A European Response to US IRA

How Europe can use its soft and financial powers to build a successful electric vehicle value chain

January 2023

Summary

The European Green Deal is one of the world's most ambitious climate policies to usher the European Union into the net zero economy by 2050. To happen, it will require a massive ramp up of technologies from wind turbines to electric car batteries, but the question is how much of the value will be captured by industry in Europe.

The global race to lead the production of these cleantech, as well as raw materials that go into them, has been unfolding for a few years now. Europe has secured much commitment and investment in the area of electric cars (EV) and batteries already. Dozens of billions have poured into scaling EV manufacturing and batteries. Over half of all lithium-ion batteries on the EU market in 2022 were produced in Europe, with the continent projected to become the world's second biggest battery cell manufacturer by the end of the decade.

But the US Inflation Reduction Act (IRA), launched in August 2022, has changed the rules of the industrial game and might make companies re-prioritise the current announcements in Europe towards the US. For EVs and batteries, the risk is that the projects - and therefore Europe's ambition - gets delayed. For critical metals and their processing, where Europe is only starting to catch up, the risk is that investments would simply go elsewhere. In just a few months since the launch of the US IRA, investments into battery factories, new mines and electric vehicles have mushroomed in North America. This is in response to the requirement that 40% of battery metals need to come from the US[1] and half of all battery components made in North America from 2024 for the full EV tax credit to apply. The battery supply chain of an electric car will receive up to USD 50 of subsidy per each kWh of battery, or over a third of the total battery costs today.

So far Europe has one of the most ambitious climate regulations in the world. The next step now is to beef it up with a robust industrial muscle to ensure we capture parts of the growing value chain for our jobs and economic resilience.

[1] Or its free trade partner

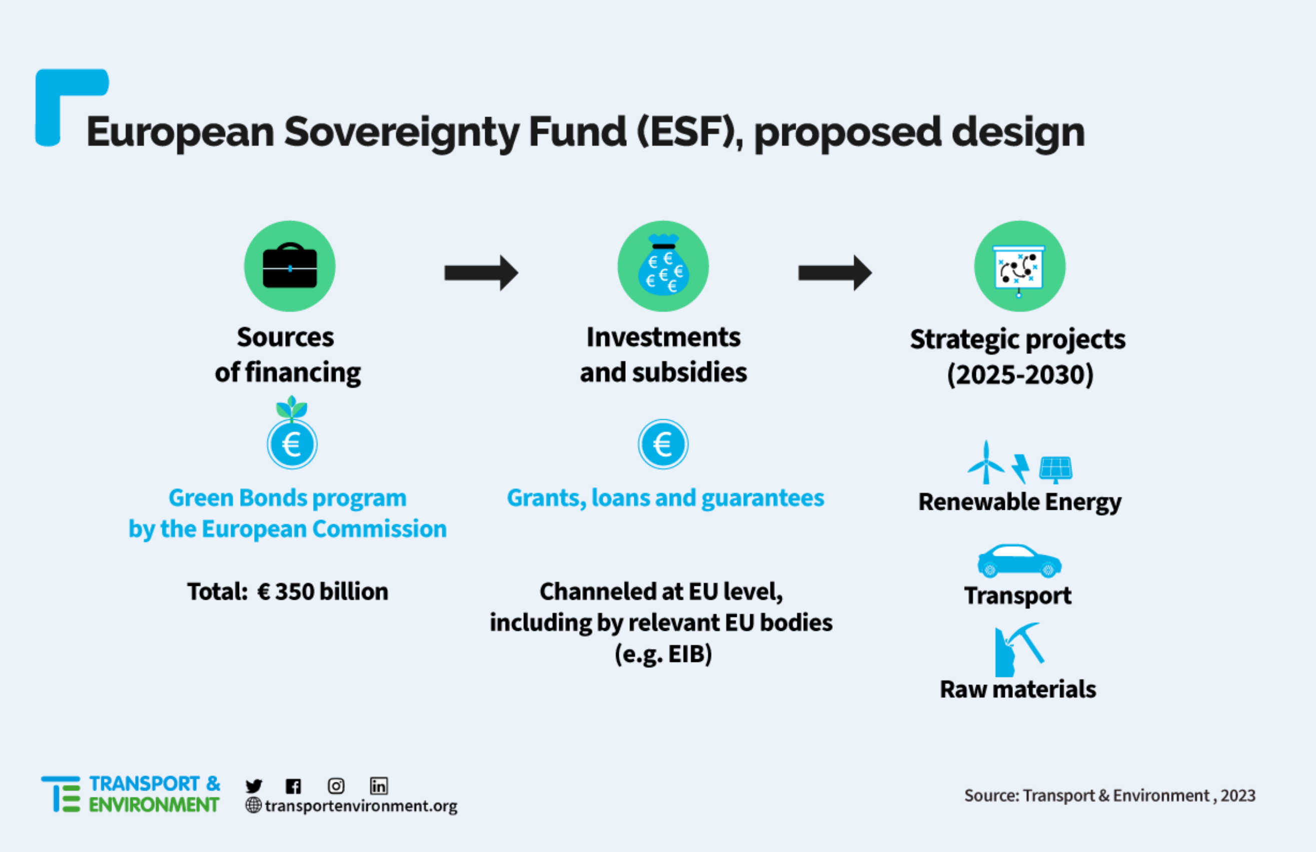
What should be Europe's response to the US IRA's provisions on electric vehicle supply chains?
The concern with the US IRA is not the electric car (EV) tax credits, since the EU is not expected to export large numbers of electric cars in the foreseeable future (if that changes - higher EV trade tariffs shall be introduced). Instead, the real risk is the long-term and bankable production tax credits, worth hundreds of billions of dollars, given to batteries and the critical metals supply chain until 2032. As the capital requirements to ramp up cleantech at the speed and scale required are enormous, Europe should look at its own funding to make production attractive.

Europe already spends a lot of money to support the sales of EVs and the supply chains, including vehicle manufacturing, battery production and upstream processing. At the EU level, more than EUR 20 billion has been devoted to the battery value chain via the IPCEI framework, the EIB and research funding in the last few years. Dozens of billions more are available via the InvestEU and the EU Recovery and Resilience Facility launched in the aftermath of the Covid pandemic, mostly disbursed at the national level. Almost EUR 6 billion was spent in 2022 alone to subsidise the sales of electric cars across the member states.

Even if not in the hundreds of billions, these sums are nonetheless substantial. The problem is not only the lack of money, but the complexity in getting it: the approval processes are often slow (with deadlines unknown), bureaucratic and not bankable in the same way as the US IRA production credits are. E.g. the **EU state aid rules** (under which most national funding falls) ask companies to prove their projects would not have been possible without such funding. In addition, many funding programmes are annual and lack the long-term certainty needed. What is needed is to streamline the state aid rules, focusing on production aid, for the electric vehicles, renewables and raw materials businesses directly affected by the US IRA. Europe should introduce a **green simplification agenda** so building a battery plant does not take the same amount of time as a coal plant.

However, simplifying state aid is not enough as it would only benefit deep pocket member states such as Germany, but leave many other countries behind. This is a big problem. First, cash rich countries might not be where the best potential for metals processing or renewables is as it depends on geology, natural resources and innovative ideas. Crucially, this is about the European level playing field to make sure Europe as a whole meets its industrial and climate ambitions, not one or two of its member states.

That's why to accelerate the development of truly European green industrial policy, the **European Sovereignty Fund** (ESF) should be established as a matter of urgency and equipped with financial firepower in the scale of at least EUR 350 billion via joint debt issuance from the European Commission. The ESF should focus on scaling excellence in renewable energy (not fossil fuels!), electromobility and green battery supply chains, i.e. target the sectors directly affected by the US IRA.



Ultimately, the ESF should become the backbone of EU's green industrial policy. There are clear benefits of joint borrowing from the standpoint of European governments. Given the different debt capacity of EU Member States, joint borrowing allows for the states in a more precarious financial situation to still access financial markets, so ensure best projects (rather than those in richer regions only) happen. Joint borrowing also provides better terms and conditions than what governments would be able to access on their own. Europe can't compete with the likes of the US or China without a strong EU financial arm to back our industrial and climate ambition.

European potential in batteries and critical metals

Some in Europe, including President Macron and EU Industry Commissioner Breton would like to see similar "made in Europe" provisions. While outright local content requirements might be difficult, there is significant potential in the EV, battery and critical metals supply chain that Europe can and should capture via strong industrial policy:

1. Europe is on track to **produce 6.7 million battery electric cars** (BEV) **by 2030**[2], or just over half of all the cars produced, which is in line with the recently agreed -55% CO2 target for carmakers for 2030 that is expected to result in a 50-60% share of BEV sales. This shows that carmakers follow climate regulations and plan domestic investments accordingly. If we accelerate the

[2] Commitments but no plans, T&E 2021 report, link.

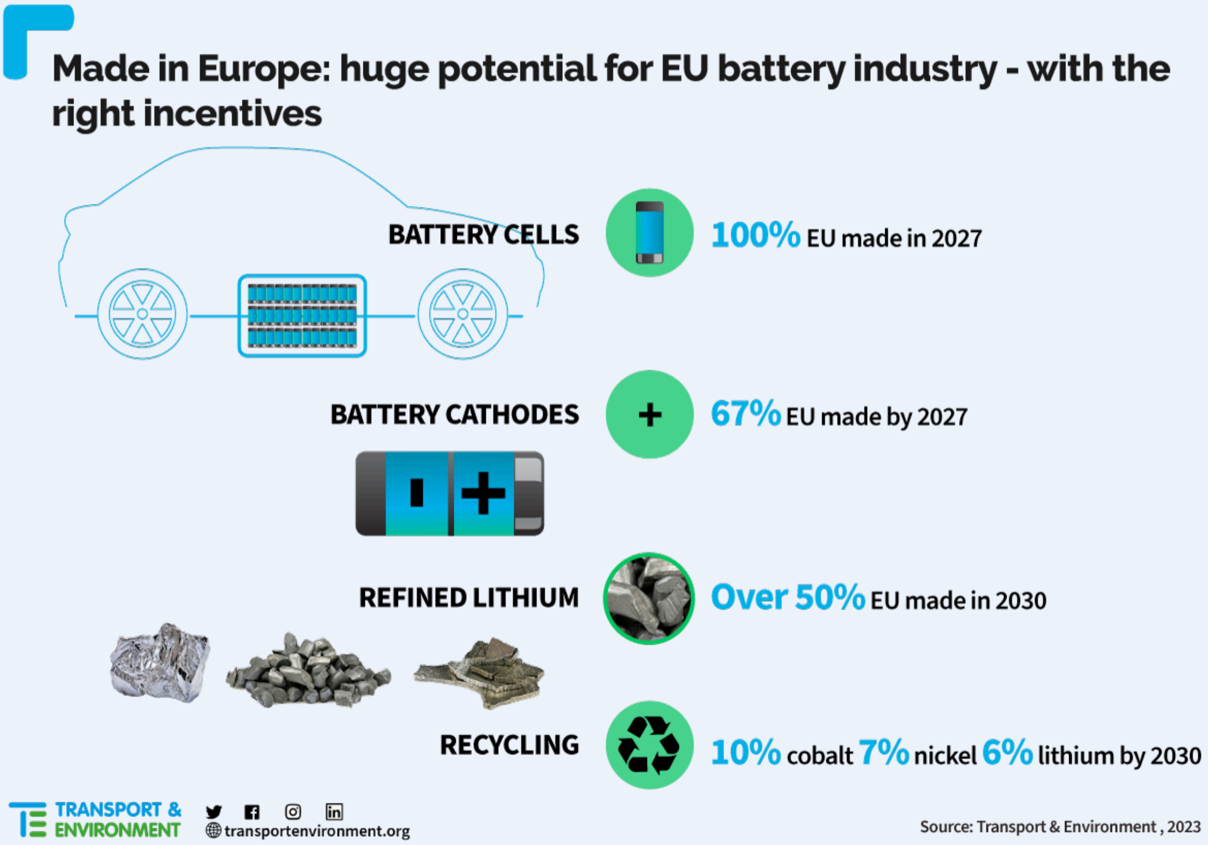
pre-2030 ambition, notably by setting an EU Fleets mandate for corporate BEV registration by 2026/7, a market for battery electric cars can be a lot bigger in 2027, creating a better business case for the battery value chain.

2. Half of the Li-ion battery cells used in electric vehicles and energy storage systems in the EU were already made in the bloc in 2022, notably in Poland, Hungary, and to a lesser extent in Germany and Sweden. T&E analysis of the battery cell capacity announcements to date shows that Europe can be self-sufficient in battery cells, i.e. produce **100% of our Li-ion battery cell demand from 2027**.

3. Looking further into battery components, **two-thirds of all the cathode active material** (the most valuable part of the battery that contains metals such as cobalt and nickel) **can be produced in Europe by 2027** already, with largest projects in Germany, Poland and Sweden. This is where Europe currently leads over the US in terms of project pipeline.

4. Investments are also happening in the refining and processing of battery metals, where China dominates today. T&E analysis of the potential to refine lithium shows that **over 50% of Europe's refined lithium demand can come from European projects by 2030**. Lithium to feed those can come from global mines, European projects provided these meet high standards (supported by the CRM act e.g.) and - crucially in the future - from battery recycling streams.

5. Significant recycling potential also exists: the **materials available for recycling** from end-of-life batteries or scrap (from European battery factories) **could meet at least 8-12% of the critical metals needs in 2030**, including a tenth of all cobalt, 7% of nickel and 6% of lithium. Even if the percentages are not huge, these can nonetheless help European companies with shortages or high prices on the spot market (which are set at the margin).



The analysis includes more certain and less mature projects, i.e. shows Europe's potential which now needs an industrial strategy and smart policy to materialise. Fast tracking best in class green projects, streamlining permitting, as well as targeted funding support, are necessary to capture this value chain in Europe. The **Critical Raw Materials act** is a key part of the answer here: it should set high-level supply targets by 2030, backed up by a list of "Strategic Projects" (in conformity with high social and environmental standards) that are then fast-tracked across the bloc. Special focus should be on refining & processing, as well as on scaling the European recycling capacity and extracting metals from existing mining waste sites across Europe. Strategic partnerships, especially with Asian and African nations, should underpin the global dimension and help bring higher ESG standards and expertise to the Global South.

Table of contents

PART I EUROPEAN INDUSTRIAL POLICY

Introduction

The European Green Deal is one of the world's most ambitious climate policies to usher the European Union into the net zero economy by 2050. It can't happen without a massive ramp up of technologies from wind turbines to electric car batteries. The global race to lead the production of these cleantech, as well as raw materials that go into them, has been unfolding for a few years now. Europe has secured much investment: e.g. the continent is projected to produce up to a third of lithium-ion batteries globally by 2030 (from just a few % today).

But the US Inflation Reduction Act (IRA), launched in August 2022, is a game changer in industrial policy and risks syphoning away investments that would otherwise go into batteries and critical metals in Europe. In just a few months since the launch of the US IRA, investments into battery factories, new mines and electric vehicles have mushroomed in North America.

So Europe must now beef up its climate policy with a robust industrial muscle. What should Europe's own response to the US IRA's provisions on electric vehicle supply chains be?

In this report, we first look at different scenarios to forecast the demand for lithium-ion batteries in Europe and compare this to the expected supply of batteries, cathode materials and refined lithium as well as the supply of key metals from battery recycling.

We then discuss industrial policies that would support the European battery value chain reach its full potential, looking in particular at the US IRA subsidy provisions and how this compares to what is being done at EU and national levels. Finally, we present T&E recommendations on what reform and new measures are needed for Europe to compete.

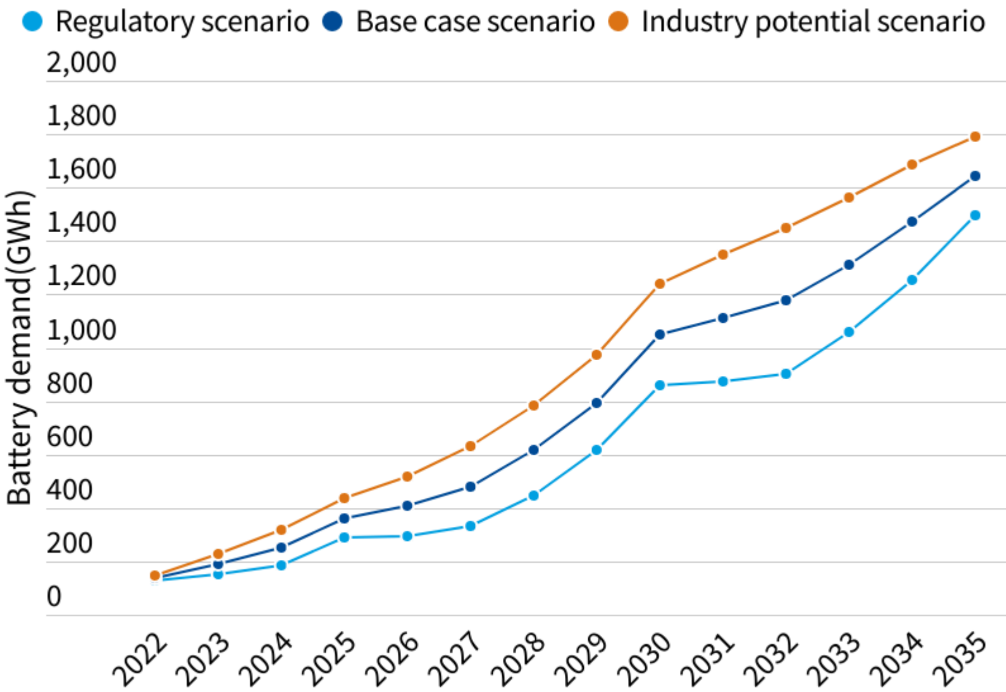
1. Creating a European battery value chain

1.1. European demand for batteries

The phase-out of diesel and petrol cars and vans in the EU - as agreed as part of the EU car CO2 standards at the end of 2022 - is expected to accelerate the demand growth for lithium-ion (Li-ion) batteries over the next decade. This will mean at least 59% of all cars sold in 2030 will have to be electric in 2030, rising to 100% by 2035.

We developed three scenarios showing the potential growth paths of the demand for batteries in the EU, UK and EFTA countries and the UK up until 2035. They take into account the electric vehicle (EV) sales of cars, vans, trucks and buses as well as the EV average battery size for each vehicle category (more details in the Annex 1.1). Demand from energy storage systems (ESS) has also been added to the analysis.

- **Regulatory scenario** follows the EU regulations' timeline for phasing out petrol and diesel cars and vans, e.g. the share of battery electric cars to reach 59% in 2030 and 100% in 2035.
- **Industry potential scenario** refers to carmarkers' commitments and assumes higher electric vehicle shares in total sales of vehicles as well as higher average battery sizes, e.g. the share of battery electric cars to rise to 77% in 2030 and 100% in 2035.
- **Base case scenario** represents the average between the regulatory and the industry potential scenarios.



