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Tracing global lithium trade: implications for securing lithium supply for electric vehicle batteries

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Summary

The considerable trade caused by the discrepancy between lithium reserve and demands distributions is keep growing. This study maps the international trade flow of major lithium containing commodities in 2015. The trade of lithium is widespread all over the world. Lithium mine and chemicals are the paramount part. Several countries play crucial roles in the global lithium supply chain. Different imports and exports structures of lithium shown in the mapping present the possibility of the restructure of the supply chain, which is conductive to the improvement of the lithium resources efficiency and lithium recycling.

Keywords: environment, lithium battery, materials, policy, strategy

1 Introduction

The past century has witnessed the fast-growing resources consumption and degradation of environment worldwide. Excessive consumption of recourses and the global climate change have posed a challenge to all countries. The restructure of energy structure and low-carbon economy are the inevitable choice to respond to the global destruction of the environment and ecology. In this case, energy-saving and emission reduction in transportation field are one of the essential parts of tackling global climate change.

Apart from the improvement of traditional internal combustion engine to reduce the fuel consumption, new energy vehicles are the keynotes of the future to satisfy the requirements of the emission and the oil consumption. Taking China for example, electric vehicle production in 2016 reached 517000 vehicles, a 51.7% increase from the previous year. As the primary ingredients of electric vehicles, lithium resources experienced a rapid increase in the demands. However, the distributions of resources and demands all over the world are uneven. And the discrepancy between lithium reserve and demand distributions would lead to considerable international trade of lithium.

The researches based on lithium material flow analysis have been pretty comprehensive. As early as 1995, Stone demonstrated the strategic role of lithium in the future and introduced the material flow, including its properties, processing, and uses(Stone, 1995). Ziemann et al. applied the elaborate MFA model to lithium, establishing the first global lithium model and elaborating the connection among the supply, demand and the flow to the environment on a global scale (Ziemann, Weil, & Schebek, 2012). Hao et al. analyzed the material flow of lithium in China for the first time, introducing the lithium flow along the whole lifetime cycle and offering a proposal of lithium resources management plans in China(Hao, Liu, Zhao, Geng, & Sarkis, 2017).

Considerable researches focused on a certain product within the lithium life cycle. Chang et al. pictured a material flow of lithium batteries in Taiwan, revealing that a majority of lithium batteries were disposed improperly or illegally and a well-established recycling system was imperative (Chang, You, Yu, & Yao, 2009). Simon and Weil developed the materials and energy flow analysis (MEFA) model of lithium batteries, as well as other electrode materials, rendering a better understanding about ecological properties of lithium batteries(Simon & Weil, 2013).

These studies provide a basic instructive structure for the lithium related researches. However, the international trade of lithium is unclear. Trade means transport and emission. Simultaneously, the supply chain worldwide can imply the dependencies and potential risks. With the aim of filling such a gap, this paper develops an international trade flow chart of primary lithium resources on a global scale. This paper will present methods and data at first, and then the results will be discussed. Finally, the relative policy issues of lithium resources will be discussed because of the promising use of lithium and its potential benefits of improving the lithium resource efficiency worldwide.

2 Methods

2.1 System Boundary

The temporal boundary is the year of 2015. For reasons of data availability, the spatial boundary is the 16 countries of the Group 20 (except UK, Germany, France and Italy) and Chile. EU28 in this paper is considered as a single unit. The trade inside European Union is not taken into consideration. China refers to mainland China. Taiwan, Hong Kong and Macau are not included in this paper. G20 members can basically cover international lithium trade all over the world. As for the lithium recourses, this paper focuses on major lithium containing materials in international trade. They are lithium mine, lithium carbonate, lithium oxide and hydroxide, lithium-ion batteries, mobile phones and portable computers, covering three basic stages of lithium industrial processing, resource mining, chemical production and product manufacture. A vast majority of lithium resources in traditional trade can be described by these six materials.

