



The Electric Car Battery

Sustainability in the Supply Chain

Tim Steinweg

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Amsterdam, March 2011

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Colophon

The Electric Car Battery Sustainability in the Supply Chain

March 2011

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Introduction

Last year the North America's International Auto Show (NAIAS) in Detroit had a so-called 'electric avenue', showcasing only electric powered vehicles.¹ Similarly, the 2009 Frankfurt auto show also showcased a number of electric cars.² These are but two of the many signs that the electric car is on its way to becoming a viable alternative to gasoline powered vehicles. In recent months, General Motors has launched its Chevrolet Volt, while Nissan brought the Nissan Leaf on the market, the first being a hybrid vehicle and the latter a fully electrically charged car. The market share of electric and hybrid vehicles is expected to increase rapidly over the next years, reaching between 12% and 45%.³ The key to the potential of the electric car is the development of the battery. The battery that is most useable for grid powered vehicles is based on the lithium ion technology. According to the Boston Consulting Group, 'The most prominent technologies for automotive applications are lithium-nickel-cobalt-aluminium (NCA), lithium-nickel-manganese-cobalt (LMO), lithium titanate (LTO), and lithium-iron phosphate (LFP)'. It is expected that these technologies will create a surge in demand for the needed raw materials, most notably for lithium⁴. Additionally, such a rapid increase in demand for electric cars will also create a surge in electric battery production, for example in countries such as China that already produce a large share of the world's batteries.

One of the main driving forces for these developments, in addition to the volatility of oil prices, is the increasing concern regarding climate change and CO2 emissions. Most of the discussions around the electric car point out the benefits of lower CO2 emissions, making it a sustainable alternative to gasoline fuelled cars. While the benefits of reduced CO2 emissions through increasing the use of electric cars are well documented, such discussions do not take into account the potential social and environmental costs throughout the supply chain. Not much is said about the conditions under which minerals such as lithium, cobalt, phosphate or rare earth metals are extracted, nor are the working conditions at production facilities included in the equation. This report aims to provide more insight into the complete picture of the social and environmental costs and benefits of this new technology, to broaden public discussions and to allow for more informed opinion making. SOMO believes that the contribution electric cars may make to sustainability can only truly be assessed when the full impact throughout the supply chain is considered.

This report aims to provide an initial overview of the supply chain of electric car batteries, and to answer the following research question: What effect does the growing demand for electric vehicles have on the social and environmental conditions throughout the electric car battery supply chain?

This report will combine various methodologies to be able to create an overall picture the electric car battery supply chain, and is targeted towards companies, public servants, opinion makers and the general public interested in the electric car.

¹ North American International Auto Show website, 'See. Learn. Drive.', no date, <http://www.naias.com/electric-avenue/electric-avenue.aspx> (17-12-10).

² CNet website, 'Frankfurt showcases electric cars', 16-11-09, http://reviews.cnet.com/8301-13745_7-10354355-10310244.html?tag=mncol:title (17-12-10).

³ The Boston Consulting Group, *The Comeback of the Electric Car? How Real, How Soon and What Must Happen Next*, 2009, The Boston Consulting Group Inc., <http://www.bcg.com/documents/file15404.pdf> (17-12-10).

⁴ D. Frisby, 'The next big investment bubble – obscure metals', Moneyweek, 21-08-09, <http://www.moneyweek.com/investments/commodities/investing-in-green-energy-lithium-and-rare-earth-metals-93412.aspx> (17-12-10).

The first chapter maps the entire supply chain, by analysing the extractive, production and consumption phase. Supply chain mapping usually starts with the analysis of general market and trade data for each of the phases, for example through market reports, import and export figures and news reports. For the extractive phase, this includes an analysis of the geographical distribution of the reserves for the resources looked at, while for the other phases it is more relevant to look at market shares. This information is subsequently complemented by an identification of the largest corporate players for each of the phases, for example the relevant mining or battery production companies. Where possible, the next step in the mapping of the supply chain includes the *tracing* of the origin of the end product (who are the suppliers?), as well as the *tracking* of the raw materials (who are the buyers?), with the goal of connecting the two ends of the supply chain.

The next two chapters discuss two case studies that look at the social and environmental conditions within the supply chain. The first case study deals with the impacts of the growing demand for lithium on Bolivia, which holds the largest reserves in the world. For this chapter, SOMO has conducted a desk study into the international and Bolivian media reports of the most relevant issues related to lithium. A particular focus is given to Bolivian sources, as it was hypothesised that their perspective might differ from large international media outlets. A number of interviews were conducted with independent experts to complement the data gathered through the desk study.

The second case study deals with the labour and health conditions at several facilities of a large battery manufacturer in China. For this case study, field research was conducted that included a range of interviews with workers at these facilities. These interviews were conducted by the Hong Kong based organisation Globalization Monitor, and took place between April and June 2010. The chapter is complemented by a short profile of the company in question, Build Your Dreams (BYD). A draft version of this report was sent to BYD for factual review, but BYD did not respond to this request and did not provide input.

The final chapter draws a number of conclusions on the ongoing dynamics of the electric car battery supply chain and the relevant sustainability issues, on the basis of the information in the preceding chapters.

There are a number of limitations to this study that need to be considered. First of all, while the case studies provide valuable information on the conditions in the supply chain, one should be cautious to draw generalising conclusions on the basis of this information. Secondly, the electric car is still very much in development, and large scale production has started only recently and for just a few brands. This means that the supply chain is still very much in development, and might grow in unexpected ways. The fact that the supply chain is still not fully matured means that a number of points made in this research might be speculative.

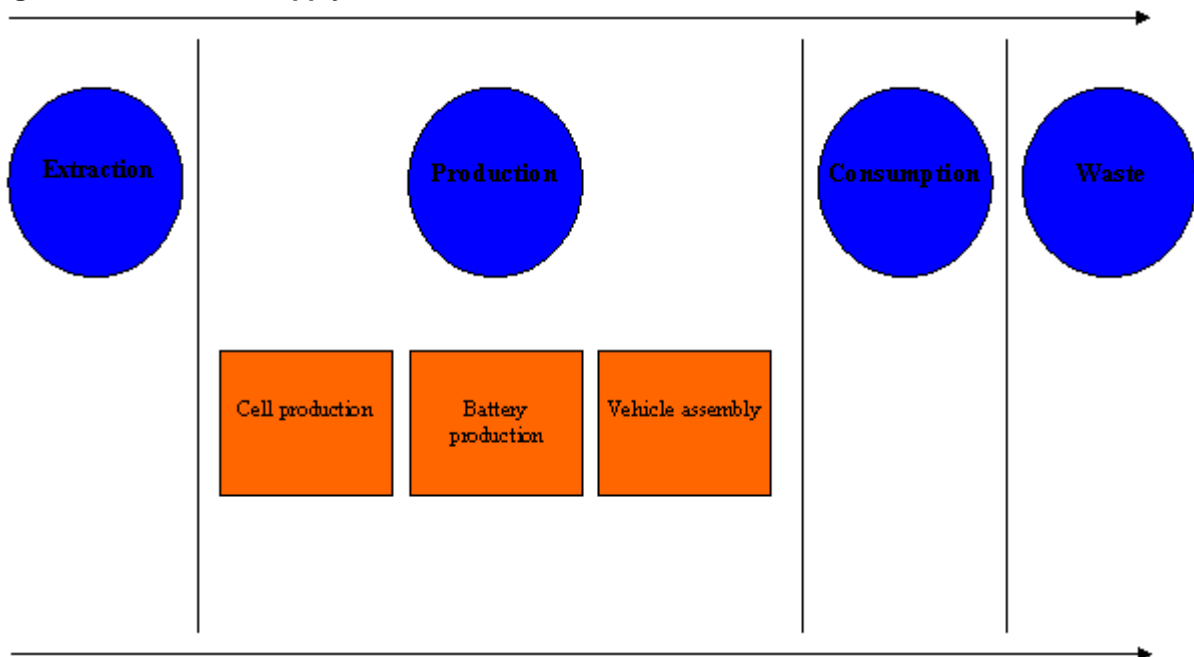
1 Mapping the electric car battery supply chain

This chapter aims to provide a general overview of the supply chain of the electric car battery, through mapping and describing the different phases.

Several general phases can be identified in the electric car battery supply chain, similar to any consumer product; first of all, the electric car battery is manufactured using a number of raw materials that need to be mined or sourced otherwise. Next, these raw materials are used to manufacture battery cells, which in turn form the building blocks of the electric car battery. This battery is then assembled into the electric vehicle. After the production phase, the car is purchased by the end consumer, whose demand is a large determinant for the rest of the supply chain. After end of use, the car will enter the waste phase, after which it is disposed of in various ways.

Figure 1 shows the schematic outline of the electric car battery supply chain.⁵

Figure 1: Electric car supply chain



1.1 Extractive phase

For most of the electric car batteries, lithium is expected to be the main component. Until recently, global demand for lithium has been minor, as the only uses for this material were to produce glass,

⁵ Based on Boston Consulting Group, *Batteries for Electric Cars; Challenges, Opportunities, and the Outlook to 2020*, The Boston Consulting Group Inc., 2010, <http://www.bcg.com/documents/file36615.pdf> (17-12-10) & D.C. Notter, M. Gauch, R. Widmer, P. Wager, A. Stamp, R. Zah and H-J. Althaus, 'Contribution of Li-ion Batteries to the Environmental Impact of Electric Vehicles', *Environmental Science & Technology*, Vol.44, No.17 (2010), p.6550-6556.

grease and mood-stabilising drugs.⁶ However, since 2003, the surge of demand for handheld electronic devices has caused a surge for lithium, as it is the main ingredient for rechargeable batteries. Lithium is a silver-white mineral that has electrochemical qualities making it very useful as anodes in batteries. It is also the lightest mineral on earth (Li has atomic number 3) making it attractive for batteries in portable products, such as laptops and mobile phones. The weight is also a factor for lithium as the basis of the electric car battery. As an electric car battery requires approximately 100 times as much lithium carbonate as a laptop, current developments are expected to have major effects on the global demand for this raw material.⁷

It is estimated that the world holds approximately 25 million tonnes of lithium reserves. These reserves are mostly located in Bolivia (9 million tonnes), Chile (7.5 million tonnes), Argentina, China and the United States (2.5 million tonnes each).⁸ It was recently announced that Afghanistan also holds significant quantities of lithium.⁹

Chile has been the largest producer of lithium, while Argentina, China and the United States have also been major producers. Most of the lithium mining is a relatively low-labour process, involving the evaporation of lithium holding brines. This is done by drilling holes into salt flats, such as the one in the border area between Chile and Argentina, and pumping the brine to evaporation ponds. The lithium that remains after the water is evaporated is then processed to produce commercially useable lithium.

