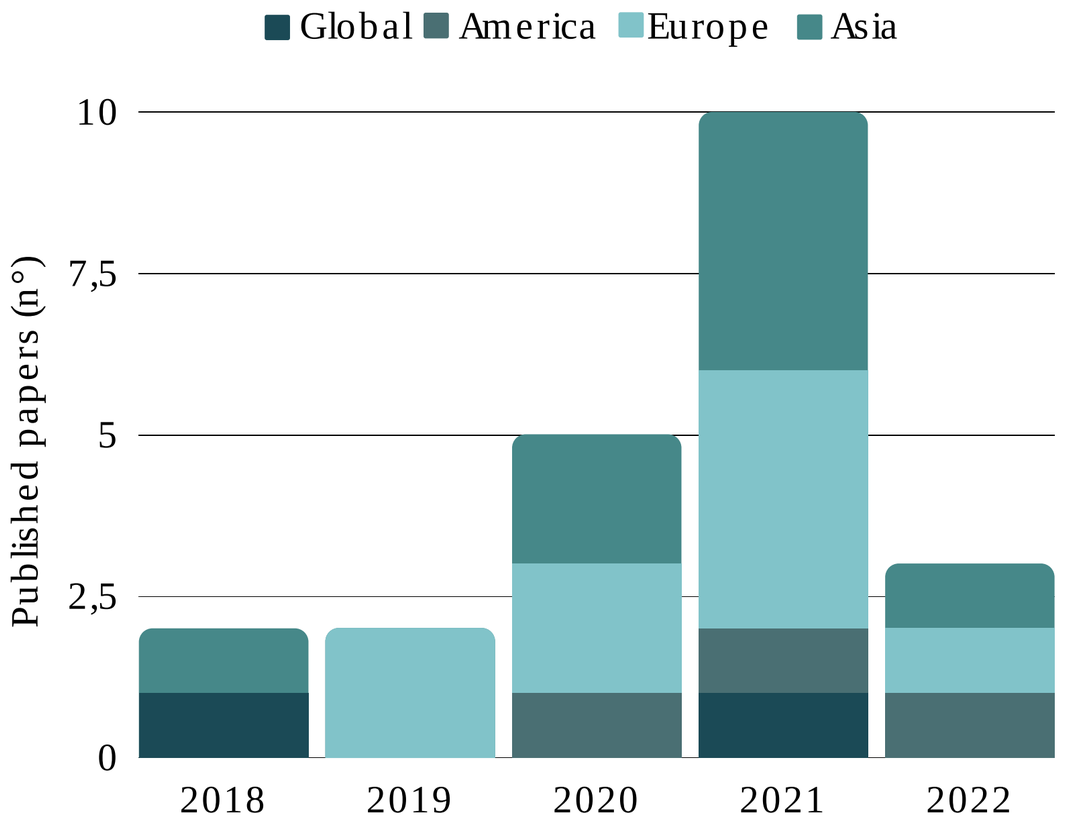
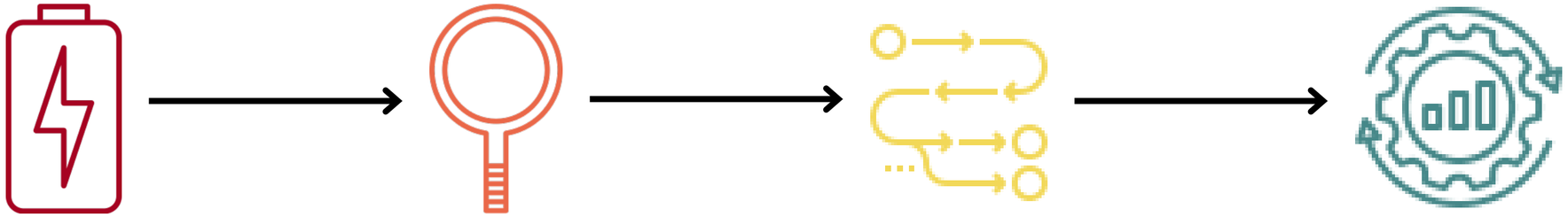
Lithium ion batteries: state of the art on material flows





