CHILE - BEACON FOR THE GLOBAL ENERGY TRANSITION

How sceptics became supporters of renewables energies

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Next page

Manual: How to move through the brochure

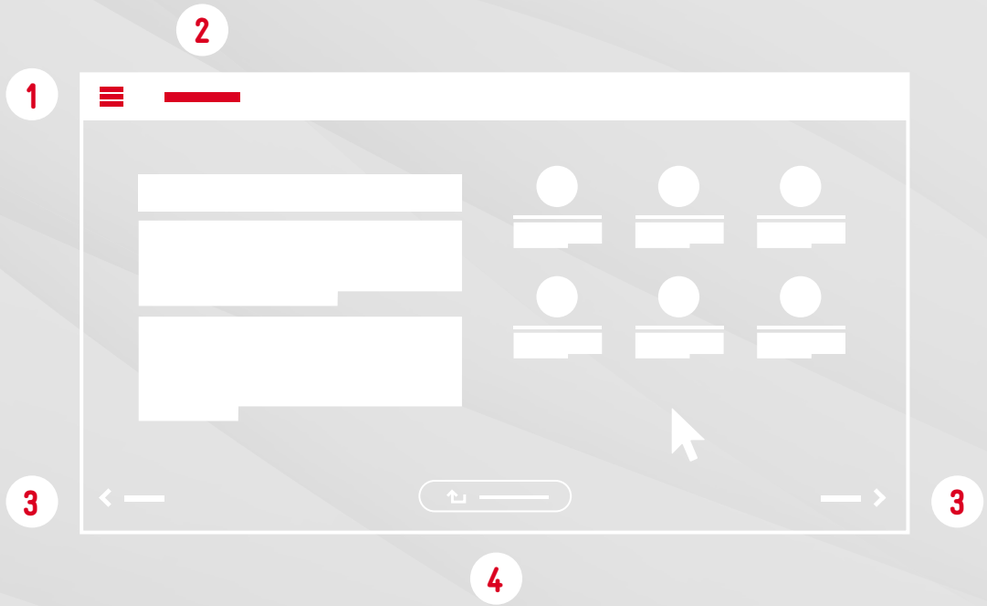
This handbook is divided into chapters. It is possible in principle to use each chapter independently of the others and jump in at any point – depending on your specific interests and level of expertise.

The chapters are linked to one another, meaning that many parts of the handbook will refer to other sections that fit the topic. Furthermore, this handbook contains links to external websites. It makes sense to be online when you use this document.

External links 1. Link address: https://www.giz.de GIZ

Internal links in the handbook → **Chapter 2.0**

This handbook has been programmed as full screen display.
To exit the full screen mode, please press the ESC key.



1.) Menu: takes you directly to the overview page (page 3) of all chapters

2.) Imprint: direct link to the imprint on the last page

3.) Previous page/Next page: click to move to the previous or next page.

4.) Back: click to return to the page you viewed last (e.g. before you clicked on a link).

Table of content

Click on the main chapters or individual subtopics to go there directly

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

1.0 Introduction

1.1 Climate neutrality and coal phase-out – why Chile will achieve its goals

There are many reasons why Chile is now a beacon for the energy transition: good geographical conditions, a pragmatic market-based approach, and many development steps that organically build on each other. That's why it's worth having a look at Chile.

Chile experienced what a gas crisis feels like in 2004. Alike being dependent on Russian gas as Europe, Chile was dependent on Argentine gas. Since the end of the 1990s, it was flowing continuously in half a dozen pipelines across the border. From 2004 onwards, it flowed more and more sporadic until Argentina - supply contracts back and forth - reneged on the agreed deliveries in mid-2007. Then Argentina cut the supplies by 90 percent overnight.

Chile responded to the shock by building diesel power plants and liquefied natural gas terminals, and by constructing coal-fired power plants along the coast. In addition, it introduced the first renewable energy regulation law in Latin America. 'Regarding Argentina's gas shock: `What had been viewed as an opportunity to be seized in the future suddenly became an urgent imperative´, the former Chilean ministers Andrés Velasco and Marcelo Tokman state. This is what connects Chile to the world today, 15 years later.

However, the market for renewable energy was to develop slowly. Important players were – as in many countries around the world – skeptical about the new technology. It took time for the market to develop dynamically. Grid access for renewable energies had to be regulated, models had to be calculated, the skeptic had to be convinced with facts, studies, and pilot projects.

Germany accompanied Chile from the very beginning. Funded by the German Federal Government, Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ) cooperates closely with the Chilean Ministry of Energy, the national electricity coordinator, associations, and companies. Over the years, mutual trust has developed. Without this, the cooperation with the key players in the vulnerable energy sector cannot function. GIZ was one of two foreign organizations having a seat in the **Chilean Coal Commission** (→ **Chapter 4.3**) – this fact is an expression of growing appreciation.

1.2 Coal-fired power plants – game changer for 100 percent renewables?

Chile can only abstain from fossil fuels if it can ensure a round-the-clock supply with renewables. The potential therefore is given. Hydrogen could work as a storage medium for grid fluctuations, but not today. This is why coal power plants could be the game changer for 100 percent renewables.

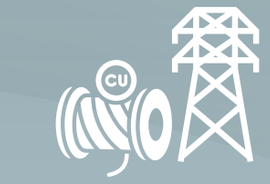
The interim solution for grid fluctuations could just be provided by coal-fired power plants that no longer drive their turbines with coal, but with renewables. Here, too, Chile is making progress. In 2023, the power utility AES will start the first pilot plant around the globe in one of its coal-fired power plants in Mejillones. The idea came from **GIZ 4e Chile** (➞ **Chapter 1.7**).

This innovative approach involves converting coal-fired power plants into **thermal energy storage units** (➞ **Chapter 4.2**) that can then generate clean electricity around the clock, combined with fluctuating renewable energies such as PV and wind. This idea, which Rainer Schröer presented to the Coal Commission in 2019, could become the gamechanger for the global energy transition. **Regarding coal see the Interview with Rainer Schröer and Rodrigo Vasquez** (➞ **Chapter 4.5**).

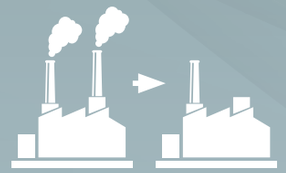
Due to the dynamic development of renewables, in 2021 the Chilean government voluntarily brought forward the phase-out date from coal from 2050 to 2040. In 2022, Chile became the first Latin American country to commit the progress by a Climate Change Framework Law.

AES coal power plant in Mejillones

1.3 Chile and energy – numbers, data, facts



10.7 MWh
of electricity is consumed per ton of copper



60 %
of Chile's coal-fired power plants could be converted into storage power plants

0,02 €
is how low the production costs are for PV electricity, 3,5 eurocents for wind power

1,865 GW
is the potential of renewables in Chile

5 billion US$
may flow into green H_2 projects by 2025

US$ 1.5
per kilo is H_2 expected to cost or less by 2030, compared to US$ 4–6 at present

1.4 Interview Alex Santander:

"Chile can become a kind of natural laboratory for the whole world."

The success of renewables in Chile is no coincidence, says Alex Santander. He is head of the Department of Energy and Environmental Policy and Studies at the Chilean Ministry of Energy.

Since 2014, a real boom has taken place in Chile around renewables, especially about the development of hydrogen (→ **Chapter 4.2**). What are the reasons for this?

Alex Santander: It's certainly not a coincidence. There is a lot of work between the beginnings and today. In the beginning, it was important for us to ensure legal certainty, to be attractive as a country for investors, and to ensure competitive energy prices for the population and grid stability.

Have the challenges changed?

Definitely. With the dynamics of renewables and the topic of hydrogen, new challenges are emerging. How do we profit from this development economically and how can we shape it sustainably and socially? Hydrogen must go hand in hand with the creation of local value. We need answers to this, also in terms of land consumption. So, we are confronted with many questions that others are also sking. In this respect, I believe that Chile can become a kind of natural laboratory for the whole world.

What role has the GIZ played in this?

It has accompanied us on many issues. Its studies, analyses and international network in various areas have been crucial for us, especially in the development of renewables, hydrogen , the conversion of coal-fired power plants into storage power plants and much more. It is a very good cooperation for which we are grateful and which we appreciate.

1.5 The Chilean energy matrix

The Chilean electricity market consists of three sectors: generation, transmission and distribution. All three sectors are carried out entirely by private companies. While the generation of energy is carried out according to free market competition, the transmission and distribution sectors are characterized by regulated monopolistic structures.