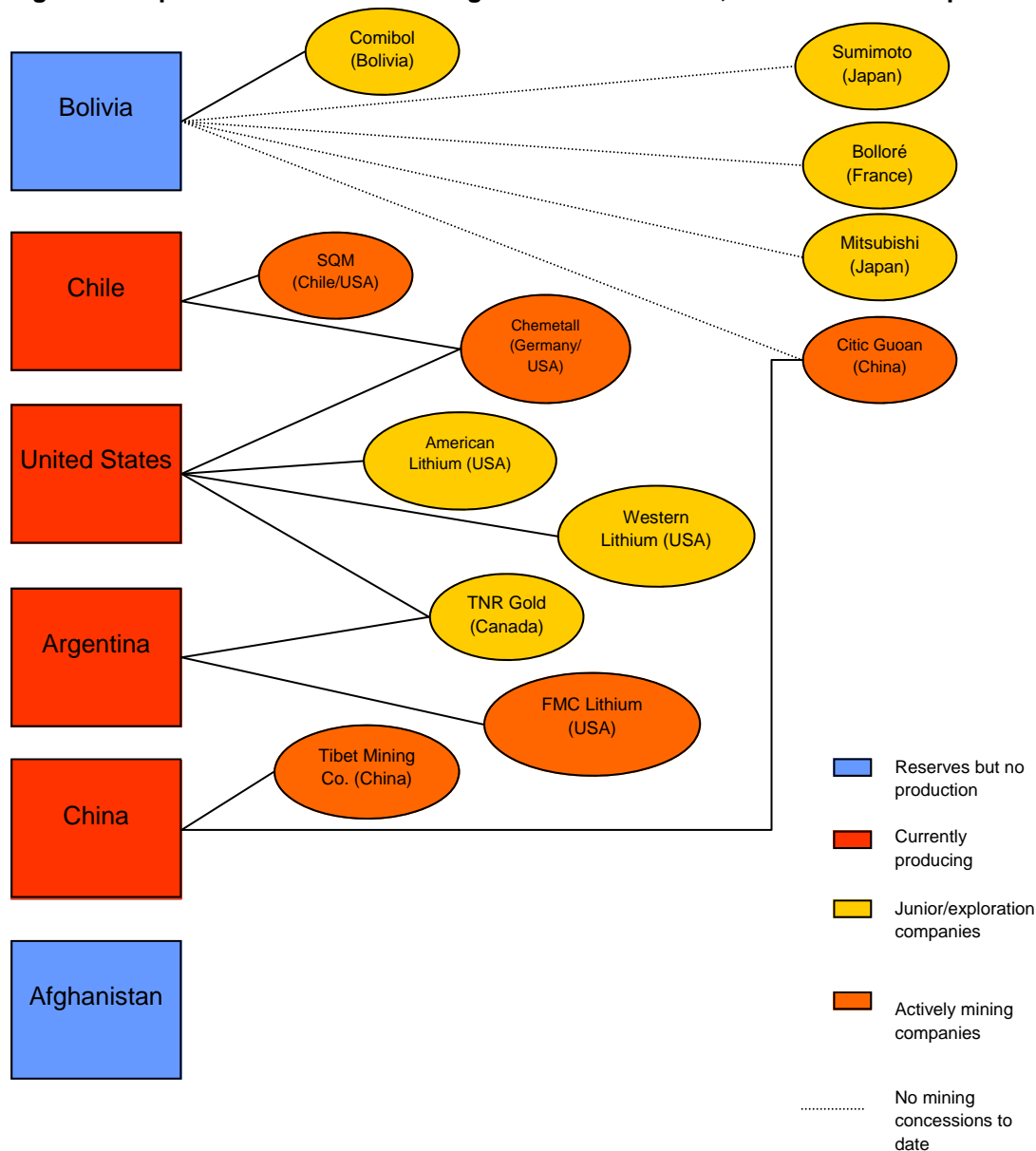
⁶ B.I. Koerner, 'The Saudi Arabia of Lithium', Forbes, 30-10-08, <http://www.forbes.com/forbes/2008/1124/034.html> (20-12-10).

⁷ B.I. Koerner, 'The Saudi Arabia of Lithium', Forbes, 30-10-08, <http://www.forbes.com/forbes/2008/1124/034.html> (20-12-10).

⁸ United States Geological Survey, Minerals Information, Mineral Commodity Summaries, 'Lithium', 2010, <http://minerals.usgs.gov/minerals/pubs/commodity/lithium/mcs-2010-lithi.pdf> (20-12-10).

⁹ J. Risen, 'U.S. Identifies Vast Mineral Riches in Afghanistan', New York Times, 13-06-10, <http://www.nytimes.com/2010/06/14/world/asia/14minerals.html> (20-12-10).

Figure 2: Map of countries with the largest lithium reserves, and selected companies



The largest lithium mining company is Sociedad Química y Minera (SQM), a Chilean company partially owned by the Potash Corporation from Canada. SQM supplies almost 50% of its lithium to Asia and Oceania, and 31% to Europe.¹⁰ Other large corporate players include Australia’s Tallison Minerals, Argentina’s FMC Lithium and Chile’s Chemetall.

Unsurprisingly, the largest producers of lithium are also the largest exporters, as shown in Table 1. Only Belgium is not a producer of lithium, but its high export figures can likely be explained by the presence in Belgium of Chemetall, the large Chilean lithium producer.¹¹ Chile, Argentina, USA and China are all known producers of lithium.

¹⁰ Sociedad Química y Minera de Chile S.A., Submission to the United States Securities and Exchange Commission, Form 10-F, for the fiscal year ended December 31st, 2008, http://www.sqm.com/PDF%5CInvestors%5C20F%5CSQM-20F_2008-%2830%20June%202009%29-EN.pdf (20-12-10).

¹¹ See Chemetall B.V. website, no date, www.chemetall.be (20-12-10).

Table 1: Top exporters of lithium carbonate, 2009¹²

Reporter	Trade Value	Net Weight (kg)
Chile	\$115,139,580	22,443,197
Argentina	\$40,203,624	8,578,000
Belgium	\$17,233,558	3,042,401
China	\$13,754,811	2,000,344
USA	\$10,742,315	1,972,717

The different types of Li-ion batteries, as described in the section below, also require a number of various other elements in addition to lithium. These include nickel, cobalt, manganese and phosphate. Most of the world's nickel is produced in Russia, Indonesia, Canada and Australia.¹³ Australia also holds the largest known reserves. By far the largest producer of cobalt is the Democratic Republic of the Congo, while Australia, Russia and China also have significant production.¹⁴ DRC also has the largest known reserves. Manganese is spread throughout the world in diverse ways, with the largest current producers being China, Australia and South Africa while the largest known reserves are in Ukraine.¹⁵ Finally, phosphate, a material also used for food fertilisers, is mostly produced in the United States, Morocco and Western Sahara and China.¹⁶ Largest known reserves are found in the Western Sahara.

1.2 Production phase

The raw materials are used to produce Li-ion battery cells. These cells define the quality of the battery itself, including its safety, performance, lifespan and other qualities. A Li-ion cell consists of an anode and a cathode, or the positive and negative end of a battery. The range of Li-ion batteries differ from one another, based on the material used for the cathode. The most prominent types of Li-ion battery cells have cathodes that consist of lithium-nickel-cobalt-aluminium (NCA); lithium-nickel-manganese-cobalt (NMC); lithium-manganese-spinel (LMO); lithium titanate (LTO); or lithium-iron phosphate (LFP).¹⁷

There are several players active in the field of battery production, which seems to be dominated by Asian companies, while there are also some American players. Some of these companies, such as LG Chem and A123, focus specifically on the production of batteries for electronics and cars, while others such as China-based Build Your Dreams integrate the battery production facilities in a vertically integrated business model that also includes the production of electric vehicles.¹⁸ Finally, a number of established car manufacturers and a number of electronics companies have also been becoming active in the production of electric car batteries. These include Toyota, Samsung and

¹² UN Comtrade database, Lithium Carbonate snapshot, no date, <http://comtrade.un.org/db/ce/ceSnapshot.aspx?px=H2&cc=283691> (20-12-10).

¹³ United States Geological Survey, Minerals Information, Mineral Commodity Summaries, 'Nickel', 2010, <http://minerals.usgs.gov/minerals/pubs/commodity/nickel/mcs-2010-nicke.pdf> (20-12-10).

¹⁴ United States Geological Survey, Minerals Information, Mineral Commodity Summaries, 'Cobalt', 2010, <http://minerals.usgs.gov/minerals/pubs/commodity/cobalt/mcs-2010-cobal.pdf> (20-12-10).

¹⁵ United States Geological Survey, Minerals Information, Mineral Commodity Summaries, 'Manganese', 2010, <http://minerals.usgs.gov/minerals/pubs/commodity/manganese/mcs-2010-manga.pdf> (20-12-10).

¹⁶ United States Geological Survey, Minerals Information, Mineral Commodity Summaries, 'Phosphate', 2010, http://minerals.usgs.gov/minerals/pubs/commodity/phosphate_rock/mcs-2010-phosp.pdf (20-12-10).

¹⁷ Boston Consulting Group, *Batteries for Electric Cars; Challenges, Opportunities, and the Outlook to 2020*, The Boston Consulting Group Inc., 2010, <http://www.bcg.com/documents/file36615.pdf> (17-12-10).

¹⁸ B. Engardio, 'The Electric Car Battery War', Bloomberg Businessweek, 12-02-09, http://www.businessweek.com/magazine/content/09_08/b4120052113533.htm (20-12-10).

NEC.¹⁹ Table 2 gives an overview of a selection of electric and hybrid vehicles, and their battery manufacturers.

Table 2: Electric vehicles and their battery manufacturers

Electric car model	Battery producer
Nissan Leaf	Automotive Energy Supply (Nissan NEC JV)
Chevrolet Volt	Compact Power (subsidiary of LG Chem)
BMW Megacity	SB LiMotive (Bosch Samsung JV) ²⁰
BYD E6	BYD
Coda	Tianjin Lishen ²¹
Ford Focus EV	Compact Power (subsidiary of LG Chem) ²²
Ford Transit Connect Electric	Johnson Controls-Saft ²³
Mini E	E-One Moli ²⁴
Mitsubishi iMiEV	Lithium Energy Japan (Mitsubishi GS Yuasa JV) ²⁵
Renault Fluence	Automotive Energy Supply (Nissan NEC JV) ²⁶
Smart ED	Tesla ²⁷
Toyota FT-EV	Panasonic EV Energy (Panasonic Toyota JV) ²⁸
Tesla Model S	Panasonic Energy ²⁹

Little information was found during the course of this research regarding the sourcing of lithium and other raw materials by these cell manufacturers. Therefore, the links between the lithium producers and the cell manufacturers remain difficult to establish.

General Motors has developed the Chevrolet Volt, a range extender car that will be put on the American market in December 2010.³⁰ The Volt has an electric range of between 25 and 50 miles (40-80 kilometres) and switches to the gas powered engine after that. It also switches when the car

¹⁹ M. Anderson, 'Li-ion Batteries for Hybrid Electric Vehicles', Auto Focus Asia, no date, http://www.autofocusasia.com/production_manufacturing/ion_batteries_hybrid.htm (20-12-10).

²⁰ 'Bosch JV to supply battery for BMW's Megacity e-car', Reuters, 03-08-09, <http://www.reuters.com/article/idUSL314152220090803> (20-12-10).

²¹ C. Dannen, 'Coda's All-Electric Sedan Revs Up U.S. Auto Market', Fast Company, 01-11-09, <http://www.fastcompany.com/magazine/140/lighting-up-the-road.html> (20-12-10).

²² 'Ford Selects Compact Power to Supply Ford Focus EV Battery Pack', Electric Vehicles News Weblog, 13-07-10, <http://electric-vehicles-cars-bikes.blogspot.com/2010/07/ford-selects-compact-power-to-supply.html> (20-12-10).

²³ 'Ford Transit Connect Electric Launches At the 2010 Hannover Commercial Vehicle Show', Electric Vehicles News Weblog, 22-09-10, <http://electric-vehicles-cars-bikes.blogspot.com/2010/09/transit-connect-electric-launches-at.html> (20-12-10).

