Supporting Information

Environmental Impacts of Specific Recyclates in European Battery Regulatory Compliant Lithium-Ion Cell Manufacturing

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I. Battery compositions

Table S1: Composition of the battery pack from Dai et al. [1]

Battery pack	**1**	**kg**
Module components	4.49	%
Pack components	21.91	%
Cells	72.6	%
Total	100	%

Table S2: NMC111 cell composition from Crenna et al. [2]

NMC111 Cell	**1**	**kg**
Electrolyte	14.63	%
Separator	1.75	%
Anode paste	20.37	%
Cu current collector	12.38	%
Cathode paste	38.94	%
Al current collector	5.34	%
Cell Container: plastic PET	0.28	%
Cell Container: plastic PP	0.13	%
Cell Container: aluminium	1.82	%
Cell Container: aluminium positive terminal	1.01	%
Cell Container: copper negative terminal	3.35	%
Total	100	%

Table S3: NMC111 cathode paste from Crenna et al. [2]

Cathode	**1**	**kg**
LiNMCO2 (active material)	89	%
Carbon black	6	%
PVDF	5	%
Total	100	%

Table S4: NMC111 anode paste from Crenna et al. [2]

Anode	**1**	**kg**
Synthetic graphite	95	%

PVDF	5	%
Total	100	%

Table S5: NMC811 cell composition from Crenna et al. [2]

NMC811 Cell	**1**	**kg**
Electrolyte	16.83	%
Separator	1.82	%
Anode paste	21.81	%
Cu current collector	12.43	%
Cathode paste	37.73	%
Al current collector	2.84	%
Cell Container: plastic PET	0.28	%
Cell Container: plastic PP	0.12	%
Cell Container: aluminium	1.81	%
Cell Container: aluminium positive terminal	1.03	%
Cell Container: copper negative terminal	3.3	%
Total	100	%

Table S6: NMC811 cathode paste from Crenna et al. [2]

Cathode	**1**	**kg**
LiNMCO2 (active material)	89	%
Carbon black	6	%
PVDF	5	%
Total	100	%

Table S7: NMC811 anode paste from Crenna et al. [2]

Anode	**1**	**kg**
Synthetic graphite	95	%
PVDF	5	%
Total	100	%

Table S8: LFP cell composition from Peters et al. [3]

LFP Cell	**1**	**kg**
Electrolyte	16.62	%
Separator	1.25	%
Anode paste	19.70	%
Cu current collector	9.14	%
Cathode paste	42.3	%

Al current collector	3.9	%
Cell Container: Multilayer pouch	02.39	%
Cell Container: aluminium positive terminal	1.09	%
Cell Container: copper negative terminal	3.61	%
Total	100	%

Table S9: LFP cathode paste from Peters et al. [3]