In December 2022, the installed capacity was 33,218 MW, according to the Chilean Association of Power Generators. 62 percent of the installed capacity was made up by renewables and 38 percent by thermal power plants. The latter are fed by 13 percent coal, 15.1 percent by natural gas and 9.8 percent by oil. Renewable energies are composed 22.3 percent by hydropower, 24.1 percent by solar energy, 13 percent by wind energy, 2.3 percent by biomass and 0.3 percent by geothermal energy.

In the past decades, the **Chilean energy matrix** (→ **Chapter 1.5**) has changed significantly. For example, the share of hydropower has declined sharply due to climate change, while the share of wind and solar energy has grown steadily.

However, the dynamic development of renewables is leading to new challenges. The existing capacities of power lines are not sufficient to transport all the electricity produced. They must be expanded, and energy storage solution must be incorporated.

The line transports electricity from Mejillones to the mining region in the Atacama Desert.

1.6 3 questions for Claudio Seebach:

"Chile has been seen as one of the most attractive countries in investing in renewables in the world."

Currently, Claudio Seebach is the Executive Chairman of the Chilean Association of Power Generators (Generadoras de Chile). He and his organization are of mayor importance for the energy transition. In this interview, he specifies the advantages of his country and points out why it is worth taking a look at Chile's energy transition.

Chile has set itself ambitious energy and climate policy goals. What makes your country so distinctive?

We have a very open economy in terms of an electricity generation market, which is open to investments, open to disruption in new technologies, and open to innovation. Investors have come here with new technologies, replacing older technologies, which have supported a quite competitive market. Additionally, we have long-term energy auctions. Enterprises bid for delivering electricity for customers in Chile for 20, 30 years. So, they commit to Chile for a long time. Chile has been seen as one of the most attractive countries in investing in renewables in the world for many, many years."

What are the obstacles on the way to the energy transition?

We need to expand transmission capacities to transport the renewable energies to the consumers, for example the mining industry. And we need storage technologies to balance the fluctuations of wind and sun.

What are the benefits of the energy transition?

Together with hydropower and renewables, we have the chance to get rid of coal. This energy transition represents a great economic and social value and has a positive impact on the environment and the climate. Against this background, our experiences are quite inspiring for other countries as well.

1.7 Chile, energy and the GIZ

It all started with an energy efficiency program in 2005, when a lack of gas supplies from Argentina strengthened the Chilean government's idea that energy efficiency could play a role for the country's energy security.

A few years later, GIZ created the basis for a rethink with an analysis of the potential of renewables. Many considered those to be too expensive, too uncertain, and too unattractive. Hence, GIZ invited proponents and critics to a round table. (**See Groundwork takes time. But it works (→ Chapter 2.2)**). This marked the beginning of an intensive, still ongoing cooperation on almost all relevant topics related to renewables: the coal phase-out, hydrogen, and the energy transition. In recent years, GIZ supported hundreds of projects and thus made a significant contribution to Chile's energy transition.

The donors changed – from the Federal Ministry for Development and Cooperation (BMZ) to the Federal Ministries for the Environment (BMUV) and Economics (BMWK) and, more recently, the EU. Together, the perspective also changed – from economic development to environmental and climate protection, as well as to economic cooperation for the benefit of both countries.

Cooperation Towards Chileans Energy Transition

Programa de Energías Renovables y Eficiencia Energética en Chile

1.8 3D model of German-Chilean cooperation

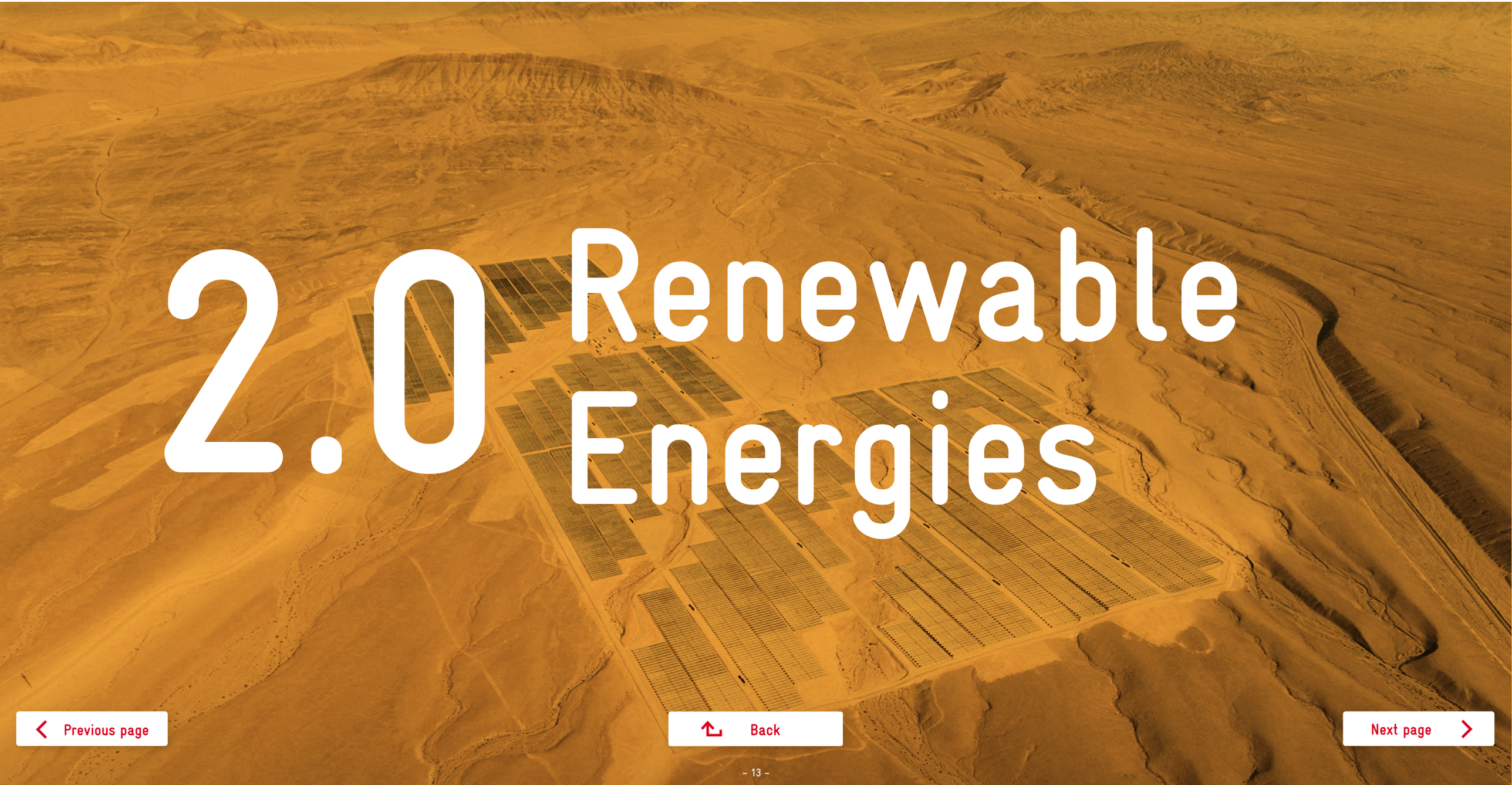
With more than 1,800 gigawatts, Chile has a huge potential for generating renewable electricity. Currently, the country uses only a very small part. For this, besides the possibility to decarbonize its own economy, it has a high potential of being an energy exporting nation.

The interactive 3D-model of GIZ outlines how Chile can stimulate a climate-neutral future. You can find the 3D model on the homepage of 4e Chile by scrolling down the page.

Many of these paths are already being followed by the country, others - such as the production of **hydrogen** (→ **Chapter 3.0**) - are planned. GIZ supports its Chilean partners with expertise in many of these activities. GIZ created this interactive 3D-model on behalf of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMUV) and the Chilean Ministry of Energy.

You can find the 3D model on the homepage of 4e Chile by scrolling down the page.

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH



2.0 Renewable Energies

2.1 Renewable energies - the new normal

Companies and donors are investing billions in Chile's renewables. The market is booming, partly because the government created the necessary framework – and GIZ assists in convincing the sceptics with potential analyses, feasibility studies, facts, and pilot projects.

If you turn off in Chile's mining town of Calama towards San Pedro de Atacama, you will see dozens of wind turbines and a sea of black PV modules soaking up sunlight in various energy parks. No matter in which direction you drive, new PV parks and transformer stations are arising everywhere. The dynamic is palpable by hand.

Its geography creates advances to the country. In the north, Chile has the highest measured solar irradiation values in the world complemented by excellent wind conditions, especially in the south of the country. Production costs of less than two Eurocents per kilowatt hour for photovoltaics and less than 3,5 Eurocents for wind power are unrivalled. The potential for wind and solar is enormous, summing up to at least 1,900 gigawatts: It exceeds the country's current capacity of electricity generation by a factor of 75.