²⁴ Cens.com website, Taiwan Economic News, Industry Reports, 'E-One Moli Supplies Batteries to Power the Future', 12-04-10, http://www.cens.com/cens/html/en/news/news_inner_32032.html (20-12-10).

²⁵ Mitsubishi Motors website, Online Press Room, Press Release, 'Mitsubishi Motors to Bring New-Generation EV i-MiEV to Market', 04-06-09, <http://www.mitsubishicars.com/MMNA/jsp/imiev/greencar.do> (20-12-10).

²⁶ http://www.renault.com/SiteCollectionDocuments/Communiqu%C3%A9%20de%20presse/en-EN/Pieces%20jointes/23225_20100707_CP_ROADSHOW_GB_892E054C.pdf

²⁷ Renault website, Press Release, 'RENAULT Z.E. ROADSHOW: FLUENCE Z.E. AND KANGOO EXPRESS Z.E. AVAILABLE FOR ROAD TESTS', 07-07-10, <http://green.autoblog.com/2009/01/13/tesla-confirms-smart-ed-battery-supply-deal/> (20-12-10).

²⁸ Toyota website, Pressroom, Press Release, 'Toyota Unveils Compact Dedicated Hybrid Concept, Reveals Future Plan for 'Prius Family' North American Marketing Strategy', 11-01-10, <http://pressroom.toyota.com/pr/tms/toyota/toyota-unveils-compact-dedicated-151199.aspx> (20-12-10).

²⁹ S. Abuelsamid, 'Panasonic delivers first 3.1Ah lithium ion cells to Tesla', Autobloggreen weblog, 23-04-10, <http://green.autoblog.com/2010/04/23/panasonic-delivers-first-3-1ah-lithium-ion-cells-to-tesla/> (20-12-10).

³⁰ B. Siceloff, 'Chevy Volt pricey but solid', News Observer, 02-11-10, <http://www.newsobserver.com/2010/11/02/774979/chevy-volt-pricey-but-solid.html> (20-12-10).

goes faster than 70 miles per hour (112 km/h).³¹ The Li-ion polymer battery for the Volt is produced by Compact Power, a subsidiary of Korea-based LG Chem.³² While it is not clear where and how LG Chem sources its lithium and other raw materials for the production of the battery cells, it has approached the Bolivian government to talk about future collaboration, indicating that the sourcing of raw materials is of strategic importance for this company.³³

Similar to the Chevrolet Volt, the Nissan Leaf will be available to consumers from December 2010 on. The Leaf is an all-electric vehicle that does not have a gas fuelled engine. The car also makes use of a similar Li-ion battery, that is produced by Automotive Energy Supply, a joint venture of Nissan with NEC.³⁴ The battery consists of a total of 192 battery cells and contains a total of 9 pounds (4 kilograms) of lithium.³⁵

1.3 Consumption phase

The development of the electric car has undergone various stages of development, and five general types of electric vehicles can be distinguished.³⁶ The *mild hybrid* is a regular car that includes a small electric motor that is used for start-stop systems. This motor is only used to assist the car's regular propulsion system when accelerating or braking. An example of the mild hybrid is the Mercedes Benz S400 BlueHybrid. Next is the *full hybrid*, of which the Toyota Prius might be the best-known example. These types of cars feature a larger electric motor as well as a large electric battery which is put to use when starting the engine, accelerating and driving at low speeds. The *plug-in hybrid* is an upgrade of the full hybrid car, whose battery can be charged through the electricity grid. Build Your Dreams developed the BYD F3DM model in China, which is a plug-in hybrid car. The penultimate phase in the evolutionary path of the electric car is the so-called *range extender*. This type is similar to the plug-in hybrids, except that the roles of the electric motor and the combustion engine are reversed. Contrary to the plug-in hybrid, the electric motor of the range extender is the main driver, and the combustion engine is only used to charge the electric battery. The end-point of the evolution of the electric car is the *full electric vehicle*. This model uses only electricity to drive the car, and the electricity from the grid is stored in a large battery, usually a Li-ion battery. The recent Nissan Leaf is an example of a full electric vehicle.

While the technological development of the electric car has evolved to the full electric stage, its market share is still in a limited early phase. In fact, most of the models are still under development, or have only been released to the broader public recently. This means that there still is a large amount of uncertainty regarding the development of the industry as a whole. However, it is clear that a large amount of attention has been directed at electric cars in the media, by politicians and consumers. In response, nearly all car makers are currently developing or producing electric models to tap into this new market.

³¹ J. Motavalli, 'Chevy Volt's Number One Fan Poised to Get Groundbreaking Car', The Daily Green website, 29-10-10, <http://www.thedailygreen.com/living-green/blogs/cars-transportation/chevrolet-volt-lyle-dennis-461010> (20-12-10).

³² LG Chem, Press Release, 'LG Chem Battery Cells to Power Chevrolet Volt', 12-01-09, http://www.compactpower.com/Documents/MicrosoftWord-LG_Chem_pressrelease_finalon20080110.pdf (20-12-10).

³³ GM-Volt website, 'LG Chem is Approaching Bolivia for Lithium', 10-02-09, <http://gm-volt.com/2009/02/10/lg-chem-is-approaching-bolivia-for-lithium/> (20-12-10).

³⁴ http://www.allcarselectric.com/blog/1033848_2011-nissan-leaf-batteries

³⁵ J. Vandervelde, '2011 Nissan Leaf: Batteries', AllCarsElectric weblog, 02-08-09,

<http://green.autoblog.com/2010/05/27/details-on-nissan-leaf-battery-pack-including-how-recharging-sp/> (20-12-10).

³⁶ The Boston Consulting Group, *The Comeback of the Electric Car? How Real, How Soon and What Must Happen Next*, 2009, The Boston Consulting Group Inc., <http://www.bcg.com/documents/file15404.pdf> (17-12-10).

The Boston Consulting Group has made an outlook projection for electric cars in 2020. Building on three different scenarios, BCG expects that the total market share for all types of electric vehicles will be between 12% and 45%. It is expected that 1.5 million cars will be sold annually in China, Japan, North America and Western Europe, and that most of the electric cars will be used for short trips and commutes in cities.

1.4 Market forces

There are a number of market forces that shape the supply chain of electric cars and its batteries, and that will determine the future shape of the industry. As the industry is still very much in development, there remains a certain level of uncertainty regarding how these forces will play out and what effect they will have throughout the supply chain. However, various consultancies and researchers have developed future outlooks of the electric car industry, and have included these factors in their analysis. The market forces can be categorised into three different factors; the price factor, the technology factor and the mineral availability factor. All these factors relate mostly to the battery of the electric car, which is the most expensive and technologically complex part of the vehicle and which requires specific raw materials not needed in other components.

Price factor

The future of the electric car industry will for a large part depend on the costs and prices throughout the supply chain. The relatively high cost of electric cars can be explained by the high production costs that are caused by the lack of economies of scale. The price developments that will have an effect on future electric car prices include those of the raw materials, the production costs of the battery packs, the total cost of ownership for consumers and the government subsidies provided to actors in the supply chain. The Boston Consultancy Group made a future outlook of the electric car market in 2020.³⁷ In their analysis, they conclude that the raw material prices, in particular the price of lithium, will have a minor effect on the cost of producing battery cells, as it only constitutes 2% of total production costs.

The current total cost for the production of electric car batteries is high, as development costs are still significant. These costs are usually calculated on a kw/h basis, and the BCG estimates that in 2009, these costs were between \$1,000 and \$1,200 per kw/h for an average battery pack. Looking at the recently released Nissan Leaf, these costs are already significantly lower at the end of 2010, estimated between \$375 and \$650 per kw/h.³⁸ The BCG is projecting an eventual cost of \$250 per kw/h for Li-ion battery packs, as battery costs will continue to decline as production increases. It should be noted, however, that they do not expect this price to be achieved by 2020.

The labour costs for the production of the battery pack are low, as the process is not very labour intensive. Therefore, there will not be a strong urge to locate production facilities in low wage countries, as the cost benefit of doing so will only be marginal. The BCG calculated that producing the battery in the United States would only be 6% more expensive than doing so in South Korea,

³⁷ Boston Consulting Group, *Batteries for Electric Cars; Challenges, Opportunities, and the Outlook to 2020*, The Boston Consulting Group Inc., 2010, <http://www.bcg.com/documents/file36615.pdf> (17-12-10).

³⁸ Calculated on the basis of M. Ramsey, 'High Battery Cost Curbs Electric Cars', Wall Street Journal, 17-10-10, <http://online.wsj.com/article/SB10001424052748703735804575536242934528502.html> (20-12-10) & Nissan Zero Emission website, 'Specs', no date, <http://www.nissan-zeroemission.com/EN/LEAF/specs.html> (20-12-10) & S. Abuelsamid, 'Report: Nissan Leaf battery pack costs only £6,000 (\$9,000) or 375/kWh!', 05-05-10, <http://green.autoblog.com/2010/05/05/report-nissan-leaf-battery-pack-costs-only-6-000-9-000-or/> (20-12-10).

which in turn is only 8% more expensive than China. One of the factors that explains this, is that car batteries are heavy and difficult, and therefore expensive, to transport.³⁹

The expected decrease in battery production costs will obviously also have a downward effect on the price that consumers pay for their vehicle. Consumer demand will for a large part be determined by the Total Cost of Ownership (TCO) of the vehicle. TCO includes not only the purchase price of the vehicle, but also the operating costs (e.g. fuel prices or maintenance costs). According to the BCG, the TCO of electric vehicles would only be at the same levels as regular cars if 1) oil prices increase to \$300/barrel⁴⁰; 2) gasoline prices increase by 200% due to either oil prices or increased taxes; or 3) governments provide financial incentives of at least \$7,500 per vehicle. The latter condition is already met by several European countries such as France and Germany who provide this amount in subsidies for the purchase of an electric car.

Technology factor

Another factor that will determine the future shape of the electric car industry is the development of technological capabilities. As described above, there is a range of different Li-ion types that use different raw materials in addition to lithium. According to the BCG, 'there is increasing interest and activity, particularly among university research laboratories, in exploring new electrochemical mechanisms that might boost the specific energy and performance of future batteries'. These developments might have an effect on the entire supply chain, as they might require other raw materials or different production processes and might have an effect on consumer demand.

Current technological developments are mostly focused on improving the performance of Li-ion batteries on a number of different dimensions, according to BCG: 1) life span (measured in terms of both number of charge-and-discharge cycles and overall battery age); 2) performance (peak power at low temperatures, state-of-charge measurement, and thermal management); 3) specific energy (how much energy the battery can store per kilogram of weight); 4) specific power (how much power the battery can store per kilogram of mass); 5) safety; and 6) costs (see above).

Of these dimensions, the safety issue seems to be most important, and could have the most effect on the supply chain. Li-ion batteries that are used in laptops and mobile phones are known to spontaneously catch fire and the scaling up of this technology to be suitable for car batteries might exacerbate this problem or create other safety and reliability issues.⁴¹ The effects of the safety concerns on the future of electric cars are as much a matter of real safety concerns as it is of image. According to Peter Roth, a researcher at Sandia, an institute that tests the safety of batteries, 'One bad incident can spoil the public's opinion'. The BCG also points out that the effects that one battery fire could have on public opinion could set back the technological development of electric cars for years.⁴²

Another factor that will play a part in the future of the electric car is the development of the charging infrastructure. While some consumers might have access to garages where they can charge their vehicle themselves, many others do not and would be dependent on a network of public charging

³⁹ S. Rahim, 'The Cold, Hard Economics of Electric Cars Points to Making Them in the U.S.', New York Times, 27-11-10, <http://www.nytimes.com/cwire/2010/09/27/27climatewire-the-cold-hard-economics-of-electric-cars-poin-7189.html?pagewanted=all> (23-12-10).

