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THE FUTURE OF NICKEL IN A TRANSITIONING WORLD: MODELLING THE GLOBAL NICKEL SUPPLY CHAIN AND ITS NEXUS WITH THE ENERGY SYSTEM

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ABSTRACT

The mining and metallurgical industry is a key player in the energy transition. This transition requires increased mining of materials and its pace can depend on the resilience of material supply chains. An important material for the energy transition is nickel, which is used in the stainless steel required for energy infrastructure and in stationary and electric vehicle batteries. To identify opportunities for the nickel industry and minimise supply constraints for the energy transition, it is insightful to explore potential future developments of the nickel supply chain.

In this paper, a new method for modelling material supply chains was used, combining exploratory system dynamics modelling and analysis and agent-based modelling to create a detailed nickel model at the level of individual mines. This model was used to explore the development and resilience of the global nickel supply chain, and its nexus with the energy system, between 2015 and 2060 under different disruption scenarios, sustainability policies and uncertainties.

In the business-as-usual scenario, a nickel demand of 6 - 18 million tonnes per year is projected by 2060, with a cumulative demand of 200 – 320 million tonnes between 2015 and 2060. In the scenarios that aim to limit global temperature increase to 1.5 °C above pre-industrial levels, projections go up to 38 million tonnes per year by 2060, with a cumulative demand up to 670 million tonnes between 2015 and 2060. This is a higher demand than previously projected. The main contributors to this large demand are electric vehicle batteries, which overtake stainless steel as the largest demand category in some energy transition scenarios.

The nickel system is conditionally resilient to the energy transition, given sufficient exploration and annual capacity increase. To increase the resilience of the nickel system, policies that support innovation in battery material composition and lifetime can play an important role. Due to the increasing share of batteries, overall end of life nickel recycling rate decreases in most scenarios. Better end of life waste management of batteries is another way to improve nickel supply chain resilience.

Modelling the nickel supply chain at mine level leads to different behaviour compared to previous research where mines were aggregated, including a more dynamic average ore grade and energy demand. The more detailed form of modelling also allows for the production of regional and national data, which can be of further interest for governments and stakeholders in the nickel industry.

The most important contribution of this work is not in the data and assumptions, but in the model itself, which can be adapted and refined in further research, where more stakeholder input is included, to make the outcomes more robust and useful for decision making. Other important avenues for further research include determining how much exploration is possible and how quickly mining capacity can be increased.

Keywords: Energy Transition, Energy-Material Nexus, Supply Chain Resilience, Nickel, System Dynamics, Exploratory Modelling and Analysis, Agent-Based Modelling