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FOCUS CHILE

Lessons learnt from the long country at the other end of the world



Introduction: Chile's relevance for climate transition

Why Chile as a focus country?

We have been asked this question much more often than when we had China, California or France in the past. Part of the answer lies in the question itself; it is important to supplement one's knowledge of the most discussed and obvious players in the transport sector's transition with what is happening in the less central or dominant markets. But in addition, not least from a Swedish perspective, there is a number of specific reasons to examine Chile's transition more closely and to deepen the exchange of knowledge between the two countries and the markets:

- Similar base industry. Both Chile's and Sweden's economy are strongly founded in the mining industry and the forest, with an increasingly strong complement in the IT sector.
- Similar geographical conditions: Sweden certainly lacks Chile's deserts, but otherwise it's very similar, with large forests, mountains and a long coastline.
- Significant exchange, with about 40,000 Chileans living in Sweden and strong business relations between the countries.

More importantly, what Chile as a country has now set itself up for in the field of climate change and in some areas is already in the process of implementing:

- Leading the electrification of public transport buses (except China), with spill-over effects to other Latin American countries and experiences relevant to the whole world.
- The world's largest lithium assets, with high sustainability ambitions in mining and a strong focus on creating added value from processing in the country.
- Hydrogen as a fuel for long-distance freight transport, with an allocation of hydrogen between the vehicles that is more well thought out than that of many other countries.
- One of the world's fastest increases in cycling's share of transport, especially in big cities and linked to a democratic participation process.
- The first developing country with the goal of becoming climate neutral in 2050, and a climate law currently being formulated in the senate.

More broadly, Chile is of relevance to many other countries with

- One of the world's fastest changes to renewable energy, with a focus on solar and wind.
- One of the first developing countries to introduce a carbon tax, which is now being discussed whether it should be raised and developed.

- One of the world's first countries to adopt the goal of climate neutrality for 2050, which is expressed in concrete climate law.

In addition, it is interesting to see how this transition and these initiatives have taken place under a paradigm that strongly emphasizes market economy, with very limited economic stimulus and a focus on finding instruments other than government-funded premiums and bonuses to achieve the climate-related objectives.

Finally, of course, we also learn from each other's challenges and problems. It is well known that the Chilean Government felt obliged, in the end, not to hold the COP25 climate summit on the ground in Santiago. The move to Madrid came after strong protests against perceived social injustices, with an announced increase in the price of metro tickets as a direct trigger. Several adjustments have already been made and a new constitution is to be developed, of direct relevance not only to Chile and its people, but to all those interested in the importance of the justice perspective in the climate transition.

Previous years' focus countries have always resulted in deeper collaborations, increased knowledge exchanges and, by extension, better opportunities to achieve the goals Sweden and the world around us have set regarding the transport sector's transition. With Chile as the focus country, the conditions are better than ever. We look forward to what it can lead to and will continue to try to be helpful in the process.

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Chile's climate targets: Climate neutral by 2050

As one of the world's first countries, and the first developing country in the world, Chile has both adopted a concrete target of net zero in national climate impact and a national climate law. This is partly because the effects of a changing climate are already so clearly seen in the country and threaten large parts of the country's basic industries.

Chile is particularly adversely affected by climate change, partly because the central parts of the country in particular depend on the glaciers for their drinking water. The forest industry is threatened by pests and increasing fires, and large export goods such as copper, wine, fruit and vegetables require a lot of water for their production. Overall, Chile ranks tenth among the world's countries in The Climate Risk Index of German Watch in terms of how much it is affected by a changing climate, and sixth in terms of its economic impact. The Chilean Senate sets temperature increases of 2-4 degrees within this century, melting glaciers and sharply changing precipitation patterns as some of the impact climate change has on Chile.

The Chilean business organization *Acción Empresa* also states that the changes in the economy could hit the country's economy hard. They point to the mining industry as particularly vulnerable, linked to a more uncertain future water supply. Chile's copper mines are by far the country's largest consumer of water, and copper is the country's largest export commodity, contributing to a national awareness of the importance of climate issues. ¹Water supplies can also be too good, with torrential rains making operations more difficult. According to the mining industry's industry body *Sonami*, heavy rainfall in the desert has already meant that operations have had to be stopped and could in the future mean a large-scale transition from open mines to underground mining.²

The major climate-driven changes that Chile is at risk of suffering and which are already beginning to be felt are part of why they as the first developing country in the world have adopted the goal of becoming climate neutral. This will take place by 2050, five years after Sweden will reach the same goal. The decision was taken before Chile's presidency of COP25, where Chile was also pushing for other countries to adopt similar targets. It paid off. Some 100 countries have adopted net-zero targets, designed in different ways but in many cases as a direct result of Chile's work.

Chile's *nationally determined contribution* under the Paris Agreement states that the country's climate impact will peak by 2027, and then decrease. Considering today's situation, it seems to be possible earlier, largely because the transition to renewable energy has picked up such momentum. In addition, the new climate agreement states

¹ Action Companies: Companies And Change Climate in Chile: The Way Towards A Adaptation Sustainable, 2019

² Personal conversation with Sustainability Manager Carlos Gajardo Roberts, 2019-12-03

that the climate impact between 1990 and 2030 will be reduced by 30%, which is considered to be in line with the Paris Agreement's temperature target, as the entire reduction will take place domestically.³ Including internationally co-financed measures, the emission reduction target is 45%.

The goal of Chile being climate neutral by 2050 has been discussed relatively frequently in Chile ahead of the decision in parliament and the Senate. Among other things, it has been preceded by regional consultations, and a special observatory for the case has been set up under the auspices of the Universidad de Chile, with design guidelines.⁴ Domestic environmental organizations have been pushing for increased ambition, for example, the Chilean FIMA estimates that emissions should peak as early as this year (2020) and be halved by 2030.⁵ This is expected to happen by, among other measures, shutting down all coal-fired power plants by the same year. Civil society presented in December 2019, a national climate roadmap for Chile, on the initiative and mandate of the Ministry of Education. The plan contains concrete proposals in a number of areas, including a strengthened urban planning instrument based on the principles of sustainable development. A specific law on sustainable transport is proposed, with a focus on replacing passenger cars with public transport and cycling.⁶ In addition, Chilean ex-President Ricardo Lagos has led the Voces Ciudadanas process, which involved 117,000 Chileans and produced 15,000 proposals, compiled in the CambiaClima report.

Industry has both embraced and questioned Chile's ambitious climate goals. The CPC, the Confederación de la Producción y el Comercio, roughly the Chilean Chamber of Commerce, wrote during the popular protests to the Ministry of the Environment that climate goals needed to be reviewed because stricter social requirements meant that available resources for climate work were reduced. It received a sharply negative response and a couple of weeks later, in connection with COP25, CPC together with four other business organizations fully supported the government's climate goals "arising in response to the scientific evidence".

Has the business community simply come to realize the benefits of an active and leading climate policy? Carlos Firat, CEO of Acera, who is coordinating the transition to renewable energy, does not believe this. "The major business organizations must confess colour. Do they want to wait for others to deal with the problem and turn a blind eye to the damage that climate change is already causing? Or do they want to be part of the necessary transition that benefits both Chile today and our grandchildren?"

³ Climate Action Tracker, 2019. Chile. Available: <https://climateactiontracker.org/countries/chile/>
Hämtdatum: 2019-09-10

⁴ <http://leycambioclimatico.cl/policy-brief-reformas-legales-para-alcanzar-la-carbono-neutralidad-al-ano-2050/>

⁵ <https://www.atlanticcouncil.org/blogs/energysource/make-way-for-chile-latin-americas-next-climate-frontrunner/>

⁶ The Mercury: About Dos Wheels, 2019-12-21

At this point (May 2020), the Chilean Senate is considering the draft climate law ⁷, with a decision likely to be made before the end of the year. ⁸ In addition to the final year, the law contains processes for deciding on interim targets for 2030 and 2040 and sectoral climate budgets, as well as a process for the development of regional climate plans. Climate adaptation processes are developed by sector, e.g. for biodiversity, infrastructure, mining, the energy sector and the health sector. A special Council of Ministers on Climate Change is set up, chaired by the Ministry of the Environment, and a special fund to support citizens' initiatives in the field of climate change is set up. Every four years, the overall climate work will be evaluated in a government-run RANCC (Reporte de Acción Nacional de Cambio Climático). Separately from this, an independent scientific council is established with nine experts to assess the overall climate work, in line with the Swedish Climate Policy Council.



Solar park in the Atacama Desert, an important part of Chile's transition to renewable electricity and climate neutrality

⁷ See the bill here <https://www.camara.cl/verDoc.aspx?prmID=13510&prmTIPO=INICIATIVA>

⁸ Follow the process here

<https://www.camara.cl/legislacion/ProyectosDeLey/tramitacion.aspx?prmID=13728&prmBoletin=13191-12>

Chile's electricity mix: greener at a fast pace

Updated June 2020

A key element of Chile's climate goals is the transition to renewable energy, which is also central to how green electric vehicles can be considered to be. Solar and wind are at the forefront of the so clearly market-driven context that Chile's economy represents. Together with a timed out-phasing of coal, the goal of climate neutrality by 2050 will be achieved. And in some areas Chile is already exceeding its milestones.

In addition to its climate targets, Chile has set a number of targets for the electricity and energy sectors:

2025: 20% renewable in the electricity mix. This was achieved by the end of 2019.⁹

2030: 75% renewable in the electricity mix, according to plan.

2040: All fossil energy sources should be decommissioned; electricity should be completely green.

Chile imports fossil fuels annually for USD 8 billion and has very limited fossil resources of its own. 99 percent of fuels used in transport are imported fossil fuels, and the transport sector stands for 24 percent of the country's greenhouse gas emissions¹⁰. At the same time, the country has the potential to more than fiftyfold the production of renewable energy, which the policy in broad agreement wants to implement. One reason is that Chile has previously failed to secure energy supplies in other ways. Chile had a serious energy crisis around 2008, when it dropped natural gas imports from neighboring countries and at the same time was hit by drought, which hit hydropower, which accounted for half of its electricity mix. In addition, several large planned dam projects were halted for environmental reasons, which together led to a severe electricity shortage and a real risk of blackout. The record high electricity prices also meant popular protests.

In order to resolve the situation, the option of investing in nuclear power or increased transmission capacity from neighbouring countries was discussed; both time-consuming and expensive. Then, from 2014, a new era of Chilean energy policy began with a focus on the transition to renewables. Chile was early on with a system of "reverse auctions" where anyone who offered to supply new renewable electricity at the lowest price wins the tender; a model that is now being used worldwide. It is in line with Chile's generally highly market-liberal character and privatized energy market, but with instruments for accelerated conversion.

⁹ <https://www.bnamerica.com/en/news/chile-aims-to-beat-its-own-renewable-energy-targets>

¹⁰ E-mail conversation, Gabriel Prudencio Flaño, Ministry of Energy, 2020-06-11

In 2014, Chile became the first in South America to introduce a carbon tax, which fully came into force in 2018.¹¹ The tax initially focuses on power plants and is an important basis for the reduction of coal power and renewable growth. In 2019, 20% of electricity generation came from renewable sources, and this could reach 30% by 2021. This is because the 2016 major procurement of new electricity production will then be inaugurated, with 50% wind. The share is thus almost four times higher than in the forecasts from the early 2010s, mainly due to the fact that solar and wind have so quickly become so much cheaper. In auctions where the winner is the one offering to build new solar and wind capacity for the lowest cost, Chile has, several times, offered the lowest cost per MW in the world. As early as 2016, new solar electricity at its cheapest cost USD 29/MWh and wind power cost USD 31/MWh, compared to new coal power at USD 57/MWh.