Source: T&E analysis

Figure 1: Scenarios for the European battery demand

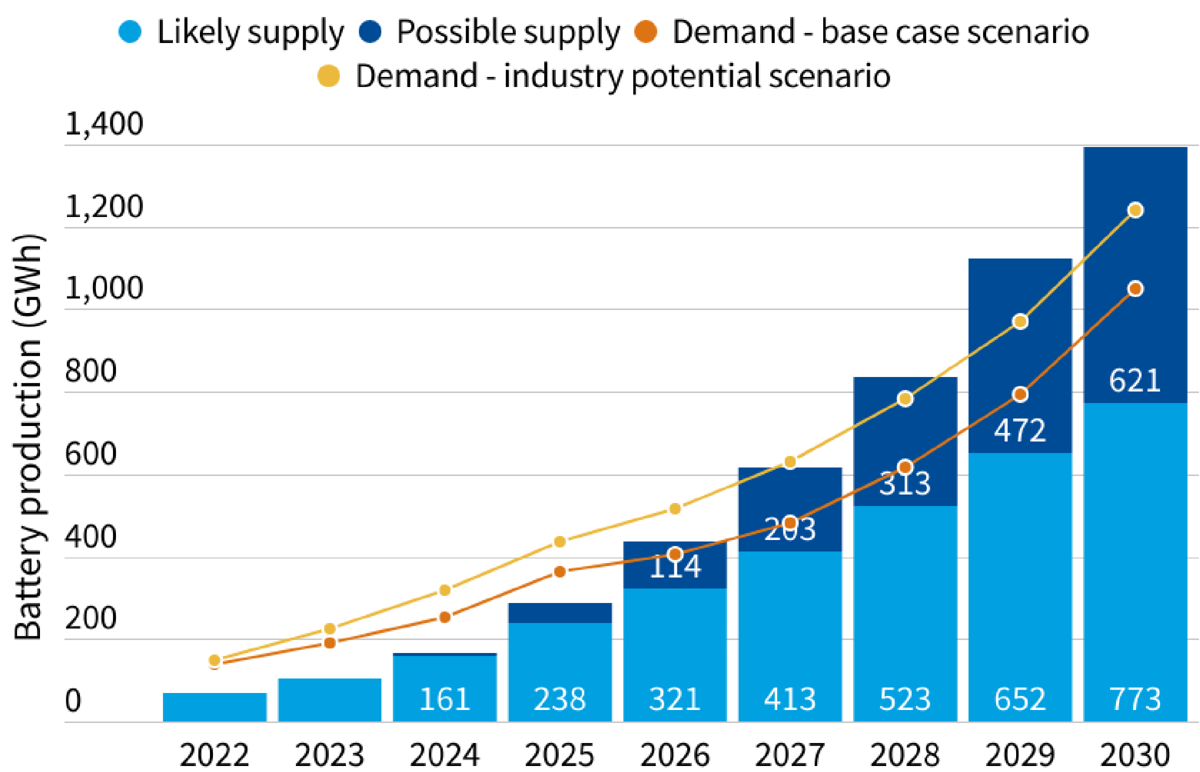
In the **regulatory scenario,** the annual demand for batteries from EVs and ESS applications would see an increase to **860 GWh by 2030** and almost **1,500 GWh by 2035 (Fig. 1)**. This is the minimum expected with the petrol and diesel cars and vans being phased out in 2035. In the industry potential scenario, which is more ambitious in terms of electric vehicles share in total sales, the demand could rise to **1,240 GWh by 2030** and over **1,790 GWh by 2035**. And finally, in the base case scenario, the demand would reach **1,050 GWh by 2030** and **1,645 GWh by 2035**.

To meet any of these demand scenarios Europe needs to build sufficient capacities along the entire supply chain, from battery cell manufacturing (or gigafactories), through cathode production and lithium refining to battery recycling.

1.2. European supply of battery cells

Based on T&E's tracking of gigafactory plans, Europe is expected to have enough battery cell supply to meet demand in the second part of the decade. Increasing from about 69 GWh of production output[3] in 2022, the most likely European battery supply is projected to ramp-up to 238 GWh in 2025, 413 GWh in 2027 and up to 773 GWh in 2030. This likely supply represents projects whose financing and building permits are at advanced stages. However, the potential capacity is a lot higher as many newer projects (with less clear financing or firm industrial plans) have been announced more recently. With all announced projects, battery production could reach **286 GWh in 2025**, **616 GWh in 2027** and **1,395 GWh in 2030**.

Companies with the largest production in 2030 include CATL, Volkswagen Group, Freyr, ACC and Northvolt. About 58% of European production in 2030 would be from European companies, while Chinese companies would account for 22% of production.



Battery plants assumed to progressively ramp-up up to 85% of their nameplate capacity.
25% to 5% production scrap included depending on plant age.
Source: T&E analysis, company reports

Figure 2: Battery cell demand and supply scenarios in Europe

[3] Based on utilised capacity and production scrap assumptions detailed in the Annex 1.2

In 2022, 50% of the demand was met by EU battery production, with the majority coming from LG Chem in Poland and Samsung SDI in Hungary. In the base case scenario for demand[4] (details in Annex 1.1), the production is projected to reach 72% of the demand in 2025 and over 100% from 2027. If all uncertain projects materialise, all demand will be met as soon as 2026. Nevertheless, in the industry potential scenario, demand would only be met in 2028 if all uncertain projects go ahead. This means there is potential for Europe to be self-sufficient in battery cells as early as 2026-2028, but Europe needs to develop a strong industrial policy to secure these investments in Europe.

By 2030, a total of about 50 planned gigafactory projects[5] means Europe will not lack cell manufacturing projects to meet demand, but battery demand in the industry potential scenario can only be met if all, including newer, projects come online.

The main gigafactory projects are presented in the following maps.

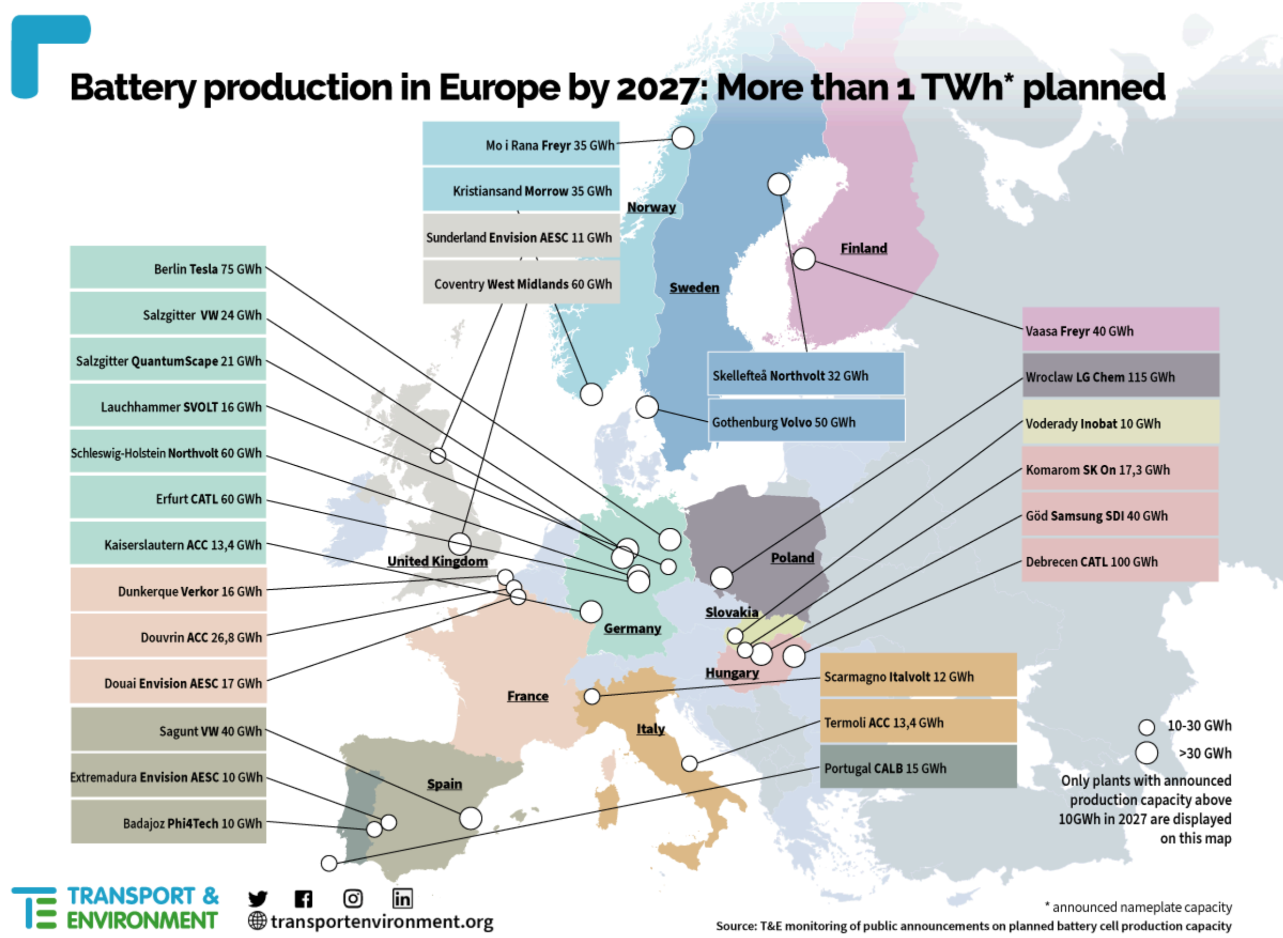


Figure 3: Battery cell manufacturing plant in Europe in 2027

---

[4] To compare supply with the expected demand, we assume that half of the uncertain supply can be achieved, so a mid-case conservative assumption.

[5] Uncertain projects are included. Only plants with a nameplate capacity of at least 2 GWh are counted. We estimated that 32 projects of the 50 can be considered as likely to go ahead.

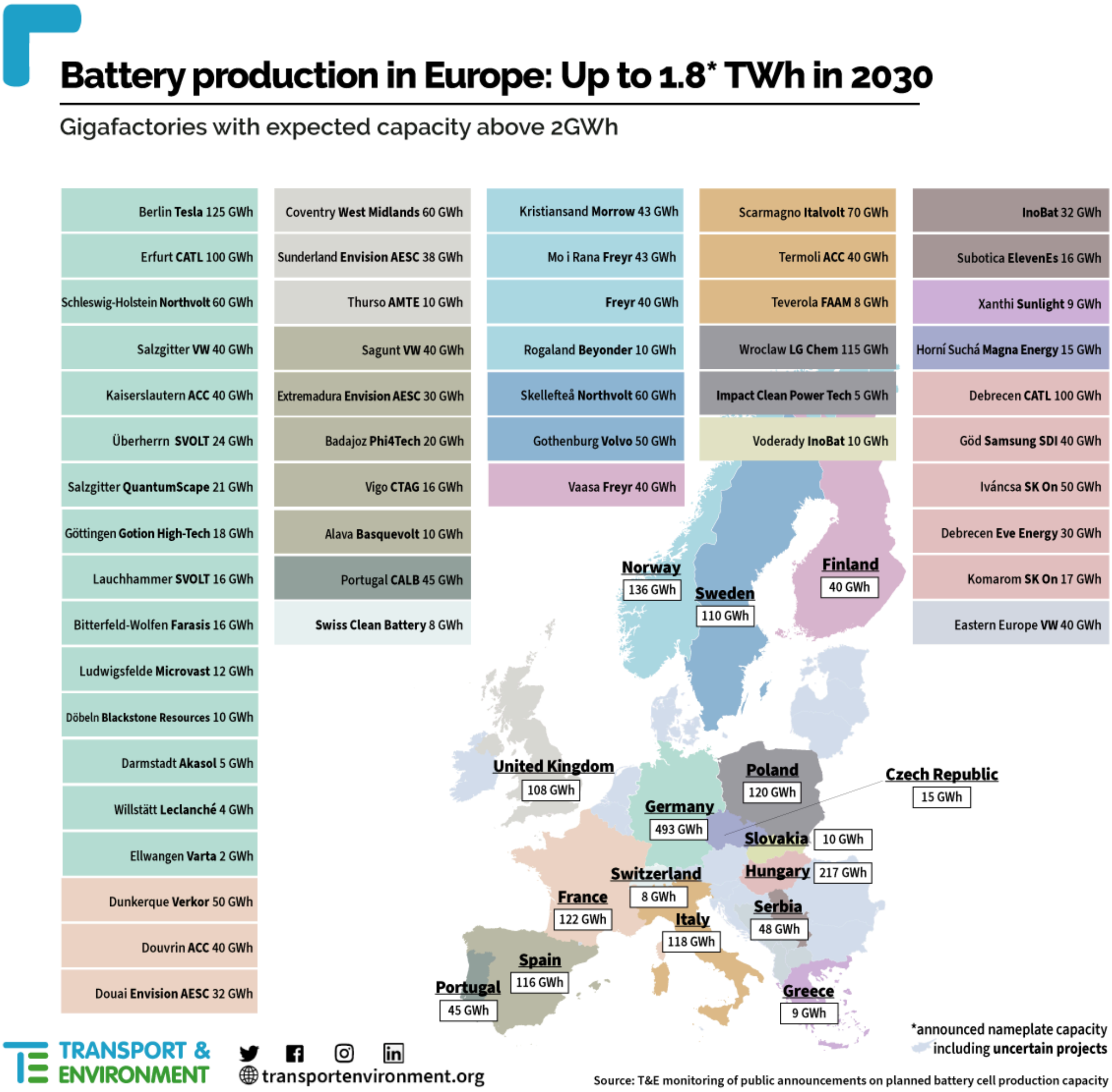


Figure 4: Battery cell manufacturing plant in Europe in 2030

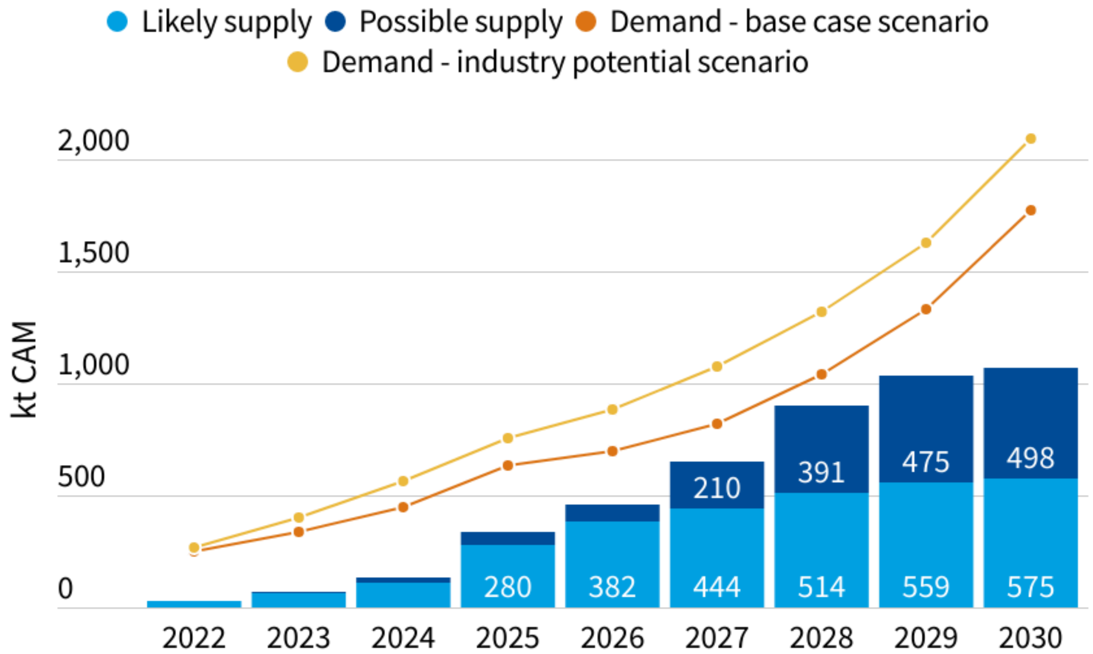
1.3. European supply of cathode materials

Based on the battery demand, Europe's demand[6] for cathode active materials (CAM) is expected to grow from about 250 kt in 2022 to 632 kt in 2025, 822 kt in 2027 and up to 1.77 Mt in 2030 in the base case scenario. In the regulation scenario, demand would be 18% less (1.45 Mt total) whereas 18% more would be needed in the industry potential scenario (2.09 Mt total).

Based on BloombergNEF data[7], company reports and press releases, Europe is expected to produce about 46% of its CAM demand in 2030. The manufacturing of CAM consists of the processing of precursors (for instance the mix of nickel, manganese and cobalt) and lithium to form the material (e.g. Lithium Nickel Cobalt Manganese Oxide - $Li(NiCoMn)O_2$) that will be used during cell manufacturing.

Twelve companies have plans to be involved in this step of the battery supply chain with 17 plants announced so far in Europe. Looking at only the most likely projects, the European supply of CAM is expected to grow from about 27 kt in 2022 to 280 kt in 2025, and 575 kt in 2030, an expansion of over 20 fold. Including newer and less certain projects for which little public information can be found, supply could nearly double by 2030 to about 1.1 Mt.

[6] CAM demand is calculated from the total amount of batteries needed in Europe (see Section 1.1). Data from BloombergNEF were used to derive the mass of cathode active materials required to form a battery cell. This takes into account the expected chemistry mix in the coming year as well as the specific material content of each battery chemistry, more details can be found in Annex 1.3.
[7] From the online dataset: BloombergNEF (2022), "*Battery Components*"



Cathode active material plants assumed to progressively ramp-up up to 85% of their nameplate capacity

Source: T&E analysis, company reports

Figure 5: European cathode active material supply and demand

In the base case scenario for battery demand and assuming half of uncertain projects would materialise, Europe is expected to supply **49% of its CAM demand in 2025**, **67% in 2027** and **46% in 2030**. Given that CAM projects take a few years to come online, the plans for the second half of 2020s can still change and - with strong industrial policy in place - increase to meet more of European demand.

Some of the main CAM manufacturing projects include:

- **Umicore** with its Nysa plant in Poland (up to 200 GWh of CAM in the second half of the decade[8]) and a second site as part of their joint venture (JV) with Volkswagen's PowerCo subsidiary (160 GWh[9] by the end of the decade)
- **Northvolt** in Sweden to supply their own battery cell plants (90 kt capacity in Skelleftea[10] and more than 100 GWh in Borlänge[11])
- **EcoPro BM** in Hungary as part of their JV with Samsung SDI (up to 108 kt[12])
- **BASF** in Germany (capacity to expand to 100 kt [13])
- **Beijing Easpring Material Technology** in Finland as part of their JV with the state-owned Finnish Minerals Group (50 kt with the potential of expanding capacity in the future[14])

[8] Umicore (21.09.2022), *"Umicore inaugurates Europe's first battery materials gigafactory"*. Link

[9] Volkswagen (26.09.2022), *"PowerCo and Umicore establish joint venture for European battery materials production"*. Link

[10] T. Sekkens, *"Webinar on Energy Storage EU - India"*, EIT InnoEnergy, European Battery Alliance. Link

[11] Northvolt (25.02.2022), *"Northvolt to transform closed paper mill in Sweden into new gigafactory"*. Link

[12] Electrive.com (09.12.2021), *"EcoPro BM to build battery materials factory in Hungary"*. Link

[13] T. Sekkens, *"Webinar on Energy Storage EU - India"*, EIT InnoEnergy, European Battery Alliance. Link

[14] Finnish Minerals Group, *"A CAM plant is planned in Kotka"*. Link

1.4. European supply of refined lithium

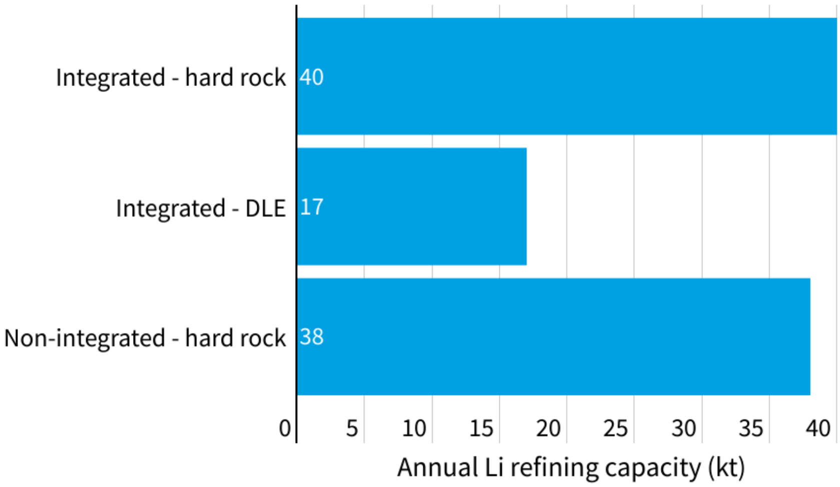
The growing demand for cathode materials driven by the rise of European gigafactories will also require substantial amounts of raw materials including lithium. We choose to focus on lithium in the present report as the EU has now a historic opportunity to stimulate the domestic supply of lithium, which has been very limited until now, and to provide at the same time a strong social and environmental due diligence via the newly agreed EU Battery regulation.

