## Table S1. Carbon footprint of key battery materials

| Material | Product at gate | Source (year) | Primary input | Location | kg CO2-eq/kg material | Comments/Primary sources |
|---|---|---|---|---|---|---|
| Sodium hydroxide | Sodium hydroxide | Ecoinvent 3.9.1[1] | NaCl | Global | **1.28** | sodium hydroxide to generic market for neutralising agent/ DOW chemical company |
| | | GREET 2022[2] | | USA | **1.92** | https://greet.es.anl.gov/publication-lib-lca |
| | | Hong et al. (2014)[3] | | China | **1.59** | https://www.sciencedirect.com/science/article/pii/S0959652613006720 |
| | | Boustead (2005)[4] | | Europe | **1.40** | http://www.inference.org.uk/sustainable/LCA/elcd/external_docs/naoh_31116f0a-fabd-11da-974d-0800200c9a66.pdf |
| Copper | Copper collector foil | Ecoinvent 3.9.1[1] | Cathode copper | Global | **8.34** | Partly extrapolated from https://pubs.acs.org/doi/10.1021/es903729a |
| | Virgin copper | GREET 2022[2] | Laterite ore | North America | **1.90** | Mix of studies and data discussed in https://www.osti.gov/biblio/1905473 |
| | | | Sulfidic ore | | **4.82** | |
| | Copper | Di Dong et al. (2020)[5] | Laterite ore | China | **7.37** | Pyrometallurgy dominant route in China/https://www.sciencedirect.com/science/article/pii/S0959652620328705 |
| | | | Sulfidic ore | | **5.88** | |
| | Copper sheet | Copper Alliance[6] | Cathode/ingot copper | North America | **2.72** | https://copper.org/environment/sustainability/pdfs/copper_life_cycle_assessment_tube_and_sheet.pdf |
| Graphite | Synthetic graphite | Ecoinvent 3.9.1[1] | Petroleum coke | China | **5.44** | Traced to https://www.osti.gov/biblio/1224963 |
| | | GREET 2022[2] | | North America | **8.27** | https://www.osti.gov/biblio/1224963 |
| | | Surovtseva et al. (2022)[7] | | China | **20.6** | Inventory updates based on literature data / https://onlinelibrary.wiley.com/doi/full/10.1111/jiec.13234 |
| | Natural graphite | Gao et al. (2018)[8] | Graphite ore | China | **5.32** | Data based on Chinese research and government publications/ https://www.scientific.net/MSF.913.985 |
| | | Engels et al. (2022)[9] | | China | **9.6** | Factory data (2019–2020) of a vertically-integrated industrialized Chinese battery anode material supplier / |
| | | Northern Graphite | | North America | **6.3** | Based on press release from Northern graphite https://www.northerngraphite.com/_resources/news/Minviro-Report-update-Final-Mar-9-2022.pdf |
| | | Minviro | | China | **16.8** | |
| Lithium | Li2CO3 | Ecoinvent 3.9.1[1] | Spodumene | China | **10.8** | Data based on https://www.sciencedirect.com/science/article/pii/S0301479720301882?via%3Dihub#fig3 |
| | | | Brine | Chile | **2.11** | Data based on environmental survey from SEIA-CONAMA (2006) and environmental reports from SQM |
| | | Kelly et al. (2021)[10] | Spodumene | Australia | **20.4** | https://www.sciencedirect.com/science/article/pii/S0921344921003712 |
| | | | Brine | Chile | **2.9** | 2.7-3.1 depending on allocation, data from SQM / https://www.sciencedirect.com/science/article/pii/S0921344921003712 |
| | | Schenker et al. (2022)[11] | Brine | Hombre Muerto, North | **8** | https://www.sciencedirect.com/science/article/pii/S0921344922004451 |
| | | | Brine | Cauchari-Olaroz | **7.7** | |
| | | | Brine | Olaroz, Argentina | **7.4** | |
| | | | Brine | Chaerhan | **33** | |
| | | | Brine | Atacama, Chile | **3.4** | |
| | | Chordia et al. (2022)[12] | Brine | Salar de Cauchari, Argentina | **13.3** | https://www.sciencedirect.com/science/article/pii/S0921344922004670 |
| | | | Brine | Salar de Maricunga, Chile | **15.1** | |
| | LiOH | Ecoinvent 3.9.1[1] | Brine-spodumene mix | GLO | **14.7** | Hydration of lithium carbonate by calcium hydroxide |
| | | Kelly et al. (2021)[10] | Spodumene | Australia and China | **15.7** | Own life cycle inventory about spodumene processing / |