These are excellent starting conditions for the Chilean government's hydrogen (H_2) strategy adopted in 2020. By 2030, the country wants to be the cheapest producer of green hydrogen. In addition to the economic options, it opens the possibility for Chile to contribute to its own climate goals with green H_2 for example in the transport sector, which was responsible for 25.5 percent of all CO_2 emissions in 2018, or the **mining industry** (→ **Chapter 6.0**), which accounts for 15 percent. Chile was one of the first countries in the world to commit in its Nationally Determined Contribution (NDC) to reducing CO_2 emissions using green H_2 by more than 20 percent in 2050.

Investors appreciate these geographical, economic and political conditions. The country regularly ranks at the top of a Bloomberg ranking of the most attractive countries for investments in renewable energies.

2.2 Groundwork takes time – but it works.

Not even visionaries would have predicted the current dynamics of renewables before 2013. Important players in the energy market such as power producers, the mining industry, regulators, and electricity grid operators were skeptical about renewables. Too expensive, too unsafe, too immature, they said.

There was a lack of know-how in the country, and a regulatory framework for renewables was not existent. 'The generation and distribution of energy was in the hand of a few companies. Therefore, the government had to enact many laws and regulations. To open the markets for renewable energies, the German-Chilean cooperation, especially with GIZ, was crucial', says Beatriz Hernández, who is responsible for international relations at the Chilean Ministry of Energy.

Rainer Schröer, head of 4e Chile from 2014 to 2022, knows how to take critical voices for the ride: 'You have to take skepticism seriously and then convince critical voices with concrete facts as well as sound technical and economic analyses for new solutions, technologies and methods.' **(See also the interview with Rainer Schröer and Rodrigo Vasquez) (→ Chapter 2.5)**.

To this end, GIZ, together with its partners in the Ministry of Energy, has, for example, recorded in detail the potential for renewable energies and examined their feed-in affects the Chilean grid. Schröer also invited experts from the German power grid operator 50Hertz to act as sparring partners for the Chilean power grid operators. 'Crucial to success is how we integrate variable renewable energies intelligently into the power grid without jeopardizing grid security', says Rodrigo Vasquez, co-leader of 4e Chile.

The 4e Chile program has also commissioned the development of a national forecasting system. With it, the expected electricity yields from solar and wind plants are recorded and processed by the electricity grid coordinator to control the national electricity grid. Additionally, 4e Chile has worked with the energy market regulator (Comisión Nacional De Energie - CNE) to develop new standards for grid integration. It advised the Ministry of Energy on optimizing long-term energy planning and helped drafting more than a dozen norms and regulations for Chile's energy sector.

This groundwork takes time. 'But it works', says Rainer Schröer: 'All these things are crucial for a sustainable energy transition. That is why the Chilean experience is of great value for many other emerging and developing, but also for industrialized countries.' In Chile, at any rate, groundwork and the government's pragmatic approach have now sparked euphoria and former sceptics like the mining industry **(See the video → Chapter 6.2)** became drivers of the energy transition. As of June 2022, photovoltaic capacities stood at almost 5.1 GW and for wind energy at 3.7 GW. And many more projects are in the pipeline.

2.3 The first Concentrated Solar Power (CSP) plant of Latin America is operating in Chile.

With 10,800 mirrors, a 250-metre-high tower and an installed capacity of 110 MW, Cerro Dominador is a power plant of superlatives. It can cover the consumption of 340,000 Chilean households and, thanks to its three salt storage tanks, can also produce electricity at night when the sun is not shining.

The Cerro Dominador is located in the middle of the Atacama Desert, about 90 kilometers from the mining town of Calama. Its mirrors reflect the sunlight towards a receiver at the top of the tower, where it heats molten salt to over 500 degrees. This flows into the tanks. With the help of heat exchanger, the heat from the salt is used to produce steam, which generates electricity by a turbine.

The GIZ supported this project from the beginning by the elaboration of the tender documents, technical and political assistance, during the construction process, assistance in the financial closing process, and the promotion of the project at international levels to show Chile's potential for the development of this technology. (**See the video statement regarding CSP of Rainer Schröer (→ Chapter 2.4)**)

Concentrated solar power plant Cerro Dominador in the Atacama Desert

2.4 Video statement Rainer Schröer:

Why Concentrated Solar Power (CSP) is so important for energy transition

To replace fossil fuels to achieve energy transition, it is not sufficient to expand fluctuating renewables like solar and wind energy. For the security of the electricity grids, base-load electricity is needed that is available 24 hours a day, 365 days a year, and this without any interruption. This is why the technology of concentrated solar power (CSP) plants is so valuable. Parts of the energy generated during the day can be stored in thermal storage reservoirs and called up when the sun is not shining.

In his video statement, Rainer Schröer explains why GIZ supported the project from the very beginning.

Go to Video

The mirrors of the CSP unit must be cleaned regularly.

2.5 "The pioneers for renewables had a hard time."

Rodrigo Vasquez

Rainer Schröer

GIZ has been supporting Chile in its energy transition since 2008, since 2014 as GIZ 4e Chile. In this interview, the current co-leader of 4e Chile and its former leader Rainer Schröer, talk about lessons learned, how Chile was able to overcome resistance to renewables and achieve the momentum it has today.

Chile is going ahead in terms of climate protection. In 2021, the government announced climate neutrality by 2050, and the country wants to phase out coal by 2040. Both are international milestones. Were such goals on the agenda when you took over 4e Chile in 2014?

Rainer Schröer: Ten years ago, you would have been called a utopian. The focus was on energy security and a cheap electricity price; climate protection was of secondary importance. That is completely different story, today!

Rodrigo Vasquez: The pioneers of wind and solar energy faced multiple challenges back then. There were and still are no subsidies; grid access was very restrictively regulated and the tenders were geared towards fossil fuels, so solar and wind power hardly had a chance.

Renewables are now the cheapest and most important energy source. How do you explain this change in so few years? And what has 4e Chile contributed to it?

Rodrigo Vasquez: In order to tap the good potential for wind and solar, you need stimulating laws, regulations and standards, which we now have. In this sense, we initially saw our mission in underpinning the debates with analyses, but also in developing solutions, such as an accurate forecasting system for PV and wind power. In this, we advised the Ministry of Energy, also with regard to more conductive tendering conditions.

Rainer Schröer: A decisive turning point was that we organized a round table. In working groups, the important actors discussed open issues. We contributed with studies, invited experts, and recorded the opportunities for renewables with a potential analysis. It was important that we worked together with the Chilean Ministry of Energy, with which could shape the transformation of the energy systems.

What are the success factors that have made Chile so successful today?

Rainer Schröer: Chile is taking a very pragmatic approach. It does not favor one energy source but remains technology-neutral. Above all, the government leaves the development of the market to companies and investors. This dichotomy of opportunity-driven entrepreneurship and clear regulation makes Chile a beacon for others.

Along the 4,000 kilometre long coastline, but especially in Patagonia, there are excellent conditions for wind energy.

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

3.0 Hydrogen

3.1 Chile fully committed to green hydrogen

With its hydrogen strategy, the Chilean government has set a benchmark. Green hydrogen stands for CO_2 reduction in the transport sector, prosperity, and jobs. However, the construction of large H_2 production plants also raises social and ecological questions.

The Chilean government's national green hydrogen strategy, announced in November 2020, does not spare superlatives. By 2025, the country intends to attract five billion US dollars for investments in hydrogen infrastructure in the country. In three years, projects with five gigawatts of capacity are to be under development. By 2030, Chile wants to be the world's cheapest supplier of hydrogen and one of the three most important H_2 exporters. And all that without subsidies.

The conditions for this are good. The government and the private sector are acting in concert. The liberal market structure promotes economic dynamism. Ports, gas pipelines and refineries are partly in place. Above all, the geography favors the country.

According to the International Energy Agency (IEA), the country could already produce more than 160 million tons of green H_2 at about two US dollars per kilo. In its green hydrogen strategy, the country is already aiming for US$1.50. On the world market, the costs today are six or more US dollars.

The green hydrogen strategy and the expansion of renewable energies are the central elements of the Chilean government's promise, made in June 2019, to be climate neutral by 2050. For an emerging country in which mining is an important pillar, this is more than an exclamation mark.

A prosperous hydrogen industry would open many additional economic options to the country. The government expects Chile's energy transition to create a lot of jobs.