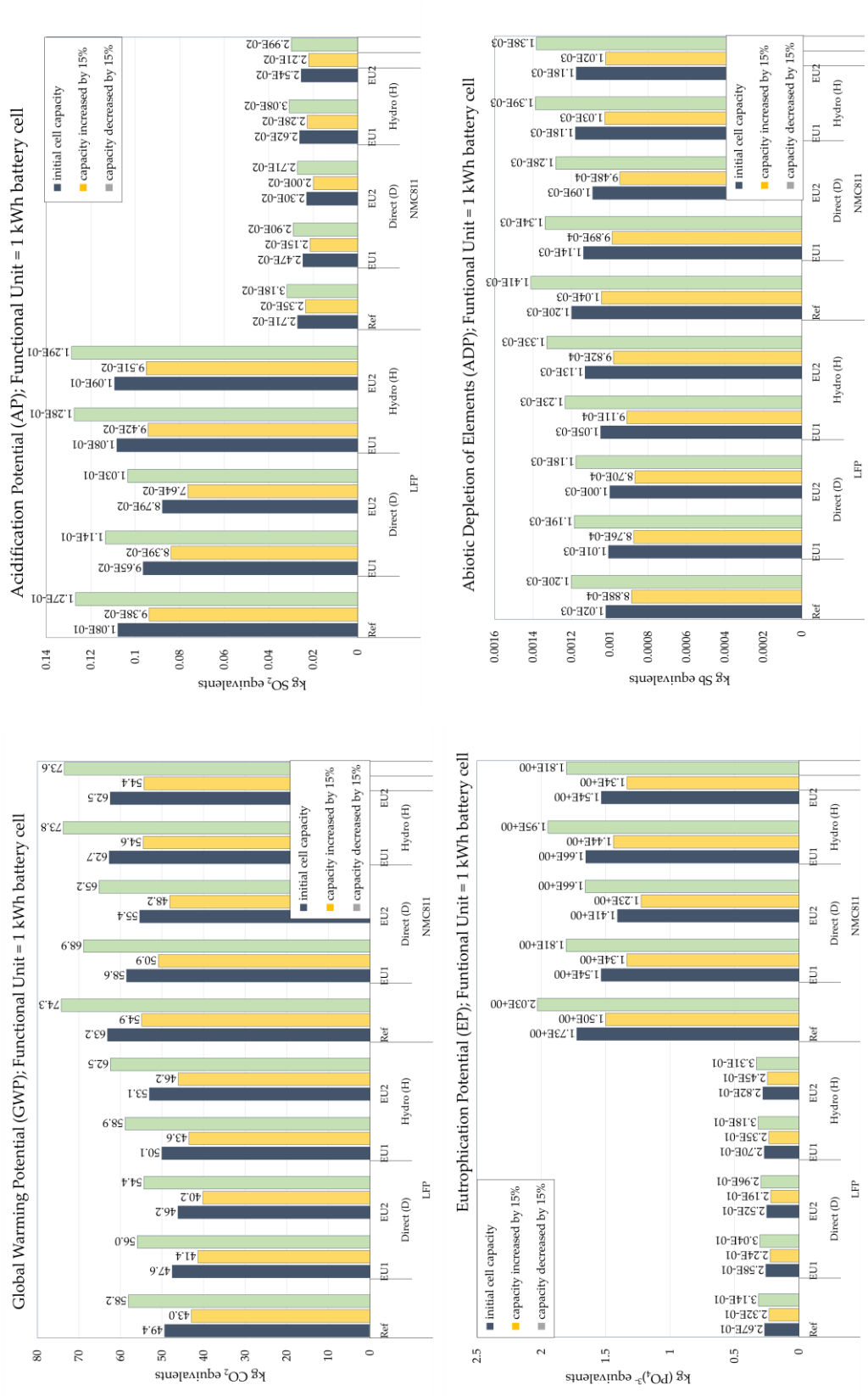
Cathode	**1**	**kg**
Synthetic graphite	96	%
PVDF	2	%
Carbon black	2	%
Total	100	%

Table S10: LFP anode paste from Peters et al. [3]

Anode	**1**	**kg**
Synthetic graphite	95	%
PVDF	5	%
Total	100	%

II. Sensitivity analysis

Figure S1: Sensitivity analysis for different energy densities for the impact categories GWP, EP, Ap and ADP



III. Mass-proportional allocation

Figure S2: Mass-proportional allocation related to the functional unit of 1 kg cell material for the impact GWP, EP, AP and ADP

