Bolivia's Lithium Frontier: Can Cleaner Technologies Harness a Mineral Development Boom?

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Abstract

In 2014, Bolivia's President Morales announced a state investment of $995 million to develop the world's largest lithium reserves, located in Bolivia's Salar de Uyuni. Lithium production is promoted as enabling development in this impoverished, indigenously populated country which has historically suffered terrible environmental and social impacts from mineral exploitation. Lacking expertise and capital to sustainably produce lithium, Bolivia's plans for lithium industrialization through vertically integrated mineral development and public-private partnerships with foreign corporations, include a desire to harness the most environmentally appropriate technologies. We discuss the debate on cleaner production for lithium, challenges of Bolivia's lithium industrialization, and investigate how the desire for clean technologies has cultivated unusual partnerships between state enterprises and foreign-owned private corporations. We consider this model for developing remote mineral reserves for advanced technologies that are necessary for the global transition from a fossil fuel to low carbon economy, and for addressing sustainable development goals. Lithium is vital for energy storage, renewable energy and the electric vehicle industry. To meet rising lithium demand, with minimal environmental and social impacts, novel approaches to international resource extraction partnerships transcending ideological biases will be needed, and their efficacy evaluated. Our research aims to pave the way to such an evaluative framework, using Bolivia's lithium as a central case. Key research issues for developing the framework and initial criteria of evaluation are proposed.

Keywords: *lithium, Bolivia, extraction, public-private partnerships*

1. Introduction

In 2014, Bolivia announced the largest state investment in a new mineral in the country's history. President Morales announced that his country would invest $995 million to develop the Salar de Uyuni's lithium reserves. The world's largest lithium reserves have been touted as a panacea for developing one of Latin America's most impoverished countries which has a terrible environmental and social legacy of environmentally damaging mineral exploitation. The silver mines of Potosi that have been exploited for over 500 years have claimed an estimated eight million lives through accidents, pollution and disease since their opening in the Spanish colonial period. This was ranked as one of the

100 deadliest atrocities in human history (White 2011). Thus, the political sensitivity around lithium mining and its environmental and social impact is acute in Latin America's most indigenously populated country (more than 60 percent of Bolivians identify as indigenous from 36 recognized tribal groups). President Morales was elected as a champion of indigenous self-determination with strong Marxist roots and has been a vocal critic of private corporate investment. His nationalization programs were widely criticized by the United States (US) and its allies, and he gravitated towards China, Venezuela and Cuba as key allies. Yet, his plans for the development of lithium have created a more complex story, partly motivated by a desire to harness the most environmentally appropriate technologies. In this regard, he has also partnered with Germany, building on strong historical ties between the two countries, to seek new ways of processing lithium carbonate that do not produce the huge amounts of sludge that have drawn concern from environmentalists and may undermine the fragile ecology of the 10,000 square kilometer Salar de Uyuni salt flat (Boissoneault 2015).

In this paper, we discuss the debate on cleaner production for lithium and investigate how the desire for cleaner technologies has cultivated unusual partnerships between state enterprises and foreign-owned private corporations in a developing country. We consider the efficacy of vertically integrated mineral development and public-private partnerships (PPPs) as a model in developing remote mineral reserves for advanced technologies, that are necessary for an economically and ecologically efficient transition to less reliance on fossil fuels internationally, and addressing broader sustainable development goals. Lithium remains key to such a global transition given its unique properties as the lightest metal with unparalleled energy density ability for storage, thereby allowing for solar, wind and other non-continuous energy development to be more effectively harnessed (Lu et al. 2017). The market has moved away from lead and sodium-sulphur to lithium-ion batteries, based on energy and power density, decreased cost and deep discharge cycle life (IRENA 2015, p. 27). Lithium is also vital for energy efficient hybrid and battery-electric cars to reduce pollution and has thus been defined as a "critical material" by the US, United Kingdom (UK), European Union (EU) and Geoscience Australia (Skirrow et al. 2013, p. 11-2; WWF-Ecofys 2014; Geoscience Australia 2016; Executive Office of the President 2016). In order to meet this demand for lithium, with minimal environmental impact and in the context of sustainable development and ethical supply chains, novel approaches to international partnerships in resource extraction that transcend ideological biases will be needed, and their efficacy evaluated. Our research aims to pave the way towards such an evaluative framework, using Bolivia's lithium as a central case.