The largest current individual investments are Andes Green Energy of SEK 80 billion for two 1000 MW parks in Antofagasta and Tarapacá, which combine solar cells with concentrated solar energy. Wind power, too, is big, and also mainly established in the north. The potential for geothermal energy is among the largest in the world, but with such low prices for solar and wind, it is not certain that it is competitive enough to materialize. Hydropower is far more controversial, with a difficult history of dams built in areas of particular importance to indigenous people, and droughts where water no longer flows freely. In addition, the future of hydropower is uncertain with climate change, as the dams are in danger of drying out.

The rapid transition has also benefited from the rapid expansion of capacity, from 15 000 MW in 2010 to 25 300 MW in 2019. The electricity market also became more dynamic when the limit was lowered for who can buy their electricity directly from producers, rather than from the network companies, as households are allowed to do. In 2010 there were 115 companies, in 2019 there are 14 times more or 1,614 companies. It also opens the way for increased demand for renewable electricity; While ordinary consumers cannot choose which electricity they buy, the major players have this option and the Chilean state, for example, has requested that the electricity.

Given the fact that the transition is so clearly market-driven, the forecasts can also be seen as more reliable than for many other markets. By 2030, renewables are expected to account for 75% of the electricity mix, with 29% coming from hydropower, 42% from solar and wind and 4% from biomass and geothermal energy, according to Asociación de Generadoras. Norwegian Statkraft conducts the same analysis and is involved in developing hydropower in southern Chile and three wind farms of over 100 MW.

In order to accelerate the transition, the Chilean Government presented at the end of 2019, in conjunction with the COP25 climate summit, a concrete plan for phasing out

¹¹ <https://uk.reuters.com/article/carbon-chile-tax/chile-becomes-the-first-south-american-country-to-tax-carbon-idUKL6N0RR4V720140927>

coal with a final year for the 28 coal-fired power plants by 2040. By 2024, 11 plants will be retired in a first phase (31% of coal installed capacity).¹²

With a couple of dry years in a row, which with climate change could become the new normal, a rapidly increasing use of electricity and the decision to close coal-fired power plants, electricity prices can be expected to rise beyond what they have already done in recent years. The new electricity from solar and wind is in return very cheap, so if it continues to expand quickly, it can be a balancing factor. Then the electricity grid must also be modernized and expanded so that electricity from large solar and wind installations in the north can reach major consumers in the central parts of the country. According to Low Carbon Chile, this is the single most important factor, and probably requires a change in land legislation. The transition to more electric public transport is also a challenge for the electricity network, where more electric buses require an expanded and modernized network.

As always in the transition to more variable renewable energy, there is an interest in being better able to store electricity from sunny and windy days to windless nights, or over seasons. Part of this is that Chile is now starting projects in vehicle to grid, where the large batteries of the many electric buses can be used to store electricity when they have finished driving for the day. However, the need for storage capacity is less than in many other countries that are transitioning to renewable energy; it is sunny all year round in northern Chile and by combining solar cells with the concentration of solar energy in saline solutions, the electricity is enough to last all evening even though the sun has long since gone down.

COP25: Chile as COP host on another continent

The Annual UN Climate Change Meeting, THE COP, is the basis for the implementation of the Paris Agreement. In December 2019, Chile was to host COP25 after Brazil, with its newly elected President Bolsonaro, renounced its role as host. However, during the popular social protests a few weeks before the meeting, Chilean President Sebastian Piñera judged that security could not be guaranteed and renounced the physical hosting but retained the position of chair of the meeting. Just 24 hours later, Spain came forward and took over the role of host, and the meeting could be held on the same date as planned, but in Madrid instead of Santiago.

The late move is believed to have played a part in the meeting becoming one of the least productive in the UN's 25-year history of climate summits: it ended without

¹² E-mail conversation, Gabriel Prudencio Flaño, Head of Division of Sustainable Energy at the Ministry of Energy, 2020-06-11

substantial progress. Many also put some of the blame on Chile as the Presidency, with a relatively inexperienced chairman of the process, Chilean Environment Minister Carolina Schmidt. However, although the Presidency may have a major impact on the outcome, many note that it was rather the lack of common will to flesh out the Paris Agreement that halted progress. In those areas where Chile could most clearly make a difference as President, steps were also taken; issues regarding the world's oceans were given more room, and many countries accepted Chile's challenge to set net zero target years for its climate impact.

Transition of the transport sector

Chile's transport sector is partly known to the outside world; the increase in the price of tickets for metro and bus became the trigger for the social protests of late autumn 2019 that have been reported worldwide. But Chile has other, more sustainable ambitions in the field of transport, which we are going through here first with a summary of a long meeting with Transport Minister Gloria Hutt, then sector by sector for electric buses, freight, passenger cars and cycling.

Chile's pride: A world leader on electric buses

Our conversation with the Minister for Transport is initially about electric buses. So far nothing is original; this is what Hutt and the Chilean Government often and rightly highlight. Santiago already has about 500 electric buses - the most in the world outside China according to their own data, and more than the entire Nordic region. With a wide range of contracts lined up, these could become 5000 electric buses already by 2021. The Minister knows every detail about the public transportation set-up; unlike in Sweden, here it is the government that decides on public transport.

The first electric bus line in each region of Chile is partly financed by the State, but the conversion will not be driven by subsidies. In order to speed up the transition, the government is still taking it upon itself to own the electric buses, bus depots and charging infrastructure, while the operators lease them for themselves. In the new tenders, they can continue to choose to run on diesel Euro 6, but the difference in operating cost is so great – a scant crown per kilometer for the electric bus against five crowns for the diesel – that the rallying around the electric alternative has been great after the government's decision to take the risk around the buses themselves. Several bus companies that have years left on existing contracts have nevertheless joined the electric bus offer outside the tenders.

Buses run on solar and wind

How climate-smart electric buses are depends, of course, partly on what they replace – and it seems to be mainly cars – and with what they are charged. Renewables take up a rapidly growing share of Chile's electricity grid, with among the world's lowest prices for solar and wind and a more controversial expansion of hydropower, but fossil fuels are still in a dominant position. It therefore makes a big difference that the two energy companies that are part of the electric bus consortium guarantee 100% renewable electricity, in one of the first steps towards offering fully green electricity to Chile's consumers. One of the bus depots is also completely self-sufficient with solar cells.

Leave your car at home

The Transport Minister sees electric buses as part of making it easier to get people to leave the car at home. "We want to achieve cities where cars are only used when there is no other alternative. We have tried congestion charges and toll roads, but the price elasticity has been very low – prices have to be very high for people not to choose the car. This is because many people do not even consider public transport where there is no metro, and therefore we need to make buses much more attractive. Electric transportation is absolutely central; we see that people are willing to wait a few minutes extra to take the electric bus instead of the regular one." The proportion of planks is also lower in electric buses, which are perceived as a service worth paying for.

Densify the city

"The main purpose of removing the cars is to facilitate the densification of the cities. The part of our population living in cities will continue to grow, which means that we need to live smaller and then to a greater extent be out in shared common areas. For that to happen, the cars can't take up as much space as they do today." To avoid "urban sprawl", Hutt announces that "Those who choose to live far outside the city centre will have expensive and limited access to the city. It is very expensive to have high-quality public transport to these low-population areas, which is why we plan to have them pay a special fee for public transport."

"The biggest cost to motorists is not to arrive or not to have a place to park the car when you arrive. Therefore, we will remove lanes from the major roads, which will instead be given to cycling and micromobility, and limit parking spaces. We're going to make it very difficult and expensive to use a car."

Street protests = increased cycling

Cycling has increased very rapidly in Chile in recent years, with a doubling since October alone, when the protests began, Hutt says. Public transport did not work, with burned metro stations, and many were reluctant to take the car to town. "Now it is important to maintain this increase, and space is the most important part of that." There will be more cycle paths, but also new processes so that municipalities have much faster means to facilitate cycling. "Today, the law on cycle paths is very complicated, among other things you have to take soil samples before, and many municipalities do not have that capacity or budget. That's why we're now letting the municipalities simply repaint existing roads so that they become cycle paths quickly, easily and cheaply."

Market economy prevails

Hutt does not see any government co-financing of these "express cycle paths", but thinks that companies can sponsor them – the cost is limited anyway. This mindset permeates all of the government's transport policy: those who choose electric buses get better conditions and more passengers, but no subsidy, and the transition to

reduced motoring will take place through more of a market economy and by fully charging for the costs caused by motoring.

This reliance on the market economy also means a completely different sequencing for the electrification of the fleet compared to other countries: in Chile, buses come first, then distribution of goods and trucks for shorter distances – as between Santiago and the port – then taxis, and then finally ordinary cars. The conversion takes place without subsidies, but with incentives, such as electric vans being allowed to drive in the city during hours when others are not allowed, on streets that are closed to other vehicles and with reserved parking spaces. In addition, Chile is in the pipeline to adopt CO2 emission requirements for new cars roughly in line with the EU's.

Not everything, of course, is a market economy even in Chile. Public transport is subsidized, parts of freight transport are part-financed by the state, and diesel has a lower tax than petrol. "These subsidies have arisen over time, one by one as a result of negotiations without an overall picture." Hutt literally has a picture of how the review should be done, so that only the subsidies that are really needed will remain – and then, in return, they can be increased. "Now, all travelers who take the subway get a share of the trip paid for by the state, even though it doesn't make any difference to most people. When we limit it to those most in need, we can do more with less."

Reduced or abolished subsidies for fossil diesel also opens up an opportunity for biofuels, not least biodiesel from the residues from Chile's forest industry. So far, Chile does not even have a low blend of ethanol in their gasoline, even though the Brazilian example is right on the other side of the Andes. And the lithium in the electric buses is probably from Australia; Chile has the world's largest deposits, but the ambition for it to be used locally has so far not materialized.

The meeting with Hutt shows how processes which in Sweden are handled on the municipality-level, are settled directly at the minister-level in Chile. This also highlights how, with a clear agenda and deep expertise, it is possible to make a big change despite the budget and political mandate being limited.



Chilean Transport Minister Gloria Hutt and Pablo Ortiz, Head of International Affairs from the Ministry of Transportation and Communications

Electric buses: world leader outside China

Updated June 2020

Just as Sweden wants to be a leading market for sustainable transport, which then spreads to other markets, so does Chile strive to be a world leader in the transition to electric buses. Because now it is spreading to other Latin American markets too.

Ahead of COP25, the Chilean government promised that the country's public transport system would be fully electrified by 2040. The target looks set to be reached earlier than that, with Santiago as the main driver. There are approximately 6,500 regular buses in Santiago, of which up to 1,500 are estimated to be electric by the end of 2020, and as many as 5,000 could be just a few years later.

Progress has been rapid; On 15 December 2018, BYD delivered its first electric bus to the operator Metbus. Only one year later, they had already delivered 300 buses in Santiago, driven 4.5 million kilometers with over 13 million passengers and over 160,000 journeys between end-stations.

"We believe that the conditions are in place to reach the 2040 target much faster," said Tamara Berrios, country manager for BYD in Chile; at the current rate, the entire Santiago bus fleet has been replaced just a few years into the 2020s. BYD is the market leader in Chile and Latin America with over a thousand buses delivered, which represents more than two-thirds of total electric bus sales. Chinese Foton is distant second while European manufacturers only sold single electric vehicles. According to BYD themselves, the electric buses they have delivered so far will provide an annual emission reduction of 222 tonnes of CO₂, based on a daily mileage of 200 km and that fossil-powered diesel buses are the ones being replaced – both perfectly reasonable assumptions in most Latin American cities.