| | | | Brines | Chile | **7.3** | SQM data / https://www.sciencedirect.com/science/article/pii/S0921344921003712 |
| | | Chordia et al. (2022)[12] | Spodumene | Canada | **9.7** | https://www.sciencedirect.com/science/article/pii/S0921344922004670 |
| | | | Spodumene | Finland | **10.1** | |
| Cobalt | CoSO4 | Ecoinvent 3.9.1[1] | Sulfide/Oxide mix | GLO for mining<br>China for refining | **24.3** | Data taken from Dai et al. (2018) |
| | | Majeau-Bettez et al. (2011)[13] | | Global | **7** | Proxy based on Co metal from Ecoinvent |
| | | GREET 2022[2] | | DRC and China | **6.9** | Mass allocation / https://greet.es.anl.gov › files › update_cobalt |
| | | Zhang et al. (2021)[14] | | China | **35.6** | Production in nickel-copper-cobalt mine in Xinjiang province, China / https://link.springer.com/article/10.1007/s11367- |
| | | Cobalt Institute[15] | | Global | **4** | https://www.cobaltinstitute.org/sustainability/life-cycle-assessment/ |
| Nickel | NiSO4 | Ecoinvent 3.9.1[1] | Sulphide/Laterite mix | Global | **8.04** | Dataset based on stoichiometric calculations |
| | | GREET 2022[2] | | Global | **3.5** | https://greet.es.anl.gov/publication-ni_2020 |
| | | Nickel Institute[16] | | Global | **4.0** | https://nickelinstitute.org/policy/nickel-life-cycle-management/nickel-life-cycle-data/ |
| | | Khan (2021)[17] | | Global | **6.8** | https://ntnuopen.ntnu.no/ntnu-xmlui/bitstream/handle/11250/2824787/no.ntnu:inspera:80324039:54223842.pdf?sequence=1 |
| | | Nornickel (2022)[17] | | Russia | **1.8** | https://www.nornickel.com/upload/iblock/b85/Norilsk_Nickel_ESG_presentation_2021_ENG_public.pdf |
| | | IEA | Laterite ore | Typical for Indonesia | **22.4** | Converted from class I nickel to nickel sulfate / https://www.iea.org/data-and-statistics/charts/ghg-emissions-intensity-for- |
| | | Minviro | Laterite ore | n/a | **11.1** | https://eitrawmaterials.eu/wp-content/uploads/2021/10/ExpertForum21-D2-S1-Minviro-Robert-Pell.pdf |
| Manganese | MnSO4 | Euro Manganese | n/a | Czech Republic | **4.8** | https://www.globenewswire.com/news-release/2022/08/02/2490956/0/en/Euro-Manganese-Announces-Results-of-Life- |
| | | Giyani Metals | n/a | Botswana | **3.2** | https://giyanimetals2020tf.q4web.com/news/news-details/2022/Giyani-Announces-Results-of-Life-Cycle-Assessment-Study- |
| | | Ecoinvent 3.9.1[1] | Manganese concentrate | Global | **0.7** | Stoichiometric calculations and approximations based on a large chemical plant |
| | | GREET 2022[2] | | North America | **0.8** | https://www.globenewswire.com/news-release/2022/08/02/2490956/0/en/Euro-Manganese-Announces-Results-of-Life- |
| Al | Al collector foil | Ecoinvent 3.9.1 | Alloy/ingot | Global | **15.7** | Current collector foil for lithium-ion battery |
| | | GREET 2022[2] | | USA | **15.5** | Virgin wrought non-automotive aluminium foil - cold rolling |
| | | Aluminum Association[19] | | North America | **4.65** | https://www.aluminum.org/sites/default/files/LCA_Report_Aluminum_Association_12_13.pdf |
| | Primary Al | Ecoinvent 3.9.1[1] | Ingot | China | **23.6** | Own dataset for primary ingot |
| | | | | Europe | **7.3** | Own dataset for primary ingot |
| Ethylene/Dimethyl carbonat | Ethylene carbonate | Ecoinvent 3.9.1[1] | Ethylene oxide | China | **1.7** | Based on Notter et al. (2010)[21] |
| | | | Ethylene oxide | Rest of World | **1.37** | Based on Notter et al. (2010)[21] |
| | | GREET 2022[2] | Ethylene oxide | North America | **0.3375** | https://www.osti.gov/biblio/1044525 |
| | Dimethyl carbonate | Ecoinvent 3.9.1[1] | Phosgene & methanol | Europe | **2.01** | Calculation based on stoichiometry and literature data |
| | | Garcia-Herrero et al. (2016)[20] | CO & methanol | Europe | **3.2** | Eni process / https://pubs.acs.org/doi/10.1021/acssuschemeng.5b01515 |
| | | GREET 2022[2] | Ethylene oxide | North America | **1.38** | https://www.osti.gov/biblio/1044525 |