According to T&E analysis, **a Li-ion battery demand of 1,050 GWh by 2030 in the base case scenario would be equivalent to 126 kt pure Li**, respectively. These volumes take into account the evolution of cathode chemistry technologies (based on data from BloombergNEF, in Annex 1.3) and are on a gross basis, meaning that they include yield losses from the battery cathode materials and battery cell manufacturing processes.

Today 100% of the refined lithium required for batteries in Europe is imported from third parties including China. However, there are a number of lithium refining projects in the pipeline that could help Europe reduce its dependency on imports. **We identified 16 integrated projects (mining and refining) and 8 non-integrated refining projects[15] with a combined theoretical capacity of 94 kt Li by 2030**.

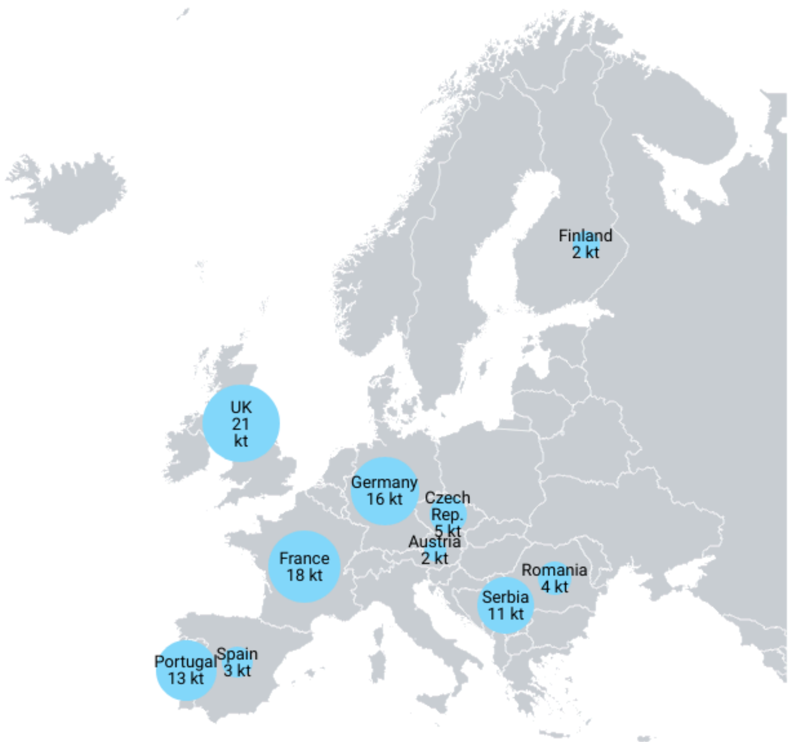
Four of them will use the Direct Lithium Extraction (DLE) process, the most environmentally friendly technology for lithium production today, led by Vulcan Energy Resources (Germany), Eramet (France), Lithium de France (France) and Northern Lithium (UK). The rest of the projects will process lithium concentrate from hard rock from owned or imported sources. The UK, France and Germany are expected to have the largest lithium refining capacities by the end of the decade. The list of projects can be found in the Annex 1.4.

[15] We considered all potential projects that have been announced in the public space as well as from other sources in order to assess Europe's full potential.



Source: T&E analysis, company reports

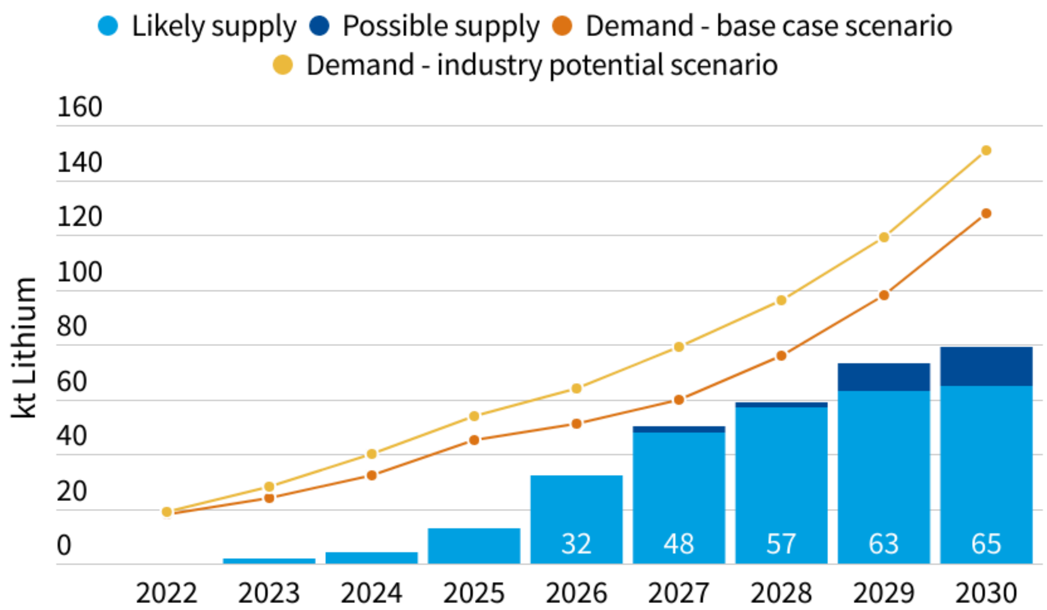
Figure 6: Lithium refining capacities in Europe by company type and feed source



Source: T&E analysis, company reports

Figure 7: Lithium refining capacities by country in 2030

Assuming capacity utilisation of 85% after the ramp-up period, these plants could produce around 78 kt Li by 2030 or 65 kt Li if we exclude the possible projects. We define possible projects as projects that are less certain to materialise due to considerable opposition from local communities on environmental concerns. Therefore, we estimate that **around 50% of the demand in the base case scenario could be met by local refined supply** (excluding less certain projects) if they go online by the end of the decade.



*Possible supply refers to projects facing opposition from local communities
Lithium refining plants assumed to progressively ramp-up production to a max. 85% capacity utilisation rate
Source: T&E analysis, company reports

Figure 8: Lithium demand and supply scenarios in Europe

Some of the most important projects in the space of lithium refining with annual capacity are[16]:

- **Green Lithium** (UK, non-integrated, ~8 kt Li capacity) - backed by the commodities trading company Trafigura and backed by the UK government with a grant of over GBP 600,000 (USD 682,074).
- **RockTech Lithium** (Germany and Romania, non-integrated, ~8 kt Li) - has a supply agreement with Mercedes Benz; is developing its own lithium mine in Canada.
- **Vulcan Energy Resources** (Germany, integrated, ~7 kt Li) - Europe's first and highest profile DLE project; has a series of supply agreements with Volkswagen, Stellantis, Renault, Umicore and LG Chem over the next several years; was granted a research permit in Italy for a potential production site.
- **Northvolt & Galp** (Portugal, non-integrated, ~6 kt Li) - output most likely to be used for Northvolt's production of cathode materials and battery cells.
- **Lithium de France** (France, integrated, ~6 kt Li) - backed by the energy companies Arverne and Equinor.
- **Imerys** (France, integrated, ~6 kt Li) - also a producer of ceramics and synthetic graphite.
- **CEZ Group & European Metals** (Cinovec project, Czech Republic, integrated, ~5 kt Li) - also planning tin production on site.

[16] The list is not exhaustive.

- **AMG Lithium** (Germany, non-integrated, ~3 kt Li) - the first lithium refining project to come online in Europe (2023); operates the Mibra lithium mine and concentrator in Brazil.
- **Keliber** (Finland, integrated, ~2 kt Li) - partially owned by precious metals producer Sibanye-Stillwater who also recently acquired the nickel refinery in Sandouville, France from Eramet.
- **Eramet** (France, integrated, ~2 kt Li) - the R&D of the EuGeLi project carried out in cooperation with manufacturers, academic institutions and research centres and supported by EIT Raw Materials.
- **Deutsche Lithium** (Zinnwald Lithium project, Germany, integrated, ~2 kt Li) - located near the Czech border in proximity of the Cinovec project.
- **European Lithium** (Wolfsberg Lithium project, Austria, integrated, ~2 kt Li) - has supply agreement with BMW; plans to explore lithium deposits in Ukraine.

The less certain, possible projects that are facing considerable local opposition are located in Serbia, Portugal and Spain and led by:

- **Rio Tinto** (Serbia, integrated, ~11 kt Li capacity) - Europe's largest lithium project, put on hold due to protests.
- **LusoRecursos Portugal Lithium** (Portugal, integrated, ~4 kt Li) - put on hold due to insufficient environmental impact study.
- **Infinity Lithium** (Spain, integrated, ~3 kt Li) - has a non-binding supply agreement with LG Chem; currently working with local stakeholders in the region to progress the project.

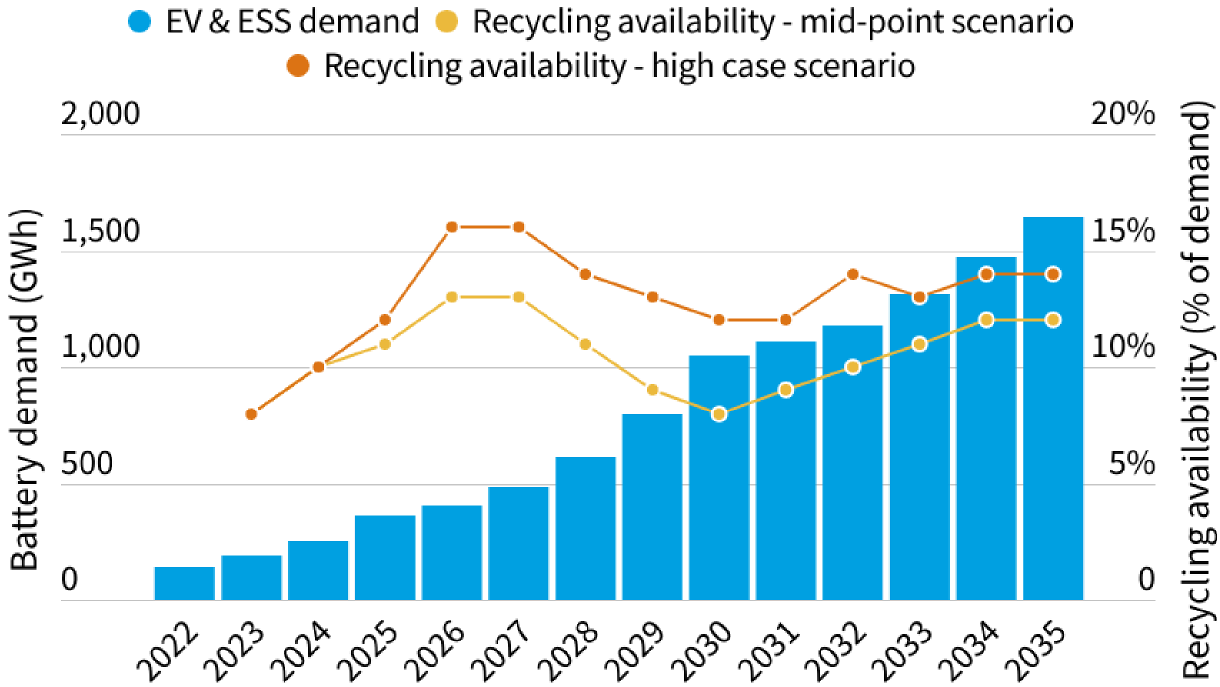
2. Battery recycling

Recycling will play a crucial role in developing a circular economy, reducing the demand for virgin materials and curbing Europe's reliance on third-country imports.

In the present analysis, two main sources of materials for recycling have been taken into account: end-of-life (EoL) batteries from EVs and ESSs, and battery production scrap. The latter refers to waste materials generated by gigafactories such as rejects, cuttings, slittings or remains in the battery production.[17]

Assuming the base case scenario for demand, we estimate that **the materials available for recycling in Europe could meet 8-12% of its needs in 2030 and 12-14% in 2035 (calculated on a GWh basis)**, depending on the availability of battery production scrap. The estimates in this section are conservative due to the simplified methodology on EoL battery retirement (more details in Annex 1.5). There is an upside potential for recycling availability volumes during this period if a battery retirement curve would be used instead. Also, the figures exclude the material available from consumer electronics, therefore the shares are likely even higher in reality.

[17] Circular Energy Storage, https://circularenergystorage.com/ces-online



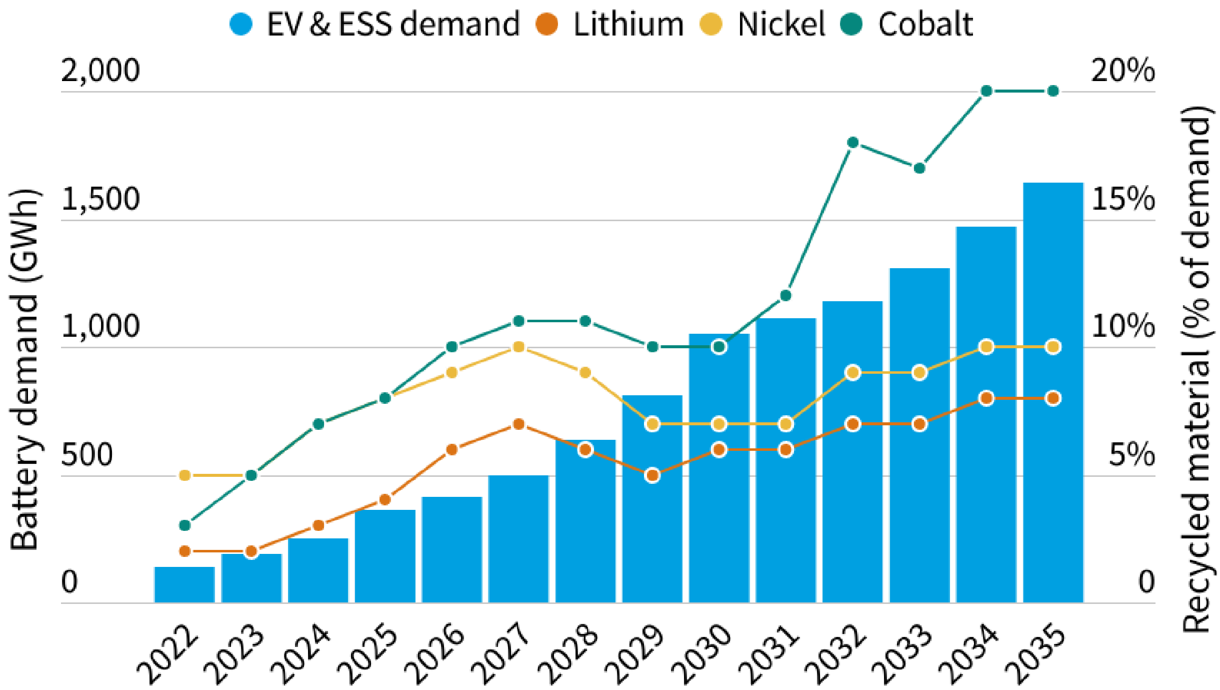
EV & ESS demand in the base case scenario. The recycling availability in the mid-point scenario includes EoL batteries and production scrap from likely gigafactory supply plus 50% of possible gigafactory supply. The recycling availability in the high case scenario includes EoL batteries and production scrap from all likely and possible gigafactories, implying a higher scrap material available for recycling.
Source: T&E analysis

Figure 9: EoL & scrap material available for recycling relative to battery demand in Europe

When looking at individual metals, specific recovery rates have to be considered since so far metals have not been 100% recovered from the materials available for recycling (more details in Annex 1.5). **The recovered raw materials from end of life batteries and production scrap could cover between 8% and 20% of Europe's demand by 2035, depending on the metal.**

The volumes of lithium (16 kt Li or 8% the Li demand) are impacted by lower recovery efficiency rates and delayed by a less ambitious policy, whereas those of cobalt and nickel (15 kt Co or 20% of Co demand and 85 kt Ni or 10% of Ni demand respectively) have been historically incentivised by higher prices and thus the recovery technologies are more advanced. In the long term, with the demand for lithium growing strongly we expect significant improvements in lithium recovery technologies as well.

The share of recycled cobalt is expected to peak by 2035 as end-of-life batteries produced in early 2020s containing more of the metal would become available for recycling. The share of recycled nickel is set to increase in the mid-2020s as gigafactories will be ramping up production and thus providing more battery production scrap for recycling, slow down towards the end of decade when the demand will be out-growing the recycling availability and then pick up again as more EV and ESS batteries would reach end of life.



EV & ESS demand in the base case scenario.
Source: T&E analysis

Figure 10: Recycled lithium, nickel and cobalt relative to battery demand

	Demand 2030*	Share of recycled material (% of demand) 2030**	Demand 2035*	Share of recycled material (% of demand) 2035**
Lithium	126 kt	6%	197 kt	8%
Nickel	550 kt	7%	816 kt	10%
Cobalt	57 kt	10%	73 kt	20%

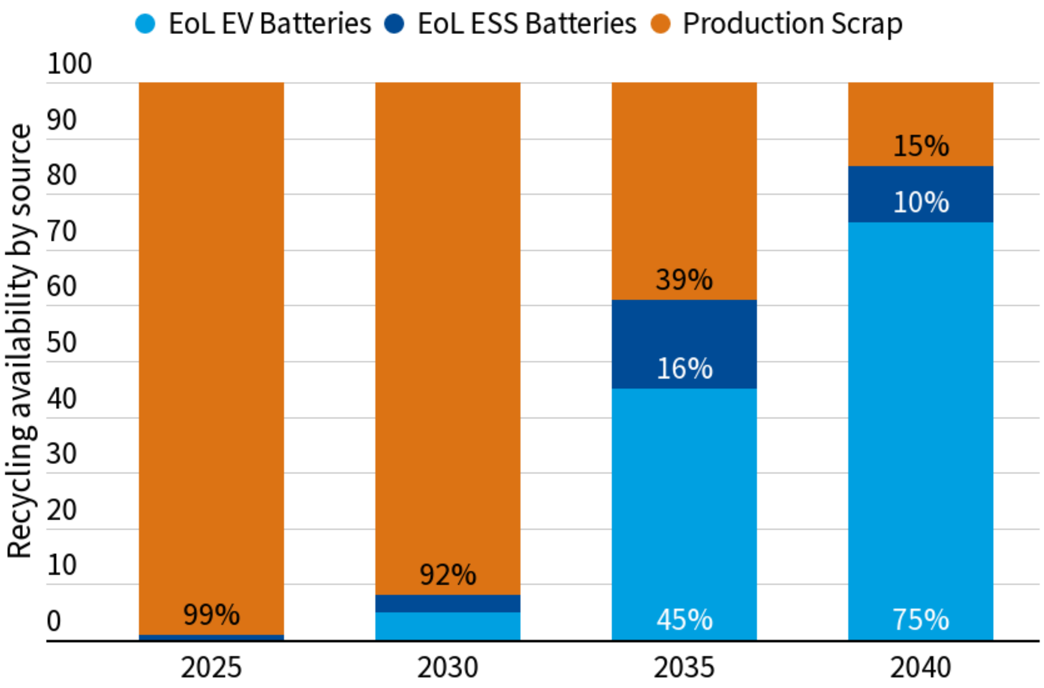
*Demand derived from the EV & ESS demand in the base case scenario.