Alameda Avenue in Santiago becomes the country's most important electrified corridor with 158 electric buses that make their way back and forth daily via the street. The largest terminal, Rinconada electroterminal, can charge 74 buses simultaneously, taking about 2 hours and 30 minutes to fully charge.¹³

Electric buses contribute to reduce climate impact, better local air quality, and increased user acceptance. According to Daniela Soler Lavín at the Ministry of Energy, more people pay for the ticket in electric buses than in other public transport, vandalism and wear and tear are lower and more are prepared to give up their own car with the electric buses.¹⁴

¹³ <https://santiagotimes.cl/2019/03/28/chile-doubles-santiagos-electric-bus-fleet/>

¹⁴ Daniela Soler Lavín, head of transport efficiency, Ministry of Energy, personal meeting 2019-12-05

Chile itself states that they are the world's largest electric bus market after China. It is now being challenged by the Netherlands, which had as many as 726 electric buses in operation by the end of 2019. The Chilean conversion is probably the most interesting, as it takes place without strong government subsidies or actual requirements for a certain proportion of electric buses.

Chile has not introduced any real subsidies for electric buses, and at least at present does not require a certain proportion of electric buses but requires the highest existing Euro-rating of buses. This can be achieved with a diesel bus of the most modern cut or an electric bus (in theory also a gas bus, but the market is in Chile non-existent). The State mainly assists by purchasing and owning the vehicles, which are then leased to the operators, which thus have lower start-up costs and take a smaller risk regarding the residual value. The state also allocates space for bus depots closer to the city centre than would be available otherwise, which is attractive to operators who are usually reliant on areas far from the routes they operate.

Longer contracts are also attractive, with users of electric buses getting a 14-year operator agreement, while those who choose Euro 6 diesel buses will only get ten years' contracts. In the procurement process, the operator must ensure that the buses are charged with green electricity, and be responsible for the charging infrastructure, but the two major electricity companies Enel and Engi have ready-made solutions for this. Metbus terminal in Los Espinos also has solar cells on the roof so that, at a minimum, the local electricity demand to be produced on site.

Lower operating costs are getting increasingly important for operators' choices; the electric bus costs one third more but has far lower variable costs for fuel, 78 CLP/km for the electric bus against 380 CLP/km for the diesel-powered according to the Ministry of Transport. The electric bus also has much cheaper service and some residual value, while the diesel bus is counted as completely written off when its year in procured traffic is over.

In addition, both the operators themselves and the state development agency Corfo, indicate that they receive increased ticket revenue with the electric buses. Partly because they are perceived as so much better that passengers actually wait for the electric bus, even if there is a diesel bus coming first, and partly because the proportion of paying passengers increases from the general level that is otherwise around 60 percent. Furthermore, this can probably be partly attributed to an increased customer satisfaction and perhaps a new customer group with strong buying power that, thanks to the electric buses, has started to travel by public transport: private car users. This is entirely in line with the government's intention with electric buses, which will not only replace fossil buses, but also make more people not take the car to the inner city.¹⁵

¹⁵ Personal Meeting, 2019-12-03, Fernando Hentzchel, head of technical development

There are currently almost 50 procured bus operators in Santiago. Not everyone is ready to operate electric buses, and Corfo sees it as positive if the changeover also contributes to a sharp reduction in the number of operators. In addition to the long tenders, procedures will now be put in place whereby those who choose to operate electric buses but do not meet the quality requirements will be replaced.

The many electric buses are currently a Santiago phenomenon, and many of the older diesel buses being replaced in Santiago end up in other parts of the country. To begin the conversion outside the capital, the Ministry of Transport is now procuring and co-financing a line in each regional capital to be served by electric buses. Centralization also means that the transition to electric buses in the rest of the country has come furthest in Viña del Mar and Valparaíso, both of which are close to the capital. In the country's second largest city, Concepción, there is a single electric bus, and in the fifth largest city – the central town of Lithium production, Antofagasta – there is none at all. In smaller cities, the conversion is more difficult, Corfo says, because a typical bus company in Santiago can have as much as 1,500 buses, while the equivalent in small towns is 1-4 buses, limiting companies' ability to invest in new technology.

During 2019, however, 220 buses on the countryside have been replaced and renovated with state funds. More than 17 000 buses across Chile are partly state-financed in order to keep the ticket prices at a lower level. And in May 2020, the government announced some news, in a video broadcast made by Gloria Hutt: Concepción and Temúco will receive the similar bus roll out as Santiago during 2020, electric or highest environmental performance. Thereafter, Valparaíso and Antofagasta are in line followed by other cities.¹⁶ In total, 2000 buses will be replaced in tendering processes during 2020-2021.¹⁷

The electric bus success story has spread all the faster to other Latin American cities. Argentine Mendoza on the other side of the Andes from Santiago has in a first stage 16 electric buses, and Guayaquil in Ecuador has launched 20 electric buses. Despite its deep crisis, the country has stated that all new vehicles in public transport will be electric by 2025. Colombian Medellín has already acquired 64 electric buses and procured 379 more that will gradually enter service in 2020, as part of Colombia's strategy to reach 600,000 electric vehicles by 2030.

What about existing buses? Here, the leap in climatic difference between electric bus and diesel bus is vast, and thoughts about biodiesel remain just thoughts; there aren't even pilot trials or low-blend. Chile's strategy is to step directly to electric power.

The goal of fully electrified public transport applies not only to buses but also to the regular vehicles "colectivos" and taxis. Here the conversion is expected to take place in the same way as with the buses; by 2025, electric cars should have fallen so much

¹⁶ <https://www.youtube.com/watch?v=tcK8LLQuHaE>, visited 2020-05-27

¹⁷ E-mail conversation, Gabriel Prudencio Flaño, 2020-06-11

in price and gained such a reasonable range that, even without financial subsidies, it is a reasonable choice for colectivos. Colectivos are common, especially on the outskirts of cities, and the state may again have to provide charging infrastructure and possibly vehicle ownership – but do not count on an electric car premium. Then the same thing is imagined for the taxi industry, also well-regulated in Chile, albeit with many smaller players, which places greater demands on the charging infrastructure to be reasonably developed.

Other electric buses: Valparaíso trolleybuses

A president interfering in the public transport of a city is not common and is hardly ever included in the job description. But when Valparaíso's consortium of electric buses in 2007 was to close down their trolleybuses, it happened. Chile's then President Michelle Bachelet, now head of the UN High Commissioner for Human Rights, made it clear that closing down the trolleybuses was unacceptable – and they are still on the streets no.

Valparaíso's trolleybuses are not just any regular old buses, but the oldest in the world that are still operating. The system was inaugurated on New Year's Eve 1952, replacing the tramway that was closed the day before. Some of the trolleybuses are American Pullman-Standard from the post-war period, beautifully bulky veteran vehicles which continue to do their job even if they don't accommodate as many passengers as the newer ones. In the early 1990s, a number of used trolleybuses were purchased from Switzerland, including the world's oldest articulated trolleybus, number 105 from Zurich from 1959. A couple of years ago, these were replaced by a new set of used trolleybuses from Switzerland, which now account for more than half the fleet. The warning signs are still in German, French and Italian and for a long time these *troles* carried the same orange color that they had in Switzerland. Now they have been painted uniformly green-and-white – perhaps a sign that they there is a future for them. Paradoxically, these slightly newer buses are more prone to breaking down as they require a slightly different amperage than what is commonly used throughout the city.

The trolleybuses are particularly welcome in the town of Valparaíso, which has a small centre wedged between the slopes and the sea. Here it's crowded, the traffic is packed and noisy, and the air is bad. The many minibuses do not exactly help the situation, with their roaring engines and black smoke pouring from their exhaust pipes. Line 802, consisting solely of exhaust-free, silent *troles*, feels like a safe haven going through the city centre, all the way from the port in the north to the parliament in the south, which has been there since Pinochet decided it should be in Valparaíso while the government is in Santiago.

The bus system in Valparaíso stands on its own, without subsidies from either the state, the region or the municipality. With diesel costing 600 CLP/litre, the trolleybus has had difficulty competing and that is why the consortium of owners in the early 2000s decided to stop running *troles*. But the pressure mounted, and so the number of lines has been reduced, but the *troles* are no longer at risk of going extinct. The ticket costs 300 pesos, just under four Swedish crowns, just like for other buses, and although the trolley buses have none of the luxury or comfort that Santiago's new electric buses have, line 802 is popular because it's less jerky and noisy.

It seems fair that those who operate the trolley buses should get something back for what they do for the city. In addition to reducing noise and exhaust gas, the trolleys were granted status as national monuments by the Chilean government in 2003. They were also instrumental in Valparaíso receiving its world cultural heritage classification from UNESCO. Furthermore, trolleybuses are now a tourist attraction – although public transport tourism is still a niche market, trolleys appear on t-shirts, as toys, puzzles and much more.

Efficient public transport cannot, however, depend on the president intervening in order to resuscitate it as it's about to close down, or on being a cute tourist attraction. And we can see a small light in the tunnel: the government decided to expand the width of the trolleybuses and therefore have extended the contracts for the trolleybus operators, so that they can invest in the buses and expand the routes.¹⁸

So what kind of future do trolleybuses have in Valparaíso and elsewhere in the world – including Landskrona, the only Swedish municipality with trolleybuses?

At major bus and public transport fairs around the world, electric buses are gaining an increasingly prominent role, with the market being divided between those who charge very quickly and those who have sufficient battery capacity to handle a full shift without charging. The trolleybuses are usually conspicuously absent. Regarding trucks, the situation is similar; electric operation is now developing quickly, but almost no manufacturer highlights the possibility of continuously transferring electricity to the vehicle. Yet the vehicles are here and several manufacturers have ongoing projects, not least in Sweden. If the trucks get their power from above like Scania's experiment with German Siemens, among others, they would more and more take on the likeness of a wire bus system.

The trolleybuses can be a way to deal with the problem of power shortages in the network. Here, relatively limited amounts of electricity are transferred continuously, rather than huge amounts being transferred in bursts, when charging. Current expensive technology for fast or ultra-fast charging is thus unnecessary. The high cost of large batteries is avoided; the trolleybuses only need energy for a few hundred meters of autonomy, and so the environmental impact of batteries is also reduced. The flaws are equally obvious: An infrastructure of electricity grids is required that can be tricky to integrate into the cityscape, and flexibility is lower than for other types of electric buses – although it is higher than for light rail and other light rail solutions.

¹⁸ <https://www.youtube.com/watch?v=tcK8LLQuHaE>, visited 2020-05-27

Electric cars: Please hold

Updated June 2020

Chile has chosen a completely different path than, for example, Norway in the transition to electromobility. The buses come first and the cars come last. The charging infrastructure is almost nonexistent and the only electric car we see in a whole month is a company car from the lithium company Albemarle. Throughout Chile, there are only a thousand or so cars out of a fleet of five million.