2. The debate on cleaner technologies for lithium production

Markets for cleaner technologies in the electric automotive industry currently favor lithium batteries due to reduced costs and their technical and performance advantages over other battery types, including energy and power density and length of life (IRENA 2015; Climate Council 2015). Lithium demand is increasing at 20 per cent year on year (Knight 2014), with lithium used in many products including mobile phones, pharmaceuticals, building tools and aeronautic systems. Its increasingly cost-competitive use in household and vehicle battery systems will also impact globally and in some geographic regions like the EU, the experience may result in a lithium bottleneck (Mieema & Moll 2013). During the next two to three decades, with low current rates of recycling, lithium supply will come under increasing pressure (Prior et al. 2013; Ali et al. 2017). Lithium production is currently concentrated in Chile, Australia, China, Argentina, US, Canada and Zimbabwe (Prior et al. 2013, p. 786). Resources are mined either as lithium ore (producing lithium hydroxide) or lithium brine (producing lithium carbonate as found in Bolivian salt flats) (Lu et al. 2017).

President Morales has established a strategic plan to develop Bolivia's lithium. Bolivia has the largest single reserve of lithium, and is predicted to experience a lithium boom around 2020 (Sagárnaga López 2015). Lithium production in Bolivia is hindered by several challenges. These include the geographic location of lithium deposits, a long rainy season and flooding of the salt lakes, high levels of magnesium, limited water resources (necessary for processing), potential environmental impacts, lack of infrastructure such as roads, and lack of technological expertise in evaporative mining (COHA 2009; Revette 2016; Sanderson and Schipani 2016).

High levels of magnesium in Bolivian lithium deposits reduce commercial viability as the magnesium must be removed using an expensive chemical process. The rate of evaporation also impacts on the

economical gathering of lithium, as well as the size and thus environmental footprint, of ponds needed for evaporation. Evaporation rates are lowered by Salar de Uyuni's rainfall levels and cooler climate. Lithium mining involves intensive use of water (at the expense of agriculture), use of toxic chemicals in processing and environmental waste disposal issues. Critics of mining note that current practices by Sumitomo Corporation in the controversial San Cristóbal mine (also in the Potosi region) include a large water-intensive (50,000 litres a day) open-pit mine that threatens local soil and water quality (COHA 2009; Minority Rights Group International 2012).

Once extracted, lithium is processed for use in batteries, including as components and/or electrolytic salt used in lithium-ion batteries. Few companies worldwide have this capacity (COHA 2009; Sanderson and Schipani 2016). Further, the investment climate in Bolivia is unsettling for corporates, as Bolivia's leftist, indigenous state has taken a "resource nationalism" approach. In 2006, Morales renationalized the hydrocarbons industry (Radhuber & Andreucci 2014). In 2016, the Swiss mining company, Glencore announced its arbitration proceedings against Bolivia over the nationalization of some of its assets (COHA 2009; O'Brien 2016). Meanwhile, lithium batteries may be usurped by other new technology (COHA 2009), so the Bolivian Government has a potentially narrow window to exploit its resource advantage.

If the challenges of lithium extraction and processing are overcome, lithium industrialization has the potential to facilitate Bolivia's and Latin American neighbors' transition to renewables. Bolivia has set a target of 79 percent renewable energy by 2030, Costa Rica (100 percent by 2030), Uruguay (95 percent by 2017), Belize (85 percent by 2027) and Guatemala (80 percent by 2030) (REN21 2016, p. 109). In 2013, Bolivia had one of the lowest electrification rates in South America (88 percent) and an estimated 1.2 million people without access to electricity (but a target of 100 percent by 2025) (REN21 2016, p. 151).

New, cleaner technologies are being developed, aimed at overcoming many of the technical, chemical and environmental hurdles. Rising lithium prices and predicted lithium shortages have fueled research and development into such technologies. For example, experimental technologies such as reverse osmosis attempt to shorten the time-lag for evaporation (around one-to-two years) of high-concentration brine (Martin 2015). To facilitate (more sustainable) lithium production and industrialization, Bolivia has entered into PPPs with private sector companies aimed at supporting vertically integrated mineral development. PPPs are crucial to Bolivia's implementation of new, clean technology and have cultivated an unusual partnership between state enterprises and foreign-owned private corporations in this developing country.