Table 1: Lithium, nickel and cobalt demand and recycled content

While large volumes of end-of-life batteries from EVs and ESSs will become available for recycling only in a decade or so, production scrap generated by gigafactories will be the primary stream of feedstock for recycling companies in the near term. Around 50 battery cell production plants with a combined output of almost 1.1 TWh are expected to operate in Europe by 2030 in a mid-point scenario[18]. These plants are expected to produce significant amounts of waste material, especially in the early phases of scaling up production, that can be immediately recycled. Depending on the maturity of the plant, scrap ratios can vary from 20%-40%, albeit for small production volumes, down to 5% at more experienced plants. On

[18] In the mid-point scenario, battery cell production is calculated as likely supply plus 50% of possible supply.

average, we considered a scrap ratio of 25% of production for plants in their first year of operation, gradually decreasing to 5% after several years (more details in Annex 1.5). We estimate that around 7% of the battery cell production (or almost 80 GWh) could be scrapped in 2030.



Note: EoL EV batteries including second life applications
Source: T&E analysis, BNEF

Figure 11: Sources of feedstock for recycling companies

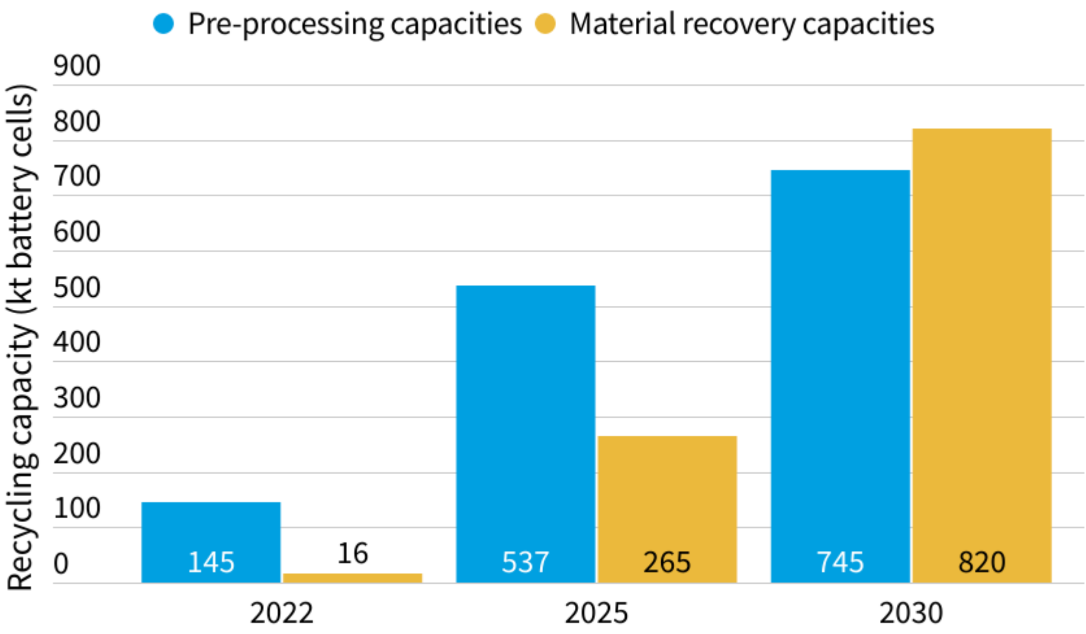
Faced with this influx of materials, Europe has to build recycling infrastructure for battery pre-processing (collecting, discharging & shredding) and, especially, for material recovery. These two stages of the recycling process require distinct capabilities and equipment and for this reason, historically, they tended to be addressed by different companies. According to Circular Energy Storage Research and Consulting (CES)[19], today there are 27 pre-processing plants in Europe able to treat 145 kt of battery cells, but only 7 material recovery plants with a combined capacity of 16.6 kt. If this capacity mismatch persists, valuable materials resulting from pre-processing, known as black mass, could leave Europe for further refining and cathode production in Asia. Therefore, **integrating the recycling value chain remains essential to secure feedstock** and, eventually, to close the loop. This can be done via the hub & spoke business model (whereby a company operates multiple pre-processing plants that feed one material recovery plant) or via partnerships along the value chain such as JVs or long term supply agreements between market players.

CES forecasts the gap between pre-processing and material recovery capacities to tighten by 2030 in Europe. CES also expects 16 integrated plants to operate in the recycling space, accounting for 54% of Europe's pre-processing capacities and 78% of recovered material volumes of battery cells. These

[19] Link to website

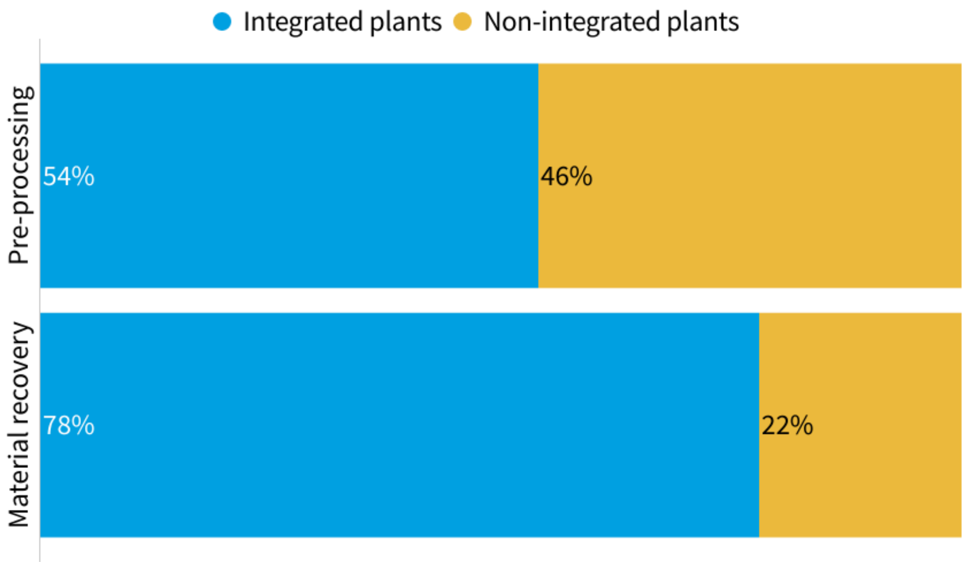
integrated plants include names such as Umicore (Belgium), Revolt (Sweden, owned by Northvolt), Redwood Materials (Germany; HQ in the US and founded by an ex-Tesla CTO), Sungeel Hitech (Hungary and Poland; HQ in South Korea), BASF (Germany), Ascend Elements (UK; HQ in the US) and Fortum (Finland).

We reiterate the importance of supporting an integrated approach to recycling as this would ensure that valuable battery materials stay within Europe in the long term.



Source: Circular Energy Storage Research and Consulting

Figure 12: Recycling capacities by processing stage in Europe



Source: Circular Energy Storage Research and Consulting

Figure 13: Integrated and non-integrated plants by recycling stage in Europe in 2030

3. EV industrial policy

3.1 The US Inflation Reduction Act

Thanks to the ambitious climate (and EV) policy, as well as the efforts of the European Battery Alliance and member states' funding support, Europe was projected to become the world's second biggest battery cell manufacturer by the end of the decade, with its share of global production expected to increase up to a third of the global battery production by 2030[20]. But in August 2022 the US Inflation Reduction Act[21] was signed into law, representing a game changer in industrial policy and unleashing a wave of investment announcements in just a few months. Companies have only a limited amount of resources to prioritise new projects - coupled with a possibility that the economic outlook in Europe worsens - the risk for Europe is that global and European companies will now prioritise the US market over Europe's as they look to expand.

The IRA package includes USD 369 billion in climate and energy provisions and represents the country's largest investment in addressing climate change. IRA's aim is to promote the development of domestic supply chains for green technologies and incentivise the procurement of materials domestically (or from free trade partners) while reducing the grip of China on the battery value chain. With regards to EVs, the IRA provides up to USD 7,500 in tax credit[22] on the following conditions:

- 50% of the tax credit (USD 3,750) is provided if at least 40% of the battery minerals are extracted, processed or recycled in the US or a free trade partner of the US.[23] The threshold for critical minerals content increases over time from 40% in 2024 to 80% by 2027.
- The balance of 50% of the tax credit (USD 3,750) is available if at least 50% of the value of the battery's components are manufactured or assembled in North America from 1 January 2024. This threshold increases to 100% by 2029.[24]

Furthermore, from 2024 battery components that have been manufactured or assembled in "foreign entities of concern" (including China and Russia) will not qualify for the tax credit. From 2025, EVs containing minerals that are extracted, processed or recycled by "foreign entities of concern" will also be excluded.

Batteries, components or electric cars produced in Europe currently do not qualify for the EV tax credit, but the negotiations between the US and the EU on this are still ongoing. However, Europe currently does not export many electric cars to the US. For conventional cars, with established European brands such as

[20] BloombergNEF expects Europe to reach 31% of the global production by 2030. Bloomberg (04.04.2021), *"The Next Electric-Car Battery Champion Could Be European"* (Link), while McKinsey expects it to reach 33% share in 2030 (link).
[21] Congress.gov, The Inflation Reduction Act of 2022. Link
[22] For vehicles that cost less than USD 55,000 for new cars and USD 80,000 for pickups and SUVs.
[23] The US has free trade agreements with the following countries: Australia, Bahrain, Canada, Chile, Colombia, Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Israel, Jordan, Korea, Mexico, Morocco, Nicaragua, Oman, Panama, Peru, Singapore. Link
[24] US Department of Energy, Electric Vehicle (EV) and Fuel Cell Electric Vehicle (FCEV) Manufacturing Tax Credit. Link

BMW and Audi, European cars exported to the US amounts to only 6%[25] of US sales (or 7% of EU car production). With electric cars it is even lower currently, with some industry experts putting it at less than 1% of production today (but public data is missing). In the short term, scaling up electric car production in both the US and Europe is expected to be mainly to cater to the fast growing market (with demand for EVs outstripping the supply). This means that the US EV tax credit is unlikely to impact EU electric vehicle manufacturing significantly. But there remains a risk that European OEMs will prioritise investments into EV manufacturing in the US over Europe in their expansion plans, so this and the EV trade balance between Europe and the US should be monitored.

On the manufacturing side, the IRA includes generous tax credits for the battery and minerals production process (known as the Advanced Manufacturing Production Credit):

- 10% of the production costs of critical minerals,
- 10% of the cost of battery electrode active materials,
- USD 35/kWh for battery cells production,
- USD 10/kWh for battery modules production, so USD 45/kWh overall if both cells and modules are produced together.[26]
- All of the above can be stacked together and claimed jointly.

This means that if a manufacturer produces an electric vehicle with 60kWh battery capacity in the US, including the cells and modules, there is a direct subsidy of at least USD 2700. This increases to USD 3600 for a bigger 80 kWh pack. At the same time, the export of that vehicle into the EU will be covered by a 10% tariff. Therefore, if this large battery pack EV was priced below USD 36,000, it would be cheaper to export it to the EU than to build it there from day one. If a vehicle had a higher price, it would require a considerable subsidy to counteract the 10% import tariff. If on top components such as cathodes and some of the battery grade minerals are manufactured in the US, the subsidy becomes influential. It is therefore important that Europe monitors the trade balance in electric cars between the US and Europe to anticipate possible risks and adjust the EV tariffs accordingly.

It is not just the sum that makes these **production credits the most significant part of the US IRA** when it comes to the battery value chain: the tax credits are simple, bankable, can be stacked by one company and are guaranteed until 2032. This makes it the most significant EV industrial policy globally. Just a few months after the US IRA was signed, more than USD 13 billion of investment[27] in raw materials production, battery manufacturing and EVs has been announced, including by European carmakers such as VW, BMW and Mercedes. Announcements keep on coming, while in Europe the expansions by Northvolt in Germany, VW in Spain and even Tesla's gigafactory in Berlin to also make cells are now in doubt.

[25] According to ACEA (Link), 648,127 European cars were exported to the US in 2021 and US passenger car sales amounted to 11.78 millions units in 2021 according to LMC Automotive's Global Hybrid & Electric Vehicle Forecast (Q2 2022)
[26] US Department of Energy, Battery Policies and Incentives. Link
[27] Bloomberg (08.11.2022), *"Democrats Supercharged EV Investment While They Had the Chance".* Link

3.2 EU-level funding

3.2.1 What EU is already doing

Over the past years, the EU has directed investments to electric vehicles and battery value chains via several avenues. The most important one has been the adoption of two sets of Important Projects of Common European Interest (IPCEIs) in 2019 and 2021 which - via Member State and private sector investment - are expected to channel respectively a total of EUR 8.2 billion[28] and EUR 11.9 billion[29] to the battery value chain.

In terms of research & development funding, via the Horizon Europe 2021-2027 funding cycle the European Commission has allocated EUR 925 million to battery related projects.[30]

Investment from the European Investment Bank (EIB) also plays an important role, with funding increasing in 2020 to EUR 1 billion[31] compared to the EUR 950 million spent in the previous decade in financing battery projects. A flagship operation in the field was the signature in July 2020 of a USD 350 million loan to support Northvolt's gigafactory for lithium-ion battery cells in Sweden, which followed an initial smaller EUR 52 million loan for the establishment of the demonstration line *Northvolt Labs* back in 2018[32]. During the same year, the EIB also financed the implementation of a cathode manufacturing facility in Poland through a EUR 125 million loan to the Belgian company Umicore[33].

Under the 2021-2027 EU budget, the role of public banks in supporting the battery value chain is set to increase. Through a EU budget guarantee of EUR 26.2 billion, the EIB and other European public banks aim to mobilise more than EUR 372 billion of public and private investment across Europe under the InvestEU programme. Developing batteries supply chain is part of the objectives of InvestEU, as demonstrated by a recent EUR 36.7 million EIB loan, backed by InvestEU, to Königswarter & Ebell, a German subsidiary of Australia's Pure Battery Technologies (PBT), to operate a commercial

---

[28] Public funding from seven Member States worth up to EUR 3.2 billion, expected to leverage extra EUR 5 billion in private investments by 2031, which is the deadline for the overall project's completion. Source: European Commission (09.12.2019), *"State aid: Commission approves €3.2 billion public support by seven Member States for a pan-European research and innovation project in all segments of the battery value chain".* Link

[29] Public funding from twelve Member States worth up to EUR 2.9 billion, expected to leverage extra EUR 9 billion in private investments by 2028. Source: European Commission (26.01.2021), *"State aid: Commission approves €2.9 billion public support by twelve Member States for a second pan-European research and innovation project along the entire battery value chain".* Link

[30] BATT4EU, Horizon Europe Calls. Link

[31] European Investment Bank (19.05.2020), "EIB reaffirms commitment to a European battery industry to boost green recovery". Link

[32] European Investment Bank, (29.07.2020), "*Sweden: European backing for Northvolt's battery gigafactory*". Link

[33] European Investment Bank, (15.06.2020), "*Belgium/Poland: EIB and Umicore conclude €125 million loan for battery materials production in Poland*". Link

demonstration plant for the manufacturing of precursor cathode active material used in the production of advanced Li-ion cells with nickel, manganese and cobalt chemistry[34].

The value chain of batteries is also supported at national level (see Section below) by European governments under their recovery and resilience plans. These plans benefit from significant EU funding stemming from the Recovery and Resilience Facility (RRF) put in place at EU level in the wake of the Covid pandemic. As part of the Next Generation EU package, the RRF is financed via the issuance of joint bonds by the European Commission and aims to mitigate the impacts of the pandemic and make European economies and societies more sustainable, resilient and better prepared for the green and digital transition. Under the RRF, European governments can access a total of EUR 723.8 billion in loans (EUR 385.8 billion) and grants (EUR 338 billion) to support investments by the end of 2026. Following the adoption of the REPowerEU plan, the bulk of the loans' component (EUR 225 billion) will be redirected to measures to support independence from Russian fossil fuels, and transition to renewables. This will virtually leave no unallocated funds left under the RRF.

3.2.2 What is needed to respond to the US IRA

The adoption of the IRA in the US has brought to the top of the political agenda at EU level the question of how Europe should protect, develop and enhance the competitiveness of its industries in line with its decarbonisation goals. Several governments, including in France and Germany[35], call for a new approach at EU level, where investments (public and private) should come in tandem with reinforced industrial policies enhancing the EU's strategic autonomy in the long run. Therefore, besides already budgeted resources mentioned above, the European Commission is currently planning to set up a **European Sovereignty Fund**, as announced by President von der Leyen in her State of the European Union in September 2022. A proposal from the Commission is expected to be tabled around summer 2023. Details about the modalities, governance and budget of the fund are not yet known.

A more ambitious set of climate and industrial policies, as expected with the EU Green Deal and the Critical Raw Materials act, needs to be supported by adequate and new funding. The financing needs for the development of a robust European battery value chain are enormous. The European Battery Alliance (EBA250) estimates that new investments worth EUR 380 billion will be needed in support of the battery value chain across Europe in order to create a self-sufficient battery industry by 2030[36]. The creation of a dedicated investment fund to back such objectives offers a window of opportunity to steer the EU on a more sustainable path and accelerate its transition.

What is needed is a new major investment plan at EU level focusing on accelerating the decarbonisation of the energy, transport and buildings sectors across Europe. For the **European Sovereignty Fund** (ESF) to match this objective, repackaging unused budget lines under the current EU budget (Multiannual

[34] European Commission, (05.12.2022), "*InvestEU: EIB invests in PBT's eco-friendly battery material production in Germany*", Link
[35] EurActiv, (19.12.2022), "*Germany and France seek to match US green industry subsidies*". Link
[36] European Battery Alliance (29.03.22), "*Joint statement for an accelerated action plan to support the growth of the European battery industry*". Link

Financial Framework – MFF) during the mid-term review of the MFF planned for 2023-2024 will not be sufficient[37]. The scale of investments needed calls for an ambitious spending programme backed by adequate firepower. The European Commission estimates that for the green and digital transition, huge investments are needed. To reach the objectives of the Green Deal, the EU needs to increase the investments by around EUR 520 billion per year until 2030, compared to what it did in the 2020s. To foster the digital transition, the Commission estimates that additional investment of around EUR 125 billion are needed per year[38]. In that regard, the current context of increasing interest rates and a possible recession, coupled with growing indebtedness of many EU Member States, make it unlikely that many European governments will be able to put fresh money from their national budgets on the table to support the creation of the fund, so that it can play a significant role in the future.