'By 2050, up to 100,000 new jobs can be created through the envisioned contributions of green H_2 to the NDC (Nationally Determined Contribution), alone. On top of that, if the country exports hydrogen, another 300,000 jobs could be created', says Rainer Schröer. He commissioned the study to back up the potential of the hydrogen industry with facts. Since 2014, he and his 4e Chile team are pushing the hydrogen issue. They were instrumental in getting Chile where it is now in the development of the H_2 industry.

3.2 "Hydrogen will become the most important industry in our country."

The excellent geographical conditions for renewables put Chile in a good position. By 2030, the country wants to be the cheapest producer of green hydrogen. The fact that Chile is ahead in hydrogen is also due to the German-Chilean energy partnership 4e Chile.

We were the hydrogen pioneers in Chile', says Schröer. There is some evidence to support this. For example, the hydrogen association H_2-Chile was founded at the GIZ office back in June 2018. In the meantime, 65 companies, some of them very large, have become members. And it was crucial for the Ministry of Energy to thank GIZ for its continuous support in the national hydrogen strategy.

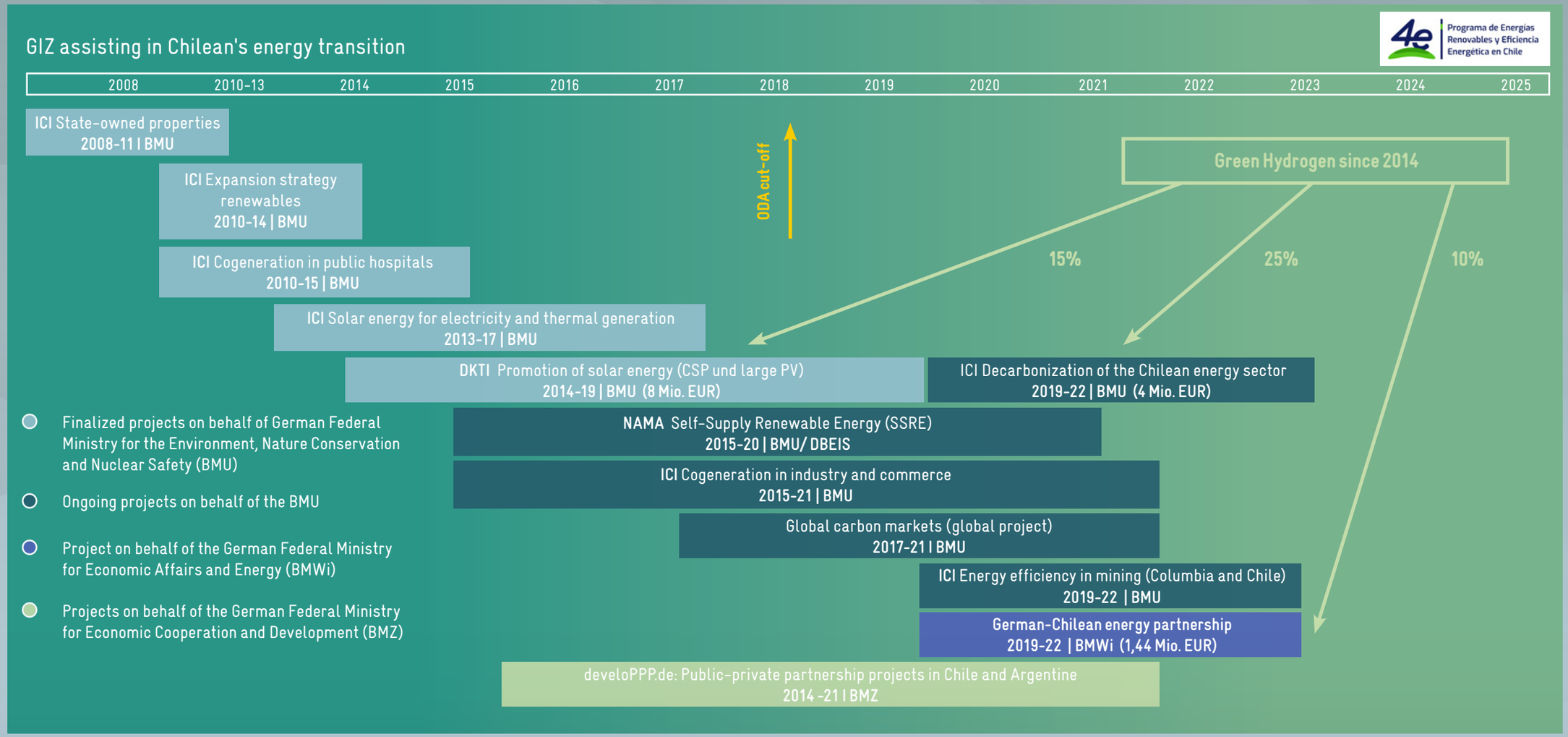
The Chilean Ministry of Energy also appreciated GIZ's input. This trust does not come by its own, and ideas do not grow into sky overnight. It takes many small steps – as the development of hydrogen in Chile shows. Each of them may seem unexciting by itself, but in the end, they lay the foundation for broad support and for investors and companies to invest billions of Euros in a vision.

'Hydrogen is a topic where you run into challenges and barriers very quickly. Solutions lie in the details. So, we look at these challenges and then work out possible solutions together with experts', says Schröer. 4e Chile has initiated many small steps. Since 2014, the project has commissioned numerous studies that have, for example, analyzed the potential of hydrogen, examined alternative lines of financing, prepared feasibility analyses or, precisely, elicited the employment potential of a Chilean H_2 industry. In addition, 4e Chile and its partners organized the first and second international H_2 conference in Chile, formulated technical standards, and involved around 6,000 participants in more than 25 technical seminars.

In the meantime, almost 100 initiatives want to invest in H_2 projects. The Haro Oni project of Siemens Energy in Chile is one of the first international pilot project supported by the German Ministry for Economic Affairs and Climate Action (BMWK) within the German H_2 Strategy. The project aims to produce synthetic fuels out of green H_2. In 2021, Chilean state development cooperation CORFO released an international tender process to support projects with a total electrolysis capacity of 388 megawatts which will enable the production of around 45,000 tons of green hydrogen.

If everything works out according to plan, exports of hydrogen in 2050 could be worth around 30 billion US dollars, i.e., a volume that is currently earned by copper mining, writes Foreign Policy. In the meantime, the project ideas are growing sky-high. And Lindley Maxwell of the Universidad Católica del Norte is not the only one to predict: 'Hydrogen will become the most important industry in our country.'

3.3 The projects of the 4e program of GIZ Chile and H_2



3.4 Video statement of Philipp Bezler:

"GIZ has played a big part in Chile regarding the development of hydrogen."

Philipp Bezler is a profound expert on Chilean hydrogen development.
In his video statement, he explains the role of GIZ in the development of hydrogen in Chile.

Philipp Bezler worked for Siemens Energy in Chile for many years and moved to the Chilean hydrogen company HIF Global after. HIF operates the hydrogen project "Haru Oni". The project now produces synthetic fuel in a pilot plant on the southern tip of Chile. It uses the excellent conditions for wind energy not far from the Chilean city of Punta Arenas.

In the first step, e-methanol is produced from wind power, water and CO_2, which is then used to produce the synthetic fuel. Siemens Energy and Porsche are among others involved in the project. Siemens Energy and other technical partners are responsible for the design of the wind farm and the methanol plant. Porsche is the mayor off-taker of the synthetic fuel produced in Haru Oni. In a press event in December 2022, the first Porsche car was refueled with this innovative fuel. The German Federal Ministry of Economics and Technology funded the lighthouse project Haru Oni. GIZ Chile supported the project because of its innovative character, in several aspects right from the beginning in early 2014. The practical experiences gained from this innovative project, the first of its kind in Latin America, may also offer solutions for the challenging effort of decarbonizing heavy transport in Chilean mining industry assumes Rainer Schröer.

In his video statement, he explains the role of GIZ in the development of hydrogen in Chile.