Novelty: few studies considered the European Lithium ion batteries market and a specific focus on the economic consequences of materials flow analysis is still missing

Methodology



Lithium-ion batteries EU market and material circularity in 2030

Inventory of recycling plants

Material flow analysis and economic assessment

Conclusions and research gaps

Li-ion batteries materials composition

Battery		LFP	NCA	NMC 111	NMC 622	NMC 811
Market shares (Statista, 2021)		2%	19%	24%	45%	10%
Composition (%mass) (Gaines et al., 2018)	PET	0.4%	0.3%	0.3%	0.3%	0.4%
	PE	0.2%	0.3%	0.3%	0.3%	0.3%
	Electrolyte DMC	9.3%	6.3%	6.2%	6.3%	7.2%
	Electrolyte EC	9.4%	6.3%	6.2%	6.3%	7.2%
	Electrolyte LiPF6	3.3%	2.3%	2.2%	2.2%	2.6%
	Al (CC)	7.5%	8.4%	8.2%	8.4%	8.0%
	Cu (CC)	14.5%	16.9%	16.4%	16.8%	15.7%
	Binder PVDF	2.7%	2.9%	2.9%	2.9%	3.6%
	Carbon black	2.2%	2.1%	2.3%	2.1%	1.7%
	Graphite	16.6%	22.0%	19.0%	20.7%	20.6%
	Li	1.4%	2.2%	2.7%	2.5%	2.4%
	Co	-	2.8%	6.9%	3.8%	1.9%
	Ni	-	14.9%	6.9%	11.5%	14.9%
	Mn	-	-	6.4%	3.6%	1.7%
	Al	-	0.4%	-	-	-
	Fe	11.4%	-	-	-	-
	P	6.3%	-	-	-	-
	O	13.1%	10.1%	11.2%	10.4%	10.2%

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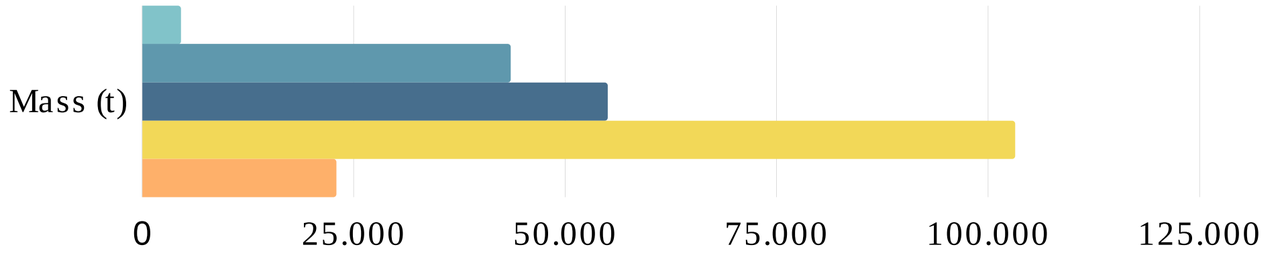
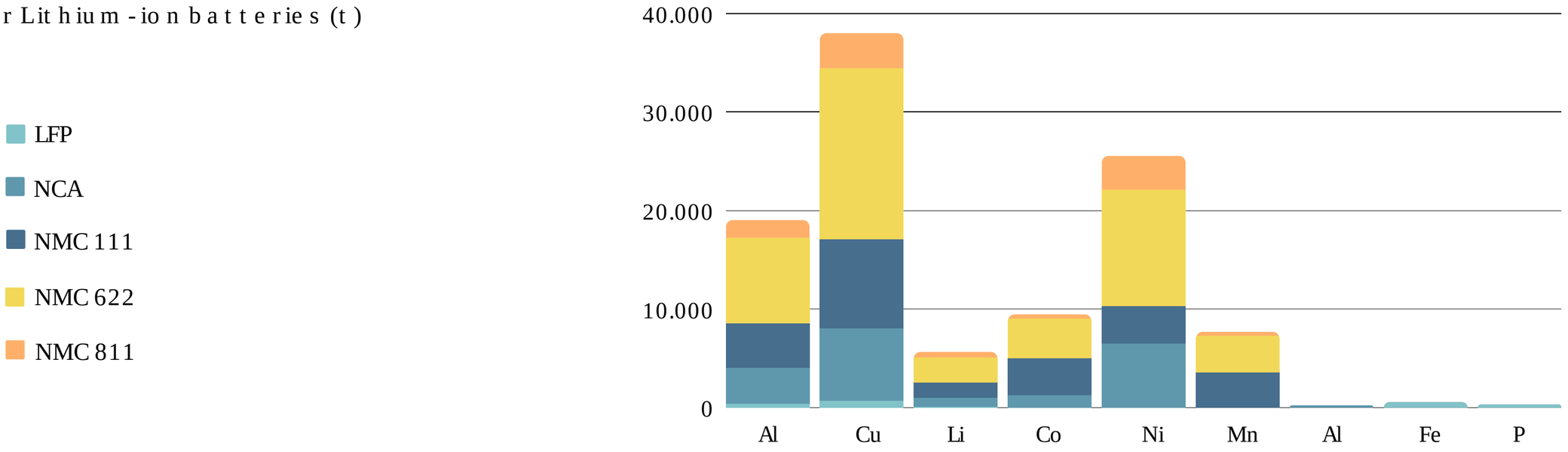
Input data for materials flow analysis