Both Transport Minister Hutt (see special interview) and state-run Corfo, describe this as a very conscious priority: Converting the passenger car fleet to electric power costs more than what it brings in, and in a few years the market will be handling the transition anyway. By 2050, 40% of Chile's passenger car fleet is estimated to be electric, with no subsidies.¹⁹

Corfo participates in the Santiago region's procurement of municipal vehicles, with requirements for clean electric power for, among other things, the transport of goods and services, garbage trucks, safety vehicles and ambulances. In addition, individual municipalities, such as Santiago, have agreements with distributors to use electric vehicles, which in return gives them the right to drive on streets that are otherwise closed to traffic. The beer distributors and Pepsi, among others, have also settled on such agreements with the municipality. The parliament is preparing legislation on the CO2 emissions of new cars, with requirements for maximum average emissions and a modified vehicle tax that accounts for CO2 emissions. There is a plan to launch subsidies to renew the taxi and colectivo fleet, according to the Ministry of Energy by June 2020: the “Renueva tu Colectivo” program consists of USD 10 000 subsidy per vehicle for the switch to electric.²⁰ Fernando Hentzchel at Corfo states that the focus of all stimulation will be vehicles that drive at least 40,000 km per year.²¹

Another initiative to develop e-mobility in Chile was announced in May 2020. This call is aimed to form a Center for development of e-mobility in Chile. The center is a consortium of actors who will promote and develop the market for techniques that use copper and lithium. The consortium can receive a co-financing of USD 7 million for a maximum of five years.²²

Pending market-based impact on electric transport, a program is being created to convert existing petrol cars to be driven on liquefied gas. A previous such program

¹⁹ Fernando Hentzchel, head of technical development, Corfo, personal meeting 2019-12-03

²⁰ E-mail conversation, Gabriel Prudencio Flaño, 2020-06-11

²¹ Personal meeting, Fernando Hentzchel, 2019-12-03

²² https://www.corfo.cl/sites/cpp/convocatorias/centro_para_el_desarrollo_de_la_electromovilidad, available 2020-06-16

specifically for taxis never had any major impact because the number of gas stations was too small, but now it is thought to have greater potential.

In the long term, Chile wants not only to be a market for electric cars, but also to participate in the development of electric cars, with a focus on batteries linked to their national lithium production. For this, the state has allocated 170 billion CLP over a ten-years period in a project on future materials. Corfo is also coordinating a second call to create added value around lithium, after the first call did not lead to anything concrete.

Toll motorways: financed by users

Route 5 runs from Tierra del Fuego in the south to Arica on the Peruvian border and continues as Panamericana all the way up to Alaska with a small gap in southern Panama. In Chile, this is the backbone of the country, which connects almost all major cities and where the majority of both passenger car and freight transport takes place. It is also a good example of how Chile has worked through many years with market economy solutions; large parts of route 5 constitute a toll motorway where the license is procured by the state and where the winning company is responsible for operation and maintenance. In return, the company receives a large part of the revenue from the tolls paid by all vehicles.

The first stretch to the north of Santiago is operated and maintained by Lampa. Here the payment is made using cameras much like for the congestion fees in Stockholm, through a system called Televia. The toll zones are a few kilometers long and the fee per zone is a penny for passenger cars. The fee varies depending on whether traffic is high, normal or off-peak. Further north, where the flow of traffic from the city has thinned out, with many kilometers between toll stations, and most drivers coming through pay in cash in the manned toll stations. Here the fee is fixed, but differentiated according to the type of traffic: from a minimal fee for the very few motorcycles to a bit more for passenger cars, to up to ten times that for the largest trucks.

In recent protests against the market liberal approach, toll roads have also been criticized. When toll fees on one of the motorways was to be increased, the customs stations were burnt down. The government conceded the increased toll fee but not the system, which has the support of even the more left-leaning parties in Chilean politics. Anyone who uses the major roads in Chile will have to pay for themselves, and that will continue to be the case.

Ports as part of the transition

As an export-oriented country with a long coastline, Chile's economy is heavily dependent on its ports. Ten of the ports are operated by the state and they are tasked with pushing for a shift towards greater sustainability.

State-owned Corfo, which works directly with the ports, clearly identifies Antofagasta as a leader in sustainability work. It is both ISO 14 0001- and Ecoport-certified, with demands first and foremost on local sustainability, but also on an incipient discussion about how climate issues can be more clearly integrated.²³ It is also the port from which the country's lithium is shipped, which may act as a driving force for increased environmental work, together with Antofagasta wanting to attract more cruise ships, which currently only account for one percent of the port's calls.

10% of Chile's exports, three million tonnes of goods, pass through the port annually, a significant part of which is from Bolivia, which has Antofagasta as its main port with free trade agreements since 1904. The large volumes are barely noticeable when we visit the port; it is quiet, calm and clean and between the large ships you can catch glances of seals and pelicans. Most of it is also relatively newly built, after large parts of the port were destroyed in the 1995 earthquake, and again in 2013.

The port's vice president Ricardo Varas Fernández explains the environmental work here with "We are in the middle of town and trains and trucks that are going here or coming from here go straight through the city center, so we are judged every hour." In a next step, the port wants to develop shore power for the ships, which would make them pioneers on the continent, and gradually increased electric power to the port's machinery. The port and the two rail companies FCAB and Ferronor also want to increase the proportion of goods on rail, from today's 65 per cent to upwards of the 90 per cent that the train accounted for ten years ago. Increased safety and reduced climate impact are the main drivers.

The decline is largely due to the fact that the copper company Codelco, which accounts for very large volumes of freight trains, has switched port to adjacent Mejillones, a change that, of course, annoys Antofagasta but where Fernández predicts that tighter environmental requirements from customers will help them get new business.

This is also why the port financed bike lanes through the city, partly with the argument that the port employees should be able to get to and work comfortably – but probably more because they want to be a good neighbor. Under the state agreement, the port is not allowed to invest using other assets than the direct revenue it receives, and therefore they rent out parts of the port area to a private operator and own a large shopping centre, which, among other things, provides funds to acquire new cranes.

Much of what Antofagasta's port is doing is also thought to happen in the other state ports. This is not least evident in Chile's largest port of San Antonio, which can be considered to be Chile's national port. This port is set to significantly expand in order to eventually triple its

²³ The text is largely based on conversations with Francisco Garcia Mac-Vicar with colleagues, Corfo

capacity. Linked to this, the railway will be expanded with the goal of 30-40% of all goods being transported by rail, compared to the current 6%. A new railway line to Santiago is a key to achieving the goal.

Cycling: the protests can strengthen Chile as a cycling country

Updated June 2020

Following the protests that started on 18 October 2019, the transport pattern in Santiago has fundamentally changed. The subway, which was at the center of the conflict, was completely closed for a few days and only arrived just before Christmas again up in two million passengers a day, against 2.75 million a day before the conflicts. Car traffic fell sharply, and new car sales reached their lowest level in almost ten years. The number of passengers at Santiago Airport decreased by ten per cent from the same month of the previous year. And the proportion of cyclists almost doubled.

It is perhaps an exaggeration to read an increase in environmental involvement in the changed travel patterns, even though the social protests also have a clear environmental dimension. Rather, the main reason is that many people found it too unsafe to take the car into the city centre, and that public transport has worked poorly. The increase is particularly marked in Santiago, where, among other things, the entire subway was closed for a few days. However, the increase is visible in all major cities. Now it is a matter of holding this increase, according to Chilean Transport Minister Gloria Hutt (see the Transport transition section).



The bike – a symbol of justice?

Chile has a long history of cycling, but it was not long before the bike became an established means of transport. The first bike came to Valparaíso's port in 1886, classified as a toy. Until the 1920s, the bicycle was mainly used by the upper classes as a leisure activity, after which use decreased as motorcycles and cars became more common. In the forties, the cycle became more common and began to be used for travel to and from work, especially in rural areas. In 1941, bicycles began to be manufactured in Chile and in 1946 the first cycling competitions were organized in the country.

In the 1980s and 1990s, Chile's economy went very well, and more and more people got their own car. In Santiago alone, a city of seven million inhabitants, there are four million cars. The then prevailing attitude that "bikes are for losers" meant that fewer and fewer trips were made by bike.²⁴

But there is much to suggest that this attitude is changing. On the one hand, the traffic jams began to grow further around the cities. In the 1990s, a significant cycling movement was also started in Chile, initially led by *Movimiento Furiosos Ciclistas*, in translation roughly "furious cyclists". With Santiago as a starting point, the organization called for more bike paths. At first, politics resisted these requests, but eventually the political goal was established that the 800 km cycle path to be built in Santiago alone.



²⁴ <https://www.theguardian.com/cities/2016/jul/21/cycling-challenging-santiago-chile-social-barriers>

The bike – a symbol of freedom?

In 2007, the Dutch organization *Interface for Cycling Expertise* started work to further improve the traffic environment, where, among other things, parking spaces for bicycles at metro stations began to be built. Through a collaboration with a local NGO called *Ciudad Viva*, workshops were also held with citizens to identify local dangerous crossings and other things.

A bottom-up perspective like this has been very unusual for the former military dictatorship, where all kinds of participation has been something that the government has been afraid of. This is now gradually changing in Chile, partly with the help of organizations such as Ciudad Viva.

In 2007, the total reform of Santiago's public transport system, *Transantiago*, was also implemented. Then all public transport was connected under the same tariff, and the subway began to expand. This not only increased mobility between residents in Santiago's municipalities, but also more order and increased safety for cyclists.

Car-free Sundays and bicycles - for better or worse

In 2018, Chile was one of the few countries in the world where cycling increased by more than ten percent in a single year, along with Luxembourg, Poland, the Czech Republic and Sweden, according to eco-counters and New City's Global Counters indicator. Since then, cycling has increased considerably faster, and on Sundays a total of 40 km of streets are being closed for car traffic, in order to offer more space for non-motorized means of transport.

An estimated 30,000 cyclists use this opportunity, *Ciclo Recrea Viva*, every Sunday. The inspiration comes from Bogotá, as part of the city's *Ciclovía* program for increased cycling. The promoters of the concept in Colombia took it to Santiago to give people the opportunity to discover cycling and get more space on the streets. This Sunday activity can also serve another purpose to speed up the transition, highlighted by cycling organization Art Bike: the need for training in how to actually cycle.²⁵

²⁵ Personal meeting, Andrés Castle and Christian Rivera, Art Bike 2019-12-19



Car-free Sundays bring together thousands of cyclists

Art Bike points here to the rapid increase in the number of bicycle accidents recently. This is due both to unaccustomed cyclists in general and, according to Art Bike, specifically to the fast-growing loan bike market, which they believe leads to reduced road safety. "Anyone who gets their own bike makes an important investment and a conscious decision. Anyone who rents a bike or scooter takes no responsibility and does not get involved. Knowledge of the rules is low, and almost none of those who use the bicycles are wearing helmets."²⁶

Several operators offer bicycles with both fixed and floating systems. Rapid expansion is made more difficult by the fact that it is municipal regulations that determine whether or not to establish ones. This means, for example, that the European Union should be able to take account of the electric scooters are not in principle taken over the municipal border, which, not least in Santiago with its many municipalities, is a clear restriction. The bikes have also been the victims of many thefts.



Bicycles in Santiago – theft-attractive possibility of increased cycling

²⁶ Personal meeting, Andrés Castle och Christian Rivera, Art Bike 2019-12-19

Increased pressure on better conditions for cyclists

The fact that there is increased pressure for better cycling conditions is also evident in the organized bike tours that take place every Sunday under the direction of Movimiento Furiosos Ciclistas. In the beginning, their arranged bike tours attracted 200-300 people, but from autumn 2019 thousands are attracted to gather at 12 o'clock to cycle together and mark community. It must also be seen as a sign against parts of the government who identify cyclists as co-responsible for the elements of street protests that degenerated, including burnt-down metro stations.

After the demonstrations began, the government also reported a doubling of cycling. However, according to César Garrido, spokesperson for Furiosos Ciclistas, neither a long-term strategy nor real improvements are behind it. "There was simply no other way to get to work," says César Garrido.²⁷ Whichever the reason, there is now a chance to get those who have started taking the bike to keep their new habit. For this to happen, road safety needs to improve rapidly, and the continued expansion of cycle paths is crucial.²⁸

According to Furiosos, the government's promised 800 km cycle path to be established in Santiago has so far only been 80. In addition, they argue, the expansion has taken place without any coherent thought and that most of the cycle paths that exist after all are in the richer Santiago municipalities. In addition, most cycle paths are too narrow or otherwise too poorly designed to really stimulate conversion.

