Can European sovereignty be achieved without sufficiency? Modelling the implications of the European Critical Raw Materials Act on the value chain of lithium.

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Abstract

The transition toward low-carbon and digital technologies is set to profoundly reshape metals markets, particularly for those metals essential to transportation electrification and battery production, such as cobalt, lithium, and nickel. In response to these evolving demands, governments are enacting policies aimed at strengthening the resilience of low-carbon technology value chains and securing stable supply sources. In this context we explore the design of the recently adopted Critical Raw Materials Act (CRMA) in Europe, and investigates the feasibility of its reshoring benchmarks in the case of battery-grade lithium. By integrating the entire lithium value chain into an Integrated Assessment Model, we analyse the interplay between lithium supply, demand, and recycling within decarbonisation scenarios. Our findings suggest significant challenges in meeting the CRMA targets without reducing industrial demand. We show that sufficiency strategies could help achieving these benchmarks while also decreasing reliance on imports. In addition, we argue that the current recycling benchmark should be replaced with an end-of-life recycling rate target to enhance policy relevance.

JEL classification: Q02 ; Q34 ; C23 ; C24

Keywords: Critical raw materials; Lithium; Integrated Assessment Model (IAM); Low-carbon scenarios

1 Introduction

Achieving raw materials security of supply has become a top priority for governments and policymakers worldwide. In the European Union (EU), interest in raw materials deemed critical and strategic to the EU economy has strengthened over the past 15 years. This is due to recent crises that have disrupted supply chains and the growing needs associated with the energy transition dynamic. Previously focusing on evaluating the criticality of materials, in 2023 the European Commission has proposed policy objectives aimed at addressing this issue. The Critical Raw Materials Act (CRMA) sets benchmarks for domestic extraction, processing, and recycling, as well as diversification of foreign suppliers, which will apply from 2030, to ensure the security of supply of strategic raw materials (SRMs) (European Parliament and Council, 2023). However, criticisms quickly emerged in the public debate pointing out the absence of any sufficiency strategy (négaWatt, 2022), a shortcoming that had already been identified in other EU climate legislation (Zell-Ziegler et al., 2021).

Our paper aims to provide insight into this new regulatory framework through a prospective modeling approach. To this end, we focus on lithium value chain. Among the SRMs used in batteries, battery-grade lithium is a particularly relevant case study: the EU is heavily dependent on lithium imports, lithium is used in all current battery technologies (Ziemann et al., 2018), and its demand is expected to increase significantly relative to its current limited non-battery uses (IEA, 2021).

Several prospective scenarios are modelled to explore technological and demand-side options that can help achieve the EU objectives. A special focus is put on the recycling of lithium from electric vehicle batteries, trying to establish coherence between the many European policies on this subject and assessing its potential contribution to the European lithium supply. Finally, a geopolitical analysis of the scenarios is carried out, focusing on the use of imports in the European lithium value chain and the associated supply risks that need to be anticipated.

2 Methodology

This study is based on the TIAM-IFPEN, an Integrated Assessment Model (IAM), which integrates a wide range of existing and future energy technologies competing to meet the energy demand of all sectors in each of the 16 different regions represented (Hache et al., 2019). This model optimizes the evolution of the energy system by following a least cost paradigm, while respecting several constraints including the limitation of global warming to 2°C in 2060.

The methodology adopted for this study involves endogenizing the detailed value chain of lithium in this model, including some links with the detailed road transport sector. The initial stage of the value chain involves mining lithium from existing deposit types (granitic rocks and salars) as well as other deposits currently under consideration (sedimentary rocks, geothermal brines and oilfield brines) (IRENA, 2022). Subsequently, we model various processing routes to produce lithium concentrates and chemicals such as carbonate, hydroxide, chloride, lithium metal, and other compounds, which are necessary for manufacturing industrial products (Hao et al., 2017; Sun et al., 2017). The production costs of the different routes vary depending on the technology type and world region. These costs were determined based on feasibility studies of current and planned lithium production projects. The lithium used in batteries is endogenously linked to the deployment of electric vehicles, stationary storage and digital devices. The amount of lithium in each battery is determined by its chemistry and size, based on data from Argonne National Laboratory. The other uses, which represent less than 10% of the total lithium uses by 2050, are projected exogenously. The vehicles modelled in the road transport sector are derived from the IEA's 2023 APS Mobility Model. The model allows for trade between the 16 different regions at different stages in the lithium value chain (concentrate, chemical, battery), with different transport costs associated to each product and each transport route.