Lithium ion batteries market shares for different cathodes chemistries

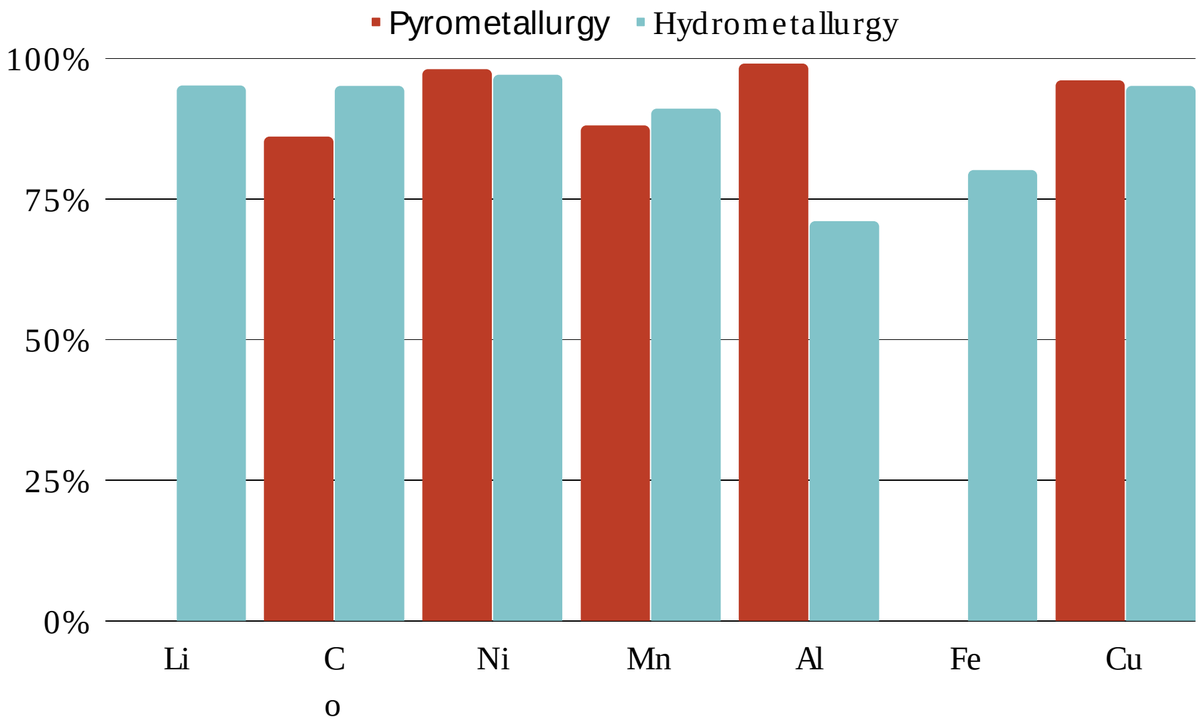


Relevant metals due to European market for Lithium-ion batteries (t)