3. Vertically integrated mineral development

Internationally, the prevailing extraction model in developing countries is that materials are extracted and shipped, with processing, manufacturing and marketing of minerals and products taking place in developed countries. Bolivia has attempted to attract foreign investment whereby investing corporations accept greater benefits going to the Bolivian state and its people, and PPPs supporting Bolivia's lithium industrialization using clean technology, while supporting sustainable development (including indigenous rights), as part of the global shift to less reliance on fossil fuels. Implementing vertically integrated models aims to help avoid the historical interface between conflict, poverty and mineral extraction by foreign corporations (Bebbington 2013; Canessa 2014; Revette 2016).

The 2009 Bolivian Constitution made significant changes regarding the relationships between the state, the people, and natural resource exploitation. Resources are acknowledged as the property of the people of Bolivia to benefit the whole country. Communities are guaranteed consultation before resources are exploited in their territory (Carbonnier and Zamora 2013; Revette 2016). Critics however, question the extent that indigenous communities realistically benefit (Radhuber & Andreucci 2014).

President Morales dismissed simply exporting refined lithium. His goal is broader lithium industrialization, spanning the value chain from lithium production, cathode and battery manufacturing, even electric vehicle production, and marketing. 'Leftist president Evo Morales and his administration think that partners are welcome, as long as they use the lithium in Bolivia. In other

words, partners must build battery factories and possibly EV/HEV assembly lines there' (COHA 2009). Morales stated 'We want partners – not owners of our natural resources' (COHA 2009).

Comibol, the Bolivian state mining company, set out an industrialization plan with three phases: the pilot phase (goal: to produce 40 tons of lithium carbonate per month); industrial phase (goal: annual production of 30,000 tons); and battery production phase (Revette 2016). In August 2016, Bolivia accomplished its first shipment of almost 10 tons of lithium carbonate to China (Sanderson and Schipani 2016). Bolivia aims to increase its lithium carbonate export, and also export 5,000 tons of lithium cathodes from 2021 (Sanderson and Schipani 2016).

Bolivia has sought to protect sovereign control of its valuable resources by vesting ownership in the state, with the state corporation Comibol heading up lithium industrialization. Lacking expertise and capital to sustainably develop its lithium resources, Bolivia has entered into partnerships with foreign companies with clean energy expertise (Sanderson and Schipani 2016). By 2014, the Chinese company, Linyi Dake Trade had established a lithium-ion battery pilot plant. In 2015, the Chinese company, CAMC Engineering was contracted to build a potassium salt industrial plant, and the German company, K-UTEC Ag Salt Technologies contracted to design a lithium carbonate pilot plant (Sagárnaga López 2015; Pagina Siete 2015). The French company, EMC Green Technology is building a pilot plant for lithium cathode materials for use in lithium batteries (La Razón 2015; Revette 2016). The Japanese company, Sumitomo Corporation which owns Bolivia's largest mine, the San Cristobal mine (for zinc and silver), has stated it 'intends to become involved in a lithium mining project at the lake' (Sumitomo Corporation 2017).

Information on these partnerships is not readily available. In 2013, Carbonnier and Zamora (2013, p. 524) advise that: '[i]nformation is limited, leaving room for speculation on the extent to which the [lithium industrialization] project will be a success and how far scientific collaboration with foreign partners (Japan, South Korea) is being pursued.'

Beyond the need for clean technology expertise, PPPs need to incorporate sustainable development approaches which also focus on social, political and indigenous rights aspects of development. Bolivia is one of the poorest countries in South America, reliant on mineral exports, with over 650 small artisan cottage industry mining cooperatives involving 75,000 mainly indigenous members in mining. The Uyuni Regional Peasant Federation 'initially proposed the industrial lithium mining project' but there are disagreements over land title and resource royalties and the intensive use of water used in mining lithium (Minority Rights Group International 2012).

Indigenous communities are vulnerable to loss of lands, uncertain land titles, foreign mining company deals with the government and large infrastructure projects such as the trans-Bolivian trade highway that traversed indigenous lands and was suspended due to protests (Minority Rights Group International 2012). Sensitivities of large projects on indigenous lands exemplify the need for transparent, ethical government-business partnerships, not just on community engagement protocols, but community involvement in decision-making (United Nations Development Group, 2009).