European Sovereignty Fund: how will it work

To adequately finance the development of green industrial policies, at least a EUR 350 billion ESF (to match the US IRA budget) should be established. This amount would mirror the green spending part of the US IRA. The bulk of its funding should come from joint debt issuance from the European Commission, hence becoming the backbone of Europe's green industrial policy. Under the ESF, EU governments, the European Commission and EU bodies such as the EIB, should support strategic projects via loans, grants and guarantees, including to back production loans for innovative companies. This would enable the ESF to deploy significant investments from 2025 to 2030 in a number of strategic projects in clearly defined eligible sectors such as energy, transport and raw materials (as identified under the Critical Raw Materials Act).

A possible solution is to finance the ESF through a **new joint bond issuance programme** piloted by the European Commission on behalf of the European Union. As the unprecedented setting-up of NextGenerationEU has demonstrated, the EU has the ability to access the financial markets and cheaply borrow in order to finance transformative investments for a major energy and climate investment programme.

Firstly, thanks to EU's creditworthiness (unlike its member states' securities, EU bonds are rated AAA), funding investments at EU level is substantially cheaper for those who need it most. As of 5 January 2023 the 10 year EU NextGen bond would pay 3%, while Italy, the EU's largest borrower, would pay 4.35%. And rates are even higher in Central and Eastern member states with the Czech Republic, Bulgaria, Poland, Romania and Hungary, paying respectively 4.81%, 5.7%, 6.4%, 8% and 8.40%. The fact that these high yielding countries are generally those that oppose faster investments in the green transition is not unrelated to their access to capital markets. In terms of pure 'costs' every 1% of saved interest payments

[37] In order to reach figures above EUR 100 billion, reshuffling funds already committed under the MFF will not be enough. For example, despite the high political priority set around it, only EUR 20 billion could be set aside to provide new grants under the REPowerEU plan. Unless Member States decide to dramatically increase their contribution to the EU budget, sourcing higher amounts to the ESF under the MFF would mean cutting down significantly on important spending programmes at EU level.

[38] European Commission (2.03.2022), "*Towards a green, digital and resilient economy: our European Growth Model*". Link

amounts to EUR 10 million for every EUR 100 million of funds borrowed over 10 years. For example, average savings of 2% on a EUR 100 billion package would translate into a whopping EUR 20 billion of savings. Also the spreads are increasing rapidly as official rates increase, making the case for joint financing even more compelling.

Surprisingly, the lower costs that EU transition financing would entail are surpassed by another argument: the true difference between member states funding themselves their transition and the EU financing it centrally, is the actual availability of capital. Here the EU enjoys virtually unlimited funding opportunities with capital markets. The EU bond market has been completely revolutionised by the issuing program launched with Next Generation EU, worth more than EUR 800 billion. EU bonds are rapidly becoming similar to government bonds in liquidity. They are considered as safe and liquid assets, as demonstrated by their categorization by the European Central Bank[39] and under the Basel Framework[40]. Other signs of the strong and promising status of EU bonds are that repurchase operations (repo) facilities are being established, and a futures market for EU bonds seems to be in the offing[41]. EU bond issuance can surpass member states issuance conditions both in cheapness and in sheer size also because the EU is an issuer with an extremely low debt to GDP ratio.

In short, there are clear benefits of joint borrowing from the standpoint of European governments. On the one hand, given the different debt capacity of EU Member States, joint borrowing allows for the states in a more precarious financial situation to still access financial markets to finance their green transition. On the other hand, for all European governments, joint borrowing provides better terms and conditions than what they would be able to access on their own.

In conclusion, in a context of high inflation, rising rates and intra European spreads, looming recession and higher debt to GDP ratios resulting from the Covid crisis, the realistic chance the EU has to fund the transition without exacerbating disparities in the Union is an ESF structured as Next Generation EU 2.0. There is no alternative with the same potential for resources availability and oversight.

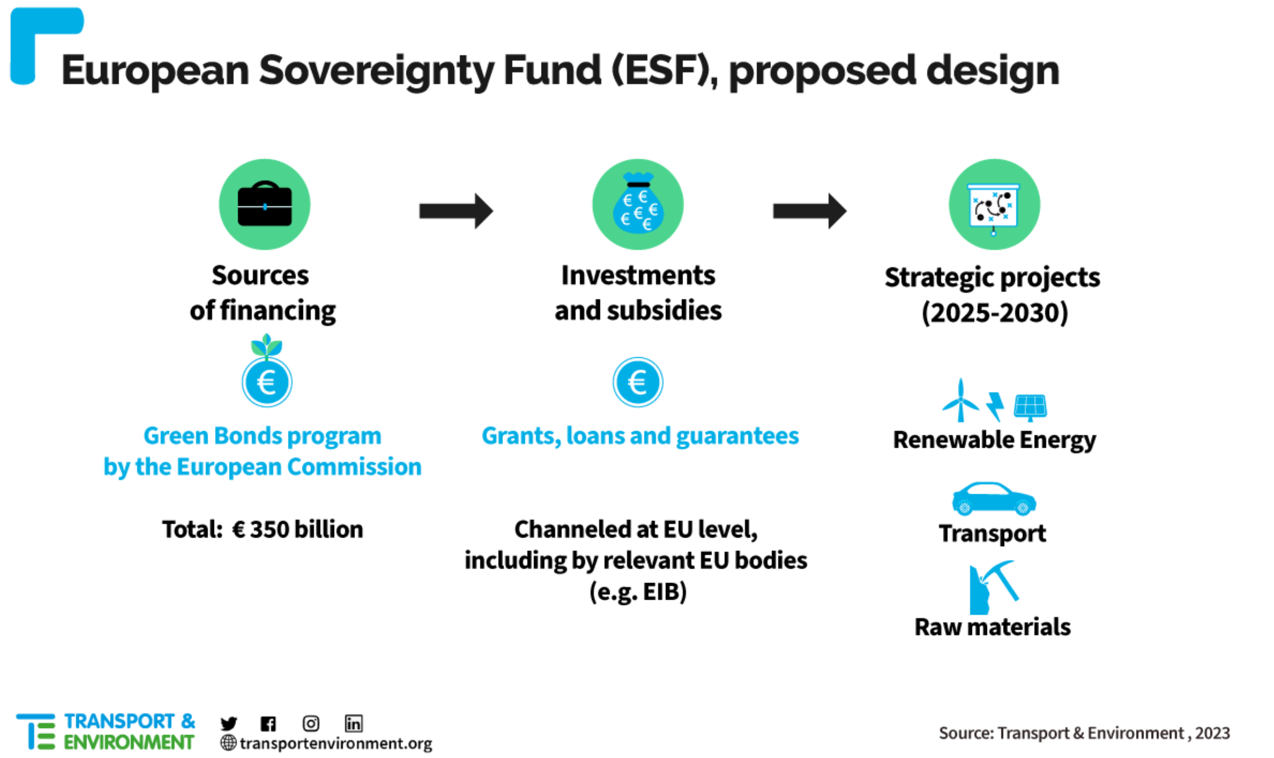
While the RRF was crafted as a countercyclical tool with multiple objectives covering most sectors of the European economy, the ESF should be a more targeted instrument focusing on fewer – but pivotal - sectors of the economy in support of EU emerging industrial policies in the energy, transport and building sectors. It should reward innovation (not vested interests), focus on the green industries directly impacted by the US IRA (renewables, batteries, green hydrogen) and target production aid (not R&D).

The ESF should prioritise support to truly sustainable and green businesses, or those directly impacted by the US IRA, including sustainable metals production, processing and recycling, batteries, green hydrogen, energy grids and renewable energy value chains. Fossil fuels in any form, including natural gas, and related infrastructure projects mustn't be eligible in any shape or form.

[39] In December 2022 the European Central Bank has granted EU bonds the haircut category I status.
[40] EU bonds are considered Level 1 High Quality Liquid Assets for Liquidity Coverage Ratio calculation under the Basel framework, with 0% risk weight for banks.
[41] A futures market is an auction market in which participants buy and sell futures contracts for delivery on a specified future date.

If backed by strong environmental, social and climate safeguards, the ESF holds the potential of being the financial arm of forward-looking EU industrial policies. It would become the missing piece in the EU financial toolbox once the NextGenerationEU funding dries out at the end of 2026: a flexible pool of funding providing long-term visibility to key industries for their greening.

T&E is currently identifying various scenarios for the rolling-out of an ESF equipped with sufficient firepower. At this stage, the most desirable option identified is the following:



3.3 National funding

A lot more money is being spent by European countries on supporting local production of electric cars, EV components and batteries, as well as wider critical metals manufacturing and chemicals. Below are a few snapshots from the largest EU member states plus the UK.

3.3.1 Overview of some national examples

France

Based on the public data, the support to carmakers in France since 2020 has been around EUR 12 billion. This includes around EUR 7 billion for EVs and EUR 3 billion of tax cuts for manufacturing. A big half of the EUR 7 billion comes from EV subsidies (EUR 1-1.4 billion/year)[42], the other (smaller) half is for support to

[42] Le Ministère de l'économie des Finances et de la Souveraineté Industrielle et Numérique, Construire la France de Demain. Link

the EV & battery industry[43]. In addition, support has been provided for the nickel industry in New Caledonia[44].
However, above are the estimates since there is no accurate and exhaustive tracking available publicly.

Germany

According to the official account of the finance ministry, Germany plans to spend at least EUR 5.6 billion[45] on electric vehicles in 2023, including EUR 2.1 billion[46] in direct purchase premiums. Germany also made EUR 500 million[47] available for research into advanced battery production methods and already agreed to EUR 150 million[48] investments in battery production for projects of common European interest.

Italy

Italy, like other countries, provides purchase support for electric cars, with around EUR 130 million in 2021.[49]

As regards the supply chain, the Italian Government allocated circa EUR 1,15 billion within the framework of the Italian National Recovery and Resilience Plan (NRRP)[50] to strengthen the automotive/e-mobility supply chain. The funding is intended to increase the national production capacity and competitiveness of semiconductors/chips (EUR 340 million as part of Mission 2 Component 1), batteries (EUR 500 million as part of Mission 2 Component 2) and e-buses (EUR 300 million as part of Mission 2 Component 2).

More recently in March 2022, as a response to the crisis linked to the breakout of the war in Ukraine, the Italian Government issued a Decree-Law to contain surging energy prices (electricity and natural gas) and relaunch industrial policies[51]. In this context, further funding for EUR 8,7 billion until 2030 was allocated for the green conversion of the automotive sector, entailing measures to support both the demand and supply of vehicles compatible with the transition. As part of the same Decree-Law, further funding for EUR 4.15 billion was allocated to boost the production capacity of semiconductors and microprocessors.

In total, T&E estimates the Italian government to allocate over EUR 15 billion during 2019-2030.

Spain

---

[43] Multiple sources including: economie.gouv.fr, gouvernment.fr, bpifrance.fr, ACC

[44] Franceinfo (13.10.2019), *"France 2030: Emmanuel Macron veut favoriser une production française des batteries au nickel"*. Link

[45] Bundesministerium der Finanzen (27.07.2022), *"Klima- und Transformationsfonds: In Klimaneutralität und Versorgungssicherheit investieren – Menschen und Betriebe entlasten"*. Link

[46] Bundesministerium für Wirtschaft und Klimaschutz, FAQ Liste Umweltbonus. Link

[47] Bundesministerium für Bildung und Forschung (08.07.2020), *"Batterieforschung in Deutschland"*. Link

[48] Bundesministerium für Wirtschaft und Klimaschutz (29.03.2022), "Erstes Großprojekt aus der BMWK-Fördermaßnahme zum Batterie-Ökosystem gestartet". Link

[49] Legge di Bilancio 2021. Link

[50] Governo Italiano Presidenza del Consiglio dei Ministri (30.11.2021), *"Piano Nazionale di Ripresa e Resilienza"*. Link

[51] Gazzetta Ufficiale della Repubblica Italiana (01.03.2022), Decreto-Legge 1 marzo 2022, n. 17. Link

Support for car manufacturers and the batteries value chain in Spain is mostly centred around the PERTE VEC (Strategic Projects for Economic Recovery and Transformation for the Electric and Connected Vehicle). This instrument serves to channel RRF money into specific projects and amounts to EUR 2,975 million.[52] Approximately 30% of the budget, EUR 877.2 million[53], has been allocated to 10 projects. Key among them is SEAT/Volkswagen Group's Future Fast Forward project, which is expected to mobilise EUR 10 billion investments in Spain, and will bring battery electric vehicles production from 2025 to the Martorell (Barcelona) and Landaben (Pamplona) plants, as well as the creation of a battery gigafactory in Sagunto (Valencia) in 2026.

The Spanish State Budget is an additional funding mechanism for car and battery manufacturers. For instance, on top of the EUR 397 million that the Future Fast Forward project will receive from the PERTE VEC, it has been announced that it will also get EUR 230 million from the 2023 state budget[54]. These projects can also benefit from regional subsidies.

As for public aid for electric vehicles, general subsidies have reached EUR 1,345 through MOVES I[55], II[56] and III[57]. On top of this, the MOVES Flotas program for fleets has reached EUR 50 million[58] and will receive another EUR 50 million in 2023; and the MOVES Singulares I[59] and II[60] for unique and innovative projects now amounts to EUR 379 million. The government has been focused on these three programs and will presumably continue to increase their budget through the coming years.

UK

The UK Government announced GBP 1 billion to support the electrification of UK vehicles and their supply chains in October 2019.[61] More recently, the Government has pledged to spend GBP 850 million of this GBP 1 billion by 2025 through the Automotive Transformation Fund.[62] This has included pledged funding for the Britishvolt gigafactory in Northumberland[63] and lithium mining trials in Cornwall[64].

---

[52] La Moncloa (18.03.2022), *"Publicada la convocatoria del PERTE del vehículo eléctrico y conectado"*. Link

[53] Ministerio de Industria, Comercio y Turismo (25.10.2022), *"Industry publishes the allocation of public grants for projects of the first call for applications for Strategic Projects for Economic Recovery and Transformation for Electric and Connected Vehicles (PERTE VEC)".* Link

[54] RTVE (09.11.2022), *"Volkswagen acepta las ayudas del PERTE y seguirá adelante con la gigafactoría de Sagunto"*. Link

[55] Instituto para la Diversificación y Ahorro de la Energía, PLAN MOVES - Incentivos A La Movilidad Eficiente Y Sostenible. Link

[56] Instituto para la Diversificación y Ahorro de la Energía, PLAN MOVES II. Link

[57] Ministerio para la Transición Ecológica y el Reto Demográfico (23.11.2022), *"La vicepresidenta Ribera anuncia un aumento de fondos para movilidad sostenible y autoconsumo".* Link

[58] Ministerio para la Transición Ecológica y el Reto Demográfico (19.01.2022), *"El MITECO abre la convocatoria de MOVES Flotas, con 50 millones para incentivar la electrificación de parques de vehículos ligeros".* Link

[59] Instituto para la Diversificación y Ahorro de la Energía, Programa MOVES Proyectos Singulares (2019). Link

[60] Ministerio para la Transición Ecológica y el Reto Demográfico (27.09.2022), *"El MITECO lanza la 2ª convocatoria de MOVES Singulares II, con 264 millones para proyectos innovadores de movilidad eléctrica".* Link

[61] Gov.uk (08.10.2019), *"New measures to back business, boost innovation and supercharge UK science"*. Link

[62] Gov.uk (19.10.2021), *"Net Zero Strategy: Build Back Greener".* Link

[63] Gov.uk (27.07.2022), *"Final grant offer provided to Britishvolt"*. Link

[64] British Lithium News (15.09.2022), *"British Lithium wins £2m in government funding".* Link

In addition, the Government has also committed funding for the Faraday Battery Challenge which aims to put the UK at the global forefront of design, development, manufacturing, and recycling of electric batteries. This has included support for the UK Battery Industrialisation Centre. Government funding for this has been GBP 541 million since 2017 with GBP 211 million in new government funding from 2022 to 2025.[65]

There are also other programmes to support the transition of the automotive sector. This includes the work of the Office for Zero Emission Vehicles, assistance for R&D through the Advanced Propulsion Centre, and work to support the growth of the UK's power electronics, machines and EV supply chain through Driving the Electric Revolution (with GBP 80 million funding for electrification technologies including power electronics, electric machines and drives).[66] [67]

3.3.2 EU State aid

All of the above national funding falls under the state aid rules in the European Union[68]. In this regard, the adoption in January 2022 of revised Guidelines on state aid for climate, environmental protection and energy (CEEAG)[69] aimed at enabling sufficient support to the objectives of the European Green Deal. The EU state aid rules are of crucial importance to allow governments to provide appropriate support and subsidies at national level, while ensuring a level playing field in the EU Single Market.

But in the context of the global race for subsidies culminating with the adoption of the US IRA, these rules fall short of putting in place a robust enough framework to ensure large scale support for the battery value chain and other major industrial sectors. The current rules stipulate that:

> *"aid can be considered as facilitating an economic activity only if it has an incentive effect. An incentive effect occurs when the aid induces the beneficiary to change its behaviour, to engage in additional economic activity or in more environmentally-friendly economic activity, which it would not carry out without the aid or would carry out in a restricted or different manner. The aid must not support the costs of an activity that the aid beneficiary would anyhow carry out and must not compensate for the normal business risk of an economic activity".*

Such a provision on additionality of state aid hinders in practice the support to most companies involved in the sector. In particular it makes it hard for companies with expertise and know-how to get funding to scale their raw materials or battery manufacturing facilities in Europe. Green business today is treated the same as approving a fossil fuel plant, which is not aligned with the needs under the EU Green Deal. In addition, companies can mobilise capital to scale their business models and develop strategic projects successfully if they benefit from long-term visibility and multi-annual funding programmes. The US IRA

---

[65] Gov.uk (21.10.2022), *"Record funding uplift for UK battery research and development"*. Link
[66] Department for Business, Energy & Industrial Strategy (09.09.2021), Letter to Philip Dunne MP. Link
[67] UK Research and Innovation, "Driving the electric revolution challenge". Link
[68] The UK has new state aid rules post-Brexit, with the Trade and Cooperation Agreement with the EU including provisions to ensure a level playing field.
[69] European Commission (21.12.2021), "*State Aid: Commission endorses the new Guidelines on State aid for Climate, Environmental protection and Energy*". Link

production subsidies are simple and bankable (up to 2032); on the contrary the EU state aid rules are complex and often lack the visibility on approval deadlines.

The scale of the challenge calls for a serious simplification of state aid guidelines to match the US production tax credits, by making them more long-term, bankable and simple to apply for. The European Commission will propose a revision of EU state aid rules in early 2023 to make it easier for public investment to power the transition. This initiative is currently backed by the French and German governments (see this joint letter in December 2022[70]) which for instance advocate for reducing the checks performed by the Commission on proposed support to companies, enabling aid to be approved ex ante (rather than ex post under current rules) and via "general national support" programmes.

Any future reform of the EU state aid rules should:

- Simplify the ability to help the green businesses affected by the US IRA - such as renewables, batteries or green hydrogen - scale their production, innovate and benefit from new learning or business models, i.e. remove or simplify the above-mentioned additionality rule for the targeted sectors;
- Consider faster (or ex ante) approval procedures;
- Create a clear list of sectors benefiting: only target industries that significantly contribute to the European Green Deal and are directly affected by the US IRA;
- Prioritise operations based on their quality and added-value for the climate and environment instead of their low cost and affordability (further weighing qualitative criteria instead of quantitative criteria).