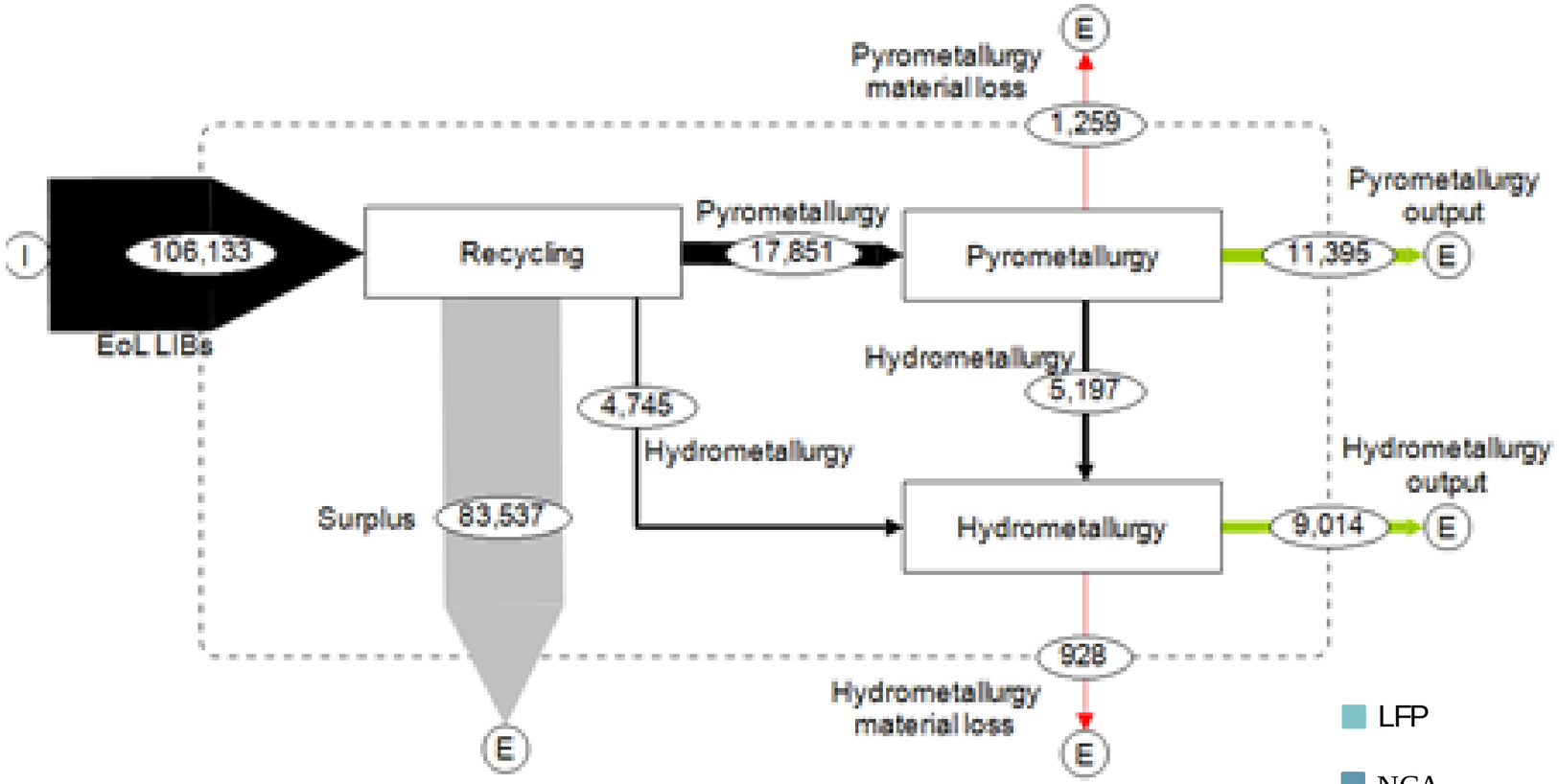
European recycling capacity in 2020: 50 Mt