## Table S2. Material demand of battery cell production

| Battery chemistry | NMC111-Gr | | NMC622-Gr | | NMC811-Gr | | NCA-Gr | |
|---|---|---|---|---|---|---|---|---|
| Cell energy density (Wh/kg) | 174 | | 299 | | 240 | | 316 | |
| Cell geometry | pouch | | prismatic | | cylindrical | | prismatic | |
| Source | Ellingsen et al.[22] | | Winjobi et al.[23] | | Chordia et al.[24] | | Ecoinvent 3.9.1[1] | |
| | kg/kWh cells | kg per kg total material demand | kg/kWh cells | kg per kg total material demand | kg/kWh cells | kg per kg total material demand | kg/kWh cells | kg per kg total material demand |
| Sodium hydroxide | 1.75 | 18% | 1.27 | 21% | 3.4 | 37% | 1.15 | 22% |
| Copper | 1.29 | 14% | 0.29 | 5% | 0.4 | 4% | 0.26 | 5% |
| Cobalt sulphate | 1.10 | 12% | 0.48 | 8% | 0.3 | 3% | 0.34 | 6% |
| Manganese sulphate | 1.08 | 11% | 0.47 | 8% | 0.3 | 3% | 0.00 | 0% |
| Nickel sulphate | 1.10 | 12% | 1.44 | 24% | 2.6 | 28% | 1.69 | 32% |
| Graphite | 0.93 | 10% | 0.89 | 15% | 1.3 | 14% | 0.90 | 17% |
| Lithium carbonate | 0.79 | 8% | 0.57 | 9% | 0.4 | 5% | 0.34 | 7% |
| EC and DMC | 0.81 | 8% | 0.32 | 5% | 0.2 | 2% | 0.30 | 6% |
| Aluminium | 0.29 | 3% | 0.16 | 3% | 0.2 | 2% | 0.12 | 2% |
| CMC | 0.02 | 0.2% | 0.03 | 0.5% | 0.04 | 0% | 0.03 | 1% |
| Acrylic Acid | 0.02 | 0.2% | 0.05 | 0.8% | 0.00 | 0% | 0.05 | 1% |
| NMP | 0.04 | 0.5% | 0.06 | 0.9% | 0.08 | 1% | 0.05 | 1% |
| PVDF | 0.09 | 0.9% | 0.03 | 0.4% | 0.00 | 0% | 0.02 | 0% |
| LiPF6 | 0.11 | 1.2% | 0.01 | 0.1% | 0.00 | 0% | 0.01 | 0% |
| Polypropylene | 0.13 | 1.4% | 0.01 | 0.1% | 0.00 | 0% | 0.01 | 0% |

