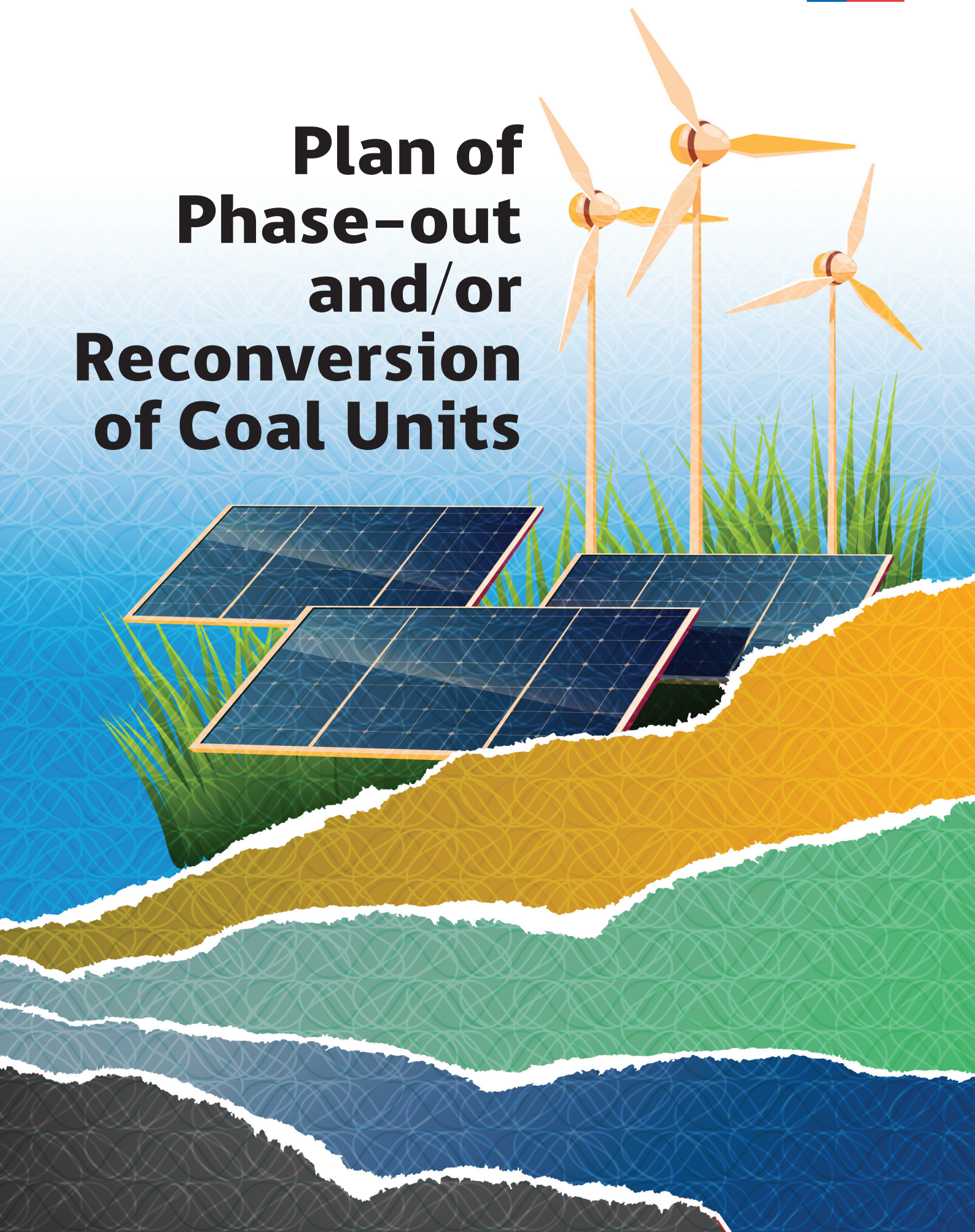


# Plan of Phase-out and/or Reconversion of Coal Units







**Plan of  
Phase-out  
and/or  
Reconversion  
of Coal Units**





## TABLE OF CONTENTS

<b>WORDS OF THE MINISTER</b>	04
<b>1. PRESENTATION</b>	06
<b>2. INTRODUCTION</b>	07
<b>3. CONTEXT</b>	08
3.1 General context	08
3.2 The role of coal in the Chilean electrical matrix	10
<b>4. COAL PHASE-OUT AND/OR RECONVERSION OF COAL UNITS ROUNDTABLE</b>	12
4.1 Goal	12
4.2 Members	12
4.3 Action plan	14
4.4 Lessons learned from the thematic sessions	15
4.4.1 Impacts on health and air quality	16
4.4.2 International experience	17
4.4.3 Impact on the Electrical System	19
4.4.4 Environmental and Social Variables	21
4.4.5 Technological alternatives	23
4.4.6 Economic and Labor Impacts	25
<b>5. "ZERO CARBON ENERGY" AGREEMENT</b>	27
<b>6. CONCLUSIONS</b>	29
<b>7. REFERENCES</b>	33



## WORDS OF THE MINISTER

**Juan Carlos Jobet E.**

Minister of Energy

For years, Chile has depended on imported sources of energy, such as oil, coal, and gas. About 70% of the energy we consume comes from imported fossil fuels. But this is changing.

Today the energy sector is responsible for almost 80% of the greenhouse gas emissions of the country, with coal-fired electricity generation being the main contributor.

On the other hand, we have an enormous potential for renewable energy development, the best solar radiation in the world in northern Chile, and the best wind resources on the planet, especially in the south of the country. This is additional to our great geothermal and hydroelectric potentials, and other sources that would allow us to generate more than 70 times the installed capacity we have today.

Five years ago, we committed ourselves to the goal of reaching 70% of electricity generation with renewable energy by 2050. Today our projections indicate that we could reach that goal before 2030, that is, twenty years earlier.

With this target, the process of the electrical mix decarbonization in the country has begun to take shape as an essential step to decarbonize the rest of the sectors. The announcement of this plan about the voluntary phase-out of coal-fired power plants represents an unprecedented process in Chile. It is the result of the will and the conviction of the State of Chile and the electricity companies to move forward a cleaner energy mix.

At the same time, this announcement was enhanced by a previous and committed work in which representatives of NGOs, civil society, companies, public sector, universities, unions, municipalities, and international organizations participated, invited, and guided by the Ministry of Energy. This work instance called "Phase-out and/or Reconversion of Coal Units Roundtable" was intended to analyze the technological, environmental, social, economic, security, and sufficiency elements of each thermoelectric unit and of the electrical system as a whole, which would allow establishing the conditions for a gradual and safe phase-out of coal-fired power plants.

This work anticipates the phase-out of all coal-fired power plants -with which today we generate almost 40% of the electricity demand- before 2040. Likewise, a first phase is established by 2024, allowing the phase-out of eleven coal-fired units equivalent to 31% of the installed capacity.

We will continue to dialogue to accelerate the phase-out of coal power plants, considering the social, environmental, and security challenges of the electricity supply. A key challenge in this area is to provide more flexibility to the system and to build the necessary power lines to bring energy from the place it is produced to the consumption centers.

It should be noted that to protect the opportunities of the most vulnerable communities, we have initiated a Just Transition plan. This transition seeks to ensure the addition of an equitable social and environmental development, promoting mobility and creating quality jobs that improve not only the economic and environmental conditions of the territories, but also the standard of living of people.

Finally, I would like to highlight that the plan to phase-out of coal-fired power plants is a State Policy, not that of a particular government. Efforts must be sustained over time, as climate change is a fact. We will continue to look for opportunities that allow us to move more quickly towards a cleaner and renewable mix, more economical and friendly to the environment and local communities.

This document focuses on the process that accounts for the planned phase-out of coal-fired thermoelectric power plants in Chile, to 2040 with a first stage of phase-out to 2024, as well as the context, background and expected results.

The willful and binding agreement for the phase-out of coal units is an unprecedented milestone in the country and has been the result of political will and a joint, coordinated work between the State of Chile, through the Ministry of Energy and the owners of coal units in the electrical system: AES Gener, Colbún, Enel and Engie.

To analyze the effects and impacts of the phase-out of coal units of the electrical matrix on the security and economic efficiency of the National Electric System, local economic activity and environmental aspects, transversal actors were convened that were involved for this purpose, the owners of coal units: AES Gener, Colbún, Enel and Engie, the public sector: Ministry of Energy, National Energy Commission and Ministry of Environment, the National Electrical Coordinator, consumer associations: ACENOR, ODECU and Mining Council, the Chilean Association of Power Generators (Generadoras de Chile), non-governmental organizations: WWF Chile, Casa de la Paz and Chile Sustentable, workers' unions and civil society organizations: COSOC of the Ministry of Energy and Coal-fired Power Generation Workers' Unions, the Municipality of Tocopilla, academia: Pontifical Catholic University of Chile and Adolfo Ibáñez University and international organizations like GIZ.