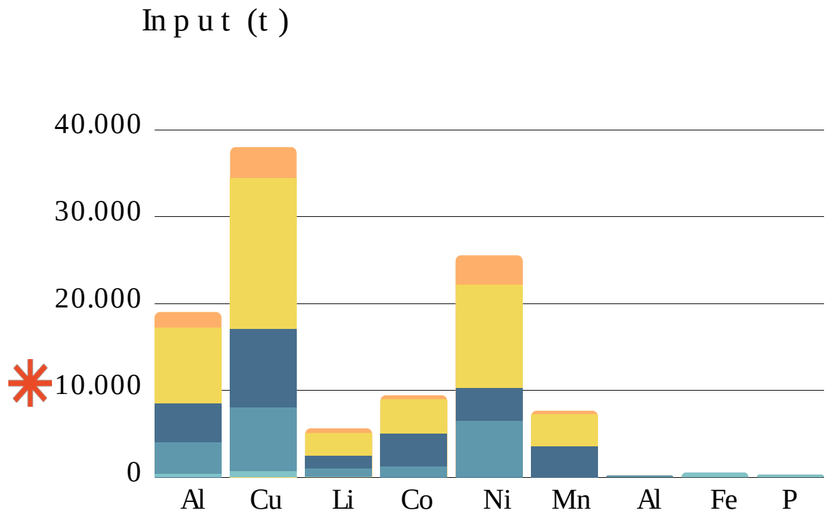
Recycling efficiency of full-scale recycling treatments