A major concern and source of opposition to the streamlining and simplification of EU state aid rules relates to the diverging fiscal and budgetary capacities in various European countries. Since only major economies such as Germany would be able to significantly support their national economies, loosened rules might exacerbate imbalances between European countries. This risk could be alleviated by making sure the European Sovereignty Fund is rapidly deployed and provides strong support to Member States which are struggling to finance their strategic projects and companies. E.g. in the case of raw materials, funding should flow to countries that have the best geological or technological potential to produce, process and recycle critical metals for the European market regardless of the investment capabilities in the country.

[70] Bruno Le Maire, Robert Habeck (19.12.22), "*For a European Green Industrial Policy*". Link

4. Conclusions & policy recommendations

4.1 Europe's response to the US IRA: simplify & expand funding

The US Inflation Reduction Act is a game changer in industrial policy and risks syphoning away investments that would otherwise go into batteries and critical metals in Europe. The concern is not so much the EV tax credits as the EU is expected to export (or import) limited numbers of electric cars produced in the US. Instead, the real risk is the long-term and bankable production tax credits that are given to batteries and the entire raw materials supply chain without limits until 2032. By some estimates these come to hundreds of billions of dollars over the next 10 years.

What we show in this paper is that Europe already spends big sums to support both the sales of EVs and the wider value chain including vehicle manufacturing, battery production and upstream processing. At the EU level, more than EUR 20 billion has already been devoted to the battery value chain directly via the IPCEI framework, the EIB and research funding. Dozens of billions more is available via the InvestEU programme (beefed up by the RepowerEU plan in the aftermath of Ukraine's invasion) and the EU Recovery and Resilience Facility launched post Covid pandemic.

Most money is being disbursed at the national level. From the limited data available we estimate that France has provided around EUR 12 billion since 2020 for the EV value chain, Germany plans to spend around 6 billion this year alone, Italy is estimated to give around 16 billion this decade while in Spain hundreds of millions in funding are given via the PERTE VEC (from RRF) and MOVES programmes. This funding is governed by the EU state aid rules to ensure the EU Single Market level playing field.

Even if the sums do not add up to the hundreds of billions under the US IRA, they are nonetheless substantial. The problem is not only the lack of money, but the complexity and red tape surrounding it. The funding is often slow (with visibility on approval deadlines rarely available), bureaucratic and not bankable in the same way as the simple US IRA production credits are. E.g. IPCEI requires numerous partners for a single project to qualify, while the EU state aid guidelines ask companies to prove their projects would not have been possible without such funding. In addition, many funding programmes are annual and lack the long-term certainty needed.

T&E recommends the following improvements:

- **Simplify & streamline** the existing EU (and national where relevant) funding mechanisms for the green sectors impacted by the US IRA, e.g. batteries. Beyond a simpler process, funding should be long-term and bankable to match the US IRA tax credits to 2032. Building a battery plant in Europe should become faster than building a coal power station. This means **EU state aid rules** for the strategic projects in the battery value chain should be reformed, i.e. the additionality rule adjusted or removed and clear deadlines for approval (or ex-ante processes) put in place.

- EU and national funding should target capital and operational support (**manufacturing subsidies**) to match the IRA's 10% tax credit for the production of cells, battery components and raw materials (focus on refining & processing in particular). This should go beyond R&D and help scale up production. The EU level playing field is important for such production aid to ensure most promising projects across Europe (based on geology, business case or technology) are supported.

- To accelerate the development of green industrial policies, the **European Sovereignty Fund** (ESF) should be established as a matter of urgency and equipped with financial firepower in the scale of EUR 350 billion via joint debt issuance from the European Commission. The ESF should focus on backing operations in a limited number of pivotal economic sectors in the renewable energy, sustainable transport and buildings, starting from flagship projects in the entire battery value chain including raw materials processing. Ultimately, the ESF should become the backbone of the European green industrial policy. It should reward innovation (not vested interests), focus on the green industries directly impacted by the US IRA (renewables, batteries, green hydrogen) and target production aid (not R&D).

- Europe's **trade & foreign policy** is key. Strategic partnerships with third countries - especially in Africa and Asia (e.g. Indonesia) - must be accelerated and responsible supply of metals made a priority under the EU investment aid. Europe also needs to ensure a comprehensive tariff suspension (ATS) for all the feedstock (raw materials, refined compounds) and machinery that is needed to scale up Europe's battery value chain in the coming years. On the other hand, monitoring the EV trade balance is necessary, with a **special EV tariff** (higher than the current 10%) introduced, if needed, to avoid Europe becoming a dumping ground for cheap EVs, including from countries lacking strong environmental and social due diligence standards.

- Governments should also support energy intensive businesses in the battery and metals processing field with energy costs while these remain high due to Russia’s invasion of Ukraine, targeting low cost renewables for industrial manufacturing.

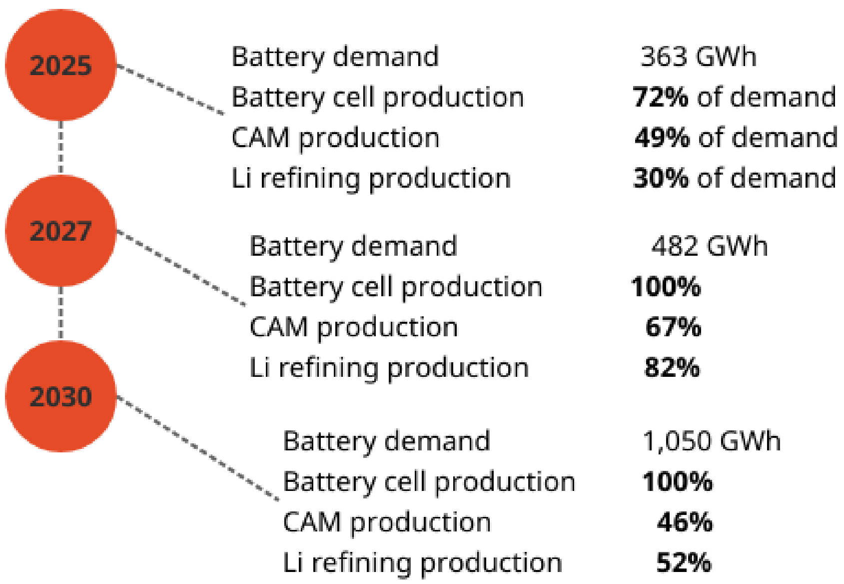
4.2 Europe’s response to the US IRA: made in Europe

Europe's car CO2 standards, and the Ff55 policies more broadly, have resulted in much investment being planned or announced. The risk is that some of this might instead flow to the US, so the policies such as the 2035 ICE phase-out for cars and vans should be cemented, not questioned, as they create investment certainty in Europe. In order not to lose our leadership in truck technology, higher 2030 truck CO2 goals and an eventual phase-out of diesel trucks should similarly be proposed for large rigs in Europe.

On top, these climate measures should be beefed up with strong industrial measures. Some countries and upcoming EU policies, such as the EU Critical Raw Materials Act are considering introducing **targets for European supply of key battery components and raw materials** (as the US IRA has done). If these (sometimes referred to as the local content requirements) were considered, T&E analysis shows the following potential for the European value chain:

- The EU already manufactured more than half of the Li-ion battery cells used in electric vehicles, storage and other applications on the EU market in 2022. This is done by companies such as LG Chem in Poland, and Samsung SDI and SK Innovation in Hungary. T&E analysis of the battery cell capacity announcements to date shows that Europe can be self-sufficient in battery cells, i.e. **produce 100% of Li-ion battery cell demand from 2027**. This includes less mature projects, where robust industrial policy on top of the climate policy certainty is key to make them materialise.

- Investments are also going further mid-stream. **Two-thirds of all the cathode active material can be produced in Europe by 2027**, slightly dropping by 2030 as the EV demand increases and investments are uncertain. This is where we currently lead over the US in terms of project announcements. Some of the largest projects announced are in Poland by Umicore, Sweden by Northvolt and BASF in Germany.
- Further upstream, investments are happening in the refining and processing stages of the battery supply chain, where China leads today. When we look at the potential to refine lithium in Europe, **50-60% of our refined lithium demand can come from projects announced in Europe**. Fast tracking best projects (via the Critical raw materials act), simplifying permitting - as well as funding support - are necessary to capture this value chain, which is critical to the geopolitical resilience and diversification goals of Europe as it accelerates its green transition to renewables and clean mobility.



Battery demand in base case scenario.
Battery cell production in a scenario of likely supply plus 50% of less likely supply.

Figure 14: The European battery values chain milestones

- Significant urban mining, or **recycling** potential, also exists in Europe. The materials available for recycling from end-of-life batteries or scrap from European battery factories could **meet 8-12% of the materials needs in 2030**, rising to 12-14% in 2035. By 2030, a tenth of all cobalt, 7% of nickel and 6% of lithium needed for batteries can come from recycling. This increases considerably in the decade following the year 2030.

This shows that considerable potential to process metals[71], produce cells and recover secondary materials exists in Europe, but requires a similarly ambitious measure to that of the US IRA to make it a reality in the global competition context.

4.3 Europe's response to the US IRA: policy (Critical Raw Materials Act)

Similar to the EU Chips Act, the European Commission plans to bring forward a European Raw Materials (CRM) act to spur production, processing and recycling of critical metals. This policy, if designed well, has the potential to boost domestic supply in a sustainable manner. Below are T&E's key recommendations.

1. EU strategic projects

The Critical Raw Materials (CRM) Act should introduce supply side targets for metals processing and recycling. E.g. T&E analysis shows that at least 50% of refined lithium can come from Europe in 2030 - this can be set as a 2030 goal, together with other critical metals, to spur investment and provide visibility.

The law should also introduce a list of strategic metals to focus on, as well as a list of European strategic projects in mining, recycling and refining to fast-track in terms of permitting and funding. But to benefit from faster permitting or finance, such projects should demonstrate that they meet high environmental and social standards. This should include:

- Water management (in line with the EU's Water Framework Directive),
- Tailings management (in line with best practice such as IRMA or Safety First),
- Biodiversity (such as the EU Habitats Directive),
- As well as the latest pollution control (EID and its implementing regulations).

On waste (see PART II below), or tailings management, in particular that CRM Act should require Europe to review the EU Extractive Waste Directive to align it with the global best practice in tailings management, notably requiring dry stacking of filtered tailings for surface mining and backfilling for underground mining.

2. Circularity & recycling

With millions of electric cars entering the fleet each year from 2020, the potential from end-of-life (EoL) products will be significant from 2030 onwards, while manufacturing scrap from the many battery factories setting up plants in Europe will be available for recycling before that (accounting for over 90% of the feedstock until 2030). Scaling recycling expertise, capacity and skills in Europe today is a no regrets strategy and is core to the bloc's supply resilience.

The CRM act should facilitate this, dismantling the barriers and harmonising standards across Europe. In particular:

[71] T&E will look into the European extraction potential at a later stage, it was not possible within the timeframe of this publication.

- Support vertical integration of the recycling value chain (especially the battery pre-processing with material recovery stages) to secure material availability such as "black mass" and close the loop (e.g. prioritise funding to companies that have an integrated approach to recycling);
- Introduce safety or quality standards for recycling production scrap and EoL materials (i.e. black mass) to aid the recyclers in Europe; or
- Alternatively, black mass should be designated as waste to prevent its easy shipments outside the EU.

Another potential comes from extracting metals from the existing mining waste, or "re-mining". Re-processing the waste that has been generated over time by mining operations in Europe could create new economic opportunities while reducing the industry's environmental impact. For example, the LKAB project in Sweden has the potential to recover rare earths from mining waste equivalent to 30% of the EU's current demand.[72]

To capture this opportunity, EU should:
- Map the tailings facilities of both operating and closed mines including their contents, the possible risks they pose and their economic potential for re-mining;
- Maintain oversight of such tailings facilities by means of a centralised platform;
- Include remaining projects into the CRM Strategic projects list;
- Separately, require re-mining projects to undergo environmental impact assessments in order to identify potential risks associated with contained substances and physical instability.

3. Global imports

Even if the end game is circularity, Europe will rely on global imports for a long time. The CRM act should promote transparent and diverse markets, as well as create a framework for the public and private investment into projects outside of Europe provided high environmental and social criteria are guaranteed (regardless of the strictness of the rules in the foreign country in question). This can help the Global South develop expertise and extract better social and economic value from their resources. This can be done as part of the many third country partnerships that are now in development, with priority given to countries in Asia and Africa where the future potential for critical metals is greatest.

The EU will from 2026 require a "battery passport" that traces where and under what conditions battery minerals were produced. Separately from the CRM law, the EU can work with countries like the US, Japan and South Korea to extend this across some of the largest electric vehicle markets. This will bring scale to better sourcing practices globally.

[72] LKAB (10.03.2022), *"LKAB increases mineral resources – and reports rare earth metals"*. Link

4. Governance

Finally, a body needs to coordinate the activities in the EU member states and ensure the compliance with the new requirements. Recognising the importance of nuclear fuel, Europe created the EURATOM agency in 1957. Similarly, the CRM act should create the European Critical Metals authority.

This should, among others[73]:

- Coordinate the efforts of 27 EU raw materials authorities & map resource gaps and potential across the Union, including collating the mining waste potential;
- Ensure high standards and due diligence (e.g those mandated in Corporate Sustainability Due Diligence Directive or the EU responsible mining principles) are applied consistently;
- Have powers to co-invest in projects globally & lead on strategic third-country partnerships; and
- Oversee joint purchasing or stockpiling shall this be necessary.

4.5 Trade policy

Currently, EU's trade policies and import tariffs on products related to the battery value chain tend to be incomplete and inconsistent.

Firstly, the Harmonised System tariff codes (HS codes) related to various battery material products are either not precise enough (e.g. they do not differentiate between cathode active materials and precursor cathode active materials) or their denominations hard to decipher (e.g. the 19 HS codes for Li-ion battery categories described in highly technical language). These caveats not only make it difficult to track trade flows and understand the present market situation in order to create efficient policies, but also are a barrier to new companies' operations in the metals field in Europe.

Secondly, tariff suspensions that should help European countries gain access to battery materials are not uniformly applied across the value chain with some products having certain import tariffs, while others allowing for a temporary suspension of tariffs **(Table 15 in Annex 2)**.

- Raw materials: Import tariff duties have been suspended for manganese sulphate and decreased to 2,6% for lithium hydroxide monohydrate for the year 2022. At the same time, there is no suspension for nickel sulphate and cobalt sulphate that have tariffs of 5,0% and 5,3% respectively for 3rd countries.
- Cathode materials: Only one category has been identified, the so-called lithium nickel cobalt aluminium oxide powder (or NCA cathode active material)[74], with a tariff suspension of 3.2% for 2022. In contrast, China and South Korea, the largest markets for battery materials, use separate HS codes for cathode active materials and precursor cathode active materials as well as for NCA

[73] A detailed list of proposed tasks is available here, p. 15

[74] For example, batteries that have been produced in the US by Tesla and Panasonic use the NCA cathode chemistry.

- and NCM (lithium nickel cobalt manganese) chemistries, while at the same time applying uniform tariff duties across these products.[75] [76]
- Li-ion batteries: Tariff suspensions were at 1,3% in 2022 (unclear whether will be continued).
- Electric vehicles: Some temporary as well as country specific arrangements at lower values than the 3rd country duty of 10%.

Therefore, T&E suggests to:

- Better harmonise the import tariff duties across the battery raw materials, with tariff suspensions in place until a more mature battery value chain is established in the EU;
- Consider raising the tariffs for EVs to higher than the current 10% if the US IRA poses concerns in the future;
- Diversify cathode material categories in line with the market trends for improved tracking of trade flows, e.g. differentiate between cathode active materials and precursor cathode active materials as they represent two separate stages of the value chain, and differentiate between the main chemistries such as NCA, NCM and others, as done in other countries such as China and South Korea;
- Simplification of the technical language used to describe some of the HS codes (e.g. HS codes covering Li-ion batteries), as done in other countries such as US[77].

Specifically on the US IRA EV tax credits, Europe currently does not export many electric cars to the US. For conventional cars, with established European brands such as BMW and Audi, European cars exported to the US amounts to only 6%[78] of US sales (or 7% of EU car production). With electric cars it is even lower currently, with some industry experts putting it at less than 1% of production today (but public data is missing). In the short term, scaling up electric car production in both the US and Europe is expected to be mainly to cater to the fast growing market (with demand for EVs outstripping the supply). This means that the US EV tax credit is unlikely to impact EU electric vehicle manufacturing significantly. But there remains a risk that European OEMs will prioritise investments into EV manufacturing in the US over Europe in their expansion plans, so this and the EV trade balance between Europe and the US should be monitored. The current vehicle tariff (10%) might need to be raised for EVs, with a specific EV tax tariff introduced as per HS codes 87038010 (BEVs) and 87036010 (PHEVs).

---

[75] China HS Codes. Link

[76] Korean Customs Service Tariff Database. Link

[77] For example, in the US, Li-ion batteries under the HS code 8507.60.00 are concisely described based on their purpose, i.e. "of a kind used as the primary source of electrical power for electrically powered vehicles [...]". US International Trade Commission, *"US Harmonized Tariff Schedule (2023 Basic Edition)",* Chapter 85, HS code 8507.60.00. Link

[78] According to ACEA (Link), 648,127 European cars were exported to the US in 2021 and US passenger car sales amounted to 11.78 millions units in 2021 according to LMC Automotive's Global Hybrid & Electric Vehicle Forecast (Q2 2022)

PART II EUROPEAN MINING STANDARDS

5. Are Europe's raw materials standards always as high as we think? The case of mining waste

5.1 Mining waste standards

The battery cell and midstream value chain in Europe as shown above will not succeed without access to the raw materials, such as lithium or nickel. Beyond imports, this means that strategic projects in Europe that meet the highest standards in the mining space will be necessary going forward. Such projects (where communities are on board) should have access to faster approval times than today as well as to capital and public funding. However, to benefit from faster permitting or finance, such projects should demonstrate that they meet high environmental and social standards.

Tailings - or mining waste from processing ores into concentrated metals - in particular represent one of the core challenges associated with mining, but independent experts point out that Europe's requirements on this are behind those in Brazil, Ecuador and China[79].

INFO BOX: What are tailings?

Tailings are waste materials left over after the valuable mineral is extracted from ore and consist of ground rock and process effluents including chemical reagents and trace quantities of metals. Tailings are discharged to a tailings storage facility which can come in many designs depending on the mineralogy as well as the chemical and physical processes used during the extraction.[80] [81]
If mismanaged, tailings can pose significant risks to livelihoods, human health and environment.

Methods	Advantages	Disadvantages
Conventional: Impoundment without dewatering Types: upstream, downstream, centerline	Low construction costs (especially upstream impoundments)	Low stability, high risk of dam failure (especially upstream impoundments) Large footprint (especially downstream impoundments) Water intensive High risk of seepage Rehabilitation only after mine closure
Conventional: In-pit deposition (pits that are no longer operational)	Low Capex	Risk of groundwater contamination Sterilisation of potential future reserves, no re-mining
Impoundment with thickened tailings or paste tailings	Higher stability, lower risk of dam failure	Higher Opex (due to dewatering, transportation)

[79] European Parliament, *"Testimony of Dr. Steven H. Emerman to the European Parliament Public Hearing on Environmental and Social Impacts of Mining in the EU"* (2021). Link
[80] Tailings.info website
[81] Earthworks, Tailings are Mine Waste. Link

	Smaller footprint Higher recycled and reused water volumes Low risk of seepage Lower closure costs	Moderately water intensive
Co-disposal of tailings and coarse mine waste (with or without dam)	Lower risk of dam failure Smaller footprint Lower risk of seepage	High Opex (for blending waste feeds) Moderately water intensive Rehabilitation only after mine closure
Backfilling of underground mines with paste tailings*	Help support the mine structures due to binders such as cement Reduced risk of groundwater contamination due to binders Smaller footprint Higher recycled water volumes Minimal rehabilitation required	High Opex (dewatering, binder, transportation, extra manpower management)
Dry stacking of filtered tailings*	Most stable, no risk of dam failures Low risk of groundwater contamination through seepage Reduced water use Small footprint Easier to close and rehabilitate Progressive costs of closure Improved recovery of dissolved metals and process chemicals	High Opex associated with dewatering Water diversion may be needed to prevent inundation of the facility
Offshore tailings (incl. submarine tailings disposal)	Low Capex and Opex	High risk of contamination and damage to the marine ecosystem High environmental liabilities and costs associated with remediation and reclamation Lack of data on environmental impacts in case of submarine tailings disposal

Preferred tailings disposal methods from sustainability perspective.