This working group, named "Phase-out and/or Reconversion of Coal Units Roundtable" has, for the first time, been able to analyze and provide background information on the challenge of phasing out coal generation from the electrical matrix, embracing technological, environmental, social, economic, security and sufficiency aspects of each plant and the electrical system as a whole, among others, that allow establishing the conditions for the planned and gradual phase-out of coal units operation. Therefore, it has been a real sustainability exercise developed by the main sectors of society involved, which has sought to protect the economic, social and environmental effects.

After the work of the Roundtable, and as a result of the work of the Ministry of Energy with the owners of coal-fired power plants, an agreement was signed, which updated to June 2020 includes the phase-out of 11 units by the year 2024, almost 1.731 MW representing 31% of the installed capacity of coal-fired power plants, and the phase-out of all units no later than 2040.



Chile emits only 0.25% of global Greenhouse Gases (GHG); however, studies position Chile within the 10 countries that will be most affected by climate change, presenting seven of the nine criteria of vulnerability (MMA, 2016a).

The energy sector, understood as the fossil fuel consumption sector, is the main responsible for the country's emissions of Greenhouse Gases (GHG), reaching 78% of total emissions in 2016. Nevertheless, the sector concentrates the greatest mitigation opportunities that will allow compliance with the goals committed by Chile in the Paris Agreement.

The Ministry of Energy, aware of this responsibility towards climate change and maintaining the focus of its action on people and their quality of life, is committed to the decarbonization of the country's energy matrix, which includes the electricity, transport, industry and mining sectors, as well as buildings, which are those where the highest emissions are concentrated. Fundamental pillars have been the greater penetration of renewable energies in the matrix, and the binding voluntary agreement for the phase-out and/or reconversion of coal-fired power plants. The latter has greater impact on emission reductions, as it allows greater penetration of renewable energies, thereby reducing the emission factor of the electrical system, which in turn, enables other electrification intensive actions, as for example, electromobility, electrification of machine drives in industry and mining, electric heating, and green hydrogen. It is expected to complement the implementation of the strategy through the application of economic instruments such as renewable energy and energy efficiency certificates, offsetting or emission reductions coming from the Paris Agreement (ITMOs<sup>1</sup>) and emission trading systems. In this regard, it should be noted that the Ministry of Energy is preparing the infrastructure required to promote the use of these types of instruments as tools that support or accelerate the country's energy decarbonization. To this end, it is generating the platform to measure, report and verify (MRV) emissions and reductions of mitigation policies, actions and projects in the energy sector, and is also involved in technical cooperation and financing agreements with entities such as the World Bank, GIZ and other countries with carbon trading systems.

The decarbonization is comprised of three axes: phase-out of coal units by 2024 (first stage, 31% total capacity), complete coal phase out by 2040, and carbon neutrality by 2050. As the electrical matrix reduces its coal-fired power generation, greater electrification in transportation and industrial processes will be possible, as well as at the residential level (electromobility and heating), so that the transition to a cleaner matrix is achieved according to the levels required by science, that is, that the temperature of the planet does not exceed 1.5°C prior to the industrial era (IPCC, 2018).

<sup>1</sup> Internationally Transferred Mitigation Outcomes.

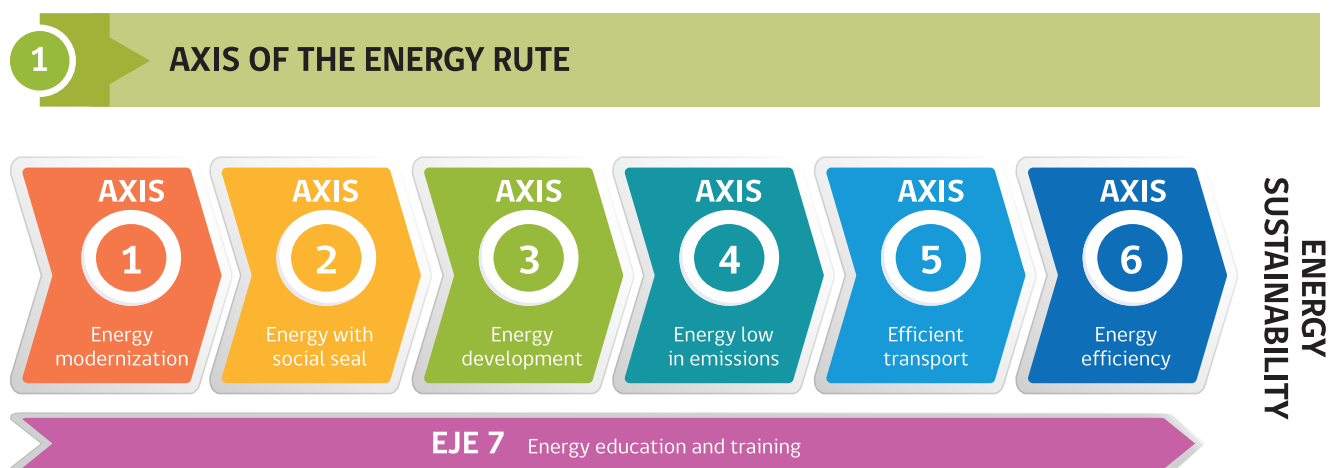
In the transport sector, the 2017 National Electromobility Strategy commits to reaching a share of electric mobility of 40% private vehicles and 100% in urban public transport by 2050. In addition, one of the 10 Mega Commitments established in the 2018–2022 Energy Route – an instrument that defines actions to be implemented during the four years of government – is to increase by at least 10 times the number of electric vehicles that run in the country to the year 2022.

The efforts in energy efficiency are equally relevant, since they are directly related to the emissions of the sector by reducing the demand for energy resources and, consequently, power generation or fuel combustion. The Energy Efficiency Bill, which is currently in Congress, encompasses measures across all productive sectors, as well as contributing to creating an energy saving culture in the entire population.

## 03 Context

### 3.1 General context

The Ministry of Energy presented the 2018–2022 Energy Route: “Leading the modernization with a citizen seal” in May 2018, which was built through a participatory process and decentralized citizen dialogue that included actors from the public sector, civil society, academic world, NGOs<sup>2</sup>, environmental groups, neighborhood committees, workers’ unions, companies, international organizations<sup>3</sup> and representatives from communities and indigenous peoples. As a result of the above, the work to be carried out in energy matters during the following four years of government was structured in seven axes, which are: 1) Energy modernization, 2) Energy with social seal, 3) Energy development, 4) Energy low in emissions, 5) Efficient transport, 6) Energy efficiency and 7) Energy education and training.



Source: Ruta Energética. Ministry of Energy (Ministry of Energy, 2018)

<sup>2</sup> NGOs: Non-Governmental Organizations.

<sup>3</sup> GIZ: Deutsche Gesellschaft für Internationale Zusammenarbeit.

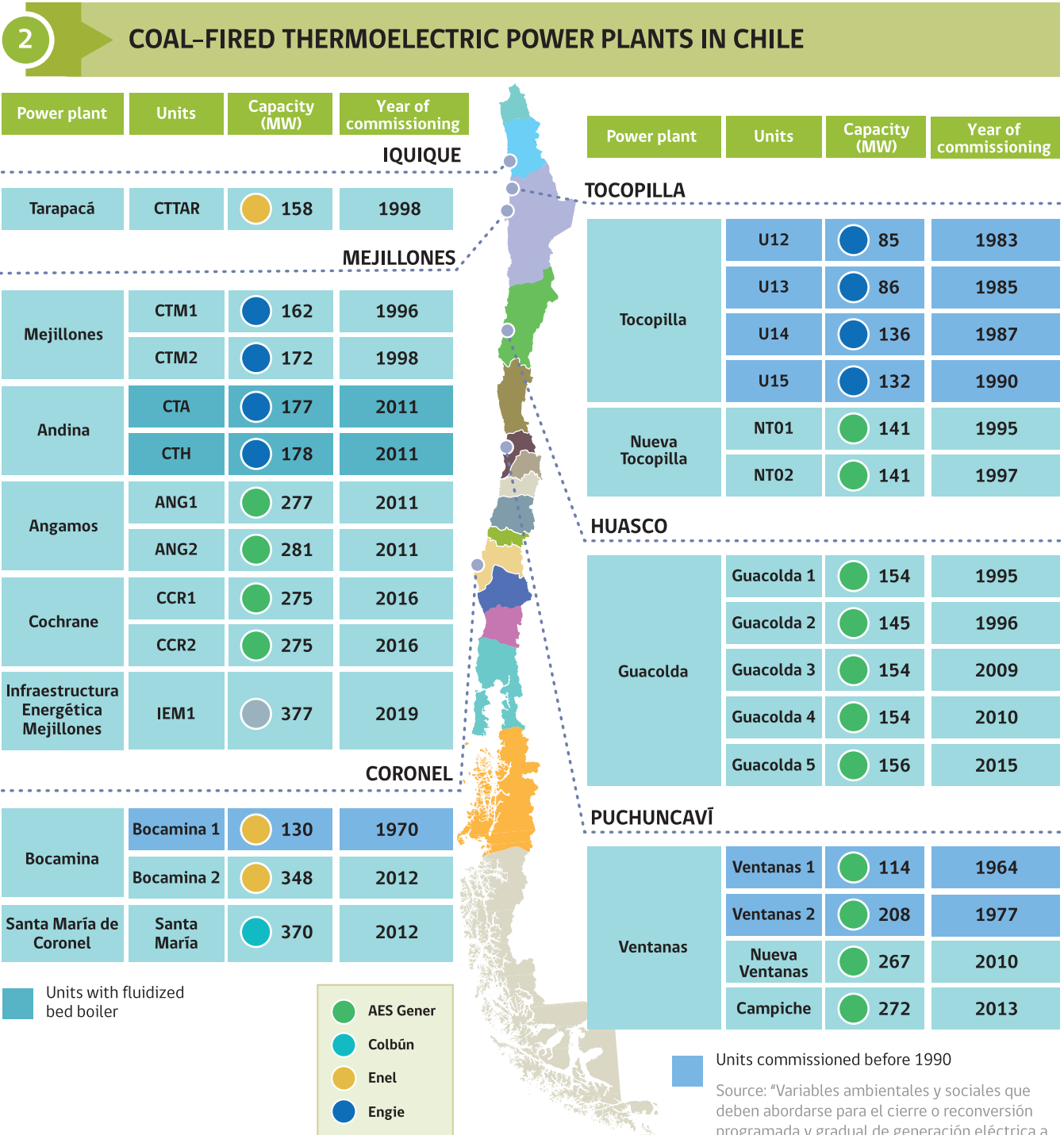
The 2018–2022 Energy Route establishes that one of the pillars of the energy sector modernization, which will be carried out by the government agenda of President Sebastián Piñera, is the decarbonization of the energy matrix stipulated in Axis 4. In this regard, the goal is a gradual but definitive construction, of a clean energy matrix that benefits current and future generations, in terms of local pollutants, that allows a green and low carbon growth for our economy, contributing to a cleaner world. To this end, a commitment is made to begin the decarbonization process of the energy matrix through the elaboration of a phase-out and/or reconversion schedule of coal-fired power plants, and the introduction of concrete electromobility measures.