## Table S3. Planned capacity per region on February 2023 to go online before 2035

| Location | Planned capacity (GWh) | Source |
|---|---|---|
| Chongqing | 193 | BENCHMARK MINERAL INTELLIGENCE, LITHIUM ION BATTERY GIGAFACTORY ASSESSMENT, FEBRUARY 2023 ASSESSMENT |
| Gansu | 44 | |
| Hebei | 48 | |
| Heilongjiang | 12 | |
| Guizhou | 93 | |
| Inner Mongolia | 60 | |
| Jiangxi | 424 | |
| Jilin | 50 | |
| Liaoning | 86 | |
| Tianjin | 95 | |
| Ningxia | 163 | |
| Guangxi | 169 | |
| Yunnan | 196 | |
| Sichuan | 731 | |
| Shanghai | 68 | |
| Hunan | 163 | |
| Fujian | 377 | |
| Guangdong | 437 | |
| Hubei | 614 | |
| Zhejiang | 563 | |
| Qinghai | 57 | |
| Jiangsu | 1276 | |
| Henan | 224 | |
| Shandong | 239 | |
| Anhui | 549 | |
| Shaanxi | 78 | |
| South Korea | 170 | |
| Japan | 104 | |
| Malaysia | 55 | |
| Taiwan | 10 | |
| Norway | 125 | https://battery-news.de/index.php/2023/02/03/16260/ |
| Sweden | 110 | |
| France | 122 | |
| Spain | 100 | |
| Italy | 118 | |
| Serbia | 48 | |
| Belgium | 3 | |
| Portugal | 45 | |
| Switzerland | 8 | |
| Slovakia | 10 | |
| Hungary | 187 | |
| United Kingdom | 105 | |
| Germany | 546 | |
| Czech Republic | 15 | |
| Poland | 115 | |
| Kentucky | 169 | https://battery-news.de/index.php/2023/02/17/16486/ |
| Indiana | 33 | |
| Ohio | 73 | |
| Colorado | 30 | https://www.cnbc.com/2023/01/05/map-which-states-will-build-the-most-ev-batteries-in-2030.html |
| Arizona | 30 | https://battery-news.de/index.php/2023/02/17/16486/ |
| Michigan | 130 | |
| Kansas | 39 | |
| Texas | 100 | |
| Florida | 2 | |
| Georgia | 101 | |
| Tennesse | 116 | |
| North Carolina | 50 | https://www.cnbc.com/2023/01/05/map-which-states-will-build-the-most-ev-batteries-in-2030.html |
| Virginia | 4 | |
| South Carolina | 6 | https://battery-news.de/index.php/2023/02/17/16486/ |
| New York | 32 | |
| California | 10 | |
| Nevada | 30 | |
| Ontario | 43 | |
| Quebec | 15 | |
| Mexico | 80 | https://www.visualcapitalist.com/chinas-dominance-in-battery-manufacturing/ |

## Table S4. Carbon intensity of electricity in battery manufacturing locations

| Location | Carbon intensity (g CO2-eq per kWh) | Source |
|---|---|---|
| Yunnan | 145.0 | Li et al.[25] https://www.sciencedirect.com/science/article/pii/S1876610217361714 |
| Sichuan | 200.0 | |
| Qinghai | 373.0 | |
| Hubei | 530.0 | |
| Guangxi | 640.0 | |
| Gansu | 680.0 | |
| Guangdong | 745.0 | |
| Hunan | 747.0 | |
| Fujian | 750.0 | |
| Guizhou | 750.0 | |
| Zhejiang | 816.0 | |
| Chongqing | 840.0 | |
| Liaoning | 860.0 | |
| Jilin | 960.0 | |
| Jiangsu | 1000.0 | |
| Ningxia | 1000.0 | |
| Jiangxi | 1030.0 | |
| Inner Mongolia | 1040.0 | |
| Hebei | 1050.0 | |
| Shandong | 1060.0 | |
| Heilongjiang | 1080.0 | |
| Shaanxi | 1100.0 | |
| Shanghai | 1120.0 | |
| Henan | 1125.0 | |
| Anhui | 1140.0 | |
| Tianjin | 1160.0 | |
| South Korea | 458.0 | https://ourworldindata.org/grapher/carbon-intensity-electricity 2021 |
| Japan | 479.0 | |
| Malaysia | 549.0 | |
| Taiwan | 573.0 | |
| Norway | 26.0 | |
| Sweden | 46.0 | |
| Switzerland | 47.0 | |
| France | 67.0 | |
| Belgium | 157 | |
| Slovakia | 168 | |
| Spain | 194.0 | |
| Portugal | 219.0 | |
| Hungary | 233.0 | |
| United Kingdom | 268.0 | |
| Italy | 341 | |
| Germany | 366.0 | |
| Czech Republic | 406.0 | |
| Serbia | 549 | |
| Poland | 660.0 | |
| Kentucky | 788.0 | https://www.statista.com/statistics/1133295/electric-sector-carbon-dioxide-emission-rate-by-state-united-states/ |
| Indiana | 726.0 | |
| Nevada | 704 | |
| Ohio | 542.0 | |
| Colorado | 533.5 | |
| Arizona | 474.5 | |
| Michigan | 454.5 | |
| Mexico | 400 | https://ourworldindata.org/grapher/carbon-intensity-electricity%202021 |
| Kansas | 397.0 | https://www.statista.com/statistics/1133295/electric-sector-carbon-dioxide-emission-rate-by-state-united-states/ |
| Texas | 384.0 | |
| Florida | 381.0 | |
| Georgia | 332.9 | |
| Tennesse | 298.0 | |
| North Carolina | 300.0 | |
| Virginia | 272.0 | |
| South Carolina | 240.5 | |
| New York | 205.0 | |
| California | 177.3 | |
| Ontario | 28.0 | https://www.canada.ca/en/environment-climate-change/services/climate-change/pricing-pollution- |
| Quebec | 1.9 | |

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