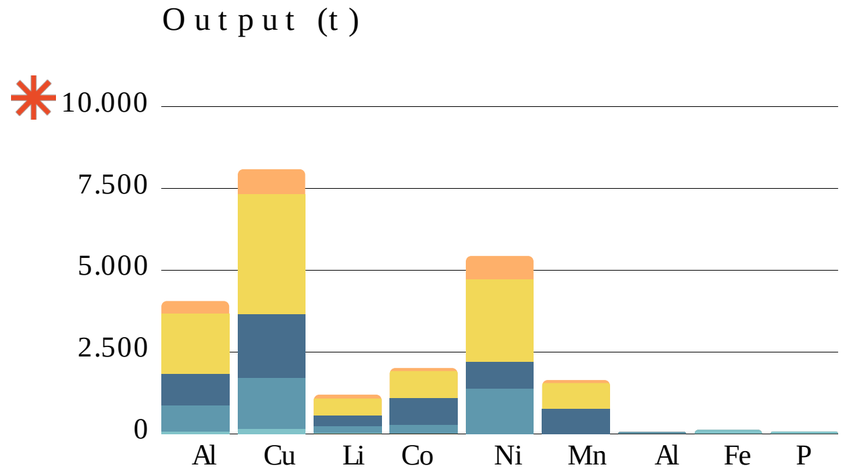


European countries with Li-ion batteries recycling plants

Material flow analysis







LFP
NCA
NMC 111
NMC 622
NMC 811

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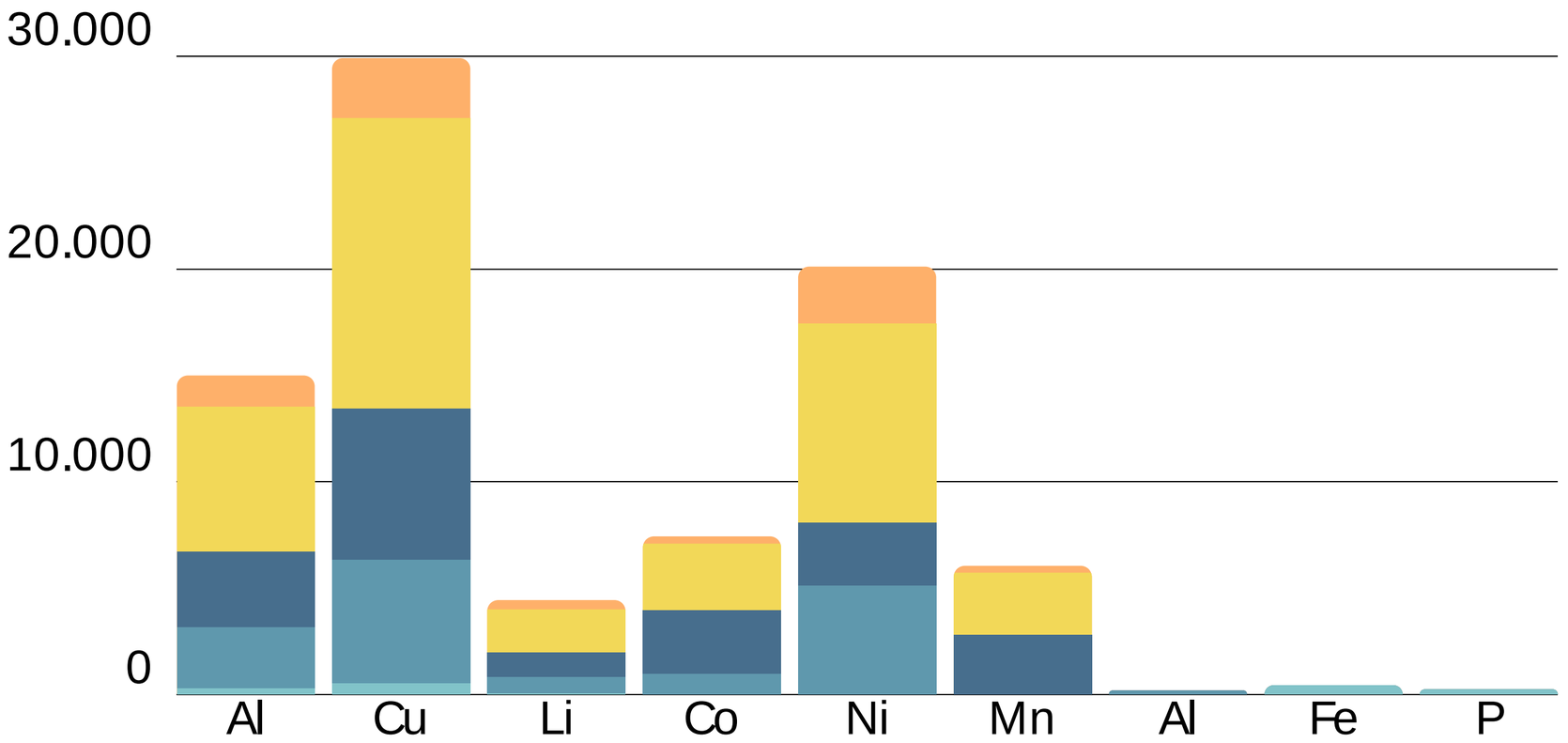
Material flow analysis

Surplus materials (t)