⁴⁰ On 3 January 2011, crude oil was priced at \$92/barrel. Reuters, 'NYMEX-Crude starts year up after 2010's 15 pct rise', 03-01-11, <http://www.reuters.com/article/idUSN0331485520110103> (03-01-11).

⁴¹ S. Simon, 'Where batteries go to be tortured', Wall Street Journal, 22-02-10, <http://online.wsj.com/article/SB10001424052748704363504575002780479073618.html> (20-12-10).

⁴² The Boston Consulting Group, *The Comeback of the Electric Car? How Real, How Soon and What Must Happen Next*, 2009, The Boston Consulting Group Inc., <http://www.bcg.com/documents/file15404.pdf> (17-12-10).

stations. The development of such a network is not only dependent on public financing for charging stations, and the necessary political will to do so, but is also dependent on additional power generating facilities to meet the additional demand for electricity. A lack of an adequate charging infrastructure would severely limit the consumer demand for electric vehicles, which could alter the development of the entire supply chain.

Material availability factor

A final factor that could have an effect on the electric car sector is the availability of the raw materials needed for the production of electric car batteries. Gaines and Nelson have researched whether the growth of the electric car sector would create shortages in lithium and a range of other raw materials.⁴³

In their paper, Gaines and Nelson make projections on the basis of various scenarios to evaluate whether the demand for electric vehicles in the United States would have an effect on material availability. The most extreme scenario that they developed projected that 90% of all light vehicles would be electric in 2050. Next, they evaluated for a range of different types of battery packs, which differed from one another regarding the total weight of lithium needed for production, as well as what other materials are used.

The authors concluded that even in the most extreme scenario, current production levels of lithium would be sufficient to meet US demand until 2030. This does not take into account that production levels might rise in the future, which would reduce the materials pressure even more. When extrapolating the results to global demand, the authors state that 'Even when our U.S. estimates are multiplied by a factor of 4 to account for world demand, it appears that there is enough lithium available to use while we work toward an even more efficient, clean, and abundant means of supplying propulsion energy'.

The authors also look at the possible effects on the availability of nickel, cobalt, aluminium, iron, phosphorus, manganese and titanium. The only material that could create a potential constraint is cobalt, as the U.S. demand for electric cars could account for 9% demand of global production. However, the authors also point out that recycling of cobalt-containing products might partially meet this demand as well.

Overall, the authors conclude that 'In the case of materials for lithium-ion batteries, it appears that even an aggressive program of vehicles with electric drive can be supported for decades with known supplies'.

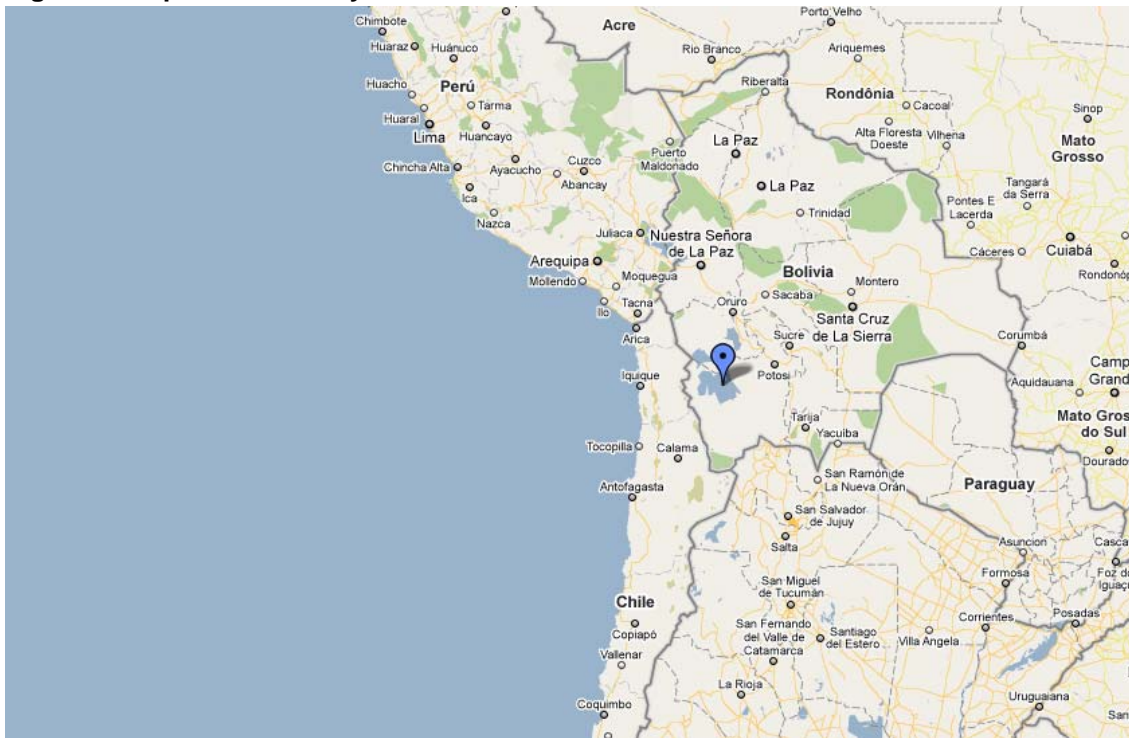
⁴³ L. Gaines and P. Nelson, 'Lithium-Ion Batteries: Possible Materials Issues', paper presented at The 13th International Battery Materials Recycling Seminar and Exhibit, Broward County Convention Center, Fort Lauderdale, Florida, March 16-18 (2009).

2 Case study: Lithium extraction in Bolivia

2.1 Introduction

The first case study in this report deals with an issue in the extractive phase of the supply chain of electric car batteries. It consists of a desk study into the political and social tensions in Bolivia that arise due to the fact that the country holds the largest reserves of lithium in the world. The desk study entails an analysis of both Bolivian and international media reports to describe the latest developments in a country that has been described as ‘the Saudi Arabia of Lithium’.⁴⁴ While this comparison does not hold true for anything other than the fact that it holds a significant portion of the world’s reserve of a resource that is needed for cars, it does signify the importance that this country would play when the world shifts from gas-fuelled cars to electric ones.

Figure 3: Map of Salar de Uyuni



Bolivia holds the largest lithium reserves in the world, but it has no lithium production to speak of to date. While the country does have significant natural gas production, it is still the country with the lowest per capita income in South America, and faces a great deal of poverty.⁴⁵ In addition, it faces immense wealth inequalities, with the top 10% of the population accounting for 44.1% of the total income. In theory, the expected global demand for lithium could pull Bolivia out of poverty, and could function as the motor for development.

⁴⁴ J. Yarow, ‘Bolivia: The Saudi Arabia Of Lithium’, Business Insider Green Sheet, 23-01-09, <http://www.businessinsider.com/2009/1/bolivia-is-the-saudi-arabia-of-lithium> (20-12-10). It should be noted, however, that Afghanistan and Chile have also been labeled the same.

⁴⁵ It ranks 118th, 103rd and 116th respectively on the lists of countries per GDP per capita of the IMF, the World Bank and the CIA World Factbook. Wikipedia, ‘List of Countries by GDP’, no date, http://en.wikipedia.org/wiki/List_of_countries_by_GDP_%28PPP%29_per_capita (20-12-10).

This chapter tries to describe a number of issues Bolivia faces in its attempts to become an important actor in this emerging industry. First, the geological context is described, as well as the way in which the Bolivian government aims to make use of the benefits of the lithium reserves. Next, the domestic social and political struggles between national level policies and local and regional perspectives are discussed. Finally, this chapter also looks at the international tensions that arise or are exacerbated by the presence of such immense natural riches. In particular, attention is given to the historical dispute with Chile over access to sea that could fire up as Bolivia might come to be in need of easy export routes.

2.2 Geological context

The US Geological Survey estimates that the Uyuni desert in South-West Bolivia contains around 5.4 million tonnes of lithium, which is around one third of the total world reserves.⁴⁶ The salt flat is located on a plateau in the Andes and measures more than 10,000 square kilometres. Lithium carbonate in the Uyuni desert is situated in shallow brines that lie under a crust of salt that covers the entire surface.⁴⁷

Compared to the Salar de Atacama in Chile, currently the largest lithium production facility in the world, extraction of lithium is more difficult at Salar de Uyuni. First of all, concentration levels of lithium vary greatly from place to place and extraction facilities could only be economically viable at a small tip of the Salar, where the lithium concentration is high enough.⁴⁸ At the same time, the level of evaporation is less than in the Salar de Atacama, because of the higher humidity, greater rainfall, floods from nearby lakes and lower temperatures.⁴⁹ Therefore, more evaporation ponds and other facilities are needed for production in Bolivia than in Chile.⁵⁰ Another issue that makes extraction at Salar de Uyuni more difficult is the high level of magnesium in the brines. This magnesium needs to be removed before the brines can be evaporated.⁵¹ Finally, there is a lack of infrastructure, such as roads and railroads, which makes it more difficult to transport the lithium after it has been mined.

In addition to the Uyuni reserves, two other reserves were recently discovered, one of which is located just north of Uyuni at Salar de Coipasa. Here, the government has recently started the

⁴⁶ United States Geological Survey, Minerals Information, Mineral Commodity Summaries, 'Lithium', 2010, <http://minerals.usgs.gov/minerals/pubs/commodity/lithium/mcs-2010-lithi.pdf> (20-12-10). USGS estimates Bolivian reserves at 5,4 million tonnes, and estimates the world total reserves at 9,9 mil in 2010 (excluding Bolivia). It should be noted that a number of different scholars have made other estimations, ranging from 0.6 million tonnes to 10.2 million tonnes. See P. Gruber and P. Medina, 'Global Lithium Availability: A Constraint for Electric Vehicles?', Center for Sustainable Systems, University of Michigan, Report No. CSS 10-05, April 2010, http://css.snre.umich.edu/css_doc/CSS10-05.pdf (20-12-10).

⁴⁷ Meridian International Research, 'The trouble with lithium 2: under the microscope', May 2008, http://www.evworld.com/library/WTahil_Lithium_Microscope.pdf (20-12-10), p.13.

⁴⁸ Meridian International Research, 'The trouble with lithium 2: under the microscope', May 2008, http://www.evworld.com/library/WTahil_Lithium_Microscope.pdf (20-12-10), p.17.

⁴⁹ D. Mares, 'Lithium in Bolivia: can resource nationalism deliver for Bolivians and the world?', Emerging market consequences of an emerging U.S. carbon management policy, September 2010, <http://www.rice.edu/energy/publications/docs/Mares%20Lithium%20in%20Bolivia%20Paper%20Secured.pdf> (20-12-10), p.15.

⁵⁰ D. Mares, 'Lithium in Bolivia: can resource nationalism deliver for Bolivians and the world?', Emerging market consequences of an emerging U.S. carbon management policy, September 2010, <http://www.rice.edu/energy/publications/docs/Mares%20Lithium%20in%20Bolivia%20Paper%20Secured.pdf> (20-12-10), p.18.