Go to Video

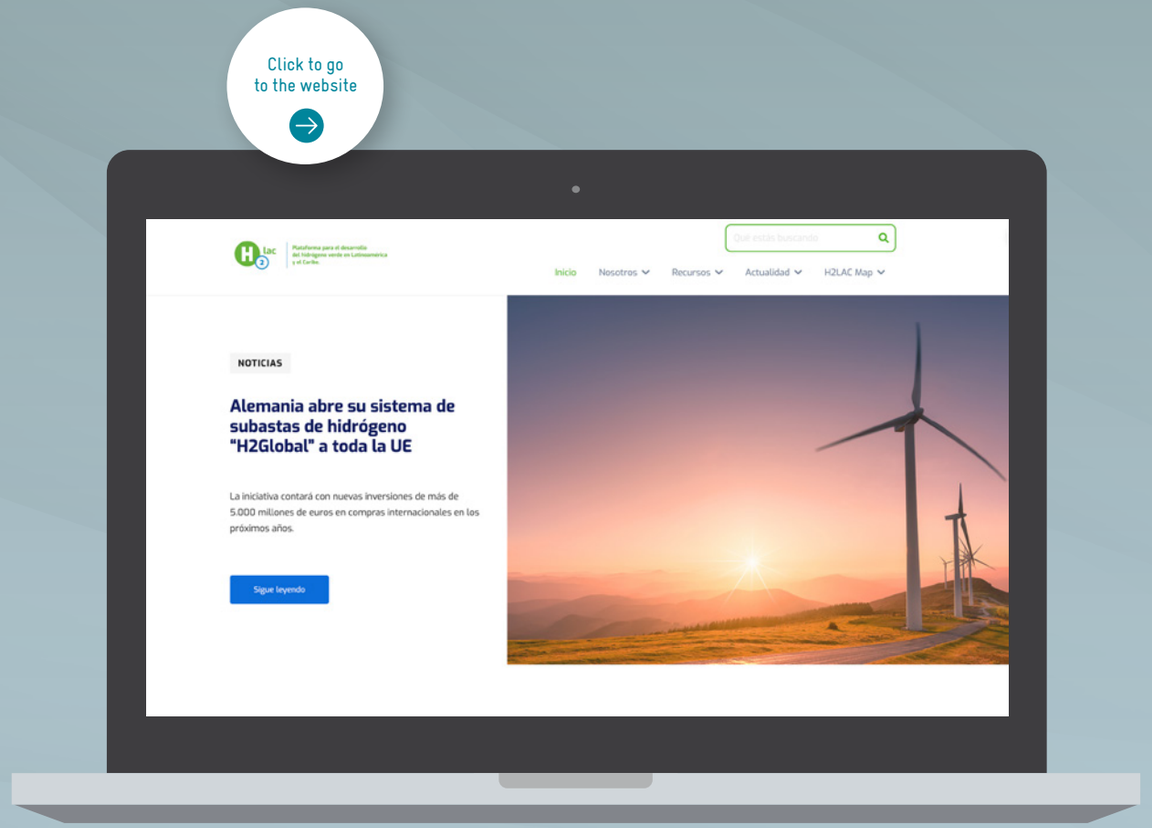
3.5 Video statement of Rodrigo Vasquez:

Hydrogen platform H2LAC

Chile has become a beacon of hydrogen development in just a few years. Delegations from all parts of the world are flocking to Santiago de Chile. More and more enquiries are reaching 4e Chile, too. As far as the topic of hydrogen is concerned, we can no longer save ourselves from enquiries, says Rodrigo Vasquez, co-leader of 4e Chile. The team is in contact with actors from more than 20 countries. Interest is also growing among our Latin American neighbors. That is why 4e Chile has founded the first regional hydrogen platform H2LAC, which covers developments from 13 Latin American countries.

In his video statement Rodrigo Vasquez explains what the platform is all about.

Go to Video



giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

4.0 Coal Phase-out

4.1 When coal-fired power plants become part of the solution

The coal phase-out by 2040 is agreed, and the first coal-fired power plants have already been taken off the grid. However, they might have a second chance. If the conditions are right, coal-fired power plants can be converted into storage power plants and become game changers for the energy transition. Furthermore, many jobs can be saved.

Perhaps the two coal-fired power plant units Angamos 1+2 of the US utility AES in Mejillones, a small Chilean town north of Antofagasta, will one day write industrial or perhaps better saying: energy-transition history. Because the units could play a key role in climate protection and energy security in the future – in Chile and around the world. Because from 2023, the first coal power plant will be transformed into a thermal storage plant. The coal will disappear, the steam turbines will remain. They then will be powered by renewables.

The fact that the AES Corporation is daring this experiment and investing more than 500 million US dollars in the conversion of its first plant has to do with the groundwork of the GIZ project 4e Chile. In the future renewables can also supply electricity at night. This will turn coal-fired power plants into green energy storage facilities and make them a game changer for climate protection. But let's go step by step.

Chile could cover 75 times of its electricity consumption with renewables thanks to its good methodological conditions. Nevertheless, coal-fired power plants still generate over 30 percent of the electricity demand. The lack of storage capacity and the stability of the electricity grid are some reasons for this. Especially since the alternative to coal – hydropower – is becoming increasingly uncertain due to a lack of precipitation and melting glaciers as a result of climate change in Chile.

To cover 100 percent of the electricity demand from renewables and to be able to do so without gas and coal, energy storage plants are needed to keep the power grid stable. ‘In addition to energy, coal-fired power plants provide important ancillary services such as voltage and frequency stability or inertia’, says Juan Carlos Olmedo, President of Coordinador Eléctrico Nacional. (See also the interview (→ **Chapter 4.3**)).

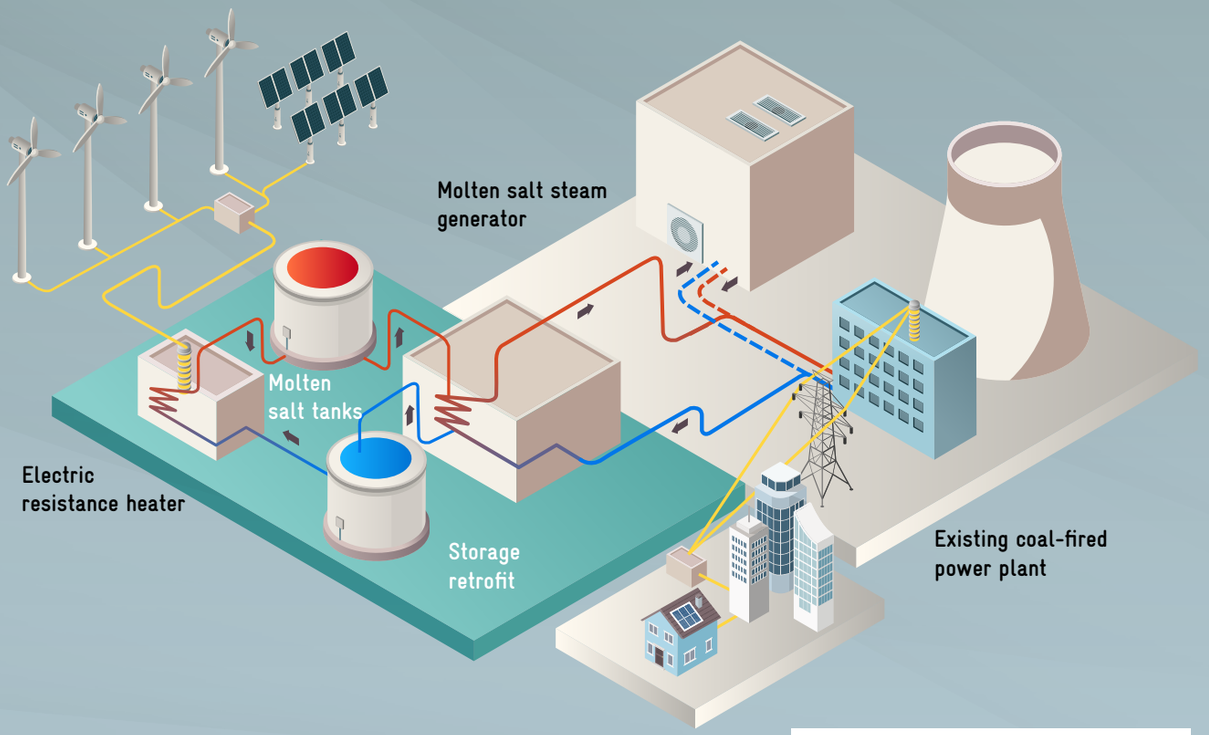
4.2 Coal-fired power plants become green storage power plants

At first, the responsible GIZ project coordinator Rainer Schröer was ridiculed for introducing the idea of converting a coal fired power plant. But now, AES is converting its first coal-fired power plant in Mejillones. It is technically complex, but feasible. It is a Win-Win situation in many regards.

The technology required for the conversion is well-known. It has already proven itself in thermal Concentrated Solar Power plants (CSP). They store solar energy in form of heat in liquid salt. The concept is known as "Carnot Battery". The heat is used to generate steam, from which turbines produce electricity. The liquid salt, which has a temperature of about 500 degrees, can be stored in tanks. The energy stored in it can be discharged at any time.