Specifically, Axis 4: Energy low in emissions, raises the initiative "Towards the decarbonization of the energy matrix" and the plans to follow to achieve this task. In first instance, it mentions that in January 2018 an agreement was announced between the Government of Chile and the partner companies of the Chilean Power Generators Association which own coal-fired units, regarding three points: (i) companies commit to not initiate new coal projects that do not have carbon capture storage (CCS) systems or other equivalent technologies; (ii) the creation of a working group to analyze, in the context of Chile's Energy Policy (Energy 2050) goals, the technological, environmental, social, economic, security and sufficiency aspects of each plant and the electrical system as a whole, among others, to establish a timetable and the conditions for the phase-out of coal-fired power plant operations that do not have carbon capture storage systems or other equivalent technologies; and (iii) the Ministry of Energy will coordinate this working group, to which all relevant stakeholders will be invited.

It should be noted that in the decarbonization process proposed in the 2018–2022 Energy Route, several lines of work are established, such as mitigation and adaptation to climate change, carbon pricing, a climate change bill and the phase-out and/or reconversion of coal units connected to the National Electrical System. The Roundtable has worked in detail on this last point, leaving the other lines to be addressed in other instances and in a complementary manner, understanding that the decarbonization of the energy matrix is a challenge that will contemplate work and actions in different sectors, in addition to the electrical sector.

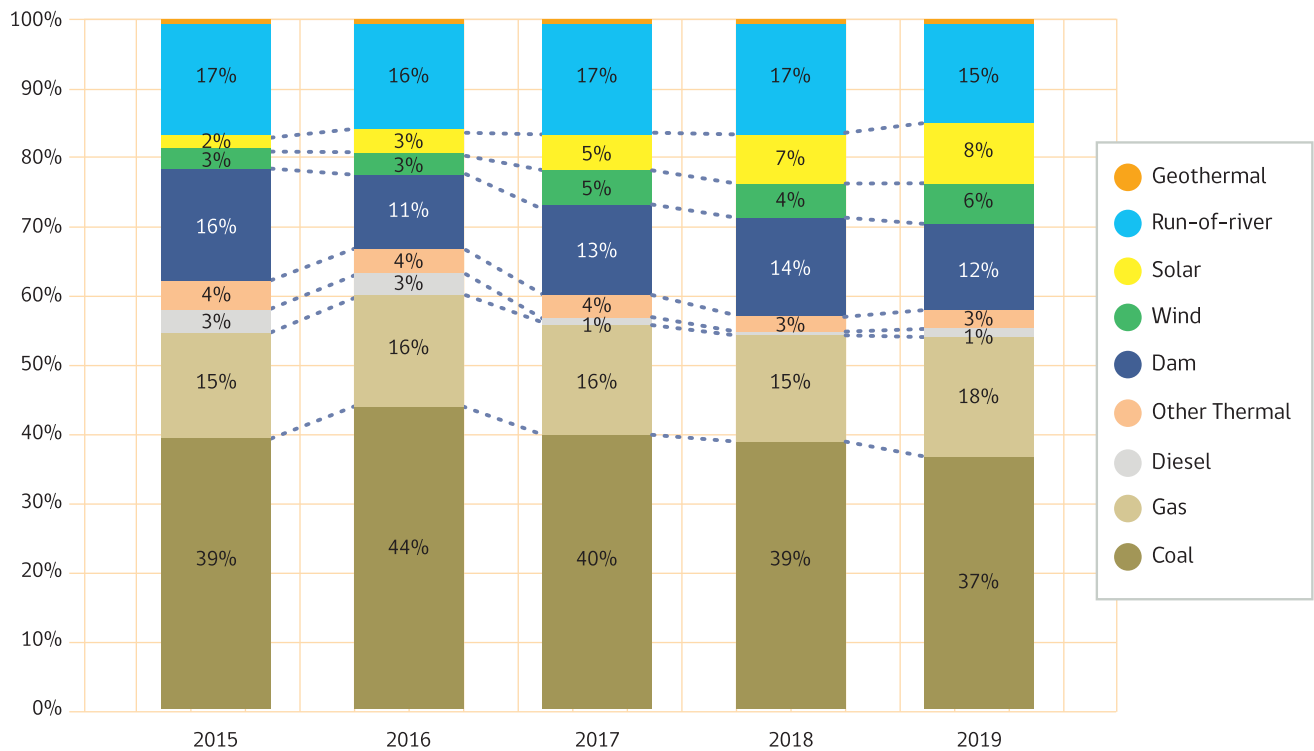
### 3.2 The role of coal in the Chilean electrical matrix

The National Electrical System has 28 coal fired plants located in six communes of the country, of which as of June 2020, 3 units have been phased-out. Figure 2 presents the geographical location, installed capacity, company and year of commissioning of each of these plants.



Coal-fired power generation has represented, on average, almost 40% of the power generation of the National Electrical System since 2015. It is worth mentioning that, during 2016, it reached the maximum share with 44%. Figure 3 shows the generation by technology between 2015 and 2017.

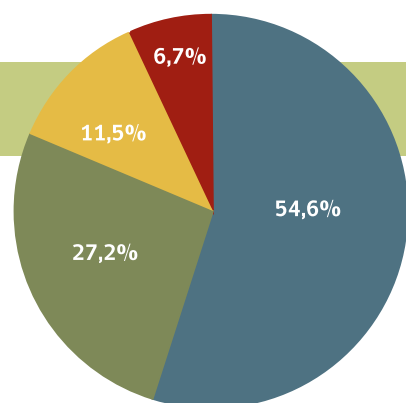
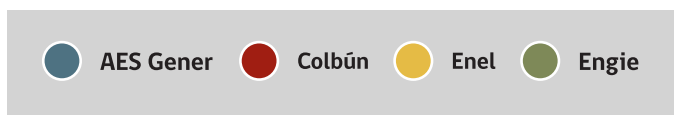
### 3 POWER GENERATION BY TECHNOLOGY IN THE NATIONAL ELECTRICAL SYSTEM



Source: Ministry of Energy, 2019

Of the total installed capacity based on coal, which reaches 5.529 MW of gross capacity, 54,6% belongs to AES Gener, 27,2% to Engie, 11,5% to Enel and 6,7% to Colbún, which can be seen graphically in Figure 4.

### 4 COMPANY OWNERSHIP, YEAR 2017



Source: NATIONAL ENERGY COMMISSION (CNE, 2019).

## Coal Phase-out and/or Reconversion of Coal Units Roundtable

### 4.1 Goal

In June 2018, the Ministry of Energy initiated a work instance under the context of electric decarbonization, called "Phase-out and/or Reconversion of Coal Units Roundtable", which carried out information gathering, diagnosis construction on the current state of coal units and technical, financial and environmental analysis of the current existing coal units. At the same time, an evaluation was carried out of the systemic, industrial, social, labor, economic, supply security, technological and environmental effects of the electrical matrix decarbonization in the six communes, where the coal-fired power plants are located: Iquique, Mejillones, Tocopilla, Huasco, Puchuncaví and Coronel. This Roundtable was chaired by the Minister and the Undersecretary of Energy, and coordinated by four departments of the Ministry: Department of Prospective and Regulatory Impact Analysis, Environmental and Climate Change Department, Department of Energy Markets and Department of Participation and Community Relations.