But there are still positive examples, such as the municipality of Las Condes, where entire streets have been made car-free and where the motorist who violates this, risks heavy fines. The organization *Bicicultura* is developing an app to provide cyclists with information about the safest and fastest road on a bike to reach their goal. In Maipo, a few miles south of Santiago, courses are held to get more people started cycling, but the main inspiration comes from municipalities in southern Chile such as Rancagua and Concepción.

Since 2018, Chile has a kind of cycling legislation, *ley de convivencia*, however this is not very governing. Among other things, the law states that motorists should keep a distance of one and a half metres from cyclists. It also got off to an unfortunate start, as it states that cyclists had to wear reflective vests in bad weather, which meant that up to 2000 violations of the law were recorded in the first two days. This in turn meant that the law likely created obstacles and a negative attitude towards cycling, rather than the intended increased safety.

During 2019, however, a decrease in the number of accidents for cyclists by 10 percent was reported, due to the law that prioritizes unprotected modes of transport. This decrease happened in a time when the number of cyclists was increasing. One reason,

²⁷ Personal meeting, César Garrido, 2019-12-15

²⁸ <https://www.furiosos.cl/>

according to transport minister Gloria Hutt in a broadcast in May 2020, was the decrease in speed limit in cities from 60 to 50 km/h.²⁹

So why is cycling increasing so fast in Chile, and what can the outside world learn? The answer, of course, cannot lie in burnt-down subway stations and vandalized cars, but well in a pride to take the bike, a community between those who cycle and an unrivalled accessibility.



Christian and Andrés at Arte Bike in Santiago

Valparaíso's elevators – a k-marked curiosity of public transport relevance?

The visitor to charming, picturesque Valparaíso can hardly escape the many *asencores* that go up the town's hills. The lifts, as it means, or the funiculars that we might rather classify them, go close to vertically up the slope, on rails and with a cable that pulls up one wagon while the other is dropped at the same time. The journey is a few hundred meters long and almost as much in meters of altitude and takes just over a minute.

The elevators were built in the early 20th century to allow the city to grow up on the hills. They became less relevant as the city grew further up the hills, and the elevators only became a first leg of the journey. It was reinforced when the car became a more obvious means of transport and *colectivos* – passenger cars in regular traffic with a tariff like a bus – started driving up the hills. Many lifts fell into disrepair and were closed down, but like the trolleybuses, they became an important part of the city being designated the World Heritage Site by UNESCO and are now renovated and in good condition. They have also gained renewed relevance as more and more business,

²⁹ <https://www.youtube.com/watch?v=tcK8LLQuHaE>, åtkomst 2020-05-27

cultural life and, not least, tourism have moved up from the sea level of the city centre to a bit up the more central hills, with the lifts as the ideal means of transport. For example, the open-air art museum is right there

Although the elevators are something of a tourist attraction, they are, above all, an obvious part of everyday life for those who live on the hills. It is also shown by the price, in principle always a hundred pesos, a good penny. In an incipient environmental and climate discussion, it is also easy to see the usefulness of the elevators, which are of course electric and replace petrol cars that with great effort and high consumption otherwise make their way up the hills.

Few cities have the height differences even in the center that characterize Valparaíso, so the general relevance of the elevators should not be exaggerated. In addition, they are above all a centuries-old phenomenon; yet functional but without really being included in future urban planning, los acensores send a signal to decision makers that tomorrow's public transport can sometimes be short, go basically vertically and be part of creating value for areas that otherwise lie abait.



Hydrogen: The choice for heavy freight transport

The green electricity from solar and wind is the main ingredient in Chile's transition to sustainable transport. This also applies to heavy goods transport, but for them electricity must be converted into hydrogen in order to respond to the country's long journeys.

Green electricity is supposed to power heavy freight transport, but not primarily on rails because the railway is lagging behind and expensive to expand. Only some of the routes and some raw materials are provided by the railways for a significant proportion, such as the transport of the copper mine to the port. In addition, the goods are transported by lorry, and the long distances of more than 400 000 km from north to south mean that ordinary, battery-powered trucks are not expected to be able to break through for a long time. Instead, the Chilean government believes in hydrogen for heavy freight transport.

Most of Chile's transportation needs are covered by the Pan American Highway, which stretches from north to south throughout the South American continent. Like a spine with its ribs, it is complemented by a couple of west-east stretches such as Santiago-Valparaíso, but in addition to the long distances, the number of routes that for the conversion must be given new infrastructure is rather modest.

Chile is now planning, among other things, with Corfo for hydrogen stations along Panaméricana, where hydrogen is to be produced using salt water from the sea and electricity from solar cells. Hydrogen thus becomes one hundred percent renewable and locally produced, in contrast to most of the world's hydrogen produced from fossil natural gas.

Since much of the route runs along the sea and Chile has among the world's absolute cheapest solar electricity, the conversion is comparatively simple and inexpensive, Corfo estimates. In addition, the large photovoltaic parks are located in the north, in about the same areas as the large mines, which also bear the greatest need for heavy transport. Corfo is now launching a PPP collaboration to develop technical specifications and business models.

The conversion is also facilitated by the fact that heavy transport will be able to run on a mix of diesel and hydrogen, with the target picture 60 percent hydrogen. Graz University has made such attempts, which are now to be scaled up. In this way, existing trucks will also be able to be converted from diesel to hydrogen. For these vehicles, therefore, it is not a question of fuel cell operation, but of using hydrogen in internal combustion engines, with less efficiency but a faster, simpler and cheaper conversion. In this way, the country's climate goals can be achieved, where heavy transport has a central part to it.

Biofuels - why not?

In order to reduce dependence on imported energy and increase security of supply, Chile has a significant investment in bioenergy. For the transport sector, crop and algae-based fuels have been tested but considered too high in price in highly market-liberal Chile. Subsidies are not given here in any case. The greatest potential instead seems to be in the residues from the forest industry.

The investment in bioenergy applies primarily to forest residues, which will be used to significantly increase the share of bioenergy in the electricity mix beyond today's two percent. In addition, there are 13 pilot projects in the field of biogas that are thought to be able to replace any of the natural gas Chile imports from Argentina.³⁰

Alternative fuels have long been a central part of Latin America's transformation of the transport sector. Brazil has built its conversion of the transport fleet on domestically produced ethanol, which has also had some impact in, among other things, the production of ethanol. Colombia. In Argentina, many thousands of vehicles are powered by natural gas, not renewable, but after all a step away from dependence on imported fossil fuels and a certain reduction in the climate impact.

Chile has also identified biofuels as a major opportunity for conversion for at least a decade. It was initially strongly linked partly to reduced import dependence and partly to better working conditions in the mining industry, where Codelco early on examined the potential to switch to biodiesel to improve air quality. The production of biofuels from arable crops has been rejected because agricultural land is too limited and valuable, and already a requirement for 2 % low ethanol blending in petrol would require large-scale imports if it were to be done, for example, with maize. For biodiesel from crops, the assessment has been more positive, with the potential for production from canola in southern Chile. However, the Government has assessed that biodiesel would have difficulty in competing in terms of price with fossil diesel.^{31 32 33}

Chile has hosted several research projects on algae for biodiesel, with algae cultivation in both fresh and saltwater plants. However, increasing production while making cultivation technology as cheap as possible has been a challenge.^{34 35}

Chile's equivalent of the Forest Agency, the state-owned Conaf, sees a clear potential to use the forest industry's residues for biofuel production. It could be ethanol, biogasoline or biodiesel for everything from low-level road traffic to biojet for aviation,

³⁰ <http://www.revistaei.cl/reportajes/futuro-los-biocombustibles-chile/>

³¹ https://www.codelco.com/biocombustibles-son-una-gran-oportunidad-para-chile/prontus_codelco/2011-02-16/112625.html

³² https://www.codelco.com/biocombustibles-son-una-gran-oportunidad-para-chile/prontus_codelco/2011-02-16/112625.html

³³ https://www.odepa.gob.cl/odepaweb/servicios-informacion/publica/Potencial_productivo_biocombustibles_en_Chile.pdf

³⁴ Fish information & services, 2017. *Micro-algae diesel reduces up to 80 pct high-powered engines contamination.*

<https://fis.com/fis/worldnews/worldnews.asp?monthyear=&day=24&id=92428&l=e&special=0&ndb=0>

³⁵ Reuters, 2017. *Chilean Scientists produce biodiesel from microalgae.* Available: <https://www.reuters.com/article/us-chile-environment/chilean-scientists-produce-biodiesel-from-microalgae-idUSKBN19L238> Hämtdatum: 2019-09-10

and politics has only just begun to look at the issue. The state is now funding four pilot plants for the production of ethanol from the forest's lignocellulose, as well as from algae.^{36 37}

Chile's large wine industry, like the French, could potentially act as a raw material supplier for ethanol production. But that is not happening, and in our meetings with leading winemakers they express limited interest in the proposal.

There are also good conditions for biogas production, from, among other things, wastewater treatment plant sludge and slaughterhouse waste, but no such waste is on the market. Since gas-powered buses are not part of Chile's cityscape, the step to switch from fossil to renewable gas is, however, greater than in other markets.³⁸

All in all, we have to assess that biofuels have a relatively obscure role in Chile's transformation of the transport sector. It also misses the chance to rapidly reduce the climate impact of transport that the blending of biofuels could provide, but with the transition to electric power, they can still meet the climate targets for 2030 and 2050.

³⁶ <http://www.conaf.cl/nuestros-bosques/bosques-en-chile/cambio-climatico/>

³⁷ <https://www.aprendeconenergia.cl/biocombustibles/>

³⁸ <http://www.revistaei.cl/reportajes/futuro-los-biocombustibles-chile/>

What about the railroad?

When we buy tickets for the train to Chillán, a couple of hours south of Santiago, we are met with great surprise from most Chileans we talk to.

Our journey puts the train's worries in flash lighting. Hardly anyone has included the train in their travel planning anymore, and it's easy to see why. Chillán is the final station to the south, and there we have to change to bus to get on to Concepción, the largest city in southern Chile. The cost is not higher than for the bus and the total travel time will no longer be, in addition we have a more comfortable trip, including a small restaurant car. But since the train and bus stations are a bit apart, we understand anyone who hesitates to use two modes of travel instead of one.

Throughout Chile, the situation is similar: The train will not take you all the way. There are no night trains left at all, the rails are not coherent, and Santiago does not have direct access by train to any of the country's other major cities. In northern Chile, the train has even had a different gauge than in the rest of the country. Well-functioning train lines are practically only those for raw materials, such as from the copper mine to the port. They are not operated at all by passenger trains. The only train service for passengers that can really be given practical relevance is Metrotren's commuter train in the capital region, as well as, of course, the metro in Santiago.