2.2 Methods

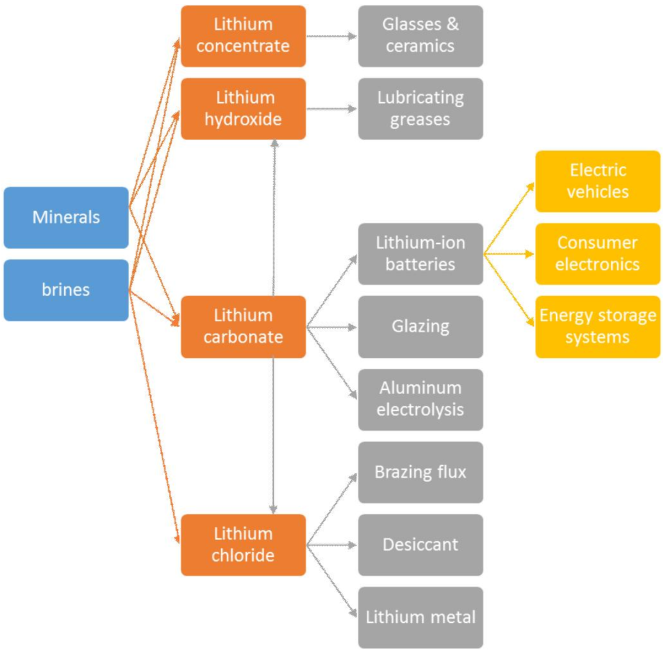

Figure1: The processing of lithium resources

Fig. 1 shows the major processes along the lithium life cycle. Initial data available are the netweight or quantity of the commodities. Then they are transferred to lithium carbonate equivalent (LCE) according to their lithium content, as equation (1) shows.

LCE=M (1)

Where,

M is the netweight or the quantities of the commodities;

is the conversion coefficient of the relevant commodity.

The imports or exports of a certain country is calculated by the equation (2) and (3).

(2)

(3)

Where,

is total export volume of country I;

is total import volume of country k;

is the export volume of commodity j from country I to country k;

i and k represents the 17 countries;

j represents the commodities, including lithium mine, lithium carbonate, lithium oxide and hydroxide, lithium-ion batteries, mobile phones and portable computers.

2.3 Data

The data of resource mining including brines and minerals are taken from the USGS yearbook(Survey, 2016). The chemical production and product manufacture data are primary based on the United Nations Commodity Trade Database (UN Comtrade). Data of European Union are from Statistical Office of the European Communities (Eurostat). The conversion coefficient is determined by lithium contents which are from the study by Hao et al(Hao et al., 2017) .

3 Results

3.1 Global Mapping

Figure2: The traditional trade of lithium carbonate

Figure3: The traditional trade of lithium oxide and hydroxide

Fig. 2 and Fig. 3 visualize the international trade of lithium carbonate and lithium oxide and hydroxide. The width of the line is proportional to the magnitude of the trade between the two countries. The arrows indicate the direction of the flow.

Fig. 2 shows that the trade of lithium carbonate is widespread. It is clear that Chile and Argentina are the major exporters of lithium carbonate, and other countries rely more on the imports. USA, EU, Korea, Japan and China are the typical importers of lithium carbonate. Chile accounted for almost three quarters of the total exports. About two thirds of Chile's exports flow to East Asia such as Korea and China. Fig. 3 presents the widespread trade of lithium oxide and hydroxide. Unlike the lithium carbonate, the trade concentration of lithium oxide and hydroxide is lower.