What may sound simple is technically demanding. 'Neither a steam turbine nor the entire process in a power plant can be driven up and down at will', says Rainer Schröer. The ramp-up flexibility must be analyzed for each coal-fired power plant individually. Finally, their operators must be convinced of the idea. 'That's why we commissioned system simulations, analyzing data of the power plants' operations and, in parallel, investigated alternative uses for the coal-fired power plants together with experts from the German Aerospace Centre (DLR)", Rainer Schröer adds. He presented eight alternatives to the Coal Commission how to keep a coal-fired plant working. The conversion of the coal-fired power plants now plays an important role in the coal phase-out.

Continued on next page →



Win-Win for many stakeholders

From an economic point of view, the conversion of power plants is a good opportunity for AES to continue operating its power plant in Mejillones. This also pleases the national electricity grid coordinator, who needs base-load capable power plants on the grid. It is also an advantage for investors and operators of solar power plants and wind farms, as they might gain new customers for clean electricity.

It is also important that the continuation of coal-fired power plants cushions the social consequences of the coal phase-out. With every coal-fired power plant taken off the grid, an average of 700 jobs are lost. With 23 Chilean coal-fired power plants still in operation, the phase-out creates a relevant social impact. Many people therefore perceive renewable energies as a threat.

For many coal-fired power plant sites, it is simply a question of existence – also in Mejillones. For six out of ten AES employees in Mejillones, the conversion starting in 2023 is therefore good news. ‘If we continue to operate our site in Mejillones as a storage power plant, we can keep 60 percent of our workforce employed’, says Rossana Gaete Stagno, who heads the hydrogen department for Latin America at AES. This is important because in 2024 the French energy company Engie also plans to close its coal-fired power plant in the town.

The AES power plant is not the only suitable storage power plant, 4e Chile's stress test found out. ‘64 percent of the power plant capacities in Chile are suitable for conversion to become a storage power plant’, says Rodrigo Vasquez, co-leader of 4e Chile. This give Chile the chance to get out of coal fired power generation even sooner. At least that's what AES is doing. In 2025, it intends to stop burning coal in its Chilean power plants.

AES coal power plant in Mejillones

4.3 Interview with Juan Carlos Olmedo:

"Renewables are the new conventional energy source."

Grid stability determines whether electricity supply can one day come 100 percent from renewables. Coal-fired power plants can play an important role in this, emphasizes Juan Carlos Olmedo, Coordinador Eléctrico Nacional.

This year, you were able to feed 60 percent renewables into the grid at the peak, not even taking hydropower into account. That is a very high value. What are the reasons for feeding in significantly more renewables than before?

That is indeed a high value. In the beginning, we acted very cautiously. With GIZ, we were able to develop a forecasting system based on a software that reliably predicts the wind and solar power for the next few minutes. We have further improved this with artificial intelligence as it now gives us a margin of ten minutes.

How important are coal-fired power plants converted to storage power plants?

Very important. If we want to feed in more renewables, that will be the challenge of the future as we have to develop additional storage facilities. Unfortunately, hydroelectric power is becoming increasingly unavailable for this purpose. In its place, converted power plants can provide not only clean energy, but also important ancillary services such as voltage and frequency stability, as well as inertia, which we need for grid stability. They can also store power surpluses that our power lines will not be able to transport in the required quantity in the future.

How are you looking towards 2030?

Renewables have evolved being the new conventional energy sources. Our challenge lies in achieving the goal of operating a grid based on 100 percent of renewable energy generation. In 2022, we released a roadmap outlining our vision for operating in this transformative energy landscape. For instance, the system necessitates enhancements to existing regulations, such as transitioning to a wholesale generation market scheme built on binding offers of energy. Additionally, there is a need for incentives to spur the development of energy storage infrastructure.

4.4 Coal commission - Chile's exit strategy

On 4 June 2019, the Chilean government announced that Chile intends to exit coal by 2040, and that eight coal-fired power plants should already go offline by 2024. Beforehand, all four coal power plant operators had signed a coal exit agreement.

The coal commission reached the consensus in nine rounds of meetings between June 2018 and January 2019. In addition, all important actors from the government, industry and associations were at the table - including Rainer Schröer from GIZ. 4e Chile's idea of converting coal-fired power plants into thermal storage power plants played an important role as it provided answers to the economic and social impositions of the phase-out.

Near the desert city of Calama, more and more new wind and solar parks are being built.

4.5 "In more than a dozen countries, this idea could also work."

Rodrigo Vasquez

Rainer Schröer

In Chile, for the first time in the world, an electricity supplier is converting its coal-fired power plant into a thermal energy storage plant. The former head and co-head of 4e Chile, Rodrigo Vasquez and Rainer Schröer, talk about chances and challenges, and for which countries the idea is attractive.

Why contribute coal-fired power plants still around 30 percent to the energy mix?

Rodrigo Vasquez: Currently, PV and wind parks in the Atacama Desert could feed in more electricity. But the electricity grids cannot transport peak quantities. Their expansion is limited. It is necessary to add storage to the grid. The production of hydrogen could be a solution here. But also converting coal-fired power plants into storage power plants could be a solution.

What is the advantage?

Rainer Schröer: In Mejillones, six coal-fired power plants produce electricity among other for the mining in the Atacama Desert. But the power lines can also be used to transport surplus PV and wind power in the opposite direction, store the energy in liquid salt, and then discharge it via the power plant's steam turbines.

Rodrigo Vasquez: Through the conversion, AES can make money with its power plant – by selling electricity, but also with important system services for grid stability, with inertia, short-circuit resistance, frequency and voltage stability. This is a weakness of renewables and conventional batteries – they can only do this to a limited extent.

Where did the idea come from?

Rainer Schröer: Within the framework of the Coal Commission, we analyzed alternative uses for the coal-fired power plants and presented eight options to the Commission after extensive preliminary work.

Continued on next page →

How did the stakeholders react?

Rainer Schröer: In the beginning, we had to use data from AES for the study. Their engineers smiled at us. But we worked it out with the German Aerospace Center (DLR) and now AES wants to invest up to 500 million US dollars into the conversion of the power plant. This shows that you have to stick with new ideas and back them up with facts. Also, as there was this win-win situation, the power utility decided in a first project.

For which countries can such storage power plants be a solution?

Rodrigo Vasquez: They are suitable for countries with convertible coal-fired power plants and those that can also generate cheap wind or PV power. Against this background, I can think of more than a dozen countries, especially India or Indonesia, Brazil, South Africa, or Greece. We have received many requests for information and technical assistance by them.

Wind farm on Chile's coast.

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

5.0 Just Transition

5.1 Shaping the transformation of energy systems fairly

Coal-fired power plants are CO_2 emitters, but at the same time they are employers for many people. If they are shut down, many people lose their livelihoods – specially in regions where there aren't any alternatives. The energy transition is therefore always a social issue.

Mejillones, the small town north of Antofagasta, is not a tourist attraction. Along the bay, energy suppliers operate six coal-fired power plants to supply mainly the energy-intensive copper mining industry high up in the Atacama Desert.

But the power plants secure direct and indirect jobs in the town of Mejillones and neighboring communities like Tocopilla further north. In this respect, many here are unhappy with the announced coal phase-out. Chile wants to phase out coal by 2040. This means that 18 of 28 coal-fired power plants will be taken off the grid by 2026. "Economically, this only plays a minor role because it only affects 12,000 direct and indirect jobs. However, at many locations the closure creates a social impact because there are no alternatives," says Veronica Vukasovic.

Veronica Vukasovic heads the Just Transition project at 4e Chile. The topic is becoming increasingly important, encompasses both social and environmental aspects and is considered by the current government to be very important. "We have conducted studies to examine previous decision-making processes and have achieved that companies must do a very careful and sensitive communication to inform their employees about closure plans at least twelve months in advance and set up round tables with the employees to find alternatives," explains the Chilean.

In the project launched in April, 4e Chile supports the social balance between power plant operators, workers and municipalities. "We take care of retraining and its sensible design," says Vukasovic. Because earlier retraining completely ignored the needs of the workers and ended in disaster.

Coal piers in Mejillones

5.2 Coal-fired power plants and just transition

Two out of three turbines and a lot of the auxiliary equipment of Chilean coal-fired power plants can be further used, repurposed for renewable energy storage. That would be an advantage for the operators – and a boon for employees and communities.

In Mejillones, the electricity supplier AES is converting its two power plant units Angamos 1-2 into a storage power plant and investing more than 500 million US dollars in the process. This should still pay off, because AES can utilize major components of the actual power plant infrastructure and all what has to do with the grid connection. It can produce and sell green electricity instead. The idea for this was developed by GIZ together with the German Aerospace Center (DLR).