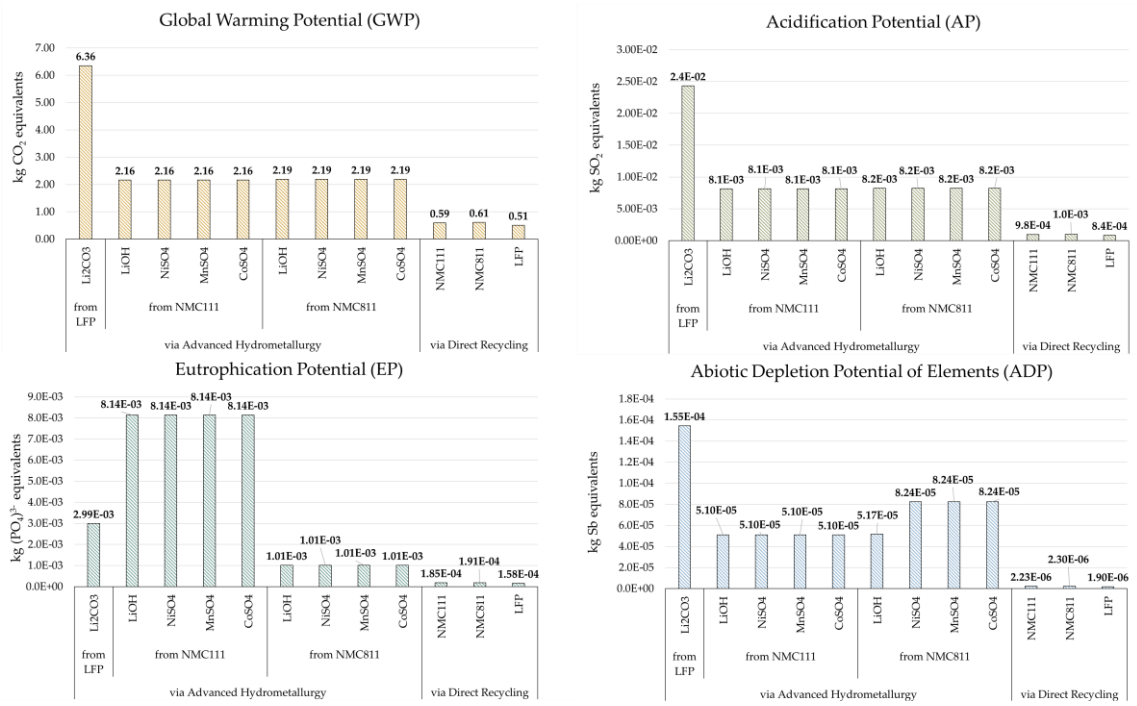
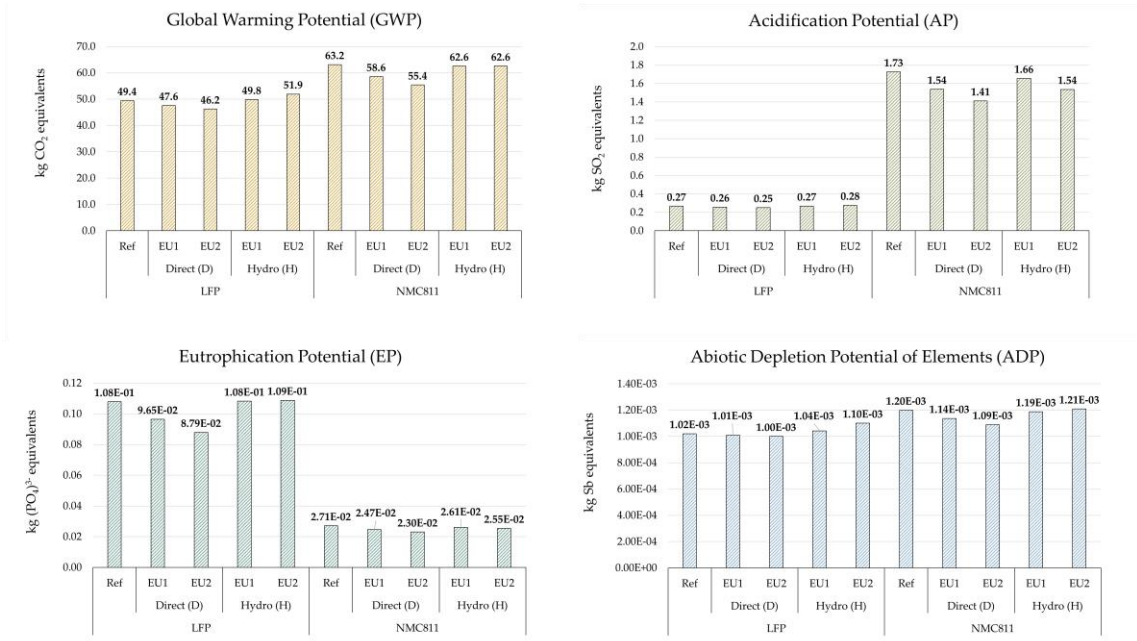
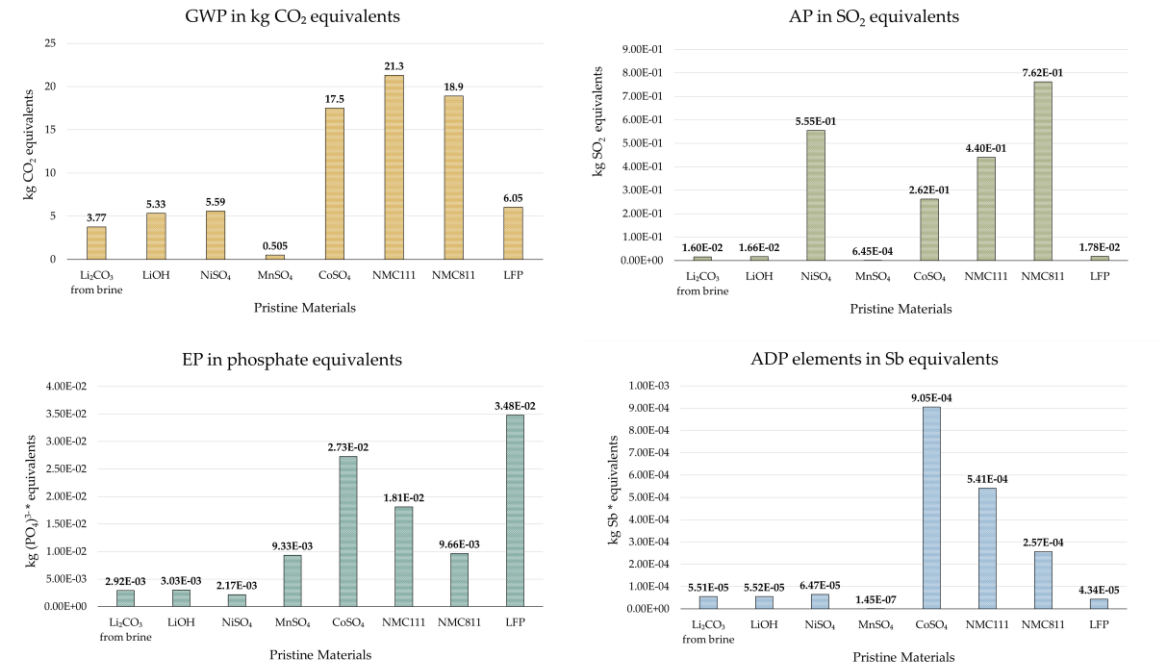