Table 1: Scenario overview table

Scenario	2°C	CRMA	NZIA	Sufficiency
S1 - Economic Efficiency	Implemented		High	
S2 - European Objectives	Implemented	Implemented	High	
S3 - European Objectives + lower sovereignty	Implemented	Implemented	Low	
S4 - European Objectives + sufficiency	Implemented	Implemented	High	Implemented

Note: The Net-Zero industry Act (NZIA) is another EC proposal aimed at increasing European sovereignty over key low-carbon technologies. By 2030, at least 40% of the EU's annual deployment needs must be met by domestic production (low target). For batteries, an even more ambitious objective is proposed of 90% (high target), following the recommendation of the European Battery Alliance.

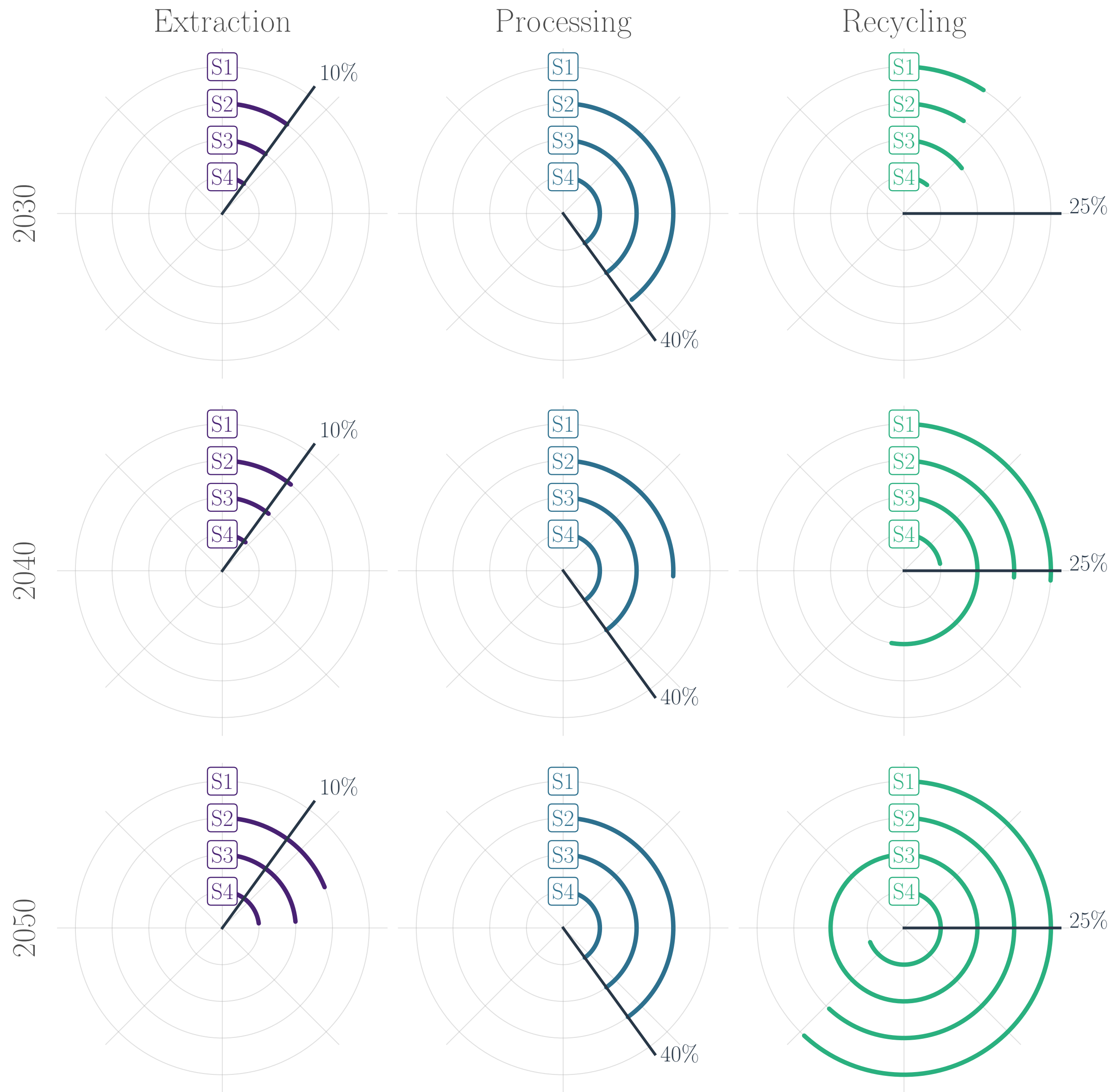
To investigate the impact of the CRMA on the European supply of lithium, we model several scenarios (Table 1). The first one, S1, referred to as 'Economic Efficiency', serves as a control case and does not impose the CRMA objectives for the optimization process. The second one, S2, or 'European Objectives', includes these targets. S3, named 'European Objectives + lower sovereignty', reduces efforts towards achieving industrial sovereignty over domestic battery production. Finally, S4 'European Objectives + sufficiency' sets the same industrial sovereignty objective as in S1 and S2, and implements additional assumptions for sufficiency in the road transport and digital sector. These include increasing the load factor and occupancy rates, reducing mobility and freight demands, and decreasing the average battery size for personal cars and light commercial vehicles.