But perhaps the situation is changing. In Concepción, the commuter train is expanded and receives new, modern train sets. Between Valparaíso and Viña del Mar, the commuter train is becoming increasingly popular as it becomes more expensive to take the car. The Chilean government has requested proposals for a high-speed train between Valparaíso and Santiago, which would be Latin America's first high-speed train after Mexico City recently shelved its plans. In Chile, too, previous plans for train connections between the two cities have had to be abandoned, due to the high cost of crossing the mountains of the coastal coral. Both proposals combine high-speed trains with goods from the ports of San Antonio and Valparaíso, which is a prerequisite for doing without subsidies from the state. At the same time, however, complications increase because the speed of trains differs so much. Passenger trains are thought to go up to 200 km/h, giving a travel time of 45 minutes. The cost is estimated to be approximately CLP 2 500 billion.^{39 40}

The plans for high-speed trains have been met with strong protests from bus operators, for whom Santiago-Valparaíso is the largest single line. They argue that state guarantees for the train provide unjust competition and argue that the train's

³⁹ <https://www.soychile.cl/Valparaiso/Politica/2019/05/01/593498/Solicitaran-instaurar-un-plan-piloto-de-buses-electricos-para-Renaca-y-Concon.aspx>

⁴⁰ <http://www.trentvs.cl/> And <https://www.emol.com/noticias/Tendencias/2019/12/17/970756/Avanza-tren-rapido-Santiago-Valparaiso.html>

climate advantage does not apply in the future, as electric buses will soon be introduced on the route.⁴¹

⁴¹ <https://www.elmostrador.cl/noticias/pais/2019/06/06/gremio-de-buses-acuso-cancha-dispareja-ante-proyecto-de-tren-a-valparaiso/>

Mining industry: Chile no longer wants to export stone

Chile has long been a distinctly commodity export country, with the mining industry at its heart. It is also the focus of the transport sector's transition both nationally and globally, as Chile has the world's largest reserves of the lithium required for electric vehicle batteries. That is why we are particularly examining the lithium industry, on site in the Atacama salt desert, at the reprocessing plant, in the port for shipment and not least in Santiago's decision corridors. We begin with a longer discussion with Chile's minister of mining.

The mining minister post is one of the really heavy in the Chilean government and Baldo Prokurica has been given the post after many years in parliament as a representative of the Renovación Nacional. He exudes the safety and weight of being the world leader for several of the minerals that are crucial in the transition to sustainable transport; copper since long and now also lithium.

Now it's time to hurry up. That is the main message from Prokurica and the Chilean Government. The lithium market will increase very rapidly until about 2025, after which it will turn downwards as the switch to other minerals picks up and lithium begins to be recycled on a larger scale. In addition, neighboring countries Bolivia and Argentina, both of which have a lot of lithium in their salt deserts, should have, until then, greatly increased their production. Chile wants to rapidly increase production in the coming years, from 96,000 tonnes in 2018 to 230,000 tonnes by 2023. Lithium would thus become as important an export commodity as the forestry sector and wine.

The increase will take place partly at the two private operators who have already received a concession to extract lithium, and partly at the state companies Codelco and Enami, which have lithium in their mining but have not yet extracted it. In addition, the government wants to invite a number of new players, but that process is probably longer.

It is also important to speed up European players if they want the lithium that Chile will take up, and here the tone of Prokurica hardens. "Europe is far behind China, Korea and Japan in terms of battery development, and is beginning to realize that, with major efforts from the EU and the Germans to get production up and running in Europe. But they have to realize that we are not going to continue exporting stone without getting anything for it; more of the value must stay in Chile."

"Economically, there is a factor of 80 between just exporting the raw material, as we do now, and being at the very top of the value chain. We don't have to come all the way, but let's say 60.

To do this, Chile's contracts with those who receive a concession on lithium require them to reserve 25% of production for operators who, within Chile's borders, process the product. Anyone who commits to this is allowed to buy lithium 15% cheaper than the world market price and is guaranteed access to lithium for 20 years. A first tender has already been made, with the lithium from Albermarle.

- It went bad. We received four offers, including from Samsung, but suddenly all four withdrew. There are monopolies, agreements and barriers to entry. You want to defend your positions.

Prokurica still believes that something can happen when a new bidding process is about to be handled, because it begins to understand the government's intentions. Moreover, Chile is not nearly as far away from the vehicle manufacturers as many people think; "Brazil is a huge vehicle market, where Volvo and Scania, for example, build trucks, Argentina also, and Mexico is one of the largest producing countries for passenger cars. They are close to us, with good trade agreements with Chile."

"But the protests in Chile did great damage. We had state visits from Germany that could have led to agreements, but which were cancelled. At the same time, it should be remembered that we have had 30 years of stability, with 50 days of unrest, while many other countries with minerals had 30 years of unrest with 50 days of calm."

Damage to reputation also made the proposal by the Communist Party to nationalize lithium resources, which obtained a majority in parliament but was then stopped in court. "Worried stakeholders got in touch and wondered what we were doing – and the whole thing was of no use because lithium already belongs to the state. Should we, as a state, expropriate what is already being handled by the state companies? There was no logic to this."

As the only mineral in Chile, lithium has special protection; But Prokurica does not believe that it reduces the outside world's interest. "No other country provides the same long-term security as us," he said, but he is asked whether the special status of lithium will remain when Chile is now to produce a new constitution as a result of the protests.

Many questions about sustainability will be answered in the government's national lithium plan, which was due to be launched in autumn 2019. However, both the expropriation proposal and the popular anti-government protests meant that the proposal will rest for a while. It will be specified, according to Prokurica, how Chile will be the world leader in sustainable minerals. The water required to concentrate lithium from a few per mille to around six per cent must be returned to the salt deserts, and

those who are going to increase their production must do so within existing water conditions. In the field of social sustainability, it is specified how part of the value of sales must remain in the villages and how a special amount should be reserved for the Regional Development Fund. Much is a formalization of what is already in the contracts with the two developers, also with the aim of making the conditions more equal, transparent and follow-up.

In addition, the government strongly wants to signal that the mining industry needs to change its transport, as some have already done. "We have the second most electric buses in the world and now it will spread."

One company that listened to this is the mining company Angloamerican. Their all buses for shift workers are electric, "Because they are noisy and vibrating less than diesel buses, workers can sleep on the bus much better than before." For the really heavy transports, Prokurica wants to see a shift from diesel to hydrogen; "Rebuilding to electric power is extremely complicated, but a diesel engine can with a couple of fairly simple adjustments be powered by hydrogen that we can produce sustainably and cheaply in large quantities." Prokurica wants to see the state companies as the frontrunner in this transition, but the government does not seem to want to go further than that, despite a history of the state regularly controlling its companies in the mining industry.

When the conversation is over, Prokurica asks us with satisfied supervision to keep our eyes open in the near future. A cooperation agreement between a European country and Chile for the upgrading of lithium will soon be published in Chile. He does not say more, but it is clear that it is not very large-scale, because he continues to point out that Europe needs to engage more: "They have to stop crying that they are falling behind and act now."

Lithium – can Chile's white gold turn green?

More than half of the world's lithium reserves are found in Chile's salt deserts, and the state has control over this strategic raw material for electromobility. For this report, we followed the extraction in the Atacama Desert, the processing plant on the coast and the discussions in the corridors of politics in Santiago.



Lithium is the world's lightest metal and is expected to soon be on the European Commission's list of critical raw materials. The materials on the list are either global shortages, or very important to the European economy. The list already includes three substances contained in lithium-ion batteries: cobalt, silica and graphite. Lithium is not yet a global scarce commodity, but it is one of the EU's strategic key areas for economic development. Furthermore, according to Pia Alina Lange of the association Recharge, the availability of lithium is crucial for electromobility and climate neutrality in which the EU has the ambition to be a world leader.⁴²

For battery use, there are two types of split: into lithium carbonate (Li_2CO_3), of which Chile has large reserves, and lithium hydroxide (LiOH), which is mined in for example Australia. Lithium carbonate is used for batteries where maximum range is not a priority, e.g. in simpler vehicles, while cars with high demands on maximum performance typically have lithium hydroxide batteries.

Chile's really big export commodity is the copper, which gives the country over \$40 billion annually in revenue. Lithium combined is exported for about one billion dollars per year. The environmental director of the mining industry's industry body Sonami,

⁴²<https://www.euractiv.com/section/batteries/news/lithium-tipped-for-eu-list-of-critical-raw-materials/>, access 20-04-17

Carlos Gajardo Roberts, highlights this particular difference in size as an argument for not having so far focused very much on lithium as a raw material and export product.⁴³

This is now changing fast. Demand for lithium for batteries for electric vehicles has led everyone to want Chile's lithium, "Chile is the cheapest country in the world to extract lithium in," says Ellen Lenny-Pessagno, country manager of Albemarle, one of the two companies currently doing this.

Since 1979, Chilean law has established that only the state may handle lithium. The reason for the decision 40 years ago was quite different from today; was seen as strategic for establishing nuclear power in Chile. A special commission, CCHEN, was created, but no nuclear power was ever created – although it was re-examined on behalf of then-President Bachelet a couple of years ago. Despite this, the same restrictions now apply as then to lithium; it has survived the new Constitution of 1980, the new mineral law of 1983, the first environmental law that Chile only received in 1984 and the Ministry of the Environment which was only established in 2010. The restrictions also remain in place despite the mining industry's clear objections. In Sonami's opinion, all operators who fulfill the requirements of the environmental legislation, should be able to extract lithium.⁴⁴ The restrictions exist in a clear market economy context, where Chile as the only country in the world has also privatized the right to drinking water.

So far, two active companies have the exploitation rights for lithium: Albemarle and SQM. They are very different: American Albemarle is the largest in the world at extracting lithium and it is central to their business idea, while Chilean SQM is basically a chemical company with mineral fertilizers for agriculture as its main source of income. SQM has, however, been given lithium as an increasingly interesting by-product when they have mined potassium in the Atacama salt desert since the 1990s.

2019, SQM extracted about 48 000 tonnes of lithium, and Albemarle 38 000. Both intend to extract far more than today, with SQM assessing its long-term potential at as much as 300,000 tonnes per year. The state-owned companies Codelco and Enami are also authorized to extract lithium and can at the same time assist private companies that have been given the right to do so, which gives them dual roles on the market.⁴⁵

SQM's Environment Manager Alejandro Bucher does not see the agreements with the state as favorable; "Over half of the income goes directly to the state, Corfo should have 22 percent of the sale price, we pay a special mining tax for ten years, and all the usual corporate taxes. In addition, the conditions are changing rapidly, which is

⁴³ Personal conversation with Sustainability Manager Carlos Gajardo Roberts, 2019-12-03

⁴⁴ Ibid.

⁴⁵ Much of the information about Albemarle from personal meetings with the company's Chile manager Ellen Lenny-Pessagno and their regional advisors Ignacio Mehech, in both Santiago and the Atacama Desert.

difficult for us because battery manufacturers and the car industry want 15-year contracts, which we cannot offer. Then we run the risk of them turning elsewhere." Bucher also stresses that increased demand for lithium doesn't have to mean rising prices but rather the contrary: they are expected to decline sharply in 2020-2021 (before and regardless of the corona crisis) "There are many players, with over a hundred lithium projects on the Canadian stock exchange."

Lithium is extracted by pumping up and treating extremely saline water, *brine*, from underground natural basins in the Atacama salt desert at depths of up to 100 metres. Lithium extractors together account for about two percent of water use from the desert area, where the big consumers are mainly the copper industry and to some extent the villages next to the salt desert. Albemarle has a concession of 170 km² or about five percent of the salt desert surface.

In a primary stage, the water evaporates in large ponds, with the sun's energy and heat as its only source. From this perspective, the Atacama Desert is ideal: it is the driest in the world with a rainfall of just over a centimeter per year. The sun shines practically every day and 2,500 meters above sea level, the desert is comparatively low, which means higher temperatures and faster evaporation. Lithium can also be extracted from brine by chemical means, but it costs more and consumes more electricity.

In addition to lithium, other materials are extracted as well: among other things potassium, magnesium, calcium, sulfates and sodium are released into the total 15 ponds. Some because they are valuable products and others because they are impurities to be removed. To reach 100,000 litres taken to the industrial process by tanker, 13 million litres of brine is used from the dams, which last for up to 40 years before they are too covered in salt. Albemarle is responsible for the water level in the lagoons; below a certain level, its use must be reduced.