Figure S3: Mass-proportional allocation related to the functional unit of 1 kWh battery capacity for the impact categories GWP, EP, AP and ADP



IV. Pristine Materials Impact

Figure S4: Environmental impacts of pristine materials used for cell manufacturing presented for comparison reasons.



V. Unit Processes Life Cycle Inventories

Table S11: Life Cycle Inventories of used unit processes.

Process			Inputs			Outputs		
			Flow	Quantity	Unit	Flow	Quantity	Unit
Waterjet-based direct recycling from Kurz et al. [4]	Dismantling	Dismantling to cell level	Electricity [Electric power]	0.0409	MJ	Aluminium [Metals]	0.1791	kg
			Traction battery [Battery recycling]	1	kg	Battery cells [Battery recycling]	0.726	kg
			Soaping agent [Operating materials]	2.27E-05	kg	Copper [Metals]	0.0031	kg
			Cleaning rags [Battery recycling]	9.09E-05	kg	GLO: electronic component, unspecified, at plant [Parts]	0.0366	kg
			Working gloves [Battery recycling]	9.09E-05	kg	Polyethylene cross-linked (PEX) [Plastics]	0.0049	kg
			Compressed air, 7 bar, average efficiency [Mechanical energy]	0.00341	kg	Polyethylene part (PE) [Plastic parts]	0.0011	kg
						Ethylene glycol [Organic intermediate products]	0.043	kg
						Steel part [Metal parts]	0.0062	kg
		Cell disassembly and electrode separation	Battery cells [Battery recycling]	0.726	kg	Aluminium [Metals]	0.0132	kg
			Compressed air, 7 bar, average efficiency [Mechanical energy]	0.00341	Nm3	CN: Cathode, lithium-ion battery, lithium manganese oxide, at plant [Parts]	0.3289	kg
			Electricity [Electric power]	0.0982	MJ	Copper [Metals]	0.1142	kg
						Graphite [Inorganic intermediate products]	0.1479	kg
						Polyethylene part (PE) [Plastic parts]	0.0025	kg
						Polyethylene terephthalate part (PET) [Plastic parts]	0.0021	kg
						Polypropylene part (PP) [Plastic parts]	0.011	kg
	Electrode water-jetting		Working gloves [Battery recycling]	3.90E-06	kg	Aluminium [Metals]	0.0461	kg
			Respiratory mask [Battery recycling]	2.00E-06	kg	NMC black mass [Battery recycling]	0.23845	kg
			CN: Cathode, lithium-ion battery, lithium manganese oxide, at plant [Parts]	0.3289	kg	Water (waste water, untreated) [Production residues in life cycle]	0.909	kg
			Electricity [Electric power]	0.220896	MJ			

