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ARTÍCULOS

The Economic Thinking of Chilean Engineers: Electrification as an Enabler of Development (1935-1956)

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EN **Abstract.** This paper studies the economic thinking of Chilean engineers who devised and implemented the country's electrification plans beginning in 1939. It shows that these practitioners formulated a complex economic development thinking in which electrification was an indispensable (but not sufficient) element for Chile's economic and social development. They linked (electrical) engineering, economics and politics as they tackled the many challenges of developing a robust and durable electrical infrastructure that could foster the industrial development of the country and improve the population's standard of living.
Keywords. electrification, development, Chile.

JEL Codes: B2, O1, Q3.

ES El pensamiento económico de los ingenieros chilenos: la electrificación como facilitadora del desarrollo (1935-1956)

ES **Resumen.** Este artículo estudia el pensamiento económico de los ingenieros chilenos que idearon e implementaron los planes de electrificación del país a partir de 1939. Muestra que estos profesionales formularon un pensamiento complejo sobre el desarrollo económico, en el que la electrificación era un elemento indispensable (pero no suficiente) para el desarrollo económico y social de Chile. Vincularon la ingeniería (eléctrica), la economía y la política al abordar los numerosos desafíos que implicaba desarrollar una infraestructura eléctrica robusta y duradera que impulsara el desarrollo industrial del país y mejorara el nivel de vida de la población.
Palabras clave. electrificación, desarrollo, Chile.

Códigos JEL: B2, O1, Q3.

PT O pensamento econômico dos engenheiros chilenos: a eletrificação como promotora do desenvolvimento (1935-1956)

PT **Resumo.** Este artigo estuda o pensamento econômico dos engenheiros chilenos que elaboraram e implementaram os planos de eletrificação do país a partir de 1939. Mostra que esses profissionais formularam uma concepção complexa de desenvolvimento econômico, na qual a eletrificação era um elemento indispensável (mas não suficiente) para o desenvolvimento econômico e social do Chile. Eles articularam engenharia (elétrica), economia e política ao enfrentar os diversos desafios de desenvolver uma infraestrutura elétrica robusta e duradoura, capaz de impulsionar o desenvolvimento industrial do país e melhorar o padrão de vida da população.
Palavras-chave. eletrificação, desenvolvimento, Chile.

JEL classificação: B2, O1, Q3.

all goes as planned: the engineer's lucidity to Chile's electrical problems, 1940s-1950s. 4.1. Main achievements of the electrification plan. 5. Delays in implementing the plan and electricity shortages in Santiago. 6. The engineers' solutions: increase both private and public investments. 7. Conclusions. 8. References.

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1. Introduction

In Latin America, electrification was an essential feature of the State-led industrialization process (1930-1980), as the United Nations Economic Commission for Latin America (ECLA) stated in specific reports - notably *Energy in Latin America* (1956) and *Studies on electricity in Latin America* (1962).

This article aims to study the economic thinking of Chilean engineers who had an influence on the country's economic planning through their promotion of electrification as a driver for development. It shows the links between the history of development thought and energy economics and puts the light on a main "behind the scenes" aspect of development planning in mid-20th century Latin America: electrification. Indeed, famous Latin American development economists of the time like Raúl Prebisch, Celso Furtado and Aníbal Pinto Santa Cruz talked about development plans in a broad way, and electricity or energy were present mostly as infrastructure or production inputs. But these Chilean engineers focused on electricity because it would be what enabled the whole development process, at the time linked with industrialization.

Why focus on engineers' economic thinking to analyze economic development planning? Because in the 1930s and 1940s, economics as a discipline was just starting to be institutionalised and was still incipient in Chile as in most of Latin America.[1] Prominent economists of the time, such as Pedro Aguirre Cerda (who later became President of Chile) and Aníbal Pinto Santa Cruz[2], graduated in law from the University of Chile before pursuing PhD studies in economics in Paris and London, respectively. At this time when the professionalisation of economics was just beginning, engineers played a central role in the economic policy of Chile, through designing the country's electrification plans produced by the Corporación de Fomento a la Producción (Production Development Corporation, hereafter CORFO).

José Edwards (2018), who studied the institutionalization of economics in Chile, contended that CORFO contributed to it. Given the leading role that some Chilean engineers played in designing this institution's electrification plans, I wish to study their economic thought regarding development, and contribute thus to the literature on the intricate links between economics and engineering, adding the dimension of development and energy.

In Chile, engineers had acquired a major influence on public works policies and industrial policies already in the 1920s, establishing a sort of "technobureaucracy" (term used by Pinto 1986, 115; see also Edwards 2018). Particularly, in the 1930s, the engineers forming this technobureaucracy focused on energy, and particularly on the electrification of the country, putting the matter forward to the government (Pinto 1986, 130). Hence, the case of Chile blurs the line between economists and engineers and recalls the case of the "engineer economists" of France, such as Jules Dupuit, Émile Cheysson and Clément Colson in the 19th and early 20th centuries (Béraud 2006; Siroën 1995; Vatin 2008) or, later in the 20th century, Marcel Boiteux, who worked at Électricité de France (EDF) (Yon 2020). The links between the two disciplines is further analysed in Pedro Garcia Duarte and Yann Giraud eds. (2020). That volume goes beyond a characterization of economists as focusing on (academic) theories and engineers on practice; it tackles the exchanges between both disciplines, which led for example to the adoption of engineering tools in economics, the economic teaching of engineers and the way engineers did economics.[3]

The Instituto de Ingenieros de Chile (the Institute of Chilean Engineers), created in 1888, was a place where many engineers expressed, debated, and developed their economic thinking. This work focuses on some members of the Institute and develops the idea that these engineers formulated an economic thought based on the development needs of Chile. The economic arguments put forward gave a key role to the State in electrification through the establishment of public electricity companies and emphasized the positive impact that this would have on Chilean industry. This does not mean that there was a monolithic approach within the Institute. Even

[1] It is only in 1924 that the Faculty of Commerce and Economic Science and the Academy of Economic Sciences of Chile were created at the Catholic University. Ten years later, the Faculty of Commerce and Industrial Economy was created in the University of Chile, while the Institute of Economics was established in 1945. In 1939, those who graduated from a Bachelor of Commerce and Industrial Economy received the title of "engineer of commerce" (*ingeniero comercial*) (Edwards 2018).