SQM's concession is from 1993, but has been renegotiated since then, including to incorporate the ILO Convention and to include since 2006 an environmental permit regulating the amount of brine that can be used. The concession is valid until 2030, while Albemarle has a concession until 2043, and environmental permits until 2041 – the last two years the area will be restored in principle to its original state, with the main difference likely to be that the surface will not be as rough as before. Then the plant should also be removed, which is relatively easy because the roads are made of materials from the extraction.

In the industrial stage, as in Albemarle's case takes place in their factory in La Negra near the coast, the liquid is dried and purified into lithium hydroxide powder with almost no remaining liquid. It is an energy-intensive process, largely powered by natural gas but increasingly electrified. Here, Chile's rapidly greening electricity mix with large wind farms and photovoltaic installations contributes to a relatively low carbon footprint. In addition, the electricity company Engie has promised origin-labelled, green electricity

from 2021, which also paves the way for more people to make green choices on the electricity market.

At present, Albemarle produces just under 40,000 tonnes of lithium per year. The company is also investing over CLP 855 billion to double production as early as 2021, with a new doubling later on. This should be done without using more water, which requires a much more efficient process – currently about 50% of the theoretically available amount of lithium is extracted, which should reach 90 percent in the long run.

Later on, Albemarle as well as Swedish Northvolt, wants to extract an increasing amount of its lithium from existing batteries in a recycling process. Since the lithium batteries last about ten years, it will take a while before there are larger volumes to recycle.

The lithium is marketed with 99.9 percent purity, in a variety of qualities. Country manager Ellen Lenny-Pessagno emphasizes that each customer has different requirements with completely different performance for batteries for mobiles and cars respectively. Virtually everything is shipped from the port of Antofagasta to battery factories on other continents, especially China, Korea and Japan.

Climate impact from production

The production of one kilogram of lithium carbonate emits five kilograms of CO₂ equivalent, according to calculations in SQM's latest sustainability report. Most of this comes from the processing plant and transport between the Atacama Desert, the coastal factory and the port of Antofagasta. A smaller part comes from the extraction of brine in the desert, which occurs by evaporation and from the energy used in the pumps that pump the water between the basins.⁴⁶

Villages in agreements with lithium companies

Social sustainability is important and sensitive in Chile's lithium production, and both major companies have had long and difficult negotiations on the issue. Albemarle distributes, as the only lithium company in the world, a fixed share of turnover to the indigenous villages concerned, while SQM distributes part of the profits. Both models have their advantages and disadvantages but only Albemarles are directly negotiated with all 18 indigenous communities in the area.

The villages concerned receive 3.5 percent of the company's turnover for the development of the area, which is distributed in 18 equal parts from Albemarle. In return, the commit to involve in monitoring water levels and protecting the desert ecosystem. The 18 groups have rotating presidencies one year at a time to ensure everyone's participation, but those closest to extraction are naturally more engaged. This is also part of the criticism slated for the model; why should all 18 groups receive

⁴⁶ Alejandro Bucher, Environment Manager at SQM, personal meeting 2019-12-20

the same compensation when they are so differently concerned? On the other hand, the villages also benefit differently, with 90% of Albemarle's employees in the extraction coming from the nearest village of Peine and the surrounding area. Albemarle has a 40% indigenous population among its employees, while SQM has 20-25%.

The collaboration is evaluated every two years by the University of Queensland in Australia, and recurrent by the participating groups. Seven of the 18 groups have development plans, which make it easier to assess the extent to which the funds from the mining companies contribute to development or not. In field, it is easy to see that the funds have come in handy, ranging from renovated churches to water purification, access to water and electricity. In addition, Albemarle has awarded over 120 scholarships for education and travel.

SQM instead distributes part of its sales revenue, 1.3% to the Government of the Antofagasta region, 0.2% to the Municipality of San Pedro and 0.1% each to Antofagasta and Santa Helena municipalities. In addition, USD 10-15 million per year goes to indigenous communities in the region, the exact amount depends on the lithium price. That is a total of about 5,000 people, who receive about two minimum wages per person. The agreements are between SQM and Corfo, which several of the indigenous peoples are so critical of that they do not want to participate in the talks with the parties. As a result, each group set up its own boards for dialogue with SQM, which is elected by universal suffrage in the villages. These boards decide what they want from SQM: when we are on site, a hotel is inaugurated funded this way.

In addition to these agreements, SQM has set up a regional research institute on sustainable mining and green energy, with funding until 2030, and SQM has two agronomists assisting the villages in the development of agriculture, including the Development of Agriculture. with a project to try to produce wine. It is in line with Corfo's guidelines that the aid should go to economic development but not health care. Bucher notes that "only two of the villages have viable drinking water, the rest have too much arsenic in the water, however they don't value it that much."

Albemarle's social affairs officer, Juan Pablo Armisen, estimates that three more years of this form of aid will cover the region's basic needs, what the Council will finance next is unclear.

To an outsider, much of what the company has financed seems like what the state should and could do: the residents' dependence on the lithium companies, and the mining industry in general, is hard to ignore. Mr Armisen acknowledges the problem but says that the state is not de facto very present; the alternative in practice is not

that the State does this but that it does not get done. Hence, partnership and cooperation have become the model for the development of villages.⁴⁷

Water in focus - and increasing interest in climate change

In the Atacama Desert there is an underground, several hundred meters deep layer of *brine*, extremely saline water. Here the salinity is upwards of 550 kilos per cubic meter, more than twice as high as in the Dead Sea and more than ten times higher than in normal seawater. This brine contains 0.2% of lithium, which is the basis for Chile's and neighboring countries' extraction.

Both companies currently extracting lithium in the Atacama Desert do so by pumping up large amounts of brine and letting the water evaporate until the lithium content reaches 6% after 18 months. They argue that this does not affect the biodiversity of the salt desert, as neither humans nor animals can live in such an extremely saline water or even use it as drinking water.⁴⁸

Others take a different view. Lithium production can never be sustainable, says César Padilla of the organization *Observatorio Latinoamericano des Conflictos Ambientales*. "There's only bad mining and worse mining." It is mainly the use of water in extraction and its impact on the ecosystem that he is critical of. He does not give much for the fact that a national policy on sustainable lithium extraction is now being drawn up; it should be a policy for sustainable salt deserts and until it is in place, a moratorium on lithium extraction should be introduced.⁴⁹

SQM uses 1500 litres of brine per second, Albemarle 442 litres (2019). Since this underground salt water has been created over thousands of years and hardly replenished at all, the abstraction by definition means that the level is falling. Albemarle has real-time information about the water condition in its pumps and monthly publishes a public report along with the surrounding villages.

The indigenous people around the desert therefore appealed against SQM's environmental permit and the Antofagasta Environmental Court ruled that the salt desert is a particularly sensitive ecosystem, that hydrological knowledge of the effects of salt water abstraction is too limited and that the project is in the area of indigenous population development. The court also considered that SQM had previously been convicted of violating its environmental permit in six areas. SQM is now condemned to comply with the conditions of its environmental permit, but also to deal with the

⁴⁷ Personal meeting, Juan Pablo Manterola, responsible for social issues and cooperation with indigenous peoples

⁴⁸ Conversation with Hugo Latorre, chief operator of Albemarle, and Jorge Garcia, hydrogeologist for the same company

⁴⁹ César Padilla, of Latin American Observatory of Environmental Conflicts, personal meeting, 2019-12-10

negative effects of failure to comply with them in the past. If this is not met, the entire operation may be closed.

The large dams have an evaporation of 20 000 m³ per day, which is seen by many as very problematic. Others see it as part of a cycle, which can ultimately lead to increased rainfall – longer measurement periods are required to determine whether it actually occurs.

When it comes to freshwater use, lithium extraction is a small consumer. SQM uses 180 litres of underground fresh water per second and Albemarle nine, at over 2,800 litres per second for the copper industry, which is also in the desert.

Berkeley University's two dedicated centers on resource efficiency and energy transition have reviewed the sustainability of the development of electric car batteries, with a special review of lithium extraction. They indicate, among other things, that the supply of lithium itself is unproblematic; there are 14 million tonnes of lithium reserves and 62 million tonnes of known assets, while in 2018 85 000 tonnes were produced. Even with a predicted nine-fold demand by 2050, lithium will not be in short supply such as cobalt and graphite can become.⁵⁰

According to this study, the largest lithium reserves are in Chile, with 30% of the world's total assets or about 45 million tonnes, ahead of Bolivia with 39 million tonnes, Australia with 15 million tonnes and Argentina with 9 million tonnes. The largest single area was the salt desert of Uyuni, Bolivia, with reserves of 39 million tonnes before the Atacama Desert in Chile (SQM), with 19 million tonnes. However, the largest production country in 2018 was Australia, with 292 000 tonnes or 60 % of total production, ahead of Chile with 97 000 tonnes, Argentina with 37 000 tonnes and China with 35 000 tonnes (we note that the data on total world production and shares of the same do not harmonize, but use them to describe proportions). The world's largest lithium producer in 2018 was Albemarle with 20 % of total production.

The 2017 Resource Governance Index, which measures transparency and accountability, has reviewed most of the countries with the largest lithium assets and rates Chile as "good" while Australia gets the slightly lower rate "satisfactory." In terms of local environmental impact, the Berkeley institutions highlight water use in the extraction of lithium in the Atacama Desert, but also stress that the problems of mining other minerals are far greater.

The study "Socio-environmental impacts of lithium mineral extraction. Towards a research agenda" identifies a number of areas where the level of knowledge needs to be raised regarding lithium extraction from the Atacama Desert:

⁵⁰ Center for Law, Energy & the Environment and National Resource Governance Institute: Building a sustainable electric vehicle battery supply chain, April 2020

- a) Baseline. The knowledge of the desert and the situation of the adjacent areas regarding, for example, water supply, flora and fauna before mining of minerals and metals began is insufficient.
- b) Health consequences. Lithium is not assessed to bioaccumulate in the body, but is toxic in high concentrations, and extraction by evaporation should give rise to increased levels of lithium in air and water, with unknown consequences for the health of humans and animals.
- c) Knowledge-based asymmetry. How the large differences in knowledge between different groups concerned, such as the producers and local residents, influence the conditions between them, also need to be examined more, for example when it comes to ground water.⁵¹

E&T and satellite analysts at SpaceKnow have reviewed SQM's impact on the Atacama Desert ecosystem. They found a strong link between rising water levels in SQM's dams and declining levels in the natural lagoons that are crucial, among other things, for Andean flamingos. In the past, SQM has indicated that the lakes' water and brine salt water were not mixed, but it is now clear that there is some interaction between the systems. In addition, it is not known how the freshwater reservoirs behave if the salt water beneath them is drained, which is done at up to 1,700 litres per second for SQM and 442 litres per second for Albemarle.

The message to the battery manufacturers: set requirements!

Some 70 actors in the battery and automotive industry have gathered in the Global Battery Alliance, which by 2022 will ensure sustainable batteries. So far, the focus has been on working conditions in the extraction of cobalt as well as energy consumption and the climate impact of battery production - not lithium extraction.

Chile's government and producers say they encourage a focus on sustainability for the lithium part as well. The water issue becomes central; industry must respond to demands from governments, environmental organizations and indigenous peoples - and lithium buyers. Climate impact also needs to be further highlighted; certainly the sun's rays are used in the first step, but then the factory process is energy intensive and the transport routes are long and are done with fossil-powered trucks and ships. Chile also wants to refine more of the lithium within the country, with the goal of getting battery production in place - and hopes that strong and measurable sustainability will contribute to it.