It is intended that the infrastructure associated with dismantled power plants, sites, ports and transmission grids can be used efficiently. For this, the possibilities of phase-out and reconversion of coal-fired power plants were evaluated considering environmental, social and economic impacts.

In that sense, the Roundtable was a space for stakeholders to be able to, for the first time, analyze and provide background information on the challenge of decarbonizing the electric matrix in our country, considering social, environmental, security and economic aspects involved; which allowed to reach a joint definition of the analyzes that should be considered in terms of impacts associated with the phase-out and/or reconversion of coal units.

### 4.2 Members

The integration of the Roundtable sought that the main actors related to the effects of the phase-out and/or reconversion of coal units could be represented: public sector, companies, clients, association of power generators, environmental NGOs, workers, civil society, universities, municipalities and international organizations.

For reasons of efficiency in the work of the Roundtable, it was not possible to include all the actors who might be interested in presenting supporting information to the discussion. For this reason, the inclusion of audience instances was foreseen, where actors who did not formally participate in the Roundtable, had the opportunity to present their studies, interests and proposals in the pertinent thematic sessions, in order to be considered by the members of the Roundtable (see chapter 4.4).

The twenty-one (21) members that formed the Roundtable are listed in the following table:

**1 MEMBERS OF THE PHASE-OUT AND/OR RECONVERSION OF COAL UNITS ROUNDTABLE**

Category	Instituciones
Companies	AES Gener
	Colbún
	Enel
	Engie
Public Sector	National Energy Commission
	Ministry of Energy
	Ministry of Environment
Trade Associations	Chilean Association of Power Generators
Clients / Consumers	Mining Council
	Non-regulated Energy Consumers Association
	Organization of Consumers and Users of Chile
NGO	Casa de la Paz
	Chile Sustentable
	WWF Chile
Civil Society	Civil Society Council of the Ministry of Energy
	Coal-Fired Power Plant Workers' Union
International Organization	GIZ - German Cooperation
Academy	Adolfo Ibáñez University
	Pontifical Catholic University of Chile
Independent Institution	National Electric Coordinator
Municipalities	Municipality of Tocopilla

### 4.3 Action plan

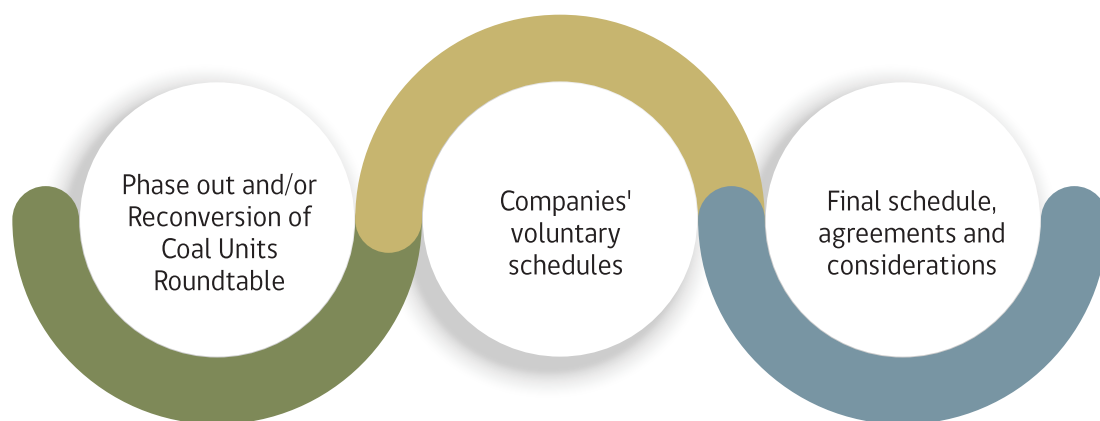
The action plan within which the work of the Roundtable is framed has three parts:

1. The first constitutes the work of the Roundtable itself. In that sense, and in order to comply with the agreement, the Ministry of Energy established the Roundtable on June 11, 2018 with the purpose of providing background information and analyzing the effects of the phase-out and/or reconversion of coal units on the security and economic efficiency of the National Electric System, local economic activity and environmental aspects of incidence. It should be noted that it was anticipated that resolutions regarding legal, statutory or regulatory changes related to decarbonization would be evaluated in their corresponding instances outside the Roundtable. In the end, the Roundtable would allow reaching a consensus on analyzes that should be considered regarding the impacts of the phase-out and/or reconversion of coal units. For example, what security criteria, economic effects, labor impacts and environmental variables should be considered.
2. Based on the results of the Roundtable, the companies that signed the agreement would voluntarily and individually submit a timetable and the conditions for a scheduled phase-out of coal-fired power plant operation.
3. As a final step, the effect of individual schedules would be analyzed by the National Electric Coordinator to ensure that it had no impact on the safety and efficiency of the electrical system. The goal was to have final phase out schedules and their associated conditions during the first half of 2019.

The Roundtable's action plan is presented schematically below.

5

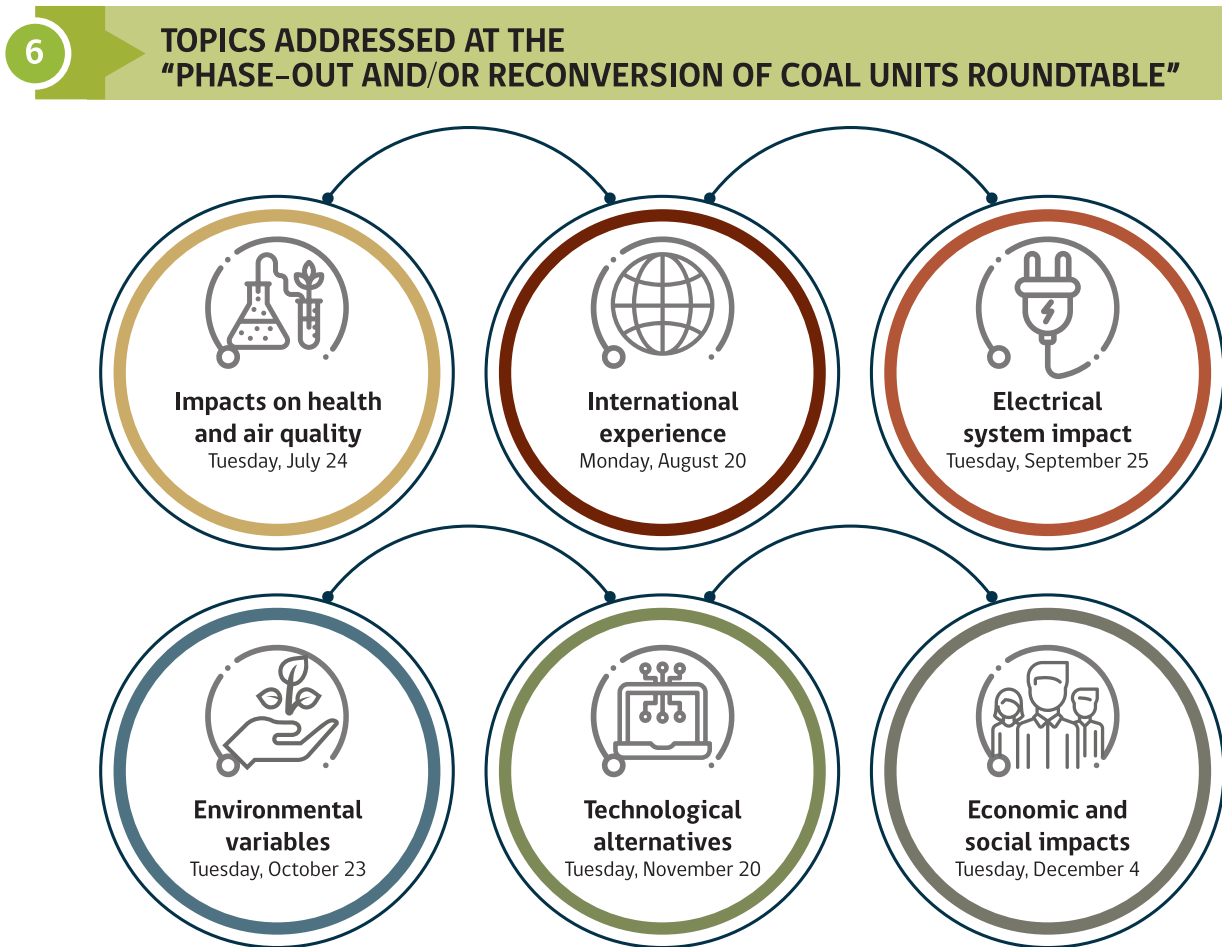
#### GENERAL OUTLINE OF THE ROUNDTABLE'S ACTION PLAN



Source: Own elaboration.