Table 2: Main tailings storage and disposal techniques [82] [83]

With orebody grades decreasing and more earth needed to be mined in order to produce one tonne of metal, the production of tailings, that need safe storage and disposal, is expected to accelerate over the coming years. If not designed, managed and monitored responsibly, these tailings may cause major environmental hazards and pose risk to human health and safety. Therefore, in order to minimise and mitigate such risks, it is imperative to hold the mining tailings management against the most stringent standards.

[82] Tailings.info website
[83] UN Environment, GRID-Arendal (2017), *"Mine Tailings Storage: Safety Is No Accident"*, Link

Conventional tailings storage facilities such as dams and other impoundments, especially the upstream type, are more likely to have stability issues and be associated with risks of failure, due to their higher water content. In fact, **upstream facilities have been banned in several countries** such as Chile (1970), Peru (2014) and, more recently, Brazil (2019) and Ecuador (2020) in the aftermath of the Brumadinho dam disaster that killed 270 people and caused damage to the local ecosystem. [84] [85]

The occurrence of such disasters time and time again in various parts of the world highlights the urgency of identifying and mandating the use of best available practices in the area of mining waste management. One such best available practice - in the case of surface mining - is the **dry stacking of filtered tailings**. In the case of underground mining, which has a reduced impact on land and biodiversity compared to surface mining, the best solution is **backfilling with paste tailings**.

INFO BOX: Dry stacking of filtered tailings

Dry stacking involves dewatering tailings to produce a filtered cake that can be transported by conveyor or truck, deposited and compacted into a freestanding and stable structure. Due to their low water content (up to 20%), filtered tailings feature physical stability and have low probability of catastrophic failure. In addition, dry stacking reduces the risks of groundwater contamination and enables progressive land rehabilitation during mining operations.[86]

INFO BOX: Backfilling of underground mines

Backfilling involves storing tailings below ground in previously worked out voids and thus preventing surface disturbance and at the same time helping support the underground mine. Prior to storage, the tailings are dewatered to a paste consistency (20-35% water content) and mixed with a binder such as cement. [87]

The consensus in the industry and among mining stakeholders is that dry stacking and backfilling are two of the safest forms of tailings storage and disposal. The first one in particular, compared to traditional methods, improves the geotechnical and geochemical stability of the tailings facility. **The Standard for Responsible Mining**[88] created by the Initiative for Responsible Mining Assurance (IRMA), the industry's truly multi-stakeholder certifying organisation, and the **Safety First**[89] guidelines developed by scientists, community groups and NGOs including Earthworks and MiningWatch Canada promote such best

[84] European Parliament, *"Testimony of Dr. Steven H. Emerman to the European Parliament Public Hearing on Environmental and Social Impacts of Mining in the EU"* (2021). Link
[85] D.M. Franks et al. (2021), *"Tailings facility disclosures reveal stability risks"*, Nature Scientific Reports, vol. 11. Link
[86] Tailings.info website
[87] Tailings.info website
[88] The Initiative for Responsible Mining Assurance (2018), *"IRMA Standard for Responsible Mining"*. Link
[89] J. Morrill et al. (2022), *"Safety First: Guidelines for Responsible Mine Tailings Management",* Earthworks, MiningWatch Canada and London Mining Network. Link

practices in the industry. In addition, the "Safety First" guidelines recommend banning upstream dams at new mines and closing existing upstream facilities.

And yet, to date very few sites exist using the dry stacking or backfilling method due to the relatively higher operating costs compared to the conventional impoundment alternatives. However, this differential has narrowed over time due to improvements in, for example, dewatering technologies making **filtered tailings more economically feasible than in the past**. According to data provided by a filtering technology company, today dry stacking can be only 13% higher in total costs (CAPEX and OPEX) per tonne than conventional methods[90]. Moreover, when considering the entire lifetime of the mine, filtered tailings for instance represent in fact a competitive solution because of the lower costs associated with the mine closure and post-closure, easier to get environmental and construction permits and potentially higher acceptance by the local communities. According to a recent study, conventional methods have double the costs of mine closure and post-closure operations and surveillance than the dry stacking method.[91]

Since tailings have been historically seen by the mining companies as a waste stream with no financial gain at the time of operation, they find little economic incentive in transitioning to newer tailings management technologies and, thus, will tend to comply with the minimum legal and site-specific requirements. Therefore, alongside the Critical Raw Materials act, Europe should review its mining waste legislation and align it with global best practices such as dry stacking of filtered tailings or backfilling of underground mines along with rigorous safety controls including for the post-closure phase.

Europe today has a very fragmented legislation on mining waste management and it is up to the member states to decide on the specific measures. This lack of policy harmonisation leads to environmental standards being applied differently, if they are applied at all, across the EU. The broad **EU Extractive Waste Directive** goes back to 2006, with its provisions being **outdated** given the technological developments since then. Therefore, a new legal framework is necessary to reflect the new realities of the mining sector in Europe that should incorporate the highest sustainability standards. A coherent and harmonised approach with clear environmental criteria and measures would also give companies and investors predictability and visibility over the long term, which is so needed when developing large scale mining projects.

The main concern with the current Directive is that its goal is to "lay down minimum requirements in order to prevent or reduce as far as possible any adverse effects on the environment or on human health […]". This means that upstream tailings are still allowed despite the considerable risks. Instead, the new law should require tailings facilities to be designed to withstand the most severe meteorological and seismic events possible at a specific location as well as **mandate the use of best available practices and best available technologies** in all EU countries alike.

[90] R. Gouveia (2020), *"Can dry tailings be economically viable?"*, Metso Outotec. Link
[91] C. Cacciuttolo et al. (2022), *" An Alternative Technology to Obtain Dewatered Mine Tailings: Safe and Control Environmental Management of Filtered and Thickened Copper Mine Tailings in Chile"*, Minerals, vol. 12, issue 19. Link

The EU has already a tool available for improving mining waste management standards. **The Standard for Responsible Mining created by IRMA** (the Initiative for Responsible Mining Assurance) sets principles and good practices for social and environmental performance at mine sites and is considered to be a benchmark in the industry. On waste management, IRMA standards require companies to take action on a number of aspects, including:

- Creating and implementing a waste management policy endorsed by the highest corporate governance levels, with protocols in place and supported by a sufficient budget.
- Performing detailed characterisation of all mine waste facilities in terms of chemical and physical properties[92] along with impact prediction on health, safety, the environment and communities.
- Documenting alternatives assessment for the selection of best waste management practices throughout the mine life cycle, including mine closure and post-closure, and eliminating alternatives that fail to meet minimum specifications.
- Performing facility assessments periodically and using analytical tools and modelling consistent with industry best practice.
- Mitigating identified risks with best available technologies and best available practices.
- Establishing procedures on waste handling, routine and event-driven maintenance and surveillance of the physical and chemical integrity and stability of mine waste facilities.
- Carrying out, throughout the mine life cycle, third party independent reviews on the design of tailings storage facilities and the selection of measures to manage chemical and physical risks.
- Implementing annual management reviews to facilitate continual improvement.
- Consulting stakeholders on the mine waste facility siting and management alternatives as well as on emergency action plans related to catastrophic failure of mine waste facilities.
- Organise evacuation drills related to catastrophic failure on a regular basis.[93]

In addition, IRMA also does not certify mine sites using aqueous disposal of mine waste materials.

5.2 Re-mining waste

With 7 billion tonnes of mine tailings generated every year globally,[94] the mining industry has to rethink waste management and increase circularity from secondary resources. One of the solutions is re-mining extractive waste.

[92] Chemical characterisation of tailings facilities includes geology, hydrogeology and hydrology, climate change projections, potential sources of mining impacted water, risk of outflow of acidic water, contaminants of concern, etc. Physical characterisation includes seepage analyses, dam breach inundation analyses, etc.
[93] The Initiative for Responsible Mining Assurance (2018), *"IRMA Standard for Responsible Mining"*. Link
[94] F. S. M. Araujo et al. (August 2022), *"Recycling and Reuse of Mine Tailings: A Review of Advancements and Their Implications"*, Geosciences, vol. 12, issue 9. Link

INFO BOX: Re-mining

Re-mining refers to the reprocessing of tailings in order to recover valuable minerals, remove hazardous substances and recycle residual waste for other applications. Legacy tailings contain valuable resources that have not been previously mined either due to inefficient technologies or lack of interest in those resources at the time of the mine's operations.[95] The projected growing demand for a variety of raw materials along with technological advancements can transform the mining waste problem into a resource recovery opportunity, while reducing its environmental impact.

From an economic perspective, re-mining can valorise commercially useful products such as metals, but also sand and aggregates which can be used as building materials. For example, replacing primary sand production with recycled residues from tailings (thereby called "ore-sand") has the potential to diminish the environmental impact of both the mining and construction industries. According to a recent study, at least 50% of the global sand market could use locally sourced ore-sand from mines nearby, while demand for ore-sand can reduce the volume of tailings generation by at least 10% at mining sites.[96]

In Europe, some 600 million tonnes of sulphidic mining waste from the production of copper, lead, zinc and nickel are generated annually in addition to some 28 billion tonnes of legacy tailings.[97] Re-mining this waste would provide multiple advantages such as:

- Recovery of new resources that provide economic value (e.g. copper, zinc, nickel, gold, cobalt, scandium, neodymium, yttrium, antimony as well as cementitious materials and aggregates);
- Lower the tailings footprint;
- Reducing the carbon footprint via metal recovery and usage of residual waste in the construction industry;
- New job creation;
- Enhancing dialogue with local communities.[98]

In response to the challenges posed by tailings, the European project NEMO ("Near-zero-waste recycling of low-grade sulphidic mining waste for critical-metal, mineral and construction raw-material production in a circular economy") has supported the development of technologies for re-mining sulphidic waste applied on three mines and processing facilities in Europe:

- Sotkamo Ni-Zn-Cu-Co mine in Finland: recovery of copper, cobalt, zinc and nickel as well as rare earth elements, manganese, magnesium, aluminium, iron and scandium; residuals used for the production of cement, aggregates and construction materials.

[95] Philipp Büttner (2017), "ReMining: Raw materials from tailings", Helmholtz Institute Freiberg for Resource Technology at Helmholtz-Zentrum Dresden-Rossendorf. Link

[96] A. Golev et al. (March 2022), "Ore-sand: A potential new solution to the mine tailings and global sand sustainability crises", The University of Queensland & University of Geneva. Link

[97] The NEMO Project - Near-zero-waste recycling of low-grade sulphidic mining waste for critical-metal, mineral and construction raw-material production in a circular economy. Link

[98] The NEMO Project - Near-zero-waste recycling of low-grade sulphidic mining waste for critical-metal, mineral and construction raw-material production in a circular economy. Link

- Luikonlahti Cu-Zn-Au processing facility in Finland: recovery of cobalt, nickel, copper and zinc.
- Tara Zn-Pb mine in Ireland: usage of tailings for the production of cement and concrete.[99]

Other re-mining projects in Europe, on an industrial scale this time, are:
- Chvaletice Mn-pyrite mine in Czech Republic (Euro Manganese Inc.): recovery of manganese to produce manganese sulphate for the battery value chain.[100]
- Kiruna and Malmberget Fe ore mines in Sweden (LKAB): extraction of phosphorus for mineral fertiliser, rare earth elements, fluorine and gypsum.[101] [102] This project has the potential to recover rare earths from mining waste equivalent to 30% of the EU's current demand.[103]

Nonetheless, it has to be noted that each re-mining site should undergo a rigorous environmental impact assessment just like new mines would, along with acquiring consent from local communities. One of the risks posed by closed tailings facilities is that they may be unstable due to liquefaction, especially when left unmonitored for a long time. Therefore, a rigorous assessment of the site is essential to ensure it does not pose a danger to the human health, safety and environment.

Lastly, and perhaps most importantly, in order to expand (sustainable) re-mining in Europe it is necessary to map the tailings facilities and their contents across the continent. Previously, we have argued that the EU Extractive Waste Directive of 2006 is outdated. In addition to this issue, the current Directive has also been poorly implemented in at least one aspect, i.e. it requires countries to draw up, regularly update and make public inventories of closed waste facilities with social and environmental risks. To date, no such inventories are accessible to the public. In fact, the mining industry as well as the governments have been disregarding the necessity of keeping track of waste tailings facilities for too long. Globally, recent initiatives for creating such databases were faced with limited response from the industry, e.g. only 15% of the contacted companies disclosed information on their tailings facilities in an initiative led by the Global Tailings Review in 2019.

Mapping tailings facilities is just as important as mapping new mineral resources and should represent an integral part in developing public policies.

[99] The NEMO Project - Near-zero-waste recycling of low-grade sulphidic mining waste for critical-metal, mineral and construction raw-material production in a circular economy. Link
[100] Euro Manganese Inc., Chvaletice Manganese Project. Link
[101] LKAB, *“Critical minerals extracted from mining waste”*. Link
[102] LKAB (19.10.2021), *“500 jobs created when LKAB extracts critical minerals from mining waste”*. Link
[103] LKAB (10.03.2022), *“LKAB increases mineral resources – and reports rare earth metals”*. Link

Annex 1. Methodology

1.1 Battery demand

We developed three case scenarios for the Li-ion batteries demand taking into account the EV sales in the EU, UK and EFTA countries up until 2035 as well as the EV average battery size for each vehicle category, i.e. passenger cars, vans, small trucks, medium trucks, heavy trucks, vocational trucks, urban buses and coaches **(Table 3, Table 4)**.

- **Regulatory scenario** follows the EU regulations' timeline for phasing out petrol and diesel cars and vans, e.g. the share of battery electric passenger cars to reach 59% in 2030 and 100% in 2035.
- **Industry potential scenario** refers to carmarkers' commitments and assumes higher electric vehicle shares in total sales of vehicles as well as higher average battery sizes, e.g. the share of battery electric passenger cars to rise to 77% in 2030 and 100% in 2035, while the average battery size would grow from 65 kWh in 2022 to 76 kWh in 2035.
- **Base case scenario** represents the average between the regulatory and the industry potential scenarios.

The figures on sales shares and battery sizes were based on internal data, public data as well as data from market intelligence providers such as S&P Global Mobility[104] and LMC Automotive[105]. The data on the ESS segment was sourced from Circular Energy Storage Research and Consulting[106].

BEV/FCEV* shares by vehicle segment	Regulatory scenario		Industry potential scenario	
	2030	2035	2030	2035
Passenger cars	59% BEV 6% PHEV	100% 0% PHEV	77% 6% PHEV	100% 0% PHEV
Vans	43%	100%	54%	100%
Small trucks	45%	80%	70%	100%
Medium trucks	38%	76%	60%	100%
Heavy trucks	34% BEV 4% FCEV	68% BEV 8% FCEV	60% BEV 0% FCEV	100% BEV 0% FCEV
Vocational trucks	16% BEV 4% FCEV	40% BEV 10% FCEV	24% BEV 6% FCEV	64% BEV 16% FCEV
Urban buses	100%	100%	100%	100%

104 Link to website
105 Link to website
106 Link to website

Coaches	15% BEV 15% FCEV	35% BEV 35% FCEV	30% BEV 30% FCEV	50% BEV 50% FCEV

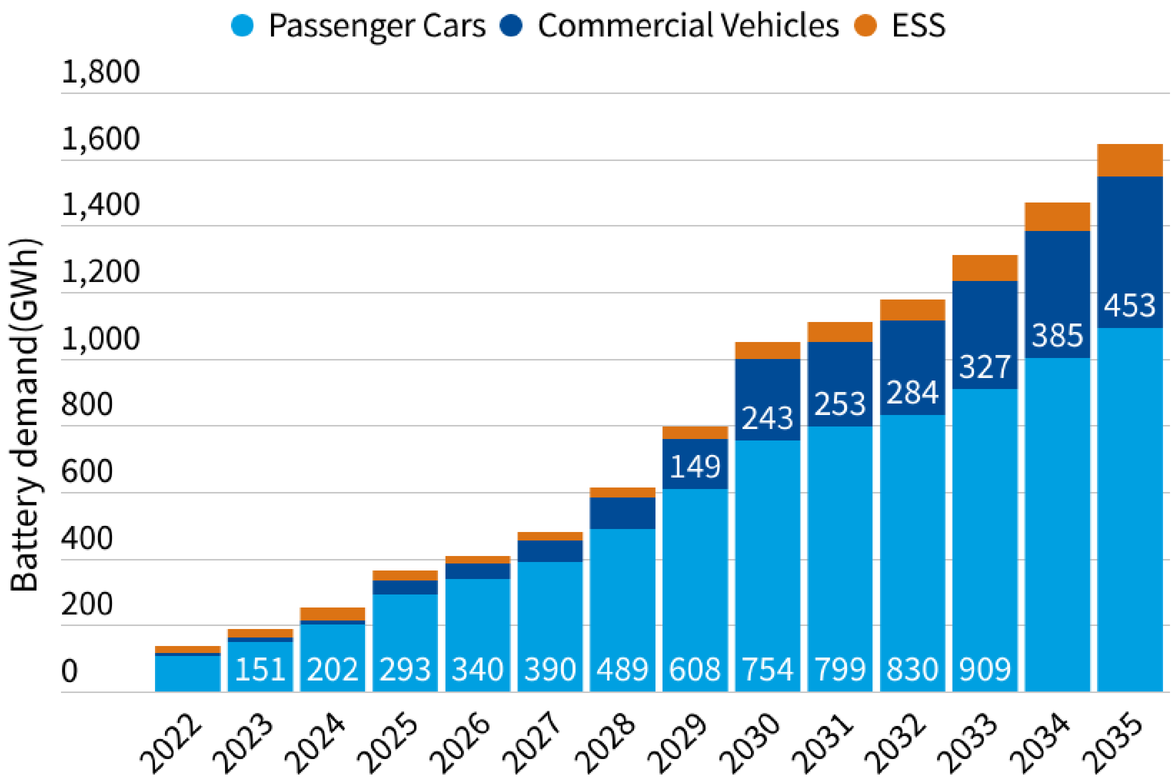
Table 3: Scenario assumptions for electric vehicles - sales shares

Average battery size	**Regulatory scenario**		**Industry potential scenario**	
	2030	**2035**	**2030**	**2035**
Passenger cars	65 kWh BEV 13 kWh PHEV	65 kWh BEV 13 kWh PHEV	72 kWh BEV 19 kWh PHEV	76 kWh BEV 21 kWh PHEV
Vans	65 kWh	65 kWh	72 kWh	76 kWh
Small trucks	126 kWh			
Medium trucks	429 kWh			
Heavy trucks	777 kWh BEV 140 kWh FCEV			
Vocational trucks	520 kWh BEV 140 kWh FCEV			
Urban buses	281 kWh			
Coaches	1243 kWh BEV 140 kWh FCEV			

Table 4: Scenario assumptions for electric vehicles - average battery sizes

Battery demand in GWh	**2022**	**2030**	**2035**
Regulatory scenario	128	860	1.498
Industry potential scenario	149	1.240	1.792
Base case scenario	139	1.050	1.645

Table 5: The European battery demand in three scenarios



Battery demand in the base case scenario.
Source: T&E analysis

Figure 15: Base case scenario for the European battery demand by application

1.2 Battery cell manufacturing

T&E tracked the nameplate capacity of battery cell factories planned in Europe based on company reporting and press articles. This theoretical capacity is then converted into the utilised capacity by taking into account a progressive ramp-up of the production in each individual plant and assuming a maximum utilised capacity of 85%. The general rule used for the ramp-up is based on the size of the plant **(Table 6)**, assuming that a smaller production capacity can be set-up more quickly than a large plant that would require the set-up of multiple production lines. For projects in which different phases are announced, the ramp-up is based on the size of the additional installed capacity.