4. Public-private partnerships

The chief mechanism of vertically integrated mineral development involves PPPs between the government and private companies which emphasize minerals extraction, chemical manufacture and product development for local and export consumption, while enabling jobs and social development outcomes. This is quite unusual and even in developed countries like Australia, lithium ore is exported to China for example for processing.

PPPs have a checkered history in public policy program evaluation, and frequently involve large infrastructure projects contracted between governments and private corporations. In developed countries from the 1990s onwards, privatization of public corporations such as utilities, led to a raft of regulatory reform aimed at licensing, monitoring, regulatory enforcement and mechanisms to address market failure and negative public interest impacts (Bovaird 2004; Hodge et al. 2010; Hodge & Duffield 2010).

Alongside these changes came a governance shift from hierarchy to flatter structures involving networks of multiple private, public, community and non-government organization (NGO) actors, with multiple points of engagement (Rhodes 1997; Considine 2005; Colebatch 2009). With PPPs, governance has become more complex, involving multiple layers and players and cross-sectoral cooperative governance. Elected governments have taken on a more arms-length role as purchaser, enabler, investor, and facilitator; and installing independent statutory regulators accountable to parliament (as prevails for example, in Australian and British electricity markets).

In the case of the Bolivian Government's partnerships with foreign companies, public interest outcomes may hinge on the extent to which regulatory bodies exist or their effectiveness and the extent to which scrutiny by NGOs is effective. Critics however, have argued that state-led lithium industrialization does not leave 'much space for debate with domestic stakeholders (private sector, civil society organizations, the academic community)' (Carbonnier and Zamora 2013, p. 524). Some partner corporations may be subsidiaries of transnational corporations with regional differentiation in work practices and standards. Others, for example Chinese companies, may be private or state-owned, bringing complex governance relationships to negotiations and contract conditions.

Our research aims to contribute to developing a framework for evaluating public interest outcomes of PPPs, aimed at implementing clean technologies for the production of resources essential for reducing reliance on fossil fuels, using Bolivia's lithium as a central case. Research issues encompass: international governance lessons from PPPs on minerals production and industrialization; and potential new international agreements and governance models for minerals extraction, production and sustainability (Prior et al. 2013; Ali et al. 2017). Analysis can also assess the impact of corporate social responsibility reporting on ethical supply chains, and the efficacy of corporate voluntary reporting on, and stewardship of, critical materials and "conflict minerals" (minerals mined which provide funds for armed groups to fuel violent conflict). For example, efforts may include addressing security of supply issues through recycling (US DOE 2011; CMI 2014), and implementing the OECD Due Diligence Guidance for Responsible Supply Chains from Conflict-Affected and High-Risk Areas (OECD 2016). Of key importance is the efficacy of contributing to the Sustainable Development Goals, particularly in developing countries, using government-business partnerships for mining (UNDP 2016) and the transfer of clean technology.

Initial key criteria of evaluation include for example, what are the benefits for communities and public interest, noting that negative impacts from partnerships/agreements can be long-term and binding? Further, how does mining and industrialization via vertically integrated mineral development, fit with indigenous, environmental and social equity interests?

5. Conclusion

The chief vulnerability of the current global governance of resources central to the transition from a fossil fuel to a low carbon new economy, is the governance void internationally. Lithium mining will bring development and large scale infrastructure that may be seen as intrusive, and resource use that may adversely impact on local communities (water, waste and mining spoil) and may detract from eco-tourism. On the other hand, a domestic clean energy industry could bring electricity and battery storage to the 1.2 million households without electricity and lift living standards.

The international and Bolivian desire for clean technologies and sustainable development has cultivated unusual partnerships between state enterprises and foreign-owned private corporations in a developing country. This calls for analysis of the efficacy of this model, in developing remote mineral reserves for advanced technologies necessary to shift towards less reliance on fossil fuels, and addressing broader sustainable development goals (including indigenous rights, ecological and social sustainability, and ethical supply chains). Our research aims to pave the way to an evaluative framework for this model of public-private partnerships and vertically integrated mineral development, which may be used internationally to support best-practice application of clean technologies for resource production.

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