⁵¹ Meridian International Research, 'The trouble with lithium 2: under the microscope', May 2008, http://www.evworld.com/library/WTahil_Lithium_Microscope.pdf (20-12-10), p.11.

construction of a \$250,000 pilot. The other reserve, at Salar de Pastos Grandes, is also located in the province of Potosí.⁵²

In October 2009, the Bolivian government announced that it would invest more than \$350 million in lithium extraction facilities that would start producing in 2013.⁵³ The first step in this process is a \$5.7 million pilot project run by the Bolivian state-owned mining company Comibol, which aims to produce an initial 40 tonnes of lithium per month starting from mid-2011.⁵⁴ This pilot project is expected to generate significant revenues once it is up and running. An estimation by the Centro de Estudios para el Desarrollo Laboral y Agrario (CEDLA) states that the pilot project would generate almost \$2.9 million per year, against going prices of \$6,000 per tonne of lithium.

Obviously, these projections are harder to make for the full investment of the Bolivian government, as full scale production at Salar de Uyuni would greatly increase global supply of lithium, which could have a downward effect on lithium prices. However, this might also be offset by the greater demand for lithium coming from the electric car market.

2.3 Bolivia's alternative model

The realisation of Bolivia's potential role in a new and sustainable economy led to a public debate in Bolivian media outlets about the role of the nation in this new industry. The need to be more than just the suppliers of raw materials has been stressed, and opinion pieces called for the building of a battery manufacturing plant in Bolivia.⁵⁵ An article from 2009 in the New York Times described the debate about lithium as having a clearly nationalistic tone.

The Bolivian government seems to have adopted these proposed positions and is actively attempting to develop an alternative development model.⁵⁶ The new Bolivian constitution, passed in 2009 and which gives significant autonomous rights to indigenous people, also declares that the natural resources of Bolivia belong to its people and must be administered by the state in their shared interest. According to Saúl Villega, head of a Comibol division, 'The previous imperialist model of exploitation of our natural resources will never be repeated in Bolivia'.⁵⁷

In the case of lithium, Bolivia aims to develop the full supply chain on Bolivian soil, including extraction, battery production and even car assembly. The state also aims to have a stake in each of these phases, and is hesitant to hand out mining concessions to foreign companies. Bolivia has received representatives from companies such as Mitsubishi, Sumitomo, Bolloré and various South Korean companies, eager to gain access to its untapped resources. During these talks, Bolivia laid

⁵² EFE, 'Bolivia posee otros dos yacimientos de litio además del Salar de Uyuni', Jornada.net, 15-01-2010 <http://www.jornadanet.com/n.php?a=42313-1> (20-12-10).

⁵³ Jornada, 'Comienza la industrialización del litio en Bolivia', 30-10-2010 <http://www.jornada.unam.mx/2009/10/30/index.php?section=mundo&article=031n1mun> (20-12-10).

⁵⁴ 'La planta piloto de litio en Uyuni comenzará a operar en diciembre con control social', EABolivia, 25-04-2009 <http://www.eabolivia.com/politica/1010-la-planta-piloto-de-litio-en-uyuni-comenzara-a-operar-en-diciembre-con-control-social.html> (20-12-10) & FM Bolivia, 'Planta piloto de litio tiene un avance del 90% y se alista a iniciar su producción', 22-10-10, <http://www.fmbolivia.com.bo/noticia38905-planta-piloto-de-litio-tiene-un-avance-del-90-y-se-alista-a-iniciar-su-produccion.html> (20-12-10).

⁵⁵ C.G. Araoz, 'El litio: un puente al futuro', El diario, 3-3-2009 http://www.eldiario.net/noticias/2009/2009_03/nt090303/1_01opn.php (20-12-10).

⁵⁶ E. Achtenberg, 'Bolivia's Lithium Challenge', NACLA, 12-04-10, <https://nacla.org/node/6510> (20-12-10).

⁵⁷ S. Romero, 'In Bolivia, untapped bounty meets nationalism', New York Times, 3-2-2009, <http://www.nytimes.com/2009/02/03/world/americas/03lithium.html> (20-12-10).

down two demands: the company would have to join a joint venture with the state as a minority partner and the companies would also have to invest in battery manufacturing plants.⁵⁸

Talks between the state-owned companies of South Korea and Bolivia were concluded in the summer of 2010 with a Memorandum of Understanding in which it was agreed that South Korea may participate in the extraction and manufacturing of Bolivian lithium in exchange for its expertise and financial support.⁵⁹ A few months later, Bolivia also signed a similar Memorandum with Iran which also included agreements around the supply of uranium, which were not further specified.⁶⁰ It should be noted that these MoUs can be interpreted as a way for Bolivia to avoid formal commitments, but to keep companies and governments interested.⁶¹

Bolivia recognises that it will need the expertise and resources available in the private sector once it commences the industrialised production of lithium. However, negotiations on the participation of these companies seems to be difficult, which is indicated by the fact that Morales announced that 'no interested company meets our requirements', in October 2010.⁶²

2.4 Domestic tensions

In the 1990s Bolivia came close to granting a 40-year concession to mine lithium at the Salar de Uyuni to the US-based Lithium Corporation (Lithco).⁶³ However, this resulted in heavy protests by the local population. Resistance from social movements in Potosí in the form of 'hunger strikes, road blockades and a general strike with no end' put pressure on the government not to sign the agreement.⁶⁴ As a result of the protests, Lithco had to abandon its concessions and moved to Argentina instead. Afterwards, interest for Bolivia's lithium waned but the question whether future extraction will benefit the people from Potosí is still very much alive. An analysis of Business News Americas in September 2009 showed that one of the hurdles for the development of a lithium industry in Bolivia is that the government needs to have the consent of the local population.⁶⁵

There is a range of conflicts that have already or are currently brewing on different levels and between different actors.

State vs. provinces

In early 2010 Morales outlined his policy for lithium extraction and manufacturing in a new law (Decreto Supremo 444), which declared lithium a strategic resource and extraction was therefore to

⁵⁸ E. Achtenberg, 'Bolivia's Lithium Challenge', NACLA, 12-04-10, <https://nacla.org/node/6510> (20-12-10).

⁵⁹ AFP, 'Corea del Sur y Bolivia acuerdan desarrollar el litio', La Razón, 27-8-2010 <http://www.la-razon.com/version.php?ArticleId=116702&a=1&EditionId=2266> (15-11-10).

⁶⁰ DPA/La Paz, 'Evo Morales quiere trabajar con Irán en litio y plantas nucleares', La Prensa Grafica, 29-10-10, <http://www.laprensagrafica.com/lo-del-dia-edi/148981-evo-morales-quiere-trabajar-con-iran-en-litio-y-plantas-nucleares.html> (20-12-10).

⁶¹ R. Hollender and J. Schultz, 'Bolivia and its lithium: can the 'gold of the 21st century' help lift a nation out of poverty?', Democracy Center, May 2010, <http://www.democracycctr.org/pdf/DClithiumenglishexecutivesummary.pdf> (20-12-10), p.24.

⁶² 'Morales: Ninguna firma interesada en litio cumple exigencias para ser socia', Noticias.com, 21-10-10, <http://www.noticias.com/morales-ninguna-firma-interesada-en-litio-cumple-exigencias-para-ser-socia.728997> (20-12-10).

⁶³ R. Hollender and J. Schultz, 'Bolivia and its lithium: can the 'gold of the 21st century' help lift a nation out of poverty?', Democracy Center, May 2010, <http://www.democracycctr.org/pdf/DClithiumenglishexecutivesummary.pdf> (20-12-10), p.24.

⁶⁴ G. Romy, 'Vuelve el litio', Los Tiempos, 3-3-09, http://www.lostiempos.com/diario/opiniones/columnistas/20090303/vuelve-el-litio_13760_21808.html (20-12-10).

⁶⁵ 'Desarrollo del litio - Un paso adelante, dos atrás', Business News Americas, 31-3-10.

be placed under a Bolivian Evaporative Resources state corporation based in La Paz.⁶⁶ In the weeks that followed the announcement of this decree, the Civic Committee of Potosí (Comcipo) protested because of the location of the headquarters of this new corporation and called for it to be moved to Potosí. Potosians resent being a 'milk cow' for the government in what they see as 'colonized relations'.⁶⁷ The protest was successful, and president Morales revoked the new law.⁶⁸ Comcipo proposed, as an alternative, to set up a body that would be 50% owned by the Bolivian state and 50% by the region of Potosí, and that would be placed under various different ministries, including the Ministry of Mines and the Ministry of Development.⁶⁹

Another protest erupted in August 2010, when former supporters of president Morales voiced their objections to the centralist approach of the Bolivian government. The main cause of the protest was a border dispute with the neighbouring province of Oruro, regarding a region rich in natural resources, while the Comcipo also demanded that an international airport would be built in Potosí.⁷⁰ The committee organised road blocks and other forms of protest for 19 days, after which the governor of Potosí, a supporter of president Morales, reached an agreement with the federal government. Morales promised to develop the international airport, concluded the border dispute in favour of Potosí and agreed to the preservation of Cerro Rico, a mountain with a distinct cone-shape that is endangered by silver-mining activities.⁷¹

The border conflict between Potosí and Oruro could foreshadow the relations between these two provinces in coming years. While the Uyuni desert is located partially in Oruro, the extraction of lithium will only take place at the opposite side in Potosí. Until now, the province of Oruro has not appeared in the central government's plans to develop lithium extraction facilities.⁷² The tensions can be illustrated by the different responses from local media after talks between civic groups of the two provinces; while newspapers from Oruro declared that they had found a compromise on the issue, newspapers from Potosí headlined that they did not give in to 'Oruro blackmail'.⁷³

More recently, the governor of Oruro has also raised concerns that, with the revoking of Decree 444 and the commencement of industrialisation of lithium extraction in Potosí, his state might be left out of the benefits of the lithium extraction at Salar de Uyuni.⁷⁴ This seems to add another dimension to the tensions between the provinces of Potosí and Oruro and the federal government.

Locals vs. multinational companies

Another dimension of conflict that might become relevant for the lithium plans is the distrust and protest of the people of the region around Salar de Uyuni directed at multinational mining companies operating in the region. One conflict dates back to 2007, when Japanese Sumimoto came in to exploit the San Cristóbal silver and zinc mine, and promised electricity, roads and drinking water to the local population. Up to date, these promises have not been fulfilled, and

⁶⁶ 'Gobierno cancela creación de empresa estatal del litio', Business News Americas 23-3-10.

⁶⁷ 'Potosí rechaza el decreto del litio', El Potosí, retrieved from CEDB website, 16-03-10, <http://www.cedib.org/index.php?noticias/potosi-rechaza-el-decreto-del-litio-el-potosi-16/03/2010.html> (20-12-10).

⁶⁸ *ibid.*

⁶⁹ 'Comunidad de Potosí propone empresa mixta para desarrollo de litio', Business News Americas, 30-3-10.

⁷⁰ 'Potosí radicaliza el paro cívico y bloquea vías', El País, 03-08-10.

⁷¹ 'Bolivia-protestas: Acaban protestas en Potosí contra Morales tras 19 días de bloqueos y huelga', Infolatam, 16-08-10.

⁷² 'Explotación de Litio debe ser coordinada entre Potosí, Oruro y Gobierno central', La patria, 06-06-10, <http://www.lapatriaenlinea.com/?nota=30306> (20-12-10).