This is also a win-win situation for the employees and the municipality. Because continued operation cushions the social consequences of the coal phase-out. With every coal-fired power plant that is taken off the grid, an average of 700 direct jobs and at least as many indirect jobs are lost.

For six out of ten AES employees in Mejillones, the conversion starts in 2023. This is therefore good news. ‘If we continue to operate our site in Mejillones, then as a renewable storage power plant, we can keep 60 percent of our workforce employed’, says Rossana Gaete, who heads the hydrogen department for Latin America at AES. The AES power plant is not the only suitable storage power plant, 4e Chile's stress test found out. ‘64 percent of the power plant capacities in Chile are suitable for conversion to become a storage power plant’, says Rodrigo Vasquez, co-leader of 4e Chile. This may open up the opportunity for Chile to bring forward the coal phase-out and, above all, to minimize the social consequences of the coal phase-out.

Coal-fired power plants in Mejillone

5.3 Green hydrogen versus the environment?

The boom in renewables and hydrogen promises economically rich pickings, but at the same time raises questions that the new government wants to answer.

"While for a long-time legal certainty and private investment were at the forefront in the discussion regarding renewables, today their dynamic development is also accompanied by social, environmental and territorial challenges," says Alex Santander, head of the Energy and Environment Policy Department at the Chilean Ministry of Energy. (see also the interview) (→ **Chapter 1.4**)

If Chile relies on hydrogen and its export, many thousands of new wind turbines will have to be installed. Also, power lines must be laid, access roads tarred, ports, desalination plants and other infrastructure built. 'However, the south of Patagonia not only has excellent wind conditions. It is also an intact ecosystem that should be looked at holistically,' says Veronica Vukasovic, who is responsible for the Just Transition project at 4e Chile.

The question of distributive justice also arises. Unlike coal-fired power plants, the operation of PV and wind farms creates relatively few jobs. The profits generated, however, usually flow to Santiago de Chile, because this is where most of the companies are based and where they usually pay most of their taxes.

Hence, the boom generates not only technical, but also social and environmental challenges. 4E-Chile is analyzing possible solutions since 2015. For example, GIZ has developed special instruments that assess the social acceptance and environmental impact of large-scale renewable energy projects.

If the current government continues to go this way, the distribution issue is on the agenda – and its outcome is uncertain after the failed constitutional referendum. The Chilean society will have to find an answer balancing economic prosperity, participation and the protection of its unique nature.

5.4 Video statement Lutz Kindermann:

"You can do a lot for acceptance, especially at the beginning of a project."

For many years, the acceptance of renewable energy projects in Chile practically did not play a role. But of course, the increased number of wind and solar parks have an impact on the region and its people. In contrast to coal-fired power plants, only a few jobs are created. The income from the plants usually not remain in the municipality.

GIZ addressed the issue of Just Transition already in 2015 and implemented an initial pilot project with the German wind power project developer WPD which has been projecting wind energy projects in Chile for more than 15 years. In 2022, WPD invested more than 500 million US dollars in a 350 MW windfarm. Together with GIZ, they have entered new ground in the Araucania region.

"From this very challenging and important experience, we have developed a tool that allows project-developing companies to determine a so-called “social acceptance index” of their projects in a kind of fast-track procedure," says Rainer Schröer.

The expansion of wind energy in Chile is progressing.

This is to give the companies a fast and easy to implement tool on hand in order to check the social environment of future renewable power projects right in the beginning in order to engage in adequate measures to avoid problems later on.

In his video statement WPD Managing Director Lutz Kindermann explains how complex it is, to find out what people really think and that you can do a lot for the acceptance, especially at the beginning.

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

6.0 Mining Sector

6.1 Chile's mining sector and the energy transition

The global energy transition depends on energy-intensive mining in order to obtain cupper, lithium, iron, etc. Without copper for instance, neither wind turbines turn, nor e-cars move. The mining industry needs 24 hours electricity, and lots of it. For a long time, this electricity was supplied by coal-fired power plants in Chile. That is beginning to change.

The world's largest copper deposits lie dormant along the Chilean Andes chain, the reason why Chile is currently the largest copper producer. Depending on the world market price, the mining industry is responsible for 50 to 60 percent of the country's export earnings. More than 250,000 people work in the mining sector.

However, this sector causes around 15 percent of the country's CO_2 emissions, because copper extraction requires a lot of energy for galvanic processes, the crushing of the rock, and the desalination of seawater, which then has to be pumped up to Andean mountains. "In 2020, the mining sector consumed almost 40 percent of the electrical energy," says Rodrigo Vasquez.

For a long time, renewables could not guarantee a 24/7 supply, as is necessary in the mining sector. The mining companies covered their electricity needs from coal. "But that has been changing within the past 3-4 years," explains the head of 4e Chile. Because in the meantime, renewables have proven their technical reliability. Moreover, the price of green electricity is now often cheaper than that from coal-fired power plants. Finally, mining companies have to reduce their emissions and comply with the sustainability requirements for internationally operating companies.

This development is fueling investments in renewables, especially in H_2 projects. Admittedly, H_2 is still a bet on the future. With synthetic fuels derived from it, mining companies could sustainably gain not only their electricity but also reduce their carbon footprint in the transport within the mines where thousands of heavy trucks are transporting the raw material. So far, each of the house-sized 400-tonne dump trucks consumes up to 4,000 liter of diesel per day. Per liter, 2.65 kilograms of CO_2 are emitted.

6.2 Video: Chilean mining sector has become one of the drivers of the Chilean coal phase-out

More and more mining companies are signing supply contracts with renewable power suppliers and opting out of supply contracts with conventional energy. BHP-Billiton, for example, accepted a penalty of more than US-$ 840 million in August 2020, to leave a conventional power supply contract behind "In the meantime, mining has become one of the main driver of the Chilean coal phase-out," says Rainer Schröer, head of 4e Chile until autumn 2022.

The video explains and gives a deep dive introduction in the fundamental changes which are on the way.

Go to Video

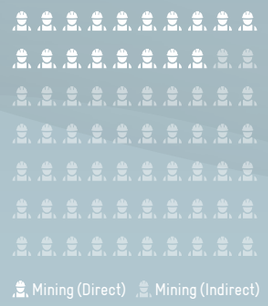
The Centinela mine is located about 1,350 kilometres north of Santiago in the Antofagasta region. Here, Antofagasta PLC extracts copper concentrate through a milling and flotation process.

6.3 Facts and figures of the Chilean mining sector

52,9%
of the country´s exports

11%
of the average GDP
(Gross Domestic Product)

16 MMt
of the annual CO_2
46% of the total electricity



9%
of the national employment
– 750,000 workers

30%
of the electric power
consumption

5,7 MMt
of the annual copper
production

Chile

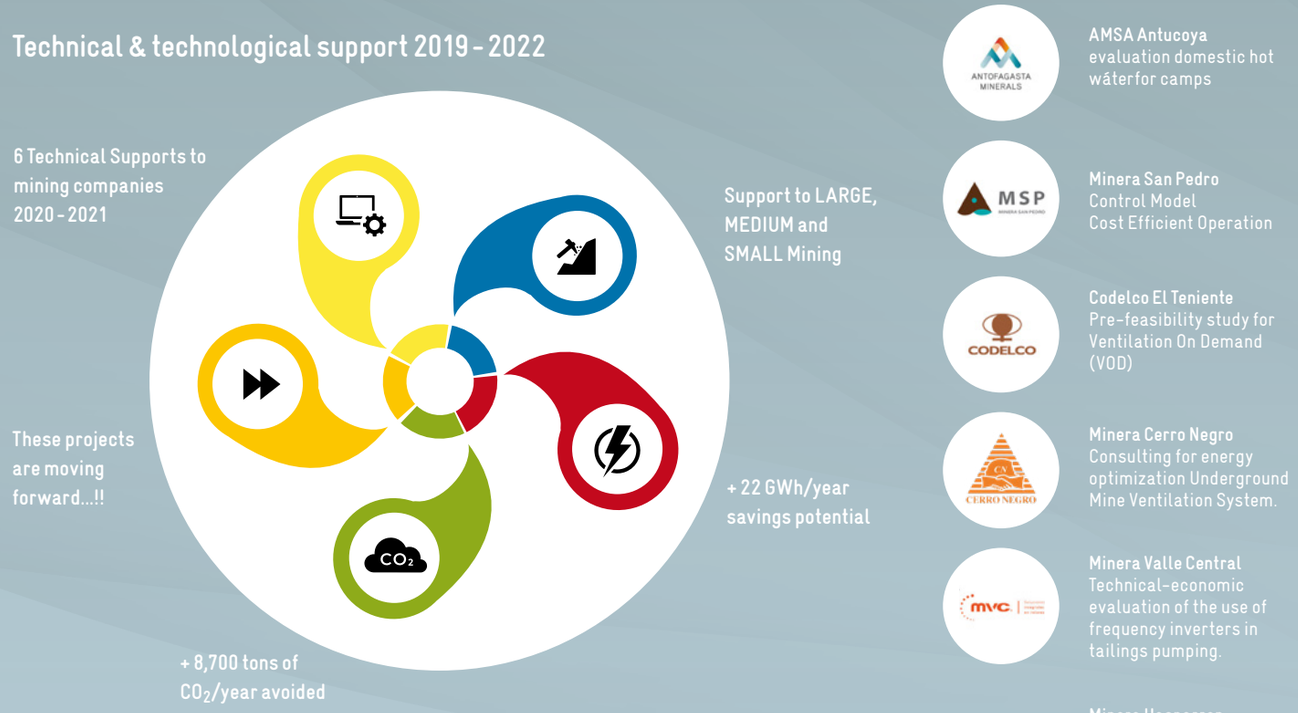
6.4 Studies and workshops pave the way for energy efficiency