In order to structure the work of the Roundtable, it was established that at each meeting different topics related to the phase-out or reconversion of coal units would be addressed. The established session planning is presented in Figure 6.



Source: Own elaboration.

#### 4.4 Lessons learned from the thematic sessions

The following is a summary of highlights, and recommendations given by experts in the thematic sessions that were held within the framework of the "Phase-out and/or Reconversion of Coal Units Roundtable"<sup>4</sup>.

<sup>4</sup> Minutes, presentations and studies shown in the Roundtable sessions available at: <http://www.energia.gob.cl/panel/mesa-de-trabajo-descarbonizacion>

#### 4.4.1 Impacts on health and air quality

**Pablo Ruiz,**  
University of Chile

"Health impact of industrial sources:  
small-areas study"

**Patricia Matus,**  
University of Los Andes

"Ecological effects of coal-fired power plants operation"

**Marcelo Fernández,**  
Ministry of Environment

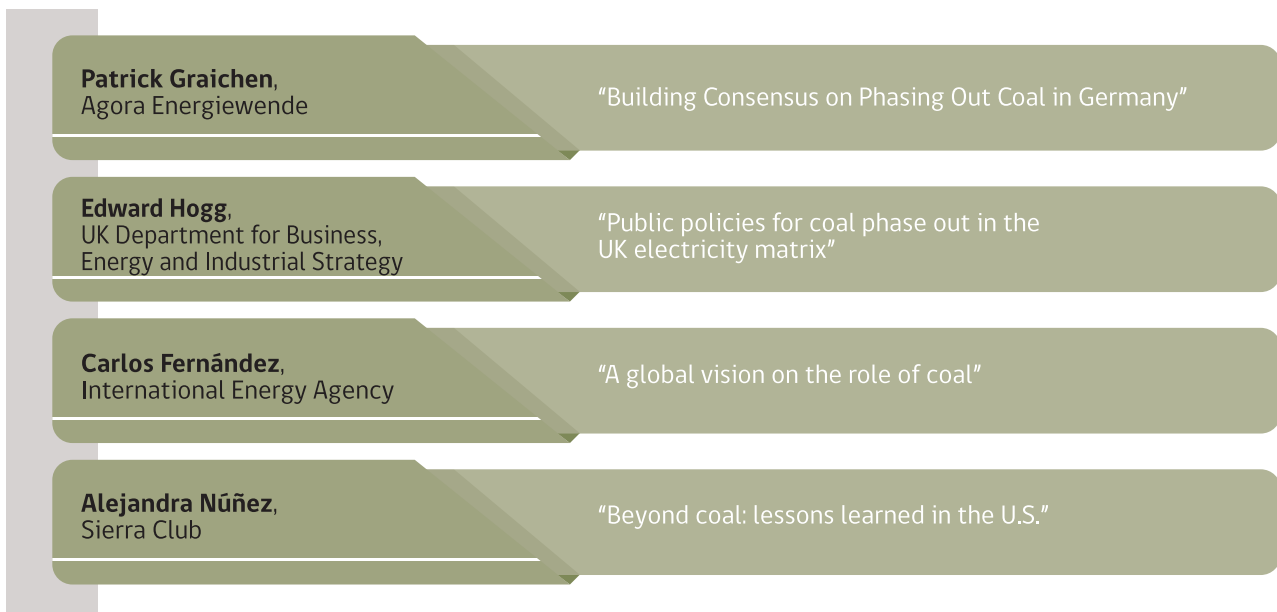
"Emission Standard for Thermoelectric Power Plants"

From the presentations and discussion that occurred in this session, it follows that:

- For the period between 2000 and 2010, there is evidence of an increase in mortality and morbidity in areas close to the mega emitting industrial sources, such as coal units or copper smelters. This, considering the statistics related to cardiovascular, respiratory and cancer diseases, as well as the mortality and hospitalization rate. In this regard, there is a suggestion to re-study the results, but in specific places and for the most vulnerable groups (elderly and children), as well as data updating, considering the effect of the emission standard for thermoelectric power plants, which was implemented in 2011.
- It is evident that the phase-out of coal units has direct and indirect consequences on the population. Among the first are: decrease in medical consultations, decrease in the consumption of asthmatic patients' medications, decrease in hospitalizations due to respiratory and cardiovascular causes, and avoided human deaths. Meanwhile, indirect effects are related to a lower global impact, which translates into a decrease in deaths due to extreme temperatures.
- Given the implementation of the emission standard for thermoelectric power plants, there is an 83% decrease in particulate material (PM), 70% in nitrogen oxide (NO<sub>x</sub>) and 72% in sulfur dioxide (SO<sub>2</sub>). This translates into a reduction of 282 deaths per year, representing a benefit of US\$332 million per year. On the other hand, measurements with Continuous Emission Monitoring Systems (CEMS) have allowed better control of pollutants, as well as the implementation of the green tax<sup>5</sup>.

<sup>5</sup> Tax on CO<sub>2</sub> emissions and local pollutants (MP, NO<sub>x</sub> and SO<sub>2</sub>).

## 4.4.2 International experience

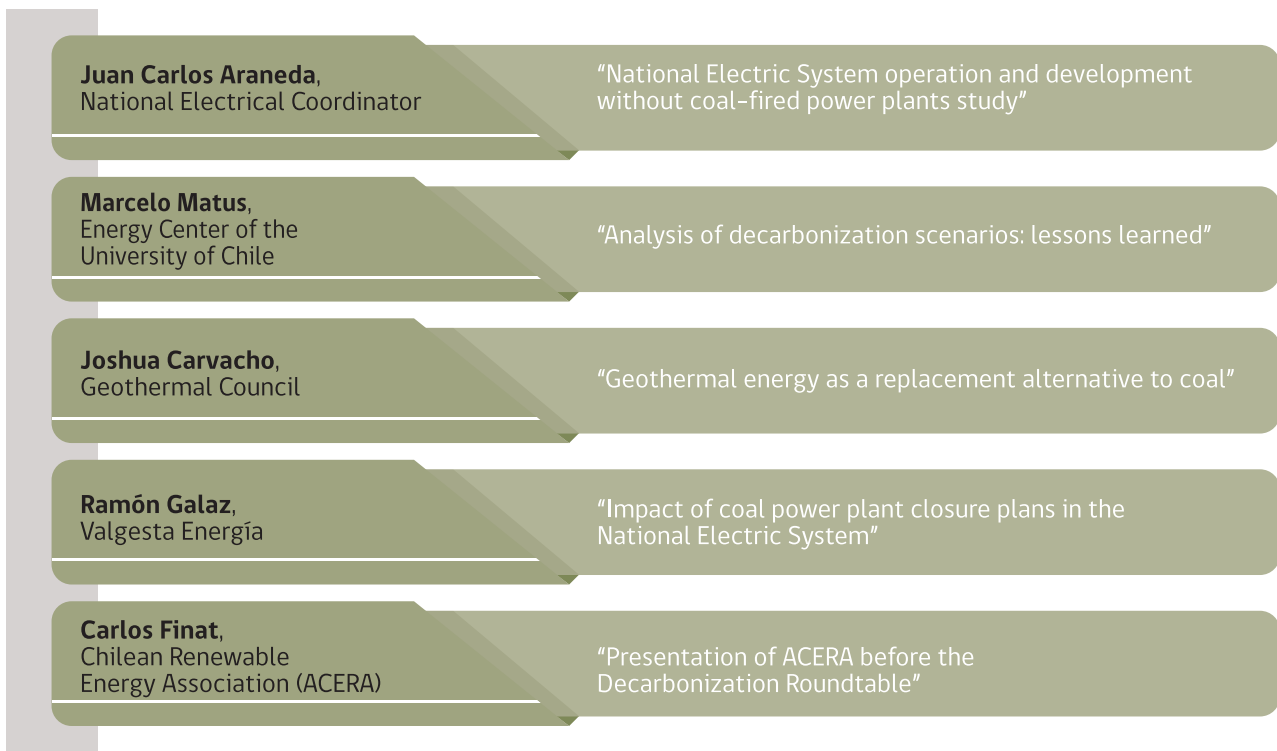


From the presentations and discussion that occurred in this session, it follows that:

- The use of coal should be cut in half by 2030, worldwide, in order to reach the goal of not raising the planet's temperature by 2 degrees Celsius. In that sense, the phase-out of coal-fired power plants will have social and economic implications, but should be perfectly manageable.
- The UK Government announced that from 2025 onwards coal will not be able to be used in the generation units, this in order to give certainty and predictability to the private sector. This seeks to ensure supply, providing incentives for new forms of reliable capacity (gas, storage, etc.), ensure an orderly transition for the phase-out and/or reconversion of coal units, and ensure the reduction of CO<sub>2</sub> emissions (and other pollutants). Specifically, an intensity emissions limit of CO<sub>2</sub> per kWh generated was established. Given this, which involves the replacement of seven coal-fired power plants by 2025, equivalent to 13.747 MW of installed capacity, the market response has resulted in five power plants already reconverted and/or phased-out.
- Beyond the general perception that coal is in retreat, the evidence shows that this is not the case yet and that, in fact, an increase in its consumption is expected in the coming years. However, today there are multiple power generation technologies with zero emissions, so the electricity sector can lead the way to a future low in coal usage. In that sense, the keys to a successful integration of these renewable technologies are: electrical and energy interconnections between different countries, demand response, energy storage and flexible generation.