⁷³ 'Oruro y Potosí al borde del conflicto por el litio del Salar de Uyuni', El País, 19-04-10, <http://www.opinion.com.bo/19/04/2010/oruro-y-potosi-al-borde-del-conflicto-por-el-litio-del-salar-de-uyuni/> (20-12-10).

⁷⁴ 'Oruro debe estar alerta para no perder sus derechos sobre el Salar de Uyuni', La Patria, 04-11-10, <http://www.hidrocarburosbolivia.com/bolivia-mainmenu-117/mineria-siderurgia/37237-oruro-debe-estar-alerta-para-no-perder-sus-derechos-sobre-el-salar-de-uyuni.html> (20-12-10).

instead the local farmers are suffering from the fact that the mine is using up all the water in the region. In March 2010, during the World Conference on Climate Change in Cochabamba, this resulted in protests and road blocks by the local population. Initially the protesters demanded that the company respect the environmental regulations, pay taxes for its water use and provide the promised infrastructure to the surrounding communities. As the protest developed, these demands changed into a call for full nationalisation of the mine, and the ousting of the multinational companies.⁷⁵ The road blocks lasted for 15 days after which the local representatives were invited to a round of talks regarding the functioning of the mine.

It is because of disputes such as the ones with Sumimoto and Lithco that local groups have publicly stated their support for a full nationalisation of lithium extraction, which would be for the benefit of local people as well as Bolivia as a whole.⁷⁶ It also makes clear that these groups are strongly opinionated and will only allow extraction to take place on their terms. Among others, these groups consist of farmers who farm around the borders of the Salar de Uyuni.

Locals vs. provinces

The farmers around the Uyuni have been amongst the most vocal critics of the lithium plans. They are organised in the Federación Regional Única de Trabajadores Campesinos del Altiplano Sud (FRUTCAS). Their main concerns deal with the infliction of the lithium plans into the already existing economy, which is mostly founded on farming and tourism. The evaporation ponds of the lithium production facilities will draw heavily on the already scarce water resources. The farmers, who mostly grow quinoa, a grain-like crop, already face water shortages and fear that this will only get worse.

The tourism industry, which currently employs approximately 60,000 people, is also afraid that it might feel the consequences. The destruction of the natural beauty of the Salar caused by lithium mining operations could have devastating effects for tourism in the region. As lithium extraction is not labour intensive, illustrated by the fact that only 240 people are directly employed in lithium mining in Argentina, there is a clear need for additional benefits to the region.

FRUTCAS even organised counter protests against the protests of Comcipo in August 2010, as it felt the focus was too much on the development of the provincial capital of Potosí. They claim that the Comcipo wants the pilot plant to be constructed near the provincial capital, instead of near the Salar, and call for a distribution of profits along the southwestern regions of the province, rather than focused on the province's capital.⁷⁷

The distribution of future revenues from lithium also continues to be disputed, with the county of Daniel Campos proposing different schemes than Comcipo or FRUTCAS. This country proposes that 40% of the revenue would go to them, while Comcipo proposes a model whereby all local benefits go through the capital of Potosí. At the same time, the federal government has proposed that only 5% of the revenues would go to the provincial level.⁷⁸

⁷⁵ 'Clima: protesta contra empresa minera', ANSA, 19-04-10.

⁷⁶ FRUTCAS, 'El salar no se vende: en defenso de un proyecto 100% estatal', Carta abierta a la opinión pública, 04-03-09, http://www.constituyentesoberana.org/3/pronunciamientos/032009/040309_2.html (20-12-10).

⁷⁷ 'Comienza la pugna por los beneficios que genere el litio', El Potosí, 31-03-10, <http://www.cedib.org/index.php?/marzo-2010/comienza-la-pugna-por-los-beneficios-que-genera-el-litio-el-potosi-31/03/2010.html> (20-12-10).

⁷⁸ 'Comienza la pugna por los beneficios que genere el litio', El Potosí, 31-03-10, <http://www.cedib.org/index.php?/marzo-2010/comienza-la-pugna-por-los-beneficios-que-genera-el-litio-el-potosi-31/03/2010.html> (20-12-10).

Given these groups' proven willingness to protest, it seems that whatever scheme is eventually chosen, this will likely lead to further unrest.

2.5 Environmental challenges

In addition to the social and political tensions that have arisen due to the potential lithium boom, the mining and production of lithium itself can also create great environmental problems. The Democracy Center has written a paper in which it describes the possible effects of large scale lithium production on groundwater, flora and fauna and soil and air pollution.⁷⁹

The Democracy Center describes how both quinoa farmers and llama herders are facing the consequences of a drought that has been ongoing for three years. Current mining operations, for example the San Cristóbal mine, already put a huge drain on the available groundwater, and the future lithium production would only increase the demand for the already scarce sources. While Bolivian officials contend that water use will be minimal for the lithium operations, Democracy Center points out that the 'implications of industrial water use in a region facing such dangerous declines are substantial'.⁸⁰

The depletion of groundwater sources could also have major effects on the flora and fauna that exist in the region. Salar de Uyuni is home to three of the six existing species of flamingos. The delta of the Rio Grande river forms a lagoon that attracts a wide range of other bird species. According to the Democracy Center 'All this could be thrown into environmental disarray by a large scale, water-using industrial project in the region'.⁸¹

The large quantities of chemicals needed in the industrial process of lithium production could also have devastating impacts on the region. Spills and emissions could impact surrounding communities and the ecosystem as a whole. The Democracy Center paper describes how existing lithium facilities in Chile have contaminated all surrounding waters with chemicals.

2.6 International relations

In addition to the domestic tensions and the environmental challenges that are arising from the large reserves of lithium and the potential revenues, Bolivia is also faced with several international tensions and disputes that might result from the lithium boom. Some of these tensions are pre-existing and date back over 100 years ago, but might flare up again because of the lithium interests.

⁷⁹ For a more detailed study of the potential consequences of lithium extraction on the basis of experiences from Argentina, see R. Hollender and J. Schultz, 'Bolivia and its lithium: can the 'gold of the 21st century' help lift a nation out of poverty?', Democracy Center, May 2010, <http://www.democracctr.org/pdf/DClithiumenglishexecutivesummary.pdf> (20-12-10), p.41- 42.

⁸⁰ R. Hollender and J. Schultz, 'Bolivia and its lithium: can the 'gold of the 21st century' help lift a nation out of poverty?', Democracy Center, May 2010, <http://www.democracctr.org/pdf/DClithiumenglishexecutivesummary.pdf> (20-12-10), p.40.

⁸¹ R. Hollender and J. Schultz, 'Bolivia and its lithium: can the 'gold of the 21st century' help lift a nation out of poverty?', Democracy Center, May 2010, <http://www.democracctr.org/pdf/DClithiumenglishexecutivesummary.pdf> (20-12-10), p.41.

Access to Chilean ports

In the 19th century, Bolivia fought Peru and Chile in the so-called War of the Pacific. As a result of this war, Bolivia lost its only access to the ocean, and became a land-locked country. The war is still commemorated in Bolivia on March 23rd, or the 'día del mar', the day that Bolivian and Chilean troops fought for the first time in 1879. This event still carries with it a sense of nationalism and a revival of demands for access to 'their' sea.⁸² Since 1904, Bolivia has relied on concessions from neighbouring countries for access to ocean ports. The 1904 agreement between Bolivia and Chile grants Bolivia the right of free access to the sea and use of Chilean ports. The port of Arica is the main port used by Bolivia and is the access point for 80% of its exports and 60% of imports.⁸³

While Bolivians still vividly remember the war and its consequences, Chileans do not. They take their borders for granted and no longer support the special arrangements to compensate Bolivia for its loss of land. The consequences of this difference became clear in 2004 when the Bolivian government threatened to move to another port because Chile had granted monopoly handling rights to a single operator in the port of Arica. This resulted in a price hike of 250%.⁸⁴ While the Bolivian protests did help to reduce the increase at that time, the problem resurfaced in 2007 when tariffs were imposed on Bolivian traders by a private goods handler.⁸⁵

In October 2009, a related incident took place when Chilean truck drivers blocked access to the Arica port, demanding that the Bolivian monopoly on the transportation of goods from and to Bolivia should end. The lack of supervision over this treaty made it possible for Bolivian truck drivers to also transport goods to places within Chile, thus giving them a comparative advantage over Chilean truck drivers.⁸⁶ The trucker protests were supported by Chilean police. From a Bolivian standpoint this was a major violation of the treaty of 1904, while Chileans referred to a Latin American treaty for international transport.⁸⁷

It took a week for regional officials to resolve the conflict by enforcing the rules and directing the issue of the international treaties to a bilateral working group.⁸⁸ However, some months later Bolivian truck drivers protested against discrimination by Chilean custom officials at the border town of Chungara. They had to wait in line for days while busses with tourists or traders could pass immediately.⁸⁹

International media have already speculated that the increasing interest in lithium might resurrect the conflict over access to the sea, and could lead to a new War of the Pacific. An article in Foreign Policy states: 'Bolivia's lack of coastline could become an issue again if the two lithium powerhouses start jostling to attract investors. Competition between Bolivian and Chilean lithium

⁸² 'Grita milicia boliviana en el Día del Mar: ¡venceremos!', FM Bolivia, 23-03-10, <http://www.fmbolivia.com.bo/noticia24801-grita-milicia-boliviana-en-el-dia-del-mar-venceremos.html> (20-12-10).

⁸³ 'Transporte pesado denuncia intención de vulnerar Tratado con Chile de 1904', Jornadanet.com, 21-10-09, <http://www.jornadanet.com/Hemeroteca/n.php?a=38792-1&f=20091021> (20-12-10).

⁸⁴ 'Árica y carga boliviana', Estrella iquique, 15-10-2004 & 'Mar para Bolivia', Youtube, 24-03-07, <http://www.youtube.com/watch?v=EgftGLRHbEs> (20-12-10).

⁸⁵ 'Tensión entre Bolivia y Chile por los aranceles en Arica', los Tiempos, 16-03-07.

⁸⁶ 'Camioneros levantan bloqueo; daños suman \$us 48 millones', Los Tiempos, 24-10-09.

⁸⁷ 'Transportistas chilenos bloquean ingreso de carga boliviana a Arica', eju! Website, 23-10-09, <http://eju.tv/2009/10/transportistas-chilenos-bloquean-ingreso-de-carga-boliviana-a-arica/> (20-12-10).

⁸⁸ 'Transportistas chilenos bloquean ingreso de carga boliviana a Arica', eju! Website, 23-10-09, <http://eju.tv/2009/10/transportistas-chilenos-bloquean-ingreso-de-carga-boliviana-a-arica/> (20-12-10).