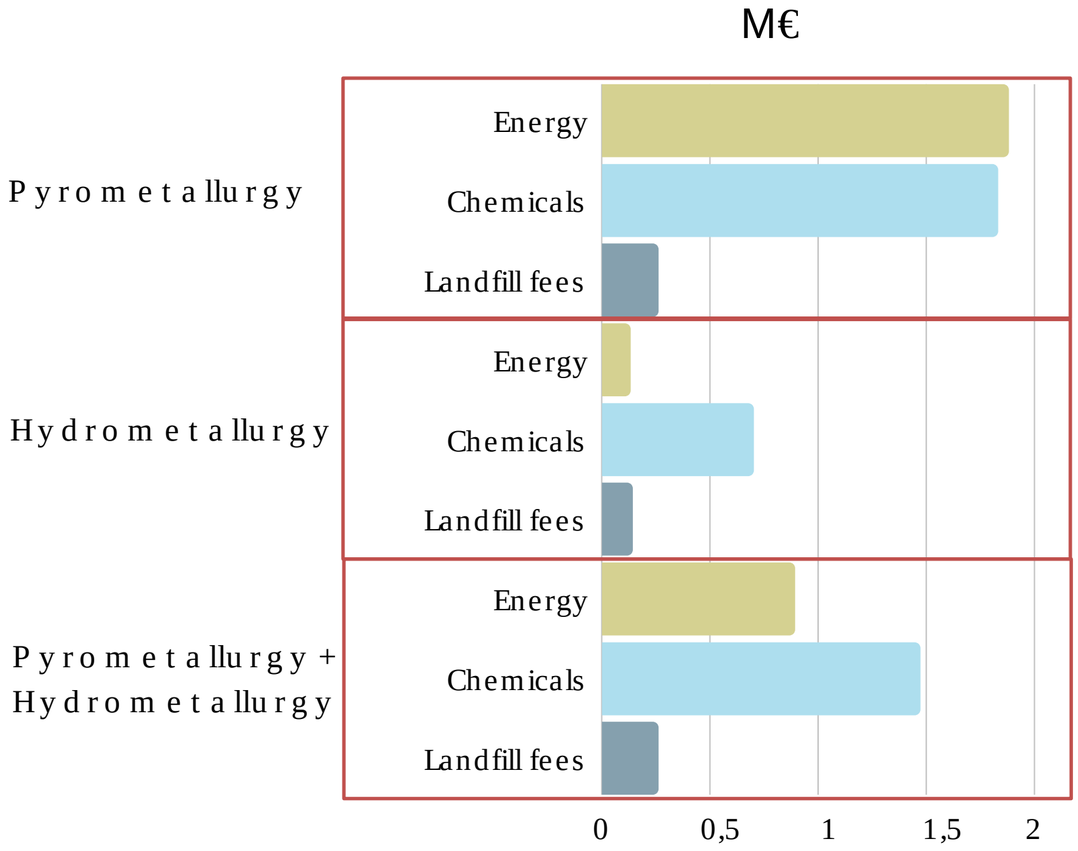


	Output (%)
Surplus	78,7%
Pyrometallurgy	10,7%
Hydrometallurgy	4,4%
Pyrometallurgy + Hydrometallurgy	6,2%

Economic assessment

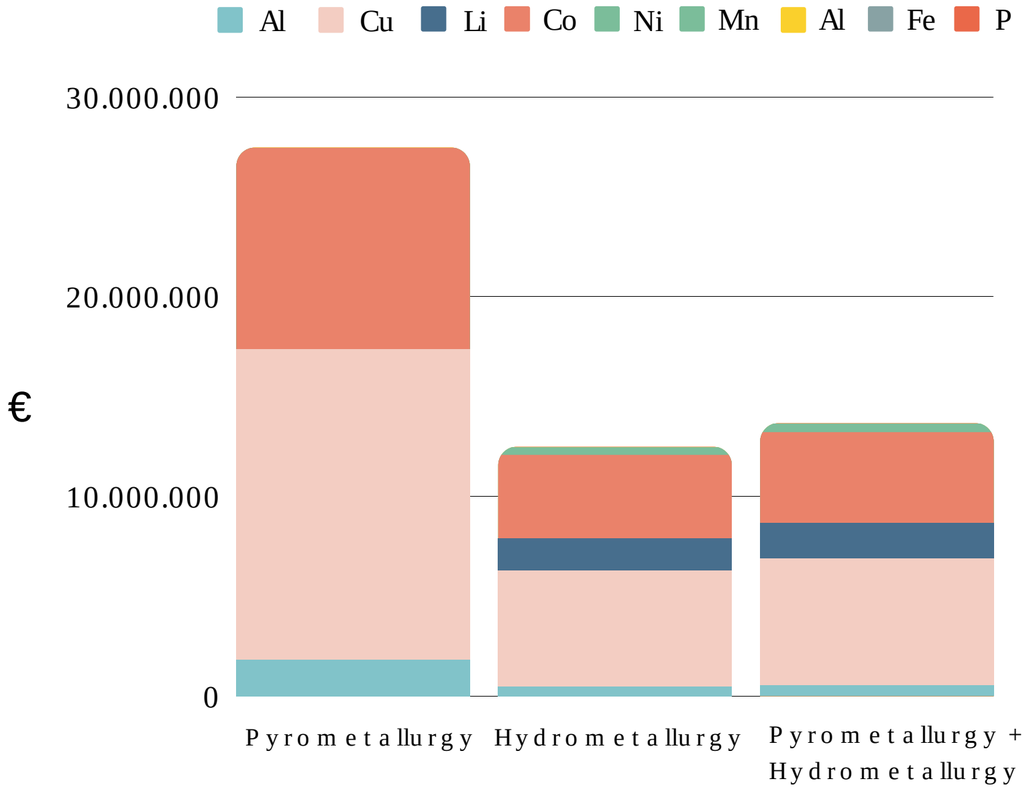
Recycling costs (M€):