3 Results

On a global scale, we find that the cumulative primary lithium extraction required by 2060 could amount to 37% of the resources identified in 2023. The current major producers, South America and Australia, could account for more than two-thirds of cumulative production, followed by Africa and China. In the S2 scenario, Western Europe emerges as the next largest cumulative producer, while the US takes this position in all other scenarios. Due to increased recycling and slower demand growth, global primary lithium production could peak between 2038 and 2047 at around 800 kt per year in the scenarios without sufficiency assumptions in Western Europe.

For Western Europe, one of the main findings is that the CRMA's target of domestic processing production of 40% of European lithium demand cannot be met in scenario S2. Achieving this objective would necessitate the development of further lithium processing capabilities, which carry a significant industrial risk. Thanks to the sufficiency hypotheses, Scenario S4 meets the objectives of the CRM Act without much difficulty Alternatively, scenario S3 also meets the targets set by the CRMA but does so at the cost of increasing the EU reliance on imports at the manufactured product stage. With regards to the recycling aspect of the value chain, none of the scenarios can meet the recycling target of the CRMA, which requires 25% of European processed materials to be covered by domestic recycling by 2030. Finally, regarding imports, our results suggest that enforcing the CRMA objective, in addition to increasing domestic production, may reduce reliance on imports of lithium chemicals (specifically battery-grade lithium carbonate and lithium hydroxide) from South America and China as compared to scenario S1. Instead, there could be a shift towards importing lithium concentrate that is further processed on European soil, primarily sourced from Australia and Africa. S4 exhibits the lowest reliance on imports throughout the entire value chain. Depending on the year, the quantity of imports in S4 decreases by between 29% and 51% compared to S2, and by between 32% and 70% compared to S3.

Figure 1: Compliance with CRMA local production targets in the four scenarios.



Notes : These graphs show the compliance with the CRMA benchmarks (represented by the black line) of BG lithium in the four scenarios. The scenarios exceeding the black line successfully achieve the specified target (extraction, processing, and recycling) by the designated time horizon (2030, 2040, or 2050).

4 Conclusion

The EU recently adopted the CRMA to enhance the security of supply for SRMs, complementing the NZIA's objective of ensuring industrial sovereingty over strategic technologies. This study assesses the feasibility of CRMA benchmarks for BG lithium value chain, taking into account other regulations impacting its dynamics. To achieve this, we integrated the entire lithium value chain into an IAM, incorporating regionalised lithium trade flows and explicit links to the energy system. Our results indicate significant challenges in meeting the CRMA objectives without reducing the industrial demand. We show that implementing sufficiency strategies can mitigate this demand while reducing reliance on imports. The current EU sovereignty policy framework, focusing primarily on increasing domestic production and recycling, should be expanded to include strategies aimed at curbing final demand. Then, our findings suggest that the current CRMA recycling benchmark lacks relevance. Rather than focusing on an input recycling rate, we propose that setting a target for end-of-life recycling rates would be more appropriate.

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