[2] Aníbal Pinto (1919-1996) was a Chilean economist who worked at the UN Economic Commission for Latin America (ECLA) from the mid-1950s to 1979. He extensively worked on the Chilean economy with a historical perspective.

[3] The link between engineering, economics and politics is particularly present in Guillaume Yon's contribution to the volume. National case studies are also of great interest, and the volume tackles electricity pricing in the United States and France, and the contribution to choice theory by Russian engineers.

among those who agreed that the State had to play a role in the electrification of the country due to the scale of the project, they differed on how important that role should be. Some, like Reinaldo Harnecker[4], put forward a mainly State-led electrification; others, like Raúl Simon[5], wished to foster the private-sector initiative in the electricity sector to limit the role of the State. However, in institutional reports, they proposed a rich and nuanced approach to the relationship between the private and public sectors. Some of these engineers like Reinaldo Harnecker had developed these ideas as early as 1935, well ahead of the 1940s Latin American developmentalist wave. They considered electricity as a necessity, indispensable for economic development and social inclusion: the urgency of its implementation called for strong State involvement.

This paradigm, that took form through the 1940s and 1960s, was abandoned during the Pinochet dictatorship (1973-1990), when the electricity market, and even the water, were privatized. At present, the private sector is responsible for the generation, distribution, and transmission of electricity. But it was the public sector that played the key role in boosting electrification, in particular hydroelectricity, from the 1940s to the 1970s, and the result of its decisions were long-lasting: in 2023, 63% of electricity production came from renewable sources, mostly from hydroelectricity. In fact, the engineers preferred hydroelectricity over other sources of electric power: after considering the geographical characteristics of Chile, they saw a great overall potential for hydroelectric plants, although they needed to be complemented by thermoelectric plants in arid regions in the North of the country that used coal.

Their ideas took center stage after the election of President Pedro Aguirre Cerda in 1938, followed by the Chillán earthquake in January 1939 which prompted the Government to put in place an ambitious reconstruction and development plan centered on industrialization (Humeres and Gil, 2024). This allowed the engineers to enter the political circles and put forward their ideas of electrification for achieving the government's plan. In other words, they acquired a major influence on energy policies and on the planification and implementation of Chile's development model.

The main institutional actor that pushed the electrification plan was the Chilean economic development agency, CORFO, created in April 1939. Its goals were to "formulate a general plan to promote production, aimed at raising the population's standard of living by taking advantage of the country's natural conditions and reducing production costs" and to "improve the international balance of payments" (CORFO 1939a). It harmonized State development agencies' activities (Nazer Ahumada 2016, 289). Immediately after its creation it prepared "Immediate Action Plans" in key domains such as energy, agriculture, mining, industry, and transports. These plans mobilized engineers and business associations of each field. Some engineers we study in this work were part of the permanent commission on energy and fuel and participated in elaborating its electrification plans of 1939.[6]

Several studies highlight the role of the Chilean engineers and their electrification plans. Mónica Humeres and Magdalena Gil (2024) have studied the birth of "energopolitics" in Chile, and particularly the importance of the engineers from the Institute of Chilean Engineers in the electrification of Chile. They notably show how the ideas of these engineers found an echo during the reconstruction and development plans put in motion by Pedro Aguirre Cerda after the disastrous Chillán earthquake of 1939. They argue these engineers dreamed about Chile's future and they show the importance of statistics in their analyses for electrification (which was a rather novel approach at the time). Although they mentioned that these engineers were thinking about the development of Chile, and referred to disagreements between them, these studies did not go deeper into the analysis of their development thought. José Soto Vejar and Carlos Sanhueza Cerda (2020) focus specifically on the sociotechnical controversies that took place from 1935 to 1939 between engineers regarding the electrification plans (mostly on the reactions to the 1935 work on electrification led by Reinaldo Harnecker) but does not analyze their development thought nor their economic thinking.

In this paper, I come back to these divergences as they are indicative of their different perception of the dynamics of development. I also focus on the link between electrification and development in these engineers' thinking and go further in time to encompass the engineers' reaction to the obstacles faced by the electrification plans in the late 1940s and in the 1950s. By doing so, I intend to highlight the links between engineering, economics, and politics. Therefore, this paper adopts a broader definition of what economics is, going beyond academia.

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4 Reinaldo Harnecker (1895-1987) graduated from Civil Engineering at the University of Chile in 1919, specializing in Electrical Engineering. He worked as a professor for many years and changed the curricula of the School of Engineering according to the needs and progress of Chilean industry. He became Dean in 1948. He worked as a consulting engineer or contractor in numerous projects. He travelled to Europe to study the development of the electrical industry in more advanced countries. This "led him to the conviction, around 1930, that it was essential to implement a comprehensive electrification plan that, along with taking advantage of Chile's natural resources, would prevent the country's stagnation, both from a social and industrial perspective" (Palma Rogers 1951, 72). Harnecker also served as Technical Manager of ENDESA.