Mining is energy intensive. On the positive side, however, this also means that a lot of CO_2 can be saved with energy efficiency. It is not only the climate that benefits from this. Accordingly, small to large companies are responding positively to the offers of 4e Chile.

In February 2021, the Energy Efficiency Act came into force in Chile. With this law, the government wants to reduce energy intensity, for example in transport, buildings, or industry, by at least ten percent by 2030 and thus avoid the emission of almost 30 million tons of CO_2.

In future, large energy consumers such as the mining industry will have to report their energy consumption and energy intensity annually to the Agency for Sustainable Energy (Agencia SE). They have to introduce an energy management system and carry out energy audits. This increases the pressure on these companies to invest in energy efficiency.

On this issue, 4e Chile has been working closely with Chilean Energy agency AgenciaSE and the mining companies already for many years. "Our expertise has been incorporated into the energy efficiency law. In addition, we have developed various training measures together with the agency, for example on the required energy audits," says Rainer Schröer. More than 6,400 people took part in the 15 technical workshops.



Continued on next page →

Previous page

Back

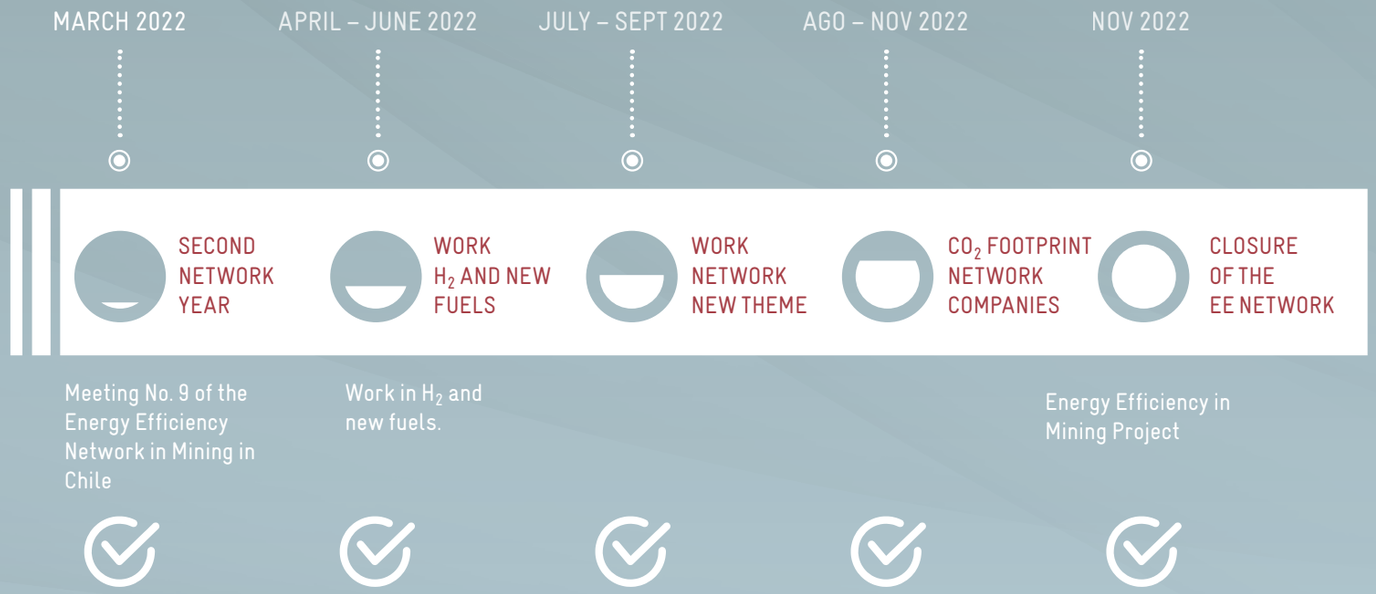
Next page

Regulations and laws also lay the foundation for energy efficiency, for example on the topic of combined heat and power. "These are not really sexy topics, but with them you get energy savings permanently on track," adds Rainer Schröer.

In addition, 4e Chile also directly supports mining companies with the aim of initiating pilot projects that ultimately contribute to CO_2 reduction. Together with the Chilean mining company Codelco, for example, GIZ carried out a prefeasibility study for pilot implementation of ventilation on demand, which enabled a reduction of 8,500 tons of CO_2.

The exchange between mining companies is essential for the dissemination of good examples. To this end, Agencia SE and 4e Chile have launched a learning network in the important mining sector, perhaps the first in the world. In this network, experts from mining companies discuss and exchange information, for example, on alternative fuels, more efficient ore grinding or efficient heating processes. This learning network now includes 16 Chilean mining companies. In addition, the agency and 4e Chile have set up an energy efficiency platform (→ **Chapter 6.5**) in the mining sector to intensify and consolidate this exchange.

Learning network in mining - timeline of activities in 2022 Learning network in mining



6.5 Digital platform for energy efficiency in mining

In mining, there are many opportunities where companies can use to improve their environmental and climate footprint. Especially if they can exchange information about these processes, get updates and lessons learned. To this end, GIZ together with the Agency for Sustainable Energy (Agencia de Sostenibilidad Energética - Agencia SE) has set up the digital platform energiaenmineria.cl, which is in Spanish.

On the website, 4e Chile and Agencia SE present feasible measures for energy efficiency and successful projects. The platform also indicates experts, equipment's and companies working in this field and supports the market development. The target group is not only mining experts, but also other stakeholders, for example environmental and climate experts. They can get an idea of the most important processes in mining themselves, and the processes are described in corresponding detail - even for non-experts.

Rainer Schröer is convinced that the high number of clicks argue for the concept: "It is not only Chileans who get information. Also, mining experts from other Spanish-speaking countries use the site because Chile is ahead in implementing energy efficiency measures in the mining sector.

The 400-tonne dump trucks run around the clock and require 2,700 litres of diesel a day.

Imprint

As a federally owned enterprise, GIZ supports the German Government in achieving its objectives in the field of international cooperation for sustainable development.

Commissioned and published by:
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Registered offices:
Bonn and Eschborn

Friedrich-Ebert-Allee 32 + 36
53113 Bonn, Germany
T +49 228 44 60 - 0
F +49 228 44 60 - 17 66

Dag-Hammarskjöld-Weg 1–5
65760 Eschborn, Germany
T +49 (0) 6196 79 – 4218
F +49 (0) 6196 79 - 804218

Project/Contact:
Programa 4e-Chile
Marchant Pereira 150, Providencia, Santiago, Chile
contacto@4echile.cl

Responsible:
Elke Hüttner, Stephan Franz, Rainer Schröer

Research, text, photo & video:
netzhammer & breiholz, Hamburg

Acknowledgement for inputs and review
Leon Becker, Anna-Leandra Fischer, Miriam Frisch, Verena Maas, Philipp Munzinger, Julia Schabel, Mónica Silva Gonzalez, Lara Teutsch (GIZ)

Concept, design & layout:
© creative republic, Thomas Maxeiner Kommunikationsdesign Frankfurt, Germany
Photo credits:
© Crupo Cerro/Alejandro Araya Inda: pages 1, 16, 17
© Michael Netzhammer, Germany: pages 1, 6, 8, 9, 10, 17, 18, 19, 23, 24, 25, 28, 29, 31, 33, 34, 35, 37, 38
© Acera, Chile: pages 13, 30, 32
© Shutterstock/Pablo Rogat: page 4
© Ministerio Energia/Keith Arkins: page 37 (right picture)
© GIZ 4e Chile: pages 40, 44

Status: Summer 2022