⁸⁹ 'Transporte pesado denuncia intención de vulnerar Tratado con Chile de 1904', Jornadanet.com, 21-10-09, <http://www.jornadanet.com/Hemeroteca/n.php?a=38792-1&f=20091021> (20-12-10).

mines and, potentially, over domestic production of lithium batteries could very well bring about a second War of the Pacific'.⁹⁰

Warm relations

Relations between Peru, Chile and Bolivia remain unstable, mostly due to the changing political colour of their respective presidents and various long standing disputes. For example, Peru and Chile are facing each other in a court case at the Court of Justice in The Hague because Peru is challenging the maritime territorial boundary with Chile, which mostly has an effect on fishing rights.⁹¹ At other times, however, relations between the countries are better. In October 2010, leaders of Peru and Bolivia agreed that Bolivia could now also own property in the Peruvian harbour city of Ilo, in the south of Peru. Free access to the Peruvian coastline was already granted in 1992 but has not yet been used as this would require better infrastructure.⁹² Peruvian politicians hope that free access for Bolivia will help boost local development. Public opinion towards neighbouring countries can be heart warming at times as well. When Morales visited Santiago last year, a manifestation of Chilean people demanded 'mar para Bolivia' (sea for Bolivia) in support of his efforts to convince Chile to concede land that gives access to the ocean.⁹³

There are also plans to improve the infrastructure needed for export of raw materials or manufactured products such as batteries. A lot of options are being considered, including highways, canals and railroads to connect Bolivia to either the Pacific or the Atlantic Ocean. Bolivia is investing \$750 million in an 'interoceanic corridor' linking the harbours of Puerto de Santos in Brazil with Arica, Chile through the southern provinces of Bolivia.⁹⁴ Chile has committed itself to investing in reconstruction of the railroads between Arica to La Paz making it ready for the transport of goods from and to the port.⁹⁵ Some of these ideas could be dependent on Bolivia's plans to industrialise the production of lithium.

2.7 Conclusions

The following conclusions can be drawn on the basis of this case study;

- The lack of infrastructure and technical capabilities of the Bolivian government might prove to be too big a hurdle to overcome. The current interest in electric vehicles is likely to spike demand of lithium at a certain point, but it is unclear whether Bolivia will be able to produce in time to benefit from this spike. In that sense, Bolivia can be compared to a junior mining company, which has large known reserves, but still faces a long road before production can take place and a lot of uncertainties regarding the future benefits. One factor to consider is that lithium is not the fuel of the car, as oil is, but a raw material for one of its components. This means that lithium could be recycled at end-of-life of the vehicle, which might put a hamper on the global demand for newly mined lithium in the long term. Another factor that will come into play is market competition. Competitors, such as SQM in Chile, are known to manipulate prices in such a way that it discourages others to mine for lithium. For example,

⁹⁰ D.J. Rothkopf, 'Is a green world a safer world? Not necessarily: a guide to the green geopolitical crises yet to come', Foreign Policy, 01-09-09.

⁹¹ The Hague Justice Portal, 'Maritime Dispute (Peru v. Chile)', initiated on 16-01-08, <http://www.haguejusticeportal.net/eCache/DEF/9/091.html> (20-12-10).

⁹² 'Bolivia krijgt haven in Peru', NRC, 20-10-10, http://vorige.nrc.nl/buitenland/article2633694.ece/Bolivia_krijgt_haven_in_Peru (20-12-10).

⁹³ 'Los errores pueden ser corregidos', Domingo Loza Mujica, december 2009.

⁹⁴ 'Presidentes de Bolivia, Brasil y Chile inaugurarán vía interoceánica', Xinhua News Agency 5-8-10.

⁹⁵ 'Chile-Bolivia: Tramo chileno de tren Arica-La Paz, reparado', ANSA, 30-04-10.

SQM announced a price cut of 20% for its lithium, shortly after Bolivia had announced its plans for industrialised lithium production. It is not unlikely that Bolivia's competitor will adopt similar strategies once Bolivia's production is really expected to go up.

- The alternative model that Bolivia is pursuing with its lithium – nationalising the extraction and developing domestic production of battery cells – is already under pressure from multinational companies and other parties, and this will likely increase in the future. There is a group of companies that is very interested in taking part in the extraction of lithium, but is very reluctant to meet the demands of the Bolivian government. It seems that even within the Bolivian government, there are forces that call for greater involvement of international companies. It remains to be seen whether the Morales government is able to see through its plans to the end. Companies involved in talks with the Bolivian government should refrain from improper corporate lobbying or other improper ways of influencing such sovereign decision making processes.
- The decisions regarding the extraction and industrialisation of lithium are sure to impact people in the region as has been the case in previous mining projects. Large-scale extraction requires a lot of water and this could have severe implications for farmers in the region. Any negative consequences are sure to result in protests as farmers have shown to be organised over the last years. If people do not see they benefit from the exploitation of natural resources in their region they will hold the government accountable, as has been the case with San Cristóbal. Companies and governments involved throughout the electric car supply chain should look closely into these developments, and should also weigh in the potential costs that their decisions might have on the people and environment around Salar de Uyuni.
- While overall relations with its neighbouring countries are generally warm and welcoming, this might change when the stakes are raised because of the lithium boom. It remains to be seen how much longer Chile is willing to respect an agreement, which is over a hundred years old, if it benefits its major competitor on the lithium market. While this is nothing more than speculation at the moment, the lithium game could have significant impacts on Bolivia's relations with its neighbouring countries. Again, this is a factor that needs to be taken into account by all players throughout the supply chain.

3 Case study: Battery manufacturing in China

The second case study in this report deals with a company that is active in the production phase of the electric car supply chain. This chapter describes the working conditions for employees of Build Your Dreams (BYD), the Chinese battery and car manufacturer.

This chapter is a general summary of findings from workers' interviews conducted by the Hong Kong based organisation Globalization Monitor. The field studies by Globalization Monitor were part of a larger research into battery production factories in China, which is published separately. Most of this chapter is based on information provided by employees of BYD, and this information is complemented with desk study into media and other reports about the factory and its conditions.

Workers were interviewed at three different facilities of BYD in Shenzhen in China; Pingshan (Headquarters), Baolong, and Kuichong. In addition to being the company's headquarters, the Pingshan facility is also a car manufacturing facility. The Baolong and Kuichong facilities produce batteries for consumer electronics, mostly mobile phones.

It should be noted that while BYD is one of the players that is presenting itself as a key player in the electric car market, it does not produce electric cars or batteries on a large scale yet. The findings described in this sector should therefore be interpreted as indications of BYD's overall handling of its employees, i.e. also in its other business segments, rather than evidence related specifically to the conditions of producing electric car batteries. However, the findings in this chapter do indicate that there are other concerns, besides the environmental benefits of the electric car, that need to be considered in this new industry.

Figure 4: Map of Shenzhen



Figure 5: Map of the investigated BYD production facilities



3.1 General corporate info

Build Your Dreams is a Chinese battery manufacturing company, listed at the Hong Kong stock exchange, and the company focuses on the electronics and automotive industry. It also recently created a New Energy division, which focuses on solar and other renewable energy generation technologies.⁹⁶ It is primarily a battery manufacturer, that produces rechargeable batteries for portable electronics, such as mobile phones and laptops, but also produces other mobile phone components and does assembly work.

According to the BYD's annual report in 2009⁹⁷, the sales volume of their products reached 34.5 billion Yuan (€ 3.9 billion), and the total income was 39.4 billion Yuan (€ 4.5 billion), which was already six times higher than in 2005.

BYD has been active in the automotive industry since 2003. It produces both regular gasoline fuelled cars, such as its F3 model, as well as hybrid and fully electric vehicles. The company's hybrid car, the F3DM, has been available on the Chinese market for almost two years, and around 300 units have been sold.⁹⁸

In January 2008, BYD made a good impression at the Detroit Auto Show, where it showcased its F3DM hybrid car. Partially in follow-up of BYD's performance at the auto show, billionaire investor Warren Buffett invested \$231 million (€ 160 million⁹⁹) for a 10% stake in the company in late 2008.¹⁰⁰ This gave the company world wide recognition.

⁹⁶ BYD Auto, Brochure, 'BYD AUTO; Guild your dreams', no date, <http://www.byd.com/downloads/broucher/1.pdf> (20-12-10).

⁹⁷ BYD IT, 'Annual Report', 2009, <http://bydit.com/docc/investor/periodicalReports/annualReport/annualReport2009/> (20-12-10).

⁹⁸ A. Zheng, 'Private purchase of BYD e6 delayed due to insufficient infrastructure', Gasgoo website, Automotive News, 04-11-10, <http://autonews.gasgoo.com/china-news/private-purchase-of-byd-e6-delayed-due-to-insuffic-101104.shtml> (20-12-10).

⁹⁹ Calculated on the basis of historical exchange rates, <http://www.oanda.com/currency/historical-rates>.

The electric model, e6, has not been released to the public yet, despite various previously announced release dates. BYD blames these delays on the lack of charging infrastructure in China. This is one of the reasons why the mass production of electric vehicles has also not yet taken off.

Mr. Wang Chuan Fu, the CEO of BYD has been openly lobbying for government subsidies for electric car manufacturing so as to lower the manufacturing cost and retail price of electric cars. For example, BYD made 30 electric-power taxis for Shenzhen, whose retail price is as expensive as 300,000 Yuan. Both the central government and the Shenzhen governments provide subsidies to taxi drivers, amounting to 120,000 Yuan.¹⁰¹

Copycat business model

BYD's business model has been described as a 'copycat'.¹⁰² BYD spends huge sums of money every year to dismantle the latest model of rival manufacturers. Through a process of 'reversed engineering', the company then copies the production techniques to produce its own products. For example, BYD's best selling F3 model is almost a perfect copy of the Toyota Corolla car. This had led to BYD being described as an 'unwelcome buyer', who places one or two large orders at a supplier – e.g. a company supplying molding machines – after which the orders stop because BYD has produced its own equipment.



3.2 Working conditions

The same article also described how BYD's business model is dependent on hard manual labour rather than well-developed technical facilities. The company usually chooses manual labour over

¹⁰⁰ 'Buffett Backs China Green-Auto Venture', Redorbit website, 30-09-08,

http://www.redorbit.com/news/business/1573012/buffett_backs_china_greenauto_venture/ (20-12-10).

¹⁰¹ Interview with a taxi driver, October 2010 & 'Electric cabs put into use in Shenzhen street', China Daily, 24-05-10,

<http://www.whatsonxiamen.com/news12348.html> (20-12-10).

¹⁰² L. Dongmei, Y. Binbin, F. Yanyan and W. Duan, 'How Manufacturing's Mockingbird Sings', Caixin online, 10-02-10, <http://english.caing.com/englishNews.jsp?id=100117245&time=2010-02-10&cl=111&page=all> (20-12-10).

machines, and only supplements manual labour when absolutely necessary, mostly out of cost considerations. The company often hires both the manual labourers as well as the engineers in batches, and it often hires complete graduated university classes of engineers at the same time to meet its demand for skilled workers.

This business model has already led to controversy at some of its facilities. In India, where BYD has a large electronics battery manufacturing plant, 3,000 workers held a strike in October 2010 to demand higher wages and more job security. In response to the strike, the BYD management 'terminated the services of 2,500 contract workers, sacked 37 permanent workers, suspended 23 more and ordered 437 others to sign a letter of apology to keep their jobs'.¹⁰³ The International Metal Federation, and the international union LabourStart have denounced these actions and are calling on local Indian government to protect the rights of the BYD workers.

Salary

The workers interviewed by Globalization Monitor in Shenzhen indicated that they receive a monthly salary between 1,100 Yuan (€126) – which is the legal minimum wage in the region - and 1,800 (€206). In addition, the workers could be entitled to performance bonuses, up to a reported 500 Yuan (€57). These salaries are dependent on the amount of overtime that the workers work as well as production targets.

Official Chinese government statistics indicate that the average salary in Shenzhen is 4,263 Yuan (€497).¹⁰⁴ Shenzhen has also suffered from high rates of inflation over the last years, with an annual average of 2.5% between 2005 and 2009.¹⁰⁵ This illustrates the difficulties that workers face to sustain themselves with the salary that BYD pays them in a city like Shenzhen.