Size	1st year of operation	2nd year	3rd year	4th year and following years
Extra small (< 2 GWh)	85%	85%	85%	85%
Small plant (<= 10G Wh)	50%	85%	85%	85%
Medium (<= 30 GWh)	20%	50%	85%	85%
Large (> 30 GWh)	10%	30%	60%	85%

Table 6: Ramp-up hypotheses for cell factories

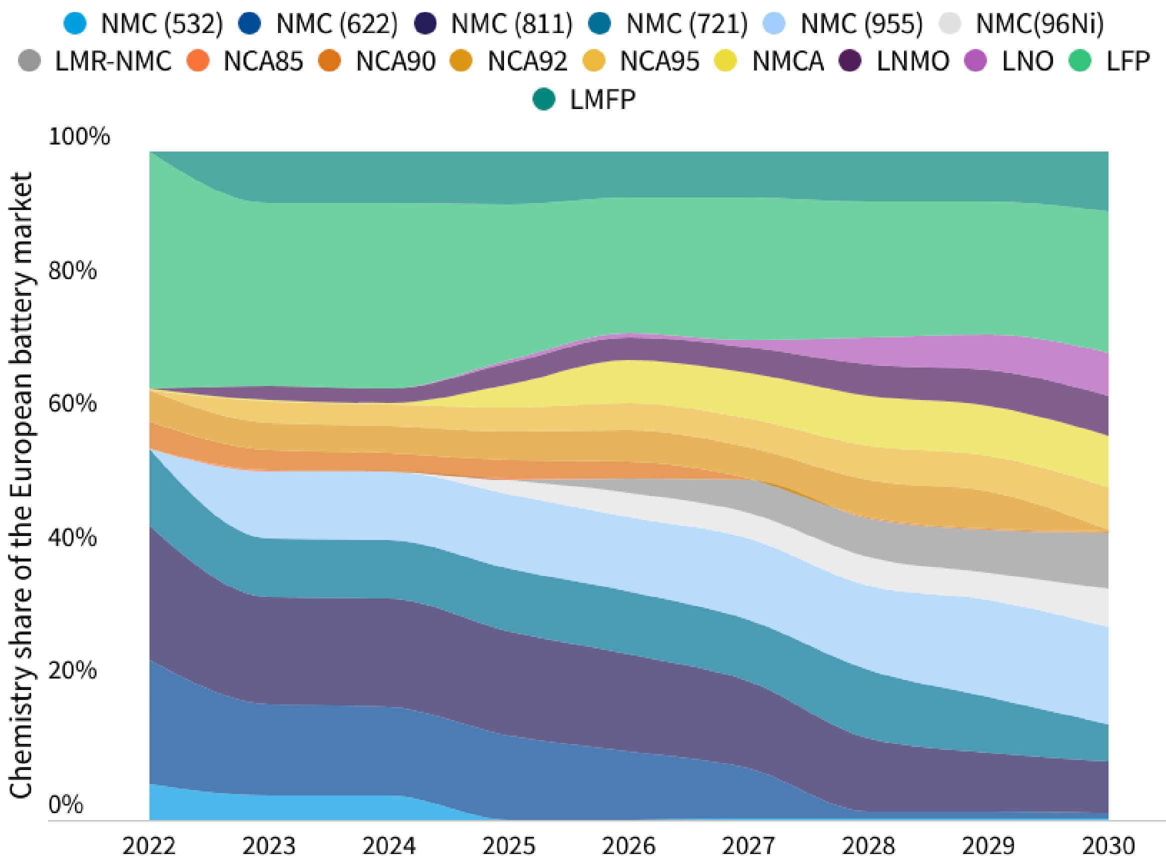
From this utilised capacity, we assume that a part of the production will be subjected to different defects and will be considered as scrap. The level of scrap is also expected to depend on the year of operation as new plants will have larger scrap rates while plants where the production is stabilised will have much lower levels of scrap. We considered the following hypotheses:

	1st year of operation	2nd year	3rd year	4th year	5th year and following years
Production scrap	25%	20%	15%	10%	5%

Table 7: Production scrap hypotheses for cell factories

1.3 Cathode manufacturing

From the battery demand (Section 1.1), we used BloombergNEF data[107] to split the battery demand by cathode chemistry for each application category. For instance, in the base case scenario, the EU market average for the chemistry mix would be the following:



Source: T&E analysis, BloombergNEF chemistry mix per application in Europe

Figure 16: Battery cathode chemistry mix in Europe

[107] BloombergNEF (2022). *"Lithium-Ion Batteries State of the Industry"*

Then, BloombergNEF data[108] on the cathode material mass per battery chemistry was used to derive the overall mass of CAM required to meet the demand. Various yield losses were considered during the cell manufacturing stages: 5% inactive material and 15% material loss during the formation cycle for lithium and 5% overall waste material.[109] For instance, in the base case scenario, we estimated that an average of 1.7 kg of cathode active material would be required for 1 kWh of battery in 2030.

Regarding CAM supply, the following ramp-up and utilised capacity are applied to the company's declared nameplate capacity:

1st year	2nd year	3rd year and following years
50%	75%	85%

Table 8: Ramp-up hypotheses for CAM factories

Below is the list of identified CAM companies with plans in Europe:

Company	Country
BASF	Germany
Beijing Easpring Material Technology and Finnish Battery Chemicals	Finland
EcoPro BM and Samsung SDI	Hungary
EV Metals Group (acquired from Johnson Matthey)	Finland
EV Metals Group (acquired from Johnson Matthey)	Poland
EV Metals Group (acquired from Johnson Matthey)	United Kingdom
Freyr and Aleees	Norway
IBU-tec	Germany
LG Chem	Not disclosed
Morrow Batteries and Haldor Topsøe	Norway
NorthVolt AB	Sweden
POSCO Chemical	Not disclosed
SVOLT Energy Technology	Germany
Umicore and VW's PowerCo subsidiary	Not disclosed
Umicore	Poland

Table 9: Companies with CAM manufacturing plans in Europe

108 BloombergNEF (2022), *"Lithium-Ion Batteries State of the Industry"*

109 Loss assumptions from the lithium supply and demand balance analysis in BloombergNEF (2022), *"Electric Vehicle Outlook"*

1.4 Lithium demand and refined supply

The demand for lithium was calculated from the Li-ion batteries demand and taking into account the evolving cathode chemistries for the EV and ESS segments **(Fig. 14 in Annex 1.3)** as well as the metal's mass per kWh in the various chemistries. The chemistry mix and metal mass data was sourced from BloombergNEF.[110]

Cathode chemistry	Lithium mass per kWh (kg/kWh)
NMC (111)	0,13
NMC (433)	0,12
NMC (442)	0,10
NMC (532)	0,12
NMC (622)	0,11
NMC (721)	0,10
NMC (811)	0,10
LMR-NMC	0,13
NCA85	0,10
NCA90	0,10
NCA92	0,09
NCA95	0,09
NMCA	0,10
LNMO	0,06
LMO	0,09
LFP	0,08

Table 10: Lithium mass by cathode chemistry

The yield losses from the battery manufacturing process (discussed in the previous section, Annex 1.3), were then added on top of the calculated lithium volumes resulting in lithium demand on a gross basis.

For the supply side, we considered all refining potential projects that have been announced in the public space and consulted other sources (industry associations, market intelligence providers) in order to assess Europe's full potential.

We noticed that the size of projects is often announced in lithium hydroxide units when in fact they refer to lithium hydroxide monohydrate units. This distinction is important for the estimation of supply volumes as the two chemical products have different lithium contents (29% in lithium hydroxide and 16.5% in lithium hydroxide monohydrate). For capacities announced in lithium carbonate equivalent units (LCE), we used 18.8% lithium content. We chose to show the volumes on pure lithium basis, as opposed to LCE, in order to stay consistent with other metals (such as nickel and cobalt) that we discuss in the section covering battery recycling.

[110] BloombergNEF (2022), *"Lithium-Ion Batteries State of the Industry"*

Below is the list of identified lithium projects in Europe.

Company/Project	Country	Estimated Capacity in 2030 (kt Li)
AMG Lithium – Bitterfeld-Wolfen Project	Germany	3.3
Bondalti Chemicals & Neometals	Portugal	3.3
British Lithium	UK	3.9
CEZ Group & European Metals - Cinovec Project	Czech Republic	4.8
Cornish Lithium	UK	1.3
Cornish Lithium & Geothermal Engineering	UK	0.4
Deutsche Lithium – Zinnwald Lithium Project	Germany	2.0
EnBW & Karlsruhe Institute of Technology	Germany	0.2
Eramet – EuGeLi Project	France	2.3
European Lithium – Wolfsberg Lithium	Austria	1.7
Green Lithium	UK	8.3
Imerys – Emili Project	France	5.6
Infinity Lithium Corp. & Valoriza Mineria – San Jose	Spain	3.2
Keliber Oy	Finland	2.5
Lithium de France	France	6.0
Livista Energy	UK	5.6
LusoRecursos Portugal Lithium	Portugal	3.5
Northern Lithium	UK	1.2
Northvolt & Galp – Aurora Project	Portugal	5.8
Rio Tinto – Jadar Project	Serbia	10.9
RockTech Lithium - Guben	Germany	4.0
RockTech Lithium	Romania	4.0
Viridian Lithium	France	4.1
Vulcan Energy Resources	Germany	6.6

Table 11: Lithium projects in Europe

The production volumes of the refining projects were calculated taking into account a ramp-up period and assuming a maximum of 85% utilised capacity, as shown below.

1st year	2nd year	3rd year and following years
50%	75%	85%

Table 12: Ramp-up hypotheses for lithium refining plants

1.5 Battery recycling

In the battery recycling analysis we took into account two main sources of materials: end-of-life (EoL) batteries from electric vehicles and energy storage systems, and battery production scrap generated by gigafactories.

- For the EOL EV batteries segment, we assumed the base case battery demand from the lithium supply and demand analysis, a 90% collection rate from 2025 onwards driven by the Battery Regulation, and an EV battery lifespan of 12 years for vehicles produced after 2018. We estimated that around 50% of the EV batteries would be used in second life applications; this would delay their recycling availability by another 5 years (source: BloombergNEF[111], T&E estimates).
- For the EOL ESS batteries we considered an average lifespan of 10 years (source: BloombergNEF[112]).
- The production scrap was calculated based on our assessment of each European gigafactory, operational and planned, in terms of scrap ratios, learning curve, nameplate capacity and estimated production volume (details in Annex 1.2). We assumed lower capacity utilisation rates and higher scrap ratios as the plant ramp up production and a maximum 85% capacity utilisation and 5% scrap ratio after several years of operations.

1st year	2nd year	3rd year	4th year	5th year and following years
25%	20%	15%	10%	5%

Table 13: Scrap ratio hypotheses for battery cell factories

The recycling availability of materials was first calculated in GWh and then, using the various chemistry splits and the metal mass we derived the theoretical demand for lithium, nickel and cobalt. For EoL batteries we used the cathode chemistry mix from the base case battery demand scenario, while for production scrap we used data from Circular Energy Storage Research and Consulting[113].

And finally, we estimated the metal recovered from battery recycling considering the metals recovery rates for lithium, nickel and cobalt. Recovery rates for cobalt and nickel have been historically higher than lithium due to better incentive prices, however, with the demand for lithium growing strongly we expect significant improvements in recovery technologies. In fact, there are today companies in North America that are recovering 90%+ lithium from spent batteries such as Li-Cycle[114], Redwood Materials[115] and RecycLiCo[116].

[111] BloombergNEF (2021), *"Lithium-Ion Batteries Recycling Market Outlook"*
[112] BloombergNEF (2021), *"Lithium-Ion Batteries Recycling Market Outlook"*
[113] Link to website
[114] Li-Cycle (05.01.2021), *"Lithium-Ion Battery Recycling Finally Takes Off in North America and Europe"*. Link
[115] Ford Media Center (22.09.2021), *"Ford, Redwood Materials Teaming Up On Closed-Loop Battery Recycling, U.S. Supply Chain"*. Link
[116] RecycLiCo (24.08.2022), *"RecycLiCo Achieves Over 99% Lithium Extraction from LFP Battery Cathode Materials"*. Link

	2025	2030	2035
Lithium	50%	90%	90%
Nickel	90%	95%	95%
Cobalt	90%	95%	95%

Table 14: Recovery efficiencies for lithium, nickel and cobalt

It must be noted that the battery recycling analysis involved a simplified approach with the recycling availability of EoL batteries being pushed further into the future. In a next step, we would include a more organic approach based on a gradual battery retirement curve. In any case, the current analysis shows a conservative estimate of battery raw materials available for recycling in 2030 and 2035. If we included a battery retirement curve, there would be an upside potential for these volumes.

1.6 Limitations

The analysis on the Li-ion batteries demand covered EVs and ESS applications, excluding marine, personal mobility and portable applications. Nonetheless, the two main segments covered account for the bulk of the demand (e.g. maritime and personal mobility account for only 2% of the total demand).

Another limiting factor in the present analysis was the limited visibility and high uncertainty of battery cell production, of battery production scrap as well as of lithium refining outputs beyond 2030.

Annex 2

HS Code	HS Code Description	Third Country Duty	Autonomous Tariff Suspension	Tariff Preference
28332400	Nickel sulphate	5,0%	-	0,0%*
28332930	Cobalt sulphate	5,3%	-	0,0%*
2833298020	Manganese sulphate monohydrate	5,0%	0% (01-01-2022 -)	0,0%*
2825200010	Lithium hydroxide monohydrate	5,3%	2,6% (01-01-2022 - 31-12-2022)	0,0%*
2836910090	Lithium carbonates - other	5,5%	-	0,0%*
3824999645	Lithium nickel cobalt aluminium oxide powder	6,5%	3,2% (01-01-2022 - 31-12-2022)	0,0%*

8507600058	Prismatic lithium-ion electric accumulator with: -a width of 120,0 mm or more but not more than 305,0 mm, -a thickness of 12,0 mm or more but not more than 67,0 mm, -a height of 72,0 mm or more but not more than 126,0 mm, -a nominal voltage of 3,6 V or more but not more than 3,75 V, and -a nominal capacity of 6,9 Ah or more not more than 265 Ah, for use in the manufacture of rechargeable electric vehicle batteries	2,7%	1,3% (01-01-2022 - 31-12-2022)	0,0%*
8507600075	Rectangular lithium-ion-accumulator with: -a metal casing, -a length of 147,85 mm or more but not more than 173,15 mm, -a width of 17,4 mm or more but not more than 21,1 mm, -a height of 90,85 mm or more but not more than 95,15 mm, -a nominal voltage of 3,3 V or more but not more than 3,65 V, and -a nominal capacity of 17,5 Ah or more	2,7%	1,3% (01-01-2022 - 31-12-2022)	0,0%*
8507600077	Lithium-ion rechargeable batteries, with: -a length of 700 mm or more, but not more than 2 820 mm, -a width of 935 mm or more, but not more than 1 660 mm, -a height of 85 mm or more, but not more than 700 mm, -a weight of 250 kg or more, but not more than 700 kg, -a power of not more than 175 kWh, -a nominal voltage of 400 V	2,7%	1,3% (01-01-2022 - 31-12-2022)	0,0%*
8507600083	Modules for the assembly of ion lithium electric accumulators with: -a length of 570 mm or more, but not more than 610 mm, -a width of 210 mm or more, but not more than 240 mm, -a height of 100 mm or more, but not more than 120 mm, -a weight of 28 kg or more, but not more than 35 kg, and -a capacity of not more than 2500 Ah and a nominal energy of less than 7,5 kW, for use in the manufacture of vehicles of	2,7%	1,3% (01-07-2022 - 31-12-2022)	0,0%*

	subheadings 8703 60, 8703 70, 8703 80 and 8704 60			
87038010	Motor cars and other motor vehicles principally designed for the transport of <10 persons, incl. station station wagons and racing cars, with only electric motor for propulsion, new	10,0%	-	General arrangements: 6,5% (01-01-2017 - 31-12-2022) Japan: 5,0% (01-02-2022 - 31-01-2023) Vietnam: 6,2% (01-01-2022 - 31-12-2022)
87036010	Motor cars and other motor vehicles principally designed for the transport of <10 persons, incl. station wagons and racing cars, with both spark-ignition internal combustion reciprocating piston engine and electric motor as motors for propulsion, capable of being charged by plugging to external source of electric power, new	10,0%	-	General arrangements: 6,5% (01-01-2023 -) Japan: 5,0% (01-02-2022 - 31-01-2023) Vietnam: 5,0% (01-01-2023 - 31-12-2023)

Table 15: European import tariffs along the battery value chain[117]

*Tariff preference list of countries/agreements: Albania, Algeria, Bosnia and Herzegovina, Cameroon, Canada, CARIFORUM (The Caribbean Forum), Central America (CAMER 2200), Chile, Colombia, Eastern and Southern Africa States, Economic Partnership Agreements, Ecuador, Egypt, EPA SADC - Southern African Development Community, European Economic Area, Faroe Islands, Fiji, Georgia, Ghana, GSP - General arrangements (GSP 2020), Israel, Japan, Jordan, Kosovo, Lebanon, Mexico, Montenegro, Morocco, North Macedonia, Occupied palestinian Territory, OCTs (Overseas Countries and Territories), Papua New Guinea, Peru, Republic of Moldova, Samoa, Serbia, Singapore, Solomon Islands, South Africa, South Korea, Switzerland, Syria, Tunisia, Ukraine, UK, Vietnam, Western Sahara.

[117] European Commission, Taxation and Customs Union. Link

Further information

US IRA and CRM:
Julia Poliscanova
Senior Director, Vehicles and Emobility
Transport & Environment
julia.poliscanova@transportenvironment.org

EU battery value chain analysis:
Alina Racu
Batteries & Metals Analysis Manager
Transport & Environment
alina.racu@transportenvironment.org

National offices
Sebastian Bock
Director
Transport & Environment Germany
sebastian.bock@transportenvironment.org

Diane Strauss
France Director
Transport & Environment France
diane.strauss@transportenvironment.org

Isabell Büschel
Director
Transport & Environment Spain
isabell.buschel@transportenvironment.org

Veronica Aneris
Director
Transport & Environment Italy
veronica.aneris@transportenvironment.org

Richard Hebditch
Director
Transport & Environment UK
richard.hebditch@transportenvironment.org

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor CINEA can be held responsible for them.

A report by TRANSPORT & ENVIRONMENT