Cristina Dorador, a Chilean biologist who studies microbiology in the Atacama Desert, is highly critical of lithium extraction, which she says knocks out villages around the desert. "Chile is a paradox. On the one hand, we will phase out our dependence on fossil fuels to reduce our climate impact and the threat to our biodiversity. On the other

⁵¹ Agusdinata, Data Buyung; Liu, Wenjuan; Eakin, H Combines and Romero, Hugo: Socio-environmental impacts of lithium mineral extraction. Towards a research agenda, 2018

hand, we are using the environment to get resources for electric car transition in the world."

In addition to the two companies that are already extracting lithium, more are coming in. One of them, Canadian Wealth Minerals, is to be located in the northern part of the Atacama Desert, next to a Ramsar-class wetland area. Sergio Cubillos, head of Chile's Indigenous Council, Consejo de Pueblos Atacameños (CPA), is concerned that the government does not have sufficient capacity to ensure that the increasing number of companies that are thought to extract lithium, comply with the regulations.⁵² Although the Environmental Impact Assessment for Wealth has already been approved, the Parliament's Justice Committee decided, following protests by the CPA, to declare the application inconsistent with the Constitution, which points to both possible problems with lithium extraction and that the process is highly politicized.

At present, it looks like the battery industry is switching from lithium carbonate to lithium hydroxide, which would weaken Chile's competitiveness – but a massive shift to electromobility can also lead to increased cost requirements and thus increase interest in the simpler and cheaper lithium carbonate. The U.S. Geological Survey states that more and more lithium will come from mining rather than salt deserts; in the mine it is easier to control the impact on the environment and the issue of water consumption is unlikely to be as topical. Albemarle is investing on both tracks; it more than doubles the capacity of Chile's salt deserts but also invests in mining for lithium in Australia. With a rapidly growing market, there may be room for everyone.⁵³

⁵² <https://investingnews.com/company-profiles/wealth-minerals-lithium-salars-atacama-chile/>

⁵³ <https://www.ocmal.org/lithium-firms-depleting-vital-water-supplies-in-chile-analysis-suggests/>

Sweden: Leader in Chile's heavy sector

The transition to more sustainable mining strengthens opportunities for Swedish exports. In underground mines, as in Sweden, electric power is already profitable. Swedish mining machine manufacturers can benefit from staying ahead when Chile makes its transitions in this sector.

Mining machine manufacturers Epiroc and Sandvik are both major in Chile and Latin America. Epiroc has a whole series of electric mining machines and sees a rapidly increasing interest from the market. "In underground mines, it is already profitable to use electric-powered machines. They have 85% efficiency, while diesel machines convert 70% of the energy into heat, which is an expensive problem in the mines because they will then have to be cooled more. In the open mines, business logic is much more difficult for electric power, and the machines so enormous that there are not yet electric machines that meet the needs.

Lithium deposits are currently open, as are several of the large copper mines. But a change is underway, says Sonami's Environmental Manager; "Climate change is making it rain more and more violent in the mining areas, and then it is more convenient and safer to have underground, closed mines." The picture is reinforced by Sandvik's Sustainability Manager for Latin America; "In several of the large mines, copper is now so far down that it is more economical to access it from below, in closed mines."

State owned Codelco recently had its first procurement of mining machinery with clean electric requirements, in line with the government's ambition that state companies will be the frontrunner in the transition to renewables. Codelco has also invested some in biodiesel with good results, although it is still relatively expensive.⁵⁴ In addition, several of the major mining companies are now analyzing how existing mining machinery can be converted, with hydrogen in diesel engines as the main track.

Epiroc uses Northvolt batteries, which unlike the machine itself are not sold but rented. This will reduce customer concerns about new technologies, while making it easier to upgrade the machines as battery technology evolves. At the same time, in a few years' time Epiroc will bear stocks of used batteries, for a second life in the mains or battery recycling. We do not yet know how to deal with this, and Chile does not yet have any legislation regulating it.⁵⁵

⁵⁴ https://www.codelco.com/biocombustibles-son-una-gran-oportunidad-para-chile/prontus_codelco/2011-02-16/112625.html

⁵⁵ <https://sustentable.uc.cl/noticias/353-vehiculos-electricos-santiago-se-mueve-con-energia-verde>

Climate justice: Chile raises difficult questions

Chile is a country hard hit by the effects of climate change. The drought of the past year, coupled with shrinking glaciers and an increase in more and more water-intensive exports such as avocados, copper and lithium, has put pressure on water conservation. As water is privatized, water has also become an increasing part of household spending.

The protests against government policy in Chile on 18 October 2019 began in response to increased prices in the subway. In fact, it was only the trigger; requirements included increased pensions and better school and education.

In Chile, the inequality in the education system is telling; money controls where the family can afford to put their children in school and university. Those who can afford it can go to private school and get a far better quality of their education, including English, than those who end up in public schools.

The protests also have, more or less indirectly, an environmental and climate dimension. How should everyone be included in the transition if you cannot afford to transport yourself climate-friendly?

Chile is the most unequal country among OECD countries, according to the Gini coefficient, which is the most accepted measure of income inequality. Although the steady growth of recent decades has pushed the poor down from 30% to just over 6% between 2010 and 2017, there is a big difference in how growth is distributed. In 2017, the wealthiest one percent of the population had 25 per cent of the country's resources, while the poorest 50 per cent had to settle for 2.1 per cent, according to the UN Economic Commission for Latin America, Cepal.

This also has an impact on the proportion of household expenditure involved in transport costs. The integration of the metro into the rest of public transport in 2007 and its subsequent expansion into more municipalities has been seen as one of the great equality reforms in the transport system because it connects the city and provides the same opportunities for the rich and poor to transport themselves. Transport can account for up to a third of household spending for low income people, compared with around six percent for those with Chilean average income. This is still almost twice as much as for people living in Stockholm, according to BBC Mundo.⁵⁶

Santiago has more than three times the values of PM10 (particle with particularly high levels of pollution) than the WHO recommends, according to official figures. The Ministry of the Environment has calculated that air pollution causes around 4000

⁵⁶ <https://www.svd.se/fem-klyftor-bakom-chiles-massprotester>

premature deaths annually. So there is huge money to be saved in pure health benefits from an electrified public transport fleet – about \$8 billion a year, according to the Environment Ministry.⁵⁷ And because bad health is so unevenly distributed, the investment itself is an way to decrease environmentally related social inequalities. Thus, it is possible to load a fair share of equality in the electric bus strategy. They make the urban environment cleaner and quieter for all, and the electric buses with their higher standard have the same fare as diesel buses. Unlike in many other cities, they do not run limited routes in the city but really connects poorer suburbs with the city centre. Electric passenger cars, an investment for individuals and companies that can afford it, receive no government bonus and the state does not spend any money on the expansion of charging infrastructure.

Economic equalization by allocating the income from major export commodities, where lithium is one, is managed to some extent by the companies. Both the major lithium companies distribute funds annually to the indigenous peoples around the extraction of the Atacama Desert, with a clear anti-poverty profile. The agreements between the companies and the villages around the Atacama Desert also has a deeper dimension of justice.

It could be argued that companies have made themselves indispensable for the villagers when they invest in community functions such as electricity, health care and school buildings. As the lithium chapter suggests, there is awareness of this at Albemarle, who also points out that the state does not make these investments, and then it is better for the company to take responsibility, otherwise the villagers would not have received anything at all. It is also possible to discuss how much of lithium's value added, in the form of electric vehicles, that comes to the villagers around the Atacama desert. Perhaps they should be the ones to be first in line to try out the electric vehicles, say in a car sharing or taxi scheme?

Both lithium-producing companies also have an awareness that what may affect life chances in the region in the long term is mostly not the individual projects, but the future water resources. SQM uses recycled waste water for parts of its process, and Albemarle doubles its production of lithium without increasing raw material extraction or water use. However, knowledge of what happens to groundwater when reserves of ultrasalt brine decrease, is limited and many are reading a social dimension into allowing extraction to increase so sharply when complementary research still seems to be needed on basic effects as well.

The port of Antofagasta, from where Chile's lithium is shipped to the outside world, is funding the city's expansion of cycle lanes. As a responsible social actor, but perhaps also to gain a better reputation and for their own benefit later on.

⁵⁷ <https://www.unenvironment.org/news-and-stories/story/electric-buses-put-chile-path-healthier-tomorrow>

At the same time, the promotion of cycling is fully in line with the government's intentions, with the expansion of bike lanes, a cycling law for increased safety and the closure of streets for cycling. And all this, as we have seen, has a clear dimension of economic equalization. Cycling provides the freedom to transport independently between and within municipalities, and any motorist who sets the car aside to ride a bike, provides a health benefit for both herself and others. And once you have a bike, it's free. Perhaps this is where the state can make an effort, by creating, in state company form or other governance, a roll-out of stable budget cycles that everyone can afford?

Conclusion: 10 lessons learnt from Chile

1. **Climate transition requires social justice.** Sweden will become the world's first fossil-free welfare nation and the EU the world's first climate neutral region based on the principle of "leave none behind". The protests in Chile and the continued work on a new constitution will – for better or worse – provide relevant input for that process.
2. **The mining sector can turn green.** If leading car and battery manufacturers and/or purchasers make demands, Chile can lead the transition to fully sustainably produced lithium. Those experiences can also be relevant to completely different metals and minerals in the transformation of the transport sector.
3. **Climate transition does not require large subsidies.** Chile's transition to sustainable transport is mainly without direct economic subsidies. Instead, it is achieved by focusing on sectors where public procurement, planning monopolies and other state and municipal smart tools can be systematically used.
4. **Climate transition can be technology neutral.** Chile's massive roll-out of electric buses has been achieved through technology-neutral emission requirements, not through, for example, the use of electric bus premiums. In this way, by allowing the market to find the best solution will provide greater security for the future than if decisions have to be confirmed in every state budget.
5. **Companies play a role, but the state needs to be present.** In northern Chile, lithium companies are responsible for basic services such as access to water and electricity. Since the state is absent, the alternative is usually nothing, but for development to be sustainable, a clearer agreement between the civilian population, businesses and the state is required - with possible learnings for investment in, for example, wind farms or hydropower.
6. **Cycling is resilience.** When the social protests in Chile broke out, many switched from car, bus and subway to bike to reduce their vulnerability and increase the likelihood of arriving. In a world where vulnerability is highly on the agenda, we need to learn about a resilient and equal mode of transport.
7. **The passenger car needs to be challenged.** Chile's investment in electric buses has the purpose to make it less attractive to take your own car to the city centre. The electric bus is so comfortable, quiet and fast that many motorists

are finally considering letting the car stand - an effect that should be similar in other parts of the world.

- 8. The energy sector and the transportation benefit from being interconnected.** Chile is rapidly expanding solar and wind, with among the lowest prices in the world, linking this to the transformation of the transport sector: for example by letting surplus electricity from solar generate hydrogen for long distance heavy transports, and by charging Santiago's electric buses on locally produced renewable electricity.
- 9. Roads are expensive, let the users pay.** Chile's toll motorways are accepted by most people, which, on the one hand, means stable revenue for the state, but on the other hand, it is not a particularly sharp instrument for reducing transport. Countries with hundreds of miles of roads that are expensive to maintain and used by a fraction of the population should perhaps consider whether the use should be free or whether it is possible to find an appropriate cost.
- 10. No one can be a front runner in everything.** In the run-up to the COP25 climate summit, Chile – a country with limited resources – strategically selected a few sectors where they want to be leaders and have something to show for the outside world. Lithium production, electric buses in big cities, the rapid expansion of solar and wind and to some extent investment in cycling. In far more areas, the country is not doing anything worth mentioning from a climate and sustainability perspective, for example within the sectors of biofuels, the conversion of aviation or electric passenger cars. We believe that such a clear demarcation is a success factor worth considering in the Swedish context as well.