Another problem is that the workers depend on the overtime work, and the additional pay that comes with it, in order to sustain themselves. However, overtime is not always required. For example, BYD slowed down production at the Pingshan factory in September 2010, when sales were down and stockpiles went up.

In one of the factories, workers were not informed how their salary was calculated, and were explicitly forbidden to discuss their salary levels with their co-workers.

Working hours

In all three factories, workers were required to work overtime, often as much as three to four hours per day, six days per week. When production targets are high, the eight hour shifts are changed into twelve hour shifts. Workers also often have to work at the weekends, leaving them with only two to four rest days per month.

Many of the workers have difficulties with these long working hours, which is also indicated by the fact that many choose to quit their job while still in their 3-month probation period. A difference seems to exist between the new, younger workers, who have more trouble adapting to these long regimes, and the older workers who are more accustomed to it.

¹⁰³ International Metalworkers' Federation, 'BYD Electronics in Chennai resorts to mass dismissals', 02-11-10, <http://imfmetal.org/index.cfm?c=24562&l=2> (20-12-10).

¹⁰⁴ <http://www.51labour.com/html/145/145245.html> (in Chinese)

¹⁰⁵ Compiled through <http://www.szti.com/main/xxgk/tjsi/tjgb/gmijhshfzgb/> (in Chinese)

Workers are assigned to work overtime by the employer, and are punished with salary deductions when they refuse to work overtime. If the workers choose not to work overtime, they need to apply for leave and the factory has to give its consent. Not applying for leave will result in salary deductions of up to 100 Yuan (€12) per day.

These practices are violations of the Chinese Labour Contract Law, which came into effect in 2008. This law stipulates that overtime hours may not exceed 36 hours per month. BYD's working regime often requires workers to work more overtime hours. Another violation is the fact that overtime work is mandatory. According to the Chinese Labour Contract Law, all forms of forced overtime work, including the deduction of salary when workers refuse overtime, are illegal.

Freedom of association

An underlying cause for the abovementioned issues is the lack of association and collective bargaining; a common issue at Chinese factories. None of the interviewed workers in either one of the three factories was aware of a functioning trade union at their factory, and none had ever turned to a trade union to solve labour disputes.

Occupational health and safety

All workers have to undergo a pre-enrolment health check, in accordance with the Chinese Occupational Disease Prevention Law. When job applicants are found to be infected with the Hepatitis B pathogen, they are refused employment. This is a violation of the Chinese Law for Employment Promotion, as well as the Regulations for Employment Services and Management, which both state that employers do not have the right to refuse an applicant on these grounds. Hepatitis B-pathogen carriers do not easily infect others, and refusing to hire on these grounds can therefore be considered as direct discrimination of Hepatitis B infected people.

While workers do receive on-site occupational training sessions that deal with the overall job tasks and responsibilities, these do not include health training regarding the handling of chemicals used in the production of batteries. The interviewed workers could not name the chemicals they are in contact with at the factory, and were not aware of the potential health risks involved.

Child labour and age discrimination

At two of the factories, BYD has an age restriction in place and does not, or is less likely to, hire employees over the age of 35. Only when there is an urgent need for new employees, for example when production targets are high or staff numbers are low, are these restrictions lifted. One of the factories hires workers between the ages of 16 and 40. While it is not illegal to hire minors between the ages of 16 and 18, they should be assigned to less strenuous and less dangerous tasks. Other than that, these workers are entitled to the same working conditions and salary schemes. This research showed no indications that BYD is violating these rules.

Social insurance

BYD has a positive record with regards to the social insurance it pays for its employees. At the Pingshan facility, workers indicate that the company allocates 100 Yuan (€12) of the workers' monthly salaries to social insurance schemes. While this contribution to social insurance is mandated by Chinese law, the company still seems to see this as a competitive advantage when recruiting workers, as it specifically mentions this fact in its job advertisements.

Maternity leave

The company is also quite flexible with regards to pregnant workers. Female workers who are pregnant are assigned easier tasks and are not required to accept overtime work. They are also given a three-month maternity leave after which they are able to return to their original positions.

Accommodation and meals

The company provides accommodation and meals for its workers at all three plants, but the evaluation of these services from the workers differ significantly between the factories. At the Baolong plant, workers are satisfied with their accommodation and meals, and indicate that there are no strict rules to abide by, and no real problems. At the Pingshan facility, the company provides accommodation that is five to seven times cheaper than similar housing outside of the factory compound and as a result almost all the workers choose to live at the factory accommodation. There are curfews in place as well as additional costs for water and electricity dependant on actual use. Workers at this factory share a dormitory with five to seven other workers.

At the Kuichong plant, workers have complained about the conditions at the factory accommodation. Here, ten workers share a dormitory on average and the interviewed workers have complained about the dirtiness of these facilities, as well as the high theft rate. One worker indicated that his mobile phone was stolen from the dormitory, as well as his blanket.

Staff turnover and job satisfaction

One strong indication of the working conditions, and how satisfied workers are with them, is the staff turnover at the factories. At the Pingshan facility, staff turnover is relatively low as most of the workers are college graduates who expect to learn professional skills and technology. Another factor is that the auto industry is regarded as a high end industry that provides a bright future for them. Finally, some of the interviewed workers have admitted that their lack of social capital also inhibits them from changing jobs.

At the two other facilities, staff turnover is higher. At the Kuichong factory, the heavy work burden and long working hours are the main driver for this high staff turnover. One contextual factor that explains why workers are able to quit their jobs relatively easily is that this facility hires mostly young workers who were born after 1990. These workers are likely to come from one child families, and are therefore less of an economic burden to their families during periods when they do not have employment.

At the same facility, mention was made of a small strike that the workers held to call for better working conditions. Those involved in the strike met with management, but their demands were not met. After the meeting, the strikers recognised that they were not likely to succeed in their struggle against the company, and decided to terminate the strike and go back to work.

3.3 Recommendations and conclusion

On the basis of the workers' interviews, Globalization Monitor formulated the following recommendations towards the company. These recommendations should also be taken into account by business partners of BYD when implementing their supply chain responsibility policies, and by BYD's investors when making Socially Responsible Investment decisions.

The following illegal measures should be rectified immediately:

1. Reduce over-time hours: overtime work must be reduced to 36 hours a month or less, even if the overtime pay is higher than the law's requirement.
2. Trade Union: the company must establish a trade union, which must be organised according to the Law of Trade Union. The workers must be informed and given the chance to participate in the formation of a trade union. In addition, the preparation and election for the trade unions should be transparent.
3. Hepatitis B-pathogen carriers: the employer should not reject job applicants for being a Hepatitis B-pathogen carrier.
4. Overtime work arrangement: the employer cannot force overtime work. This should be negotiated between the trade union and the employer. Forced overtime work, which leads to salary deduction and job termination when refused, is illegal.

Apart from these, the company should also improve the following unsatisfactory conditions, even if these are not direct violations of the law:

5. Raise the level of salary: China's very low minimum wage is under criticism. BYD should consider raising the level of salary given the high level of inflation rate in Shenzhen.
6. Clarify salary calculation: the company management has the responsibility to clearly explain how they calculate the salary, and clearly specify the pay items, namely basic wage, overtime pay and other rewards, on the wage slips
7. Job assignment: the employees should be given a chance to choose their job nature.
8. Remove age restriction: the plants should remove the age limitation on hiring workers over 40, not only during the time of labour shortage.
9. Workers' rules: workers should be given the chance to raise arbitration through a grievances mechanism when being involved in any violation of rules, instead of being dismissed immediately.
10. Improve training: in many cases, the training, which may only last for a day, only covers the job operation and basic safety. This is not enough, and cannot protect the workers on its own. It should also include Labour Contract Law and the potential health hazards of their jobs. All the workers should be informed of occupational health and safety issues as well as preventive measures.
11. Pay for pre-job health examination and the annual body check up: BYD should pay the job applicants for the health examination, and all their employees for the annual body check up, which is required by the law. In addition, the workers should be informed about the results without delay.
12. Improve the accommodation environment: the company should reduce the number of workers in a room, and improve the cleaning services work and security inside the dormitory.
13. For external inspectors: all the BYD plants are subject to regular inspection by external institutions. But it seems only the products are inspected, while the working conditions are not. The inclusion of frontline workers' job satisfaction in their assessment would help improve the process and therefore the quality of the products and working conditions.
14. Child labour: BYD should not hire any workers under the age of 18 for the posts that may be exposed to hazardous chemicals. Even though BYD may not assign work that directly exposes minors to occupational health hazards, the work environment may already be contaminated with hazardous materials and could cause permanent health damage to those young workers.

Conclusions

This report shows that the environmental impact of the use of electric cars is but one of several sustainability impacts, especially when the full supply chain is taken into account. The findings described in this report complement previous findings of bad working conditions at production facilities in China, for example at electronic component manufacturers, and the conditions around mines where the needed minerals are sourced, for example cobalt mines in the Democratic Republic of Congo (DRC). These findings are signs of a troubling reality that includes grave damage done to people and the environment in the supply chain. All these issues need to be taken into account to be able to have a fruitful discussion about the costs and benefits of electric cars.

On the basis of the mapping exercise and the two case studies, the following general conclusions can be drawn:

- The electric car is on the rise, and the fact that every large automotive company has developed, or is currently developing, electric models, is a sign that this trend is irreversible. While many factors for the success of the electric car are still uncertain, it is unlikely that those that shape the market – companies, regulators, governments – will change their course. The fact that the development of the electric car is taking place on multiple continents is also a sign that this is more than a niche trend.
- As the electric car market is still very much under development, the supply chain still needs to mature. This means that current players might be outcompeted in the future, while new actors will appear. It also means that it is currently too early to draw solid conclusions on the nature of the electric car supply chain and its eventual formation.
- It is clear, however, that the sustainability of the electric car goes beyond the environmental benefits during the use of the car. Most of the debates about the electric cars, however, limit themselves to that single element. The limited scope of the debate does not do justice to all the elements that need to be considered before electric cars are to be seen as more sustainable alternatives for gas-fuelled cars.
- Issues such as working conditions of labourers that produce electric car batteries, or the environmental and social impacts of large industrial mining of lithium and other natural resources, need to be taken into account as well.

This paper has attempted to gain insight into the social and environmental effects of the growing demand for electric cars. On the basis of the mapping exercise and the two case studies, the following effects are identified:

- The development and the production of electric car batteries in China follow a classic labour-intensive model. Contrary to other regions, such as the United States, the Chinese actors make use of less technology and rely more on cheap manual labour. The case study at BYD has uncovered a number of violations of national and international labour standards, while it should also be noted some other critical issues are handled properly. However, it can be argued that this labour-intensive model is very vulnerable to, and possibly even a structural cause of, labour violations.
- The sudden surge in interest for lithium as a raw material for electric car batteries is having large consequences for the political and social landscape of Bolivia. The pursuit of alternative economic models, the relations between local, regional and national representatives and Bolivia's relations with neighbouring countries are all impacted by the

presence of large reserves of lithium. Many of these developments still need to be played out, and it is too early to say what the exact effects are. However, previous rushes for specific natural resources in other regions of the world, such as for gold or coltan, have exposed the potential danger of social and political unrest, or even civil war.

There is a clear need for continuous monitoring and future research into the developments of the supply chain of electric cars. An overarching approach to sustainability, that includes consideration for the social, labour and environmental effects throughout the supply chain, needs to be a determining factor in companies' business strategies, governments' choices regarding subsidies and other benefits for the electric car, and consumers' choices in purchasing their next car.