- The phase-out of coal-fired power plants in the United States has been achieved based on robust environmental regulations and litigation and public campaigns at the state level. This has resulted in a phase-out of 270 power plants today, leaving a pending balance of 260. Among the implications of this phase-out are: 45% and 41% reduction in SO<sub>2</sub> and NO<sub>x</sub> emissions, respectively; a total of 3.000 million dollars saved in health costs; and 550 million tons of CO<sub>2</sub> avoided. In this context, and especially in labor matters, it is important to keep in mind the concept of Just Transition, which implies, among other things: advanced notification, and the inclusion of workers and community members in the closure of coal-fired power plants and/or coal mines; accountability to workers by business owners; transition assistance from various government entities; and the generation of jobs in the clean energy industry.

### 4.4.3 Impact on the Electrical System



From the presentations and discussion that occurred in this session, it follows that:

- From the development of optimal national generation and transmission infrastructure in a timely manner, the electrical system can operate maintaining service security requirements in a scenario of planned phase-out of coal power plants. However, the above has additional investment costs compared to scenarios without decarbonization. In that sense, in the totality of the scenarios studied by the National Electric Coordinator<sup>6</sup>, the need to develop a 2.000 MW High-Voltage Direct Current link (HVDC) between the northern and central areas of the country was identified, between the Kimal and Lo Aguirre substations, and depending on the scenario, the subsequent need for a second line of 2.000 MW between the Nueva Taltal (Parinas) and Lo Aguirre substations. Along the same line, the need to advance local transmission developments in areas with several coal-fired power plants was identified, as is the case in the Puchuncaví area.

<sup>6</sup> Study developed by the National Electrical Coordinator for the "Phase-out and/or Reconversion of Coal Units Roundtable".

- From an operational point of view, the National Electric System (SEN) can be efficiently developed, managing to maintain sufficiency and service security, with the consequent investment in transmission and technologies such as solar photovoltaic, wind and hydraulic generation, accompanied by flexible generation power plants such as Concentration Solar Power (CPS), hydraulic pumping or natural gas or LNG. The foregoing, because coal substitute infrastructure developments, added to the existing power plants, will allow to meet the growing requirements of the necessary operational reserve due to a high insertion of variable renewable energies. In this regard, the cycling operation of thermoelectric power plants (frequent starting and stopping) will require daily starting and stopping of the power plants, which will imply greater local emissions in the starting stages that could lead to exceeding air quality and/or emission standards, so this matter must be studied in depth in order to determine the environmental viability of such operating strategy.
- Currently existing combined cycling power plants are, in theory, capable of operating with daily cycling patterns, which must be validated with the owners of the generation facilities. If not feasible, higher operating costs will be incurred, or a new natural gas generation capacity that has such flexibility must be incorporated.
- In calculating the operating and investment costs of the evaluated scenarios, the cost associated with the starting and stopping of combined cycle thermoelectric power plants has not been incorporated, so they should be analyzed in detail in future studies. This implies that starting and stopping cost overruns of natural gas and LNG units, used to provide services at the time of maximum insertion of variable renewable energy (VRE), could increase the costs associated with the phase-out of coal-fired power plants.

#### 4.4.4 Environmental and Social Variables

<b>Jorge Moreno,</b> Inodú	"Study of environmental and social variables that must be addressed for the planned and gradual phase-out and/or reconversion of coal-fired power generation"
<b>Boris Chamorro,</b> Municipality of Coronel	"Presentation before the Decarbonization Roundtable"
<b>Robin Hervé,</b> Aria Technologies	"Presentation before the Decarbonization Roundtable"
<b>Juan Pablo Boisier,</b> CR2	"Climate change, international context and impacts in Chile"
<b>Marina Hermosilla,</b> CLG Chile	Presentation before the Decarbonization Roundtable"

From the presentations and discussion that occurred in this session, it follows that:

- In the Chilean electricity matrix there is an important set of coal units with less than 10 years of operation, which coexist with older units, so the reconversion or phase-out of the latter will take place in a land where a newer unit will continue to operate. In this regard, international experience shows that countries such as the Netherlands and Italy have coal units that, by 2030, will have the same years of operation as some units in our country, so they face similar challenges. In contrast, this is not the case in the United Kingdom, which has 50 year-old units, for example.
- From the twenty-eight (28) coal units in Chile, seven (7) do not have an Environmental Qualification Resolution (RCA in Spanish) associated with the original project, six (6) are required to submit a closure plan in their RCA, before starting the phase-out (between six months and one year prior to closing), and the remaining fifteen (15) indicate that the units are most likely to be reconditioned or reconverted to another generation technology. In case it is required to leave the site, the structures, surface and marine equipment will be dismantled and removed<sup>7</sup>.

<sup>7</sup> Study developed by Inodú for the "Phase-out and/or Reconversion of Coal Units Roundtable".

- It would be advisable for dismantled plants to submit to the Environmental Impact Assessment System (SEIA in Spanish), describing the activities, works and actions to dismantle and ensure the stability of the infrastructure used, the restoration of any environmental component that has been affected, indicate how to prevent the impact of the ecosystem, including air, soil and water and indicate the maintenance, conservation and supervision that are necessary. It is also recommended to use the international EPA regulations for ash deposits, Regulation 40 CFR Part 257, on the management of coal combustion waste. The Electric Power Research Institute (EPRI)<sup>8</sup> has also published certain indications that should be considered in the case of partial or total dismantling of equipment and structures, that is: survey of requirements associated with the environmental regulation to which the site is subject; environmental research of the site (reference standards: ASTM E1527-13, ASTM E1903-11); planning, signing of contracts and requesting permits; plant shutdown; coordination with system operator; try to empty input and piping storage; site preparation; dismantling (recycle and resell as much as possible, excavation of foundations and piping only as far as necessary); and remediation and restoration of the site (coal field cleaning, closing of the ash deposit, cleaning of land under tanks and fuel lines, and asbestos removal, if applicable).
- The operation of coal-fired power plants has global effects on climate change, since they emit CO<sub>2</sub> and in a greater proportion than other thermal generation technologies. On the other hand, it has local impacts on air quality, due to the emission of pollutants such as NO<sub>x</sub>, SO<sub>2</sub> and MP, although to a lesser extent than diffuse sources emitted at low altitude such as heating with firewood and vehicular traffic.
- While Chile plays a secondary role in terms of global greenhouse gas emissions, it is a country highly vulnerable to the effects of climate change. In that sense, the review of Nationally Determined Contributions (NDC) is key, and Chile could exercise a global leadership in low-carbon development, taking advantage of resources for renewable energy, considering that economic losses due to mitigation costs, globally and particularly for Chile, could be higher than the costs associated with early decarbonization.

<sup>8</sup> EPRI, «Decommissioning Handbook for Coal-Fired Power Plants» Palo Alto, California, 2004; EPRI, «Power Plant Closure Guidebook» Palo Alto, California, 2010.



## 4.4.5 Technological alternatives

**Jorge Moreno,**  
Inodú

"Study of technological alternatives to the phase-out and/or reconversion of coal units in Chile"

**Chris Littlecott,**  
E3G

"Experiences learned in the phase-out of coal in the United Kingdom"

**Mariano Morazzo,**  
Enel Energy Transition

"Walking the path towards a decarbonised economy"

From the presentations and discussion that occurred in this session, it follows that:

- Today there are mature options such as fuel replacement, which have average investment costs, reduce CO<sub>2</sub> emissions, but could reduce the flexibility of the units. The economic feasibility of these options depends largely on the availability and cost of alternative fuels (natural gas and biomass). Another alternative associated with fuel replacement is partial conversion, for example, the use of natural gas only for the starting and operation processes at a technical minimum. This allows reducing emissions in the short term and making units more flexible, which may represent an option for the transition to a higher conversion<sup>9</sup>.
- In the case coal plant decommissioning, there are alternatives that reuse infrastructure in order to solve other local needs such as: water desalination for industrial processes and waste management and processing.
- There are emerging reconversion alternatives, which could contribute more efficiently and effectively to reducing CO<sub>2</sub> emissions than mature alternatives. Among these is the use of carbon capture and storage systems, incorporation of battery storage or coupling with thermal storage systems using molten salts. In this regard, the attributes of these alternatives are expected to evolve over time to reduce the associated costs and implementation risks.

<sup>9</sup> Study developed by Inodú for the "Phase-out and/or Reconversion of Coal Units Roundtable" financed by GIZ.