- Chemicals
- Energy
- Landfill fees

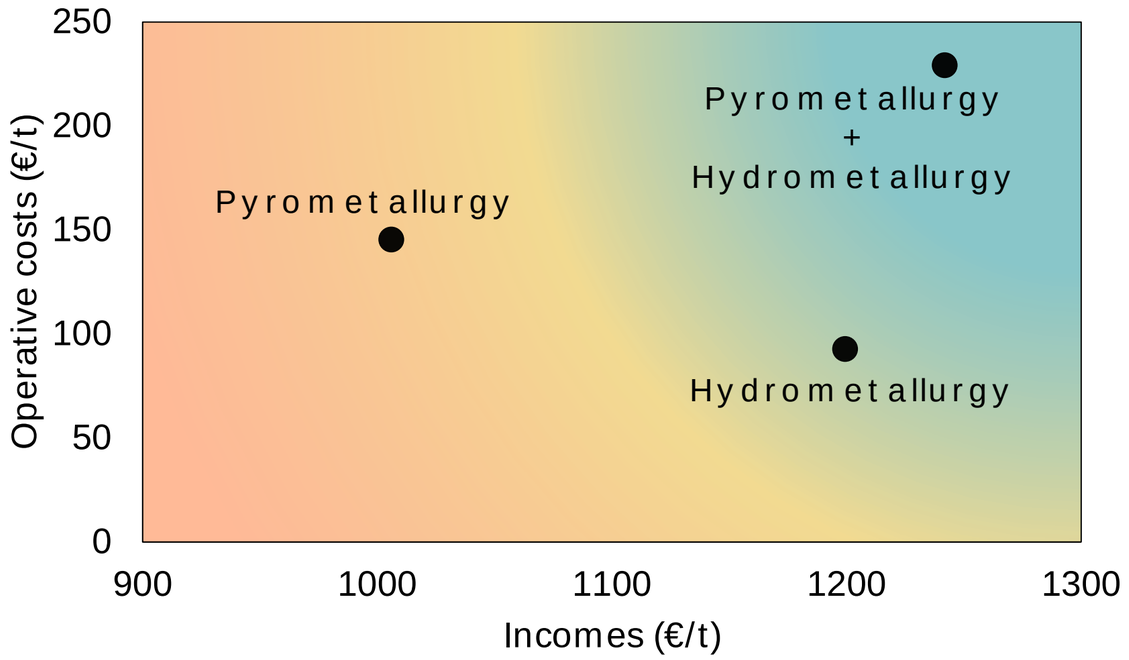


Incomes:

- from sales of recovered materials



Economic assessment



	Incomes (€/t)	Operational costs (€/t)
Pyrometallurgy	1006.07	145.33
Hydrometallurgy	1199.47	92.64
Pyrometallurgy + Hydrometallurgy	1242.05	229.09

Conclusions

- **Shortcoming** in the current management of resources for Li-ion batteries recycling.
- Lack of **economic implications** associated with LIBs recycling material flows analysis
- **Inadequacy** of current recycling infrastructure: elevated amount of surplus materials
- Wide-spread reliance on **pyrometallurgical processes**, which are not able to recover Lithium
- Best trade-off between operating costs and incomes entailed by **hydrometallurgical processes**

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Thank you!