3.2 Product Perspective

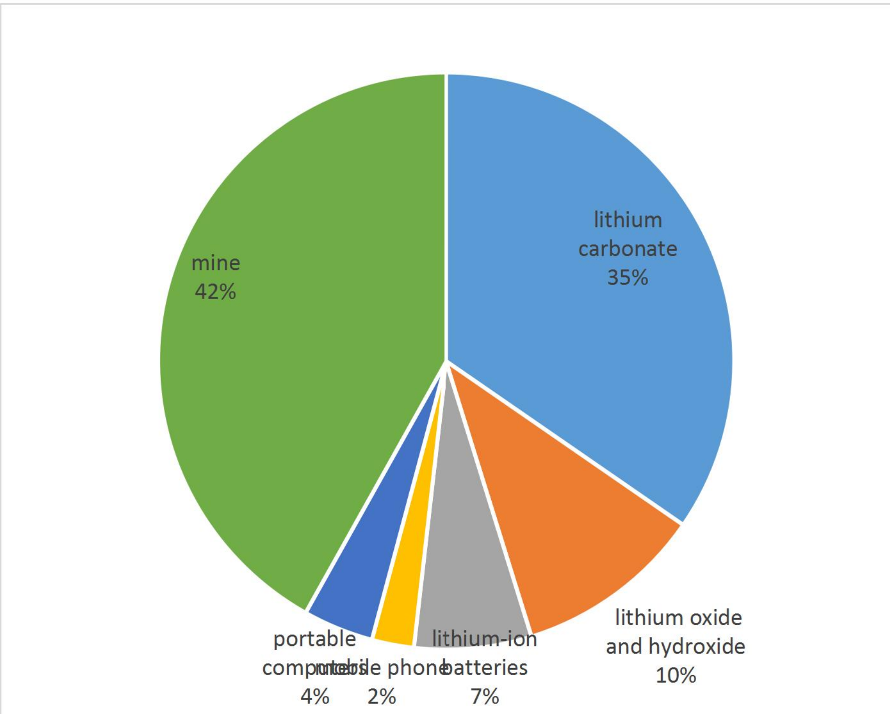

Figure4: International trade of different lithium products

Fig. 4 presents the international trade of different lithium products. Each part of the chart represents the total international trade volume of a certain lithium product among all countries. Among all the international trade flows, Lithium chemicals including Lithium carbonate and lithium oxide and hydroxide are the majority, accounting for 45% of the total trade volume. The trade volume of lithium mine accounts for 42% of the total trade volume, ranking the second. While the shares of lithium-ion batteries, telephones and portable computers are much lower and add up to no more than one third.