- The reconversion and/or phase-out solution of each power plant must be analyzed in particular according to the technical characteristics, time of use, manufacturer, etc. On the other hand, it is possible to consider the implementation of modifications gradually, starting with a partial reconversion (to increase flexibility) and then a total reconversion.
- The economic analysis of the reconversion and/or phase-out alternatives will depend on the evaluation of the existing infrastructure, market conditions and regulation, where the main factors to consider are: fuel prices, CO<sub>2</sub> emissions price, flexibility needs in the electrical system, investment costs, etc. In that sense, it is important to consider that there are opportunities to solve local needs by reusing existing infrastructure of the units that they determine to close.
- In the case of the United Kingdom, the coal units have not chosen the reconversion, for the most part, but have preferred to continue operating until it becomes uneconomical to continue doing so, due to the market operation and/or reconditioning needs that must be implemented. In that sense, when they have decided to close, the possibility of using the site for new developments has been considered. On the workers' side, employers have chosen to redistribute them in other roles within the same company and/or have offered the possibility of early closed.

## 4.4.6 Economic and Labor Impacts

**Verónica Alaimo,**  
BID

"Evaluation of the labor and macroeconomic impact of three proven scenarios of phase-out or reconversion of coal-fired power plants in Chile"

**Alicia Viteri,**  
Consultant

"Economic and labor impact of the phase-out and/or reconversion of coal units in Chile"

**Ana Belén Sánchez,**  
Consultant

"ILO and Just Transition. Definition and experiences"

From the presentations and discussion that occurred in this session, it follows that:

- The phase-out and/or reconversion of coal units generates more employment, in renewable energies, industry and services, in relation to a reference scenario (without phase-out or reconversion). Two thousand to eight thousand more jobs, in a scenario of phase-out or reconversion to 2030 and between thirteen thousand to twenty thousand more jobs in a scenario of phase-out or reconversion to 2050. However, in detail it is observed that there would be around 4,000 direct jobs (workers with contract and subcontract) and 9,000 indirect jobs displaced in coal-fired power plants, which, while representing a minor impact from the macroeconomic point of view, is significant for communities and workers of the areas involved.
- The Mejillones, Tocopilla and Huasco communes are the ones that have the greatest impact in terms of commune employment (the power plants represent 4%, 4% and 7% of employment, respectively). Meanwhile, in the lower income communes, the dependence on the Municipal Common Fund (FCM in Spanish) is higher. For example, if all the municipalities in the country are added, the dependency indicator is 42%, while for Tocopilla it reaches 44%<sup>10</sup>.
- The majority of coal-fired power plant workers perform tasks under the subcontract modality (63%). In addition, employment is mainly male (91%) and the staff is relatively young (63%), since they are under 45 and the average age is 40 years.

<sup>10</sup> Study developed and financed by the Inter-American Development Bank (IDB) for the "Phase-out and/or Reconversion of Coal Units Roundtable".

- The level of education and the income levels of the hired staff are high when compared to the level of education and income of the other people who work in the communes where the power plants are located: 58% have a technical, university and/or graduate level, and 45% of the contracted employment has a monthly income of over two million pesos.
- The Puchuncaví and Coronel communes, although inserted in regions with great productive diversification, have unemployment rates and social protection deficiencies that make it necessary to evaluate an intervention combining direct assistance programs and commune or regional development programs. In that sense, the Commune or Regional Development Programs are an opportunity to convert local economies towards a green or more sustainable economy.
- The socio-economic reality of each commune and region is different, so employment conversion strategies must be specifically designed. For example, it may be sufficient for Iquique to implement direct assistance programs for workers of the only coal unit there, but for Tocopilla, Mejillones and Huasco, these programs must be complemented with other commune or regional development programs to generate new sources of employment.
- Within the framework of a coal phase-out process, care must be taken to ensure a just transition in labor and environmental terms, which requires:
  - A dialogue between those affected and the decision makers.
  - Definition of a clear schedule of cessation of activities, linked to an alternative development strategy.
  - Employment-focused measures, including: training and retraining of workers, early retirement and employment insurance, support programs for new entrepreneurs, and a focus on the green sectors of the economy (renewable energies, energy efficiency, recycling, etc.) for the generation of new jobs.

## "Zero Carbon Energy" Agreement

After the work of the Roundtable, the Ministry of Energy, held bilateral meetings with coal-fired power plants company owners, individually, with the objective of agreeing a timetable for the permanent phase-out or reconversion of these power plants. An orderly and gradual scheduling of power plant decommissioning ensures the security of energy supply.

On June 4, 2019, the President of the Republic Sebastián Piñera Echeñique and the Minister of Energy signed an agreement with each company, which consists of a plan to close coal-fired power plants that will be carried out in two stages, short and medium term.

The short-term stage considers a commitment to phase-out eight units in five years, starting with two units of the Tocopilla power plant, owned by Engie, which were closed in June 2019. Thus, in this first stage, units will be closed in Iquique (one unit), Tocopilla (four units), Puchuncaví (two units) and Coronel (one unit), which together represent 19% of the total installed capacity of coal-fired power plants, that is, 1.047 MW.

The U12 and U13 units of Engie in Tocopilla were disconnected on June 7, 2019 (171 MW in total). At the end of June 2019, the Tarapacá power plant of Enel was authorized to anticipate its disconnection as of December 31, 2019. The U14 and U15 units of Engie anticipated their closure to January 2022.

Within the framework of the COP25 Climate Change Conference, the Ministry of Energy, announced that two units, CTM1 and CTM2 of Mejillones power plant owned of Engie, join the first stage (2024), withdrawing a capacity of 334 MW. In addition, an agreement was reached to close Ventanas 1 and Ventanas 2 power plants of AES Gener before the originally scheduled date, withdrawing a capacity of 322 MW. Finally, in May 2020, ENEL announced the advancement of the closure of Bocamina 1 and included Bocamina 2 in the closing schedule before 2024. In summary, this allows to anticipate the output of 1.134 MW, which gives a total closure of 11 units, and 1.731 MW by 2024, representing 31% of the installed capacity of coal-fired power plants.

This schedule was analyzed by the National Electric Coordinator, regarding its impact on the electrical system, to safeguard the necessary security and efficiency conditions. Figure 7 describes the schedule of the first stage, it includes the recent announcements of the generators:

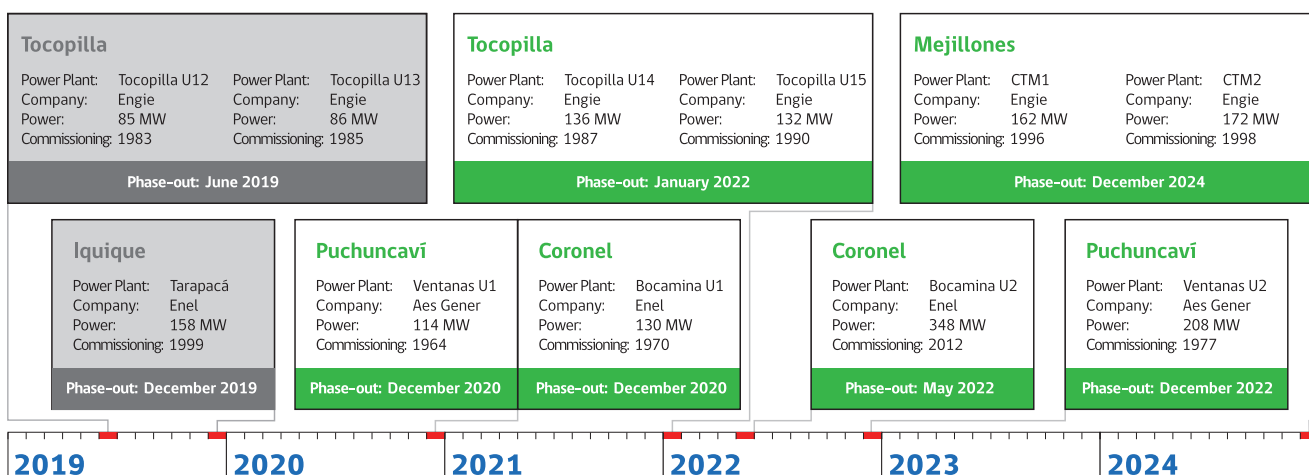
## 7 CLOSING SCHEDULE OF COAL-FIRED POWER PLANTS, FIRST STAGE



### CLOSING SCHEDULE OF COAL-FIRED POWER PLANTS 2019-2024



**First stage: 1.731 MW**



Source: Ministry of Energy

Update to May 2020

Meanwhile, the medium-term stage consists of the commitment to define dates in a flexible way in new roundtables to be carried out every five years, which will allow the establishment of specific phase-out schedules, taking into account the economic, social and environmental impacts of this decision. All of the above, with the objective of a phase-out of operations of all coal-fired power plants no later than 2040, essential actions for Chile to reach carbon neutrality by 2050.