		Sodium hydroxide (50%; caustic soda) [Inorganic intermediate products]	0.0693602	kg			
		Water (decarbonised, softened) [Operating materials]	0.909	kg			
	Drying	Electricity [Electric power]	0.098172	MJ	NMC black mass [Battery recycling]	0.2828	kg
		NMC black mass [Battery recycling]	0.2828	kg			
	Air purification	Activated carbon [Organic intermediate products]	0.008	kg	Activated carbon (charged) [Hazardous waste for recovery]	0.008	kg
		Electricity [Electric power]	0.018	MJ			
	Packaging and sampling	Electricity [Electric power]	0.008172	MJ	Rezyclate (NMC) [Other parts]	0.171	kg
		NMC black mass [Battery recycling]	0.171	kg			
Advanced hydrometallurgical recycling from Mohr et al. [5]		Activated carbon [Organic intermediate products]	0.0648	kg	Aluminium [Metals]	0.2385	kg
		Electricity [Electric power]	4.932	MJ	Cobalt compound (CoSO4) [Metals]	0.181	kg
		Hydrated Lime [Minerals]	0.0796	kg	Copper [Metals]	0.1173	kg
		Nitrogen liquid [Inorganic intermediate products]	0.809	kg	Electrolyte [Operating materials]	0.1062	kg
		Oxygen liquid [Inorganic intermediate products]	0.0956	kg	Ethylene glycol [Organic intermediate products]	0.043	kg
		Quartz sand (silica sand; silicon dioxide) [Non renewable resources]	0.0796	kg	GLO: electronic component, unspecified, at plant [Parts]	0.0366	kg
		Soda (sodium carbonate) [Inorganic intermediate products]	0.478	kg	Graphite (from anode) [Materials]	0.148	kg
		Sodium hydroxide (50%; caustic soda) [Inorganic intermediate products]	0.191	kg	Lithium compound (LiOH) [Metals]	0.0701	kg
		Sulphuric acid (100%) [Inorganic intermediate products]	0.796	kg	Manganese compound (MnSO4) [Metals]	0.144	kg
		Traction battery [Battery recycling]	1	kg	Nickel compound (NiSO4) [Metals]	0.18	kg
					Plastic (unspecified) [Consumer waste]	0.0216	kg
					Steel part [Metal parts]	0.0062	kg
Cell Manufacturing from Accardo et al. [6]		Aluminium sheet [Metals]	0.095	kg	LIB Cell with LFP cathode [Systems]	1	kg
		Carbon black [Organic intermediate products]	0.027	kg	n-Methyl pyrolidone [Organic intermediate products]	0.003	kg
		CN: ethylene carbonate, at plant [organics]	0.069	kg			
		Copper sheet [Metals]	0.184	kg			
		Dimethyl carbonate [Organic intermediate products]	0.069	kg			
		Electricity [Electric power]	5.04	MJ			
		Graphite [Inorganic intermediate products]	0.211	kg			
		Lithium iron phosphate (LFP) powder [Valuable substances]	0.396	kg			
		Lithium-Hexafluorophosphate (LiPF6) [Minerals]	0.025	kg			
		Polyethylene compound (PE) [Plastics]	0.004	kg			
		Polyethylene terephthalate-film (PET) [Plastic parts]	0.003	kg			
		Polypropylene granulate (PP) [Plastics]	0.016	kg			
		Polyvinylchloride-sheet (PVC) [Plastic parts]	0.034	kg			
		RER: N-methyl-2-pyrrolidone, at plant [organics]	0.003	kg			
		Thermal energy from natural gas (MJ) [Thermal energy]	23.6	MJ			
LFP Hydrothermal Synthesis from Majeau-Bettez et al. [7]		LiOH [Battery materials]	0.46	kg	Lithium iron phosphate (LFP) powder [Valuable substances]	1	kg
		Phosphoric acid [Inorganic intermediate products]	0.65	kg	Iron [ecoinvent long-term to fresh water]	0.019	kg
		RER: iron sulphate, at plant [Benefication]	1	kg	Lithium, ion [ecoinvent long-term to fresh water]	0.1	kg
		Thermal energy from natural gas (MJ) [Thermal energy]	15	MJ	Phosphate [ecoinvent long-term to fresh water]	0.032	kg
		Water (deionised) [Operating materials]	45	MJ	Waste heat [Other emissions to air]	1.5	MJ
NMC111 Synthesis from Dai et al. [1]		Ammonia (liquid, agrarian) [Agro chemicals]	0.117	kg	NMC111 cathode active material [Valuable substances]	1	kg
		CoSO4 [Battery materials]	0.541	kg			

	Electricity [Electric power]	25.2	MJ			
	LiOH [Battery materials]	0.25	kg			
	MnSO4 [Battery materials]	0.523	kg			
	NiSO4 [Battery materials]	0.541	kg			
	Sodium hydroxide (50%; caustic soda) [Inorganic intermediate products]	0.844	kg			
	Thermal energy (MJ) [Thermal energy]	42.6	MJ			
	Water [Operating materials]	7.6	kg			

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