5 Raúl Simon (1893-1969) studied civil engineering at the Univeristy of Chile. He worked as an engineer at the Ferrocarriles del Estado (the State Railways Company). He became Secretary of the Faculty of Physical and Mathematical Sciences, then its dean and, in 1926, he was briefly rector of the University of Chile. He was also a professor of Political Economy at the Faculty of Physical and Mathematical Sciences of the University of Chile, and the president of the Chilean Institute of Engineers from 1939 to 1942 (Guajardo 2010).

6 In the permanent commission on energy and fuels were engineers Raúl Simon (its president), Gustavo Rivera, Gustavo Loyola, Cesar Fuenzalida, Hernán Videla and Walter Müller. The technical committee of energy comprised the engineers Guillermo del Pedregal, Desiderio García, Guillermo Moore, Eduardo Reyes Cox, Domingo Santa María and Reinaldo Harnecker. In this work, we study more specifically the contributions by Raúl Simon, Reinaldo Harnecker and Guillermo Moore Montero.

After a quick description of the electrical sector in Chile before the electrification plan of 1939, I study a text from 1935 that proposed to conduct an electric policy, and I show how the authors linked development and electrification. I also study how the divergences between the engineers of the Institute regarding this text show different visions of development. I then study the CORFO 1939 electrification plan that the engineers wrote and link it to texts from 1938 to better explain it. In this plan, their vision of development corresponded with that of President Pedro Aguirre Cerda's government: as their thinking found an institutional echo, electrification became a central element of the development plan and new institutions were put in place to carry it out. I then study the period from the end of the 1940s to the mid-1950s, to study the reaction of the engineers to the problems encountered in the implementation of the electrification plan. Through this study, we see that these engineers reacted to the problems and proposed concrete solutions, always directed towards economic and social development. This also shows the holistic nature of their economic thinking: they thought about the economic mechanisms as they designed concrete energy policies.

2. Early development ideas have no influence if the conjuncture is not right

2.1. The electrical sector in Chile before 1939

Before the 1939 CORFO's Electrification Plan, private companies provided electricity supply. The larger part was generated by the big industries of saltpetre, copper, steel, and coal for they their own consumption, using mainly thermoelectricity.

The first step in the electric development of Chile as a public service was the introduction of electric tramways in 1897 by the company "Chilian Electric Tramway and Light Co.", based in London and made up of German capital. This led to the construction of the first thermoelectric plant in Santiago (the Mapocho plant), that started functioning in September 1900. Technical standards and machinery for this plant came from Germany, and it used steam motors. The same company installed another thermoelectric plant in Valparaíso in 1905 (the Aldunate plant). German engineers then constructed hydroelectric plants of El Sauce near Valparaíso in 1908 and La Florida, near Santiago in 1909-1910. The company's ownership changed during the First World War, since the German assets "were requisitioned by the British government and handed over to British capitalists in 1920" (ENDESA 1956, 105-106). In 1919, a new enterprise - Compañía Nacional de Fuerza Eléctrica, a combination of US and Chilean capitals - started building the hydroelectric plant of Maitenes (which started operating in 1923). In 1921, the two companies merged and formed the Compañía Chilena de Electricidad (Chilean Electricity Company, mostly English-owned), which practically became the only company providing electricity as a public service in Santiago and Valparaíso.

In 1925, the Government established by decree a special contract that gave the Compañía the 1st electric concessions to develop the electrical service in the provinces of Santiago, Valparaíso, and Aconcagua and to build hydroelectric plants that could use the river Maipo and the river Aconcagua. In the other parts of the country other enterprises were established using domestic capital, and they also benefited from concessions. But most of these enterprises were of modest size and used for watering in agriculture or public lighting.

From 1924 to 1929 "English capitalists, who through the Company controlled the electrical development of the three provinces of Santiago, Valparaíso, and Aconcagua, made new investments in the construction of generation plants and power lines, which led to the supply of electrical energy preceding and stimulating demand" (ENDESA 1956, 108).[7] According to the National Electricity Company (hereafter ENDESA), these new investments were linked to demands made by the Empresa de los Ferrocarriles del Estados (the State Railways Company), in a context of economic growth. The electrification and the increase in consumption of this region "contributed to greater industrial development and a concentration of population in that area, with the consequent rise in the standard of living relative to the rest of the country" and "in turn, created new demands for electrical energy" (ibid, 108).

The ownership of the Chilean Electricity Company changed "during the period of expansion preceding" the Great Depression, when the "English capitalists were [...] replaced by North American capitalists from the South American Power Co.." However, with the Great Depression the "development of electric power facilities came to a virtual standstill," and this situation lasted until 1938-1939. According to ENDESA, "this situation led to restrictions on electricity consumption, which severely affected the development of production and other national activities." With this background, a group of engineers drafted the report *Política Eléctrica Chilena* (Chilean Electrical Policy) (ibid, 108). That text represented an early development thought in which electricity was the core concern.

2.2. An early plea for State-led electrification as a prerequisite of development: "Política Eléctrica Chilena" (1935)

In 1935, engineers Reinaldo Harnercker, Fernando Palma Rogers, José Luis Claro Montes, Hernán Edwards Sutil, Vicente Monge Mira, Darío Sánchez Vickers, and Domingo Santa María wrote *Política Eléctrica Chilena*. All of them were members of the Institute of Chilean Engineers. In this text, they emphasized the importance for Chile to have a clear electricity policy, to develop its electrical infrastructure and to increase its electricity production because that would allow the country to industrialize and to develop. Electrification is presented as a necessary (but not sufficient) condition for development. They present the issue as being urgent, saying that "this problem constitutes a fundamental point in the development of our country and must be studied without delay" (ibid, 507). They put it on par with the satisfaction of basic human needs:

[7] I translated all quotes.