The decarbonization of the electricity matrix is framed in the international context of compliance with the Paris Agreement, to which our country signed, and that requires ambitious actions to achieve the goal of limiting the planet's temperature rise to less than 1.5°C, prior to the industrial era. Although our country contributes only 0.25% of total GHG emissions (MMA, 2016a), we are one of the most vulnerable countries in the face of the effects of climate change.

In that sense, the “Phase-out and/or Reconversion of Coal Units Roundtable” was an instance that allowed analyzing and providing background information on the challenge of phasing-out coal-fired power generation from the electricity matrix, considering technological, environmental, social, economic, security and sufficiency aspects of each plant and the electrical system as a whole, among others, that allow the establishment of a schedule and the conditions for the planned and gradual cessation of the operation of coal-fired power plants in Chile. In that sense, the Roundtable represented a sustainability exercise, developed by stakeholders of the main sectors of society involved in the challenge of coal phase-out from the electricity matrix, which has sought to safeguard the economic, social and environmental effects involved in the process.

The phase-out of coal-fired power plants represents a significant effort by Chile, given the current composition of the power generation matrix, where coal has contributed with almost 40% of the total energy generated in the last three years. It is the case to mention that, within Chile's own challenges in the path to phase-out coal from the electricity matrix, is a group of coal units that started operations just a few years ago, and, in addition, the country does not have strong electrical interconnections with other countries, as is the case in other regions of the world, which identifies some challenges that the country must address to eliminate coal from the electrical system.

In this regard, it is important to mention that the phase-out will be carried out without direct State subsidies and will have positive effects in reducing global and local atmospheric emissions; environmental impacts on soil and water; and dependence on foreign fuels and fossil fuels. Likewise, although coal phase-out results in greater investment mainly in renewable energy sources, the lower operational costs of these could have a positive effect on the reduction of electricity tariffs in the medium and long term (due to higher investment costs in generation and transmission, and lower operating costs), employability rates and the safety and reliability of the electrical system, if done properly. This highlights the need to safeguard the gradualness of the process, understanding the need to develop greater capacity in transmission and electricity generation in order to replace the contribution of coal generation; an accompaniment for the labor transition of the power

plant workers and the communes in which they are located; and the adequacy of the relevant regulations that allow for an electricity market that recognizes attributes of power, energy and flexibility with environmental protection.

Regarding environmental and social issues, in one of the studies developed for the Roundtable (Inodú, 2018a), it is recommended:

- To communicate with sufficient anticipation to the community that will be affected about the intention to close the power plant;
- That companies make an early definition of goals and purposes for the site where the power plant is located and conduct an early environmental investigation on the site to determine if there is any contamination that should be remedied;
- To convene groups from different related sectors to identify possible uses of the site and/or advise studies in those cases that aim to find alternative uses to the location of the power plant that will cease to operate and define the most convenient way to evaluate the different options identified;
- That the municipalities develop a vision for the area and advocate a new project that is consistent with the vision of territory development and create economic stimulus plans for the transformation of work capacities; and
- Define limits of responsibility between the company that performs the closure and the one that restores the site, regarding the future development of the site and the community.

According to the National Energy Commission (CNE, 2019), the installed capacity of coal units is approximately 5.500 MW. The first stage of the coal phase out will withdraw 1.731 MW by 2024 (31% of the installed capacity), so in the second stage, by 2040, it is necessary to replace the remaining 3.769 MW of coal-fired power generation, which, according to projections of the Ministry of Energy (see Background Update Report 2019 of the Long Term Energy Planning process<sup>11</sup>), would be based primarily on renewable generation technologies.

As a consequence of the above, one of the biggest challenges as a country to achieve a successful coal phase-out from the electricity matrix, and move towards carbon neutrality, is the expansion of electrical transmission systems, to be able to connect renewable generation areas with consumption centers. The materialization of the necessary generation and transmission projects requires an adequate deadline, moreover, considering that the total phase-out of coal-fired power generation will take place before 2040, which

<sup>11</sup> Available at: <http://pelp.minenergia.cl>



added to the time necessary for environmental processing and other factors that may affect the execution of the transmission construction, poses a transversal challenge that must be addressed in a joint and participatory manner, with all the actors of the society.

On the other hand, climate change will affect the amount and distribution of rainfall, which may affect the capacity of generation of non-variable backup renewable sources, such as hydroelectricity. Thus, it is responsible to propose a phase out scenario within a prudent term, which allows decarbonization to be carried out with the necessary time and that does not mean a significant increase in electricity costs.

The coal-fired power generation is responsible for approximately 4.300 direct jobs and 9.000 indirect jobs, which should be considered when establishing the closure of the power plants. The phase-out of these units to the year 2040 will allow addressing the labor and economic impacts on the communes and regions where they are located today, delivering a reasonable period for the reconversion of the workforce, the materialization of new investments or the retirement of a part of the workers that apply. A strategy to accompany the labor transition will be coordinated by the Ministry of Energy, which will incorporate sector support required for such purposes, for example: Ministry of Labor and Social Welfare, etc. The actions that will be included are the following:

- Detailed diagnosis and quantification of the workforce directly affected.
- Characterization of job profiles and competencies of affected workers.
- Survey of potential job opportunities in new investment projects in each area, associated with investments to be materialized in the short term.
- Identification of gaps between the competencies that the affected people possess and the skills they will need to acquire for their reconversion.
- Identification of other existing government programs or existing local development initiatives in these communes that can support this process.

One aspect to consider in this strategy is to estimate that, according to the information collected by 2030, between 11% and 35% of current coal-fired power plant workers will have reached retirement age, depending on the commune they reside. In 2040, it reaches between 38% and 61%, while in 2050 all the communes exceed 71% (Viteri, 2019). In the case of the power plants that are close to stop operating, this strategy has already been implemented in conjunction with the companies, which have committed efforts to relocate the affected people in other projects and implement voluntary retirement and retirement plans.

As for security of supply, it is a key element that must be considered in any decarbonization schedule. This, considering that Chile is a country highly vulnerable to climate change and natural events, so that situations such as droughts, forest fires, earthquakes or other disasters, as well as technical failures of units or major restrictions on the supply of LNG, could be critical for the supply and generation of certain power plants. In that sense, the projections of the Ministry of Energy and the National Electric Coordinator show that the country's renewable energy potential would allow replacing the power generation of the coal units, which will require significant investments in new power plants and the expansion of electrical transmission systems.

Among the benefits of the phase-out of coal units is the decrease in emissions of global and local pollutants. In this regard, if the operation of the coal-fired power plants in 2018<sup>12</sup> is taken as a reference, the phase-out of these power plants will reduce approximately 25 million tons of carbon dioxide (CO<sub>2</sub>eq), 1.400 tons of particulate material (PM), 27.000 tons of sulfur dioxide (SO<sub>2</sub>), and 31.200 tons of nitrogen oxides (NO<sub>x</sub>) per year<sup>13</sup>.

Specifically, with the phase-out of the first power plants by 2024, Ventanas 1 and Ventanas 2 units in the Quintero-Puchuncaví area, a reduction of 5% in PM, 10% in SO<sub>2</sub> and 30% in NO<sub>x</sub> emissions will be generated, which by adding the Nueva Ventanas and Campiche units (located in the same area) will achieve a total reduction of 15% in PM, 30% in SO<sub>2</sub> and 70% in NO<sub>x</sub>. It should be noted that the rest of the PM, SO<sub>2</sub> and NO<sub>x</sub> emissions in this area are due to copper mining, oil refinery and, to a lesser extent, transportation. For the Tocopilla area, the phase-out of the four units of the Tocopilla power plant will reduce the emission of PM by 35%, SO<sub>2</sub> by 40% and NO<sub>x</sub> by 30%, which, when complemented by the phase-out of the two units of the Nueva Tocopilla power plant, the reduction in the commune amounts to 70% in PM, 75% in SO<sub>2</sub> and 70% in NO<sub>x</sub>. Finally, for Coronel, the phase-out of the Bocamina 1 will generate a reduction of 1% in PM, 15% in SO<sub>2</sub> and 10% in NO<sub>x</sub>, which by adding the phase-out of Bocamina 2 and the Santa María power plant, would reach a 10% reduction in PM, 100% in SO<sub>2</sub> and 99% in NO<sub>x</sub>.

Finally, the schedule seeks to adequately balance the three pillars of sustainability in order to achieve the desired environmental impact but, at the same time, safeguard the economic security and efficiency of the system and the social problems linked to the loss of jobs in the communes where these power plants are located.

<sup>12</sup> Emissions reported to the Superintendence of Environment for the payment of the green tax, year 2018.

<sup>13</sup> Own elaboration based on emissions reported to the Superintendence of the Environment for the payment of green tax, year 2018; Inventory of emissions obtained from "Plan de Prevención y Descontaminación Atmosférico para las comunas de Concón, Quintero y Puchuncaví", year 2018; "Registro de Emisiones y Transferencia de Contaminantes", year 2017; "Análisis General del Impacto Económico y Social del Plan de Prevención y Descontaminación Atmosférico del Gran Concepción", year 2017.

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