3.3 Country Perspective

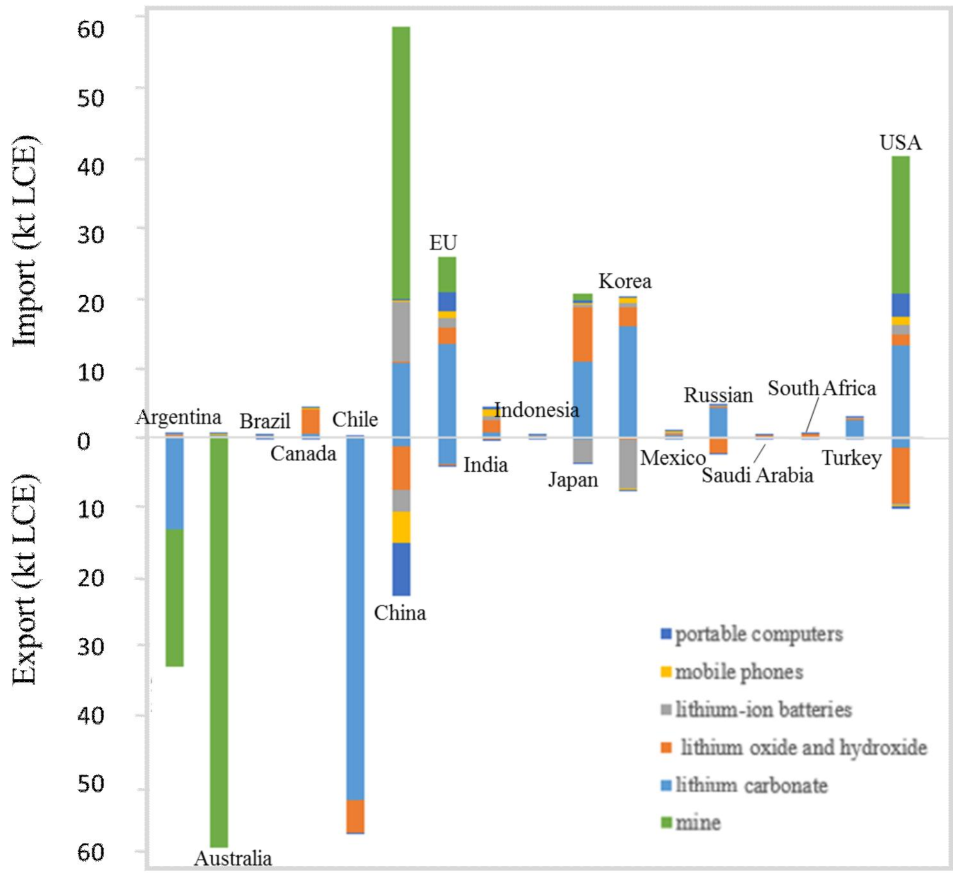

Figure5: International trade of lithium by countries

Fig. 5 shows the aggregated lithium trade by countries. The main mining countries, Chile, Australia and Argentina are the typical net exporters. Chile mainly exports lithium carbonate and Australia mainly exports mine product. Argentina is also a significant exporter of lithium, with around half lithium carbonate and half lithium mine. China, USA, EU, Japan and Korea are heavily dependent on imports. Some countries such as Brazil, Indonesia, Mexico, Saudi Arabia and South Africa have a small trade volume of lithium and are all net importers.

Korea, Japan and China are the main exporters in terms of lithium-ion batteries. Simultaneously, China is the largest importer of lithium-ion batteries, almost six times as much as that of EU or USA. China is the dominating exporter of mobile phones and laptop computers, mainly to EU, India, Korea and USA. The proportion of USA's imports is remarkably similar to EU's, mostly in the form of mine product, lithium chemicals and the final products. But China shows a totally different pattern. China import lithium-ion batteries and export final products. This implies different positions of these countries in the lithium supply chain.

4 Policy Implications

The extreme mismatch of lithium reserve and demand distributions leads to considerable international trade.

With the development of electric vehicles and the more stringent energy requirements, the demand for lithium will keep growing in the near future. It is certain that such a trend will intensify the imbalance and result in sustained growth of international trade.

Trade means transport. The energy consumption and emission it brings cannot be ignored. In addition, such an increase of international trade will exacerbate the concern on resources security for many countries. Many countries are pretty sensitive to the changes or disruptions of supply chain. Excessive reliance on lithium imports makes them vulnerable to these fluctuations such as disasters and geopolitical constrains(Liu & Muller, 2013).Last but not the least, increasing international lithium trade brings on a great challenge of establishing the lithium resources recycling system, especially for lithium-ion batteries. The geographical distance between production and final destination make it a difficult task to trace the lifetime of lithium batteries, especially the recycling of batteries. The disunity of battery manufacturing and recycling standards magnified the problem.

To constrain the growth of lithium trade, the restructure of the supply chain is imperative. Further optimization of supply chain from ecological perspective should be taken into consideration. Taking Australia and Chile for example, they are both the main producer of lithium minerals, but represent different export patterns. Australia mainly exports primary mine. Chile, on the other hand, does not rely on primary mine export, but mainly exports lithium chemicals. Apparently, the latter one can reduce the trade volume. Besides, it can be found that China imports a great deal of lithium batteries as ingredients and then exports final products like mobile phones and portable computers. It will be more environment friendly and energy-saving if these manufacturing products can be produced locally.

5 Conclusions

Environment problems and stringent policy promoted the development of electric vehicles, as well as the demand of lithium. The considerable trade caused by the mismatch between lithium reserve and demands distributions should be concerned. The mapping of international lithium resources provide the insight of how to develop and restructure the lithium supply chain. The whole life cycle of lithium resources based on trade-linked MFA model can be explored in the further work.

Acknowledgments

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