> It is now an undisputed axiom that, apart from the basic needs of food, clothing and housing, nothing is as closely linked to human progress and well-being, in its technical, economic, and social aspects, as electrical energy in its many applications (ibid, 508).

They also contended that Chile's development was being prevented by its lack of electricity, and that the country was suffering from "stagnation" and "backwardness." This could be addressed by an active policy of electrification:

> Chile reveals not only a situation of incredible backwardness, but, more seriously, a situation of stagnation that is suffocating healthy industrial progress, a suffocation that will become increasingly accentuated in its technical, economic, and social consequences as time goes by in inaction (ibid, 513).

They defined themselves as being "guided by the desire to contribute to the development and prosperity of the country" (ibid, 547). Their vision of development linked industrialization, education, and technological progress, as they argued that "the only way to solve our problems solidly and definitively is to address [...] the physical and intellectual improvement of our race (*"nuestra raza"*) and to increase our productive and consumer capacity". They positioned themselves as experts that could contribute to Chile's development and argued that "by studying the possibilities of having adequate electrical energy, we are using our knowledge to enhance our means of production and consumption." (ibid, 547). They did not develop in detail how industrialization would bring about development, but they clearly linked manufacturing and industrial activities to wealth and development. They contended that "electricity is an indispensable element for the development of industry" (ibid, 548), as electrification allowed industrialization and the mechanization of agriculture, hence:

> In a country of incipient development like ours, whose development should be stimulated and properly channelled toward industrial horizons, both extractive and manufacturing, as well as toward the industrialization of our agriculture and the increase of irrigated areas [...] in a country with a low standard of living [...] it is necessary for the State to decisively address a policy of development of our sources of electrical energy generation (ibid, 509).

Electricity "being a service of extreme public necessity," the State needed to actively intervene in Chile's electrification, either by leading it or by strictly regulating and supervising the "private individuals" that exploited it (ibid, 509). This was also justified by the fact that "the electrical industry, due to the strong and incessant capitalization it requires to adequately meet the ever-increasing energy demands, can only survive economically under monopoly regimes, just like the railways." (ibid, 509). By establishing since the beginning that the electricity sector has the characteristics of a natural monopoly, they showed a clear preference for the State to control it because they argued that "control over electrical energy gives control over the country's economy" (a quote they attributed to Mussolini[8]).

They believed that Chile, although lacking capital, had enough natural resources and thus could become a developed country if its resources were properly exploited. Chile was "a country poor in money but rich in the possibilities for wealth creation" (ibid, 547-548). But to become developed, Chile needed also to adopt innovative technologies, and investment in education as skilled workforce was essential (ibid, 548).

2.3. Peer reactions to *Política Eléctrica Chilena* show that this view of development was not mainstream

This 1935 text did not convince all the engineers of the Institute, in particular Guillermo Cox and Arturo Aldunate (Humeres and Gil 2024; Soto Vejar and Sanhueza Cerda 2020). Cox, a fellow engineer member of the Institute of Chilean engineers expressed some reservations regarding the 1935 text. He contended that the State was busy enough with problems linked to Chile's poverty, and adding electrification to its duties would be "creating more problems to the State" (Cox 1937, 4). He argued that there were more urgent matters than electrification that the State had not resolved yet: ensuring access to food, clothing and housing; building infrastructures such as better roads and bridges; establishing sewer systems and access to drinking water throughout the country; and tackling the fact that hospitals lacked funds and the capacity of helping those in need (ibid, 4-5).

According to him, focusing on the country's electrification would mean "to further restrict the execution of all these projects necessary for the country's progress" (ibid, 6). Cox argued that the private sector had already taken the role of providing electricity and could continue managing it:

> Private initiative, without any financial aid from the State [...] has so far been able to satisfy the ever-increasing demand for electricity and distribute it to almost all populated areas of the country (ibid, 4).
>
> [...] there is no obvious benefit in the State taking into its hands what, until now, has been in the hands of individuals (ibid, 5).

It seems that, in Cox's view, Harnecker et al. were going too fast in the development path of Chile, missing a step before electrification. Without mentioning a theory or narrative on development stages, he seemed to oppose the typical methods of late industrializing countries, where technological advances are introduced despite the backwardness of local industries, seeking a rapid structural change.

Meanwhile, Arturo Aldunate – a fellow engineer member of the Institute of Chilean Engineers who worked at the Compañía Chilena de Electricidad – agreed in principle with the 1935 *Política Eléctrica Chilena*, and with the leading role of the State in im-

[8] There was no clear source or year mentioned. This reference could make sense with these engineers' profiles since, until the mid 1930s, Mussolini was closer to technocracy than to corporatism.

plementing the country's electrification. Indeed, he said to be "convinced that liberalism has already had its day" and that there was a need to accept "the new economic and social orientations of the moment." For him, "sociological concepts and their influence on the economy change and will continue to change despite ourselves, and therefore it would be absurd to remain attached to old ideas." (Aldunate 1937, 44).

He also agreed that given the importance of electricity in development, "it is the duty of the modern State to make up for the deficiencies of private initiative, considering that the country's interest must prevail over immediate commercial interest." (ibid, 44). However, he saw a main flaw in *Política Eléctrica Chilena* regarding predictions of future electricity consumption and thus in its conclusions about how much extra capacity needed to be installed. Besides, the 1935 text put a great emphasis on the importance of lowering electricity prices to increase electricity consumption, but Aldunate thought this element was not realistic and missed the real problem. He argued that the purchasing power of most Chileans was too low to afford installing electricity at their homes, and that buying products that either used electricity or that were produced with electricity was impossible for most households: "the purchasing power of the vast Chilean workforce for the electrical industry is almost non-existent" (ibid, 56). He added that out of 90 000 clients of the Compañía, only 6 000 owned electric kitchens or water boilers. Hence, he argued that the issue was the limited purchasing power of households: increasing the production of electricity and lowering electricity tariffs would not increase electricity consumption of households, although decreasing the prices of these new electrical appliances could increase the demand for them (albeit in the richer urban populations) (ibid 54-55). City lighting, could indeed be improved more realistically. However, the increase in electricity consumption as a whole would not be as high as the predictions of *Política Eléctrica Chilena*, even in the Santiago region. Hence, Aldunate thought there was no need to greatly increase electricity supply (ibid, 59). He also pointed out that there were statistical mistakes in the report by Harnecker et al., both because it was difficult to have trustworthy data and because there were some inconsistencies in the report.

Finally, like Guillermo Cox, he emphasized that before thinking about electricity, Chileans were mostly worried about food, clothing, and housing (ibid, 46-47). To illustrate this point, he compared shoes production in the United States and in Chile: while the US produced every year 2,9 shoes per head, Chile only produced 0,8. Hence, he argued that most people went barefoot, an argument to emphasize that Chile's main problem was its poverty (ibid, 47).

That being said, he showed his support to the project of the electrification of the country, although he believed it was ambitious and needed to reconsider some of its policy conclusions:

> This does not mean that there is nothing to do; on the contrary, because our conditions are precarious, we must put all our capacity and effort into the struggle and cooperate with the government to build the country's prosperity, but with a clear understanding of the facts, without illusions, and starting with the recognition that Chile is a poor and harsh country (ibid, 62).

Thus, Cox and Aldunate did not share the vision of *Política Eléctrica Chilena*, for which electrification opened new possibilities that could increase wealth and the standard of living of the population. According to the Report, electrification could allow existing industries to increase their output, upgrade their production process, and modernize, and new industries to settle in Chile. Agriculture could also benefit through mechanized watering. This seems similar to how the early structuralist theory of development considered that social change would naturally follow the changes in the productive structure. We can deduce that if electrification is followed by industrialization, these changes in the productive structure could have an impact on the social structure through job creation and greater urbanization, which permits a new social dynamic in which new industrial classes would emerge, and revenues would increase.

Still, Cox and Aldunate put forward a crucial element, which is that Chile's poverty and the lack of purchasing power of the people needed to be taken into consideration in the electrification plan. More broadly speaking, in every development plan there can be important obstacles to changes in the productive and social structures.[9]

3. Electrification as a necessary but not sufficient element for Chile's development process
    3.1. The creation of CORFO: a conjunction of political possibilities increases the engineers' influence

Like most Latin American countries, Chile's industrialization was spurred by the economic crises that followed the First World War and, most importantly, the Great Depression. The latter normalized State intervention through monetary, fiscal and trade policies, spurred the ideas on industrialization, and marked the beginning of more-or-less planned Import Substitution Industrialization (Bulmer-Thomas 2003; Gil 2022). But these changes were rarely sufficient to properly industrialize the region, and there were no proper development plans implemented by the State. In other countries like Argentina, the outbreak of the Second World War and its disruptions in trade provided the setting for state-led industrialization plans. But Chile's industrialization plans started before the war and were linked with another type of disaster, not man-made.

[9] Land tenancy system has been identified as an obstacle to Chile's development. Indeed, it was an important limitation to productivity increase in agriculture. A land reform had been among the objectives of President Pedro Aguirre Cerda (1938-1941) and the Frente Popular but was put to the side while industrialization became the objective. The land reform finally took place between 1964 and 1973. The Pinochet dictatorship put an end to the reform but did not seek to restore the ex-ante situation; rather, by allowing the peasants to sell their parcels, it favoured a redistribution of the land to the benefit of a new rural bourgeoisie.

Chile's State-led development planning properly started with the creation in April 1939 of the Production Promotion Corporation (CORFO). It was part of the measures following the Chillán earthquake – the deadliest earthquake in Chile's history[10]– that happened in January of the same year. Gil (2022) insists on the importance of the earthquake in the creation of CORFO, because it functioned as the perfect occasion to put in motion an ambitious reconstruction and development plan. In 1938, Pedro Aguirre Cerda from the leftist coalition Frente Popular was elected President of Chile, and his program consisted in pushing forward Chile's development through an industrialization plan led by the State. However, he faced an important political opposition which was a major obstacle to implementing this policy (Gil 2022, 779). Because of the degree of destruction of the earthquake, the Government gained support for his ambitious plan that linked reconstruction and industrialization. Many intellectuals, engineers and business associations argued for the need to promote national industrialization through State intervention. Some were also in favour of protectionist and import substitution economic policies, such as those implemented after the Great Depression.

The government adopted several policy measures such as authorizing loans, general tax increase, an additional tax on the profits of copper companies and the temporary use of funds allocated to servicing the foreign debt. It also put in motion the creation of CORFO that was responsible for developing and implementing a comprehensive productive development plan. CORFO was the main institutional actor that pushed the electrification plan. It created ENDESA in 1943, a state-owned enterprise that had to implement the electrification program presented in 1939.

3.2. At the core of Chile's planning, the engineers' vision of development is institutionalized

In August 1939, only some months after its creation, CORFO presented an "immediate action plan" for the electrification of Chile. As many people engaged in its creation, it is not possible to clearly determine the paternity of the ideas. Among the engineers involved in the report were Raúl Simon, president of the Chilean Engineering Institute and of CORFO's permanent commission on energy and fuels, as well as other engineers of the Institute: Guillermo del Pedregal, Guillermo Moore, Eduardo Reyes Cox, Domingo Santa Maria, and Reinaldo Harnecker. All of them were part of the energy technical committee. Raúl Simon, with other engineers, had already suggested in March 1939 a similar electrification plan (Simon et al. 1939), which allowed them to quickly propose this new plan as soon as CORFO was created.

CORFO's 1939 electrification plan starts right away with a detailed study of the Chilean economy by sectors and its comparison with the United States' economy. The study stressed that manufacturing industry (and later the industry in general) was what placed the US far ahead Chile and that energy (electricity and fuels) was what allowed the US to have such a high manufacturing production. They linked the amount of horsepower installed in the US and the value added of manufacturing production:

	Population in millions	Installed Power in HP millions	Manufacturing value added in USD millions
1880	50.1	3.41	1 973
1930	122.8	42.87	31 783

Source: CORFO 1939, 6.

The study also compared the kWh output per year per person of the US, the UK, Germany, Canada, Norway, Chile, and China, showing that energy is directly linked with the level of development, since it is what allows the countries to have high industrial production. This comparison also allowed them to argue that Chile's electricity output was very low, and that it was stagnating (CORFO 1939b, 7). The authors stated that the insufficient access to electricity was a main obstacle for the development of Chile: existing industries could not properly function, and contended that this situation deterred other industries from existing altogether. This also affected the standard of living of the population (city lights, electricity consumption), and the need to electrify the railways (ibid, 11). That was also an element that Harnecker had pointed out in 1938 as a main element of concern, saying that Chile suffered from "serious backwardness" in generating, transporting, and distributing electricity as a public service (Harnecker 1938, 319).

CORFO's 1939 plan stressed Chile's main problem was that it could not immediately increase its energy production: while the electricity needs of the country were much higher than what the existing companies could provide, there was not enough capital to increase electricity production through the creation of hydroelectric plants, or to expand coal mining; in addition, there were not enough foreign currencies to import more oil (CORFO 1939b, 7).

The main message of the Report is that electricity production needed to increase. The engineers studied Chile's energy potential: although the country is very diverse, there are several regions with enough water to build hydroelectric plants. Hydroelectricity was also favored because it was a non-exhaustible resource, while the country's coal was needed for arid regions in the North and other industries such as steel. Also, (imported) oil was non-replaceable for cars or some machinery (ENDESA 1956, 19-20, 30).[11]

The problem was that it was too costly for private enterprises to build this infrastructure. Hence, in the writings of Harnecker and Simon, the State had to strongly intervene (Harnecker 1938; Simon 1939; Simon et al. 1939). In the 1939 electrification plan, CORFO was to lead the creation of hydroelectric plants by financing them. Indeed, the authors stressed that private capital did not invest enough in the sector and would not be able to do so. They also mention that the 1929 crisis was a main obstacle for private electricity companies to increase their production.

[10] There is no clear report on the number of casualties: Gil (2022) estimated the number to be around eight thousand; "Memoria Chilena", the website of the National Library of Chile, ventures twenty-four thousand.

[11] Engineers at ENDESA also thought about future potential renewable energy sources that Chile could rely on like wind power and solar power once the technologies existed (ENDESA 1956, 74-77).

But even though State intervention seemed inevitable, CORFO's 1939 plan still warned against relying too much on the State. This point is also found in Raúl Simon's work, and less in Reinaldo Harnecker's, showing that among the engineers they did not have the same view of State intervention.

Indeed, Harnecker thought that "because of the extreme public necessity" and because of the "many benefits, but only indirect, that [electrification] would provide to the collective", this endeavour was "not at the reach of national or foreign private capital, and there are dangers of all sorts [...] that foreign or national capital monopolize our public service of electrical energy supply, and that it creates a considerable and dangerous economic power" (Harnecker, 1938, 319). On the contrary, Raúl Simon feared that there would be a crowding out effect: if the State took care of the energy sector, the private capital could lack incentives to invest there because it would fear competing against the State "which can never lose" (Simon 1939, 554-555). Finally, a nuanced point of view was the one that prevailed in the 1939 CORFO plan. On the one hand, it states:

> This is why we think that, of all the investments that the Corporation can make, the least dangerous for the national economy would be the creation of a large system of electricity plants (CORFO 1939b, 9).

But also, CORFO's report proposes an electrification plan where both the State and the private sector would play a role. In this sense, it suggests the creation of Mixed capital enterprises in which CORFO would invest two hundred million pesos in 5 years that would be completed by 180 million coming from the private capital. CORFO would also give loans to already existing electricity companies. With this plan, the engineers believed it would be possible to match the energy demand. The Mixed Capital Companies would take care of the primary electrical transmission, while private companies would take care of secondary electrical transmission, because "they would best adapt the supply to the public's needs" (ibid, 9).[12]

CORFO's document mentions that Chile's electrification plan would proceed by dividing the country's electricity grid between several regions in a first period, then all the regions would be interconnected to have a centralized electricity production. This is indeed the plan that was adopted by ENDESA. More details about the division of Chile can be found in Reinaldo Harnecker's 1938 text, since it seems that the division it proposed was eventually adopted.

This work, presented at the first south American congress of engineering in 1938, suggests dividing Chile in 7 regions.[13] Chile is a very long country (4 265 km from North to South), so starting with a centralized electrical system would be difficult. Although Harnecker stressed that the technology to link electrical grids across long distances existed, it was still too costly (Harnecker 1938, 326-327). But in the medium term, he believed it would be possible to share excess electricity produced in a region with other regions that need it.

The first two regions did not have much potential for hydroelectricity. The first region was the North of country, from Arica to Vicuña (1250 km), characterized by an arid or desertic weather, with very little rainfall. This region should rely mostly on thermoelectric plants. The second region went from Vicuña to Petorca (280km) and only had an annual rainfall of 80mm.

The third region went from Petorca to Linares (410km). It is the region where Santiago (the capital) is located, with annual rainfall of 700mm. It is a steep mountainous area with rivers manly originating from the melting of snow. Hydroelectric plants would provide most of electricity, and it would be completed by thermoelectric plants.

The fourth region went from Linares to Temuco (320km). With annual rainfalls of 1550mm, it had an important potential for hydroelectricity. Having also coal mines, it could build thermoelectrical plants too. Hence, Harnecker suggested having both sources for electricity, and he forecasted that manufacturing industries could increase in that region, but also that agriculture would benefit from mechanic watering of crops. He also thought it would allow for rural electrification in that region, electrifying railways, and other public services.

The fifth region went from Temuco to Puerto Montt (320km). With annual rainfalls of 2300mm, it was the region with the most possibilities for hydroelectric production, also because it has lakes that could be exploited. Hence, this region presented a very favourable setting for heavy industries (major consumers of electricity) such as electrometallurgy, electrochemistry and manufactures directed to exports.

Harnecker had much less information for the last two regions, which went from Puerto Montt to Golfo Penas (560km) and from Golfo Penas to Punta Arenas (670km). Although Harnecker did not have enough information, he thought there was an interesting potential for hydroelectricity at least in the sixth region.

Harnecker thought that in the short term (without saying when), the fifth and fourth regions could be interconnected [...] Finally, the fourht and the fifth. Correct "sixth" and seventh regions seemed to be more complicated. The last step of achieving a total interconnection would happen in a longer term.

However, the implementation of this electrification plan and particularly the interconnection between regions suffered important delays. The interconnection only started in 1955, which was later than planned. The last stage was only completed in 1985 (Garrido Lepe 2023, 48-49). Actually, an electrical crisis erupted in the late 1940s, which was an obstacle to Chile's industrialization process.

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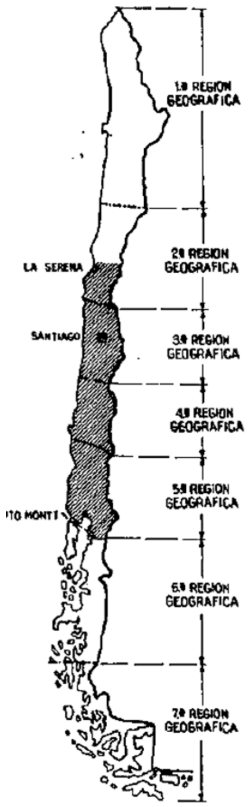
[12] Primary electrical transmission is the first stage in the power distribution process. This stage involves transmitting electricity from generating stations to substations, typically with high voltage. Secondary electrical transmission occurs after the primary transmission when electricity has reached the distribution substations. The voltage is lowered to be suitable for end-user consumption.

[13] Although the regions were generally consistent with administrative borders, they were determined according to geographical characteristics and potential for (hydro)electricity production and thus could be considered "eco-regions."



Source: ENDESA (1958, 10), used in Garrido Lepe (2023, 48).

4. Not all goes as planned: the engineer's lucidity regarding to Chile's electrical problems, 1940s-1950s

4.1. Main achievements of the electrification plan

CORFO began state coordination of electrification in 1939, the year of its creation. In March 1943, CORFO's board approved the National Electrification Plan (prepared in 1939), and in July 1943 ENDESA was created and entrusted with the country's electrification.

The engineer Guillermo Moore Montero wrote in 1955 an assessment of the first part of the electrification plan. He highlighted that the installed capacity had already expanded from 154 600 kW in 1939 to 568 240 kW, as the private companies added 102 700 kW, and ENDESA 310 940 kW, with a significant decrease in the share of thermoelectricity. According to Moore Montero, this "has meant for the country a lower fuel consumption that can be estimated at around 7 million dollars per year." (Moore Montero 1955, 547-549). He also emphasized that 84% of the new installed capacity had been financed by CORFO: "this means that since the creation of CORFO and of ENDESA, the installed capacity for public service has more than tripled (an increase of 268%)" (ibid, 547).

Moore Montero shows that, although the electrification plan was not yet fully implemented, its start had already been a success:

> The benefits that the works conducted during this period have brought to the national economy are of great value: they have been the basis for the development of vital industries, for improving services in cities and towns, and for the electrification of rural areas. In short, they have contributed, in a significant part, to raising the Chilean standard of living and increasing production (ibid, 549).

Indeed, if we look retrospectively at the electricity generation in Chile for that period, we see a notable change in the production of electricity and its uses. In 1939, 67% of electricity in Chile was produced by companies for their own consumption, notably by private copper or saltpetre (foreign-owned) companies in the North of the country. Companies used mostly thermoelectricity, representing 67,7% of their total production.

Public service electricity companies could be public (like ENDESA) or private (like the Chilean Electricity Company), and produced electricity as a service for households, public utilities, or industries. The electrification plans led to a dramatic increase of public service electricity: in 1955, it represented 47,8% of total electricity produced in Chile, relying mostly on hydroelectricity (85,8% of total public service electricity). Since 1960, public service electricity surpassed self-generation of electricity by companies, representing 58,7% of total electricity produced in 1965 (with 87,1% of hydroelectricity). Garrido Lepe (2021, 86) estimated the share of private public service electricity companies and the share of ENDESA in total electricity production. From 1945 to 1950, ENDESA's electricity production went from 2% to 35% of total public service electricity. Its share kept rising: it was of 52% in 1955 and 73% in 1965.

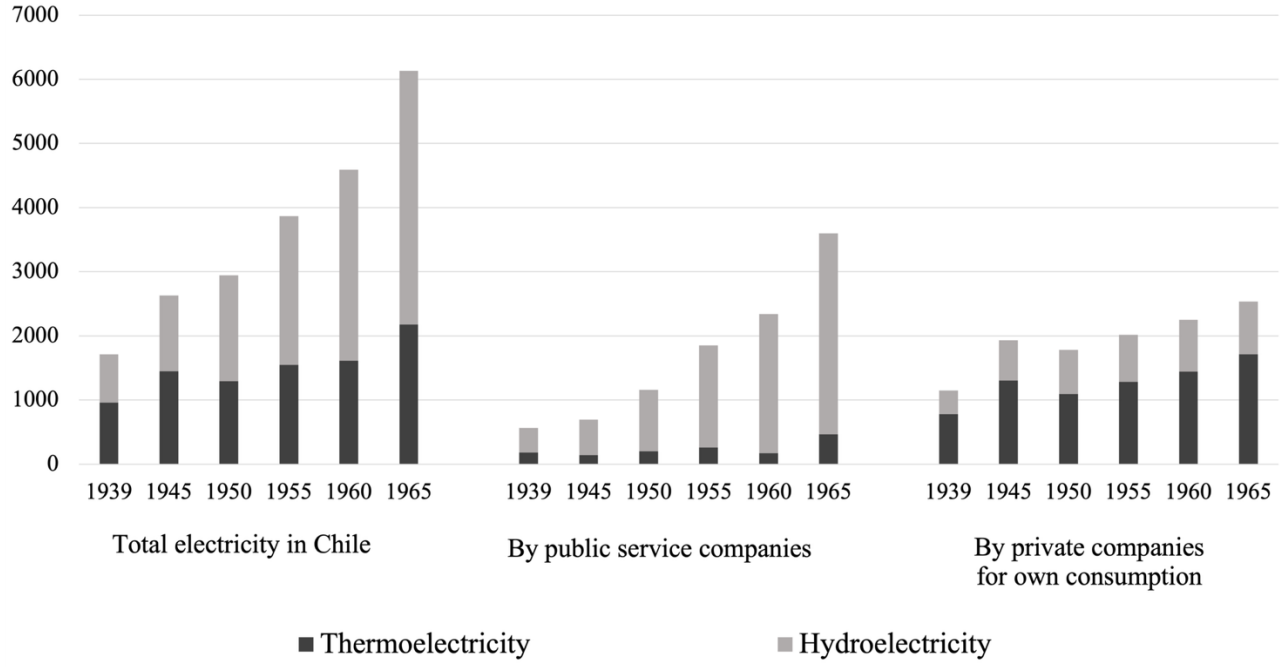
The electrification plans succeeded in increasing public service electricity generation in Chile: it went from 588 GWh in 1940 to 3597 GWh in 1965, a sixfold increase (Garrido Lepe 2021, 86). ENDESA was the main actor behind it. However, despite the positive results of the electrification plans, there were still some setbacks in carrying them out.

5. Delays in implementing the plan and electricity shortages in Santiago

There were delays in implementing the electrification plan, which led to an electricity crisis between the 1940s and the 1960s. Public utilities expanded significantly, but private companies were unable to meet the necessary electrical requirements. The annual growth in electricity generation (1,3%) and installed capacity (0,5%) of private electricity companies was among the worst of the 20th century. The consequence was electricity supply restrictions (Garrido Lepe 2023, 47-48).

Electricity rationing affected the most populated regions of the country, as it included the capital, Santiago, and a main port city, Valparaíso. These regions' electricity was supplied by the Compañía Chilena de Electricidad (the Chilean Electricity Company, later renamed CHILECTRA), a private company, which had an electricity distribution monopoly in these two regions and in Aconcagua, which were the main industrial and urban centres of Chile (Garrido Lepe 2023, 49). Given that it was failing to increase its electricity production, the Company imposed restrictions on electricity consumption from 1946 to 1959. Until 1951, restrictions were imposed by sector, causing losses for Chilean industries. In 1952 the Company put in place an electricity quota system and fines for excess consumption to relieve industries, but these penalized residential and commercial consumers (ibid, 50).

Figure 1: Electricity generated by public service companies* and by private companies for their own consumption in Chile, 1939-1965 (GWh)



* public service companies refers to both State and privately owned companies

Source: Figure based on data from Garrido Lepe 2021, 221-222.

In a conference given at the Institute of Chilean Engineers on April 23rd 1948, Hernán del Río Aldunate stressed that a main element behind the electricity shortages – the rapid demographical growth of the Santiago region, which increased demand and put the electrical grid under stress – was "foreseeable given the general pace of consumption over the past twenty-odd years" and that "the pace of growth and the lack of installed capacity, have been predicted by national experts since 1936 onwards with great insistence and on repeated occasions" (Río Aldunate 1948, 124). While there had been investments to increase the number of hydroelectric plants, there was a "delay in the delivery of the Sauzal Plant with 25 000 kW, which was to provide considerable relief to the Chilean Electricity Company system" (ibid, 126).

Río Aldunate also mentions that there were unforeseeable events that added to the stress on the grid. For instance, there was "the malfunction of the Laguna Verde machinery, a completely unforeseen event with extremely serious consequences, rendering the company's largest unit unusable" along with "seven serious and unforeseeable accidents at different points in its system" that happened in the lapse of one and a half months (ibid, 126).

He insisted that "the actions of Chilean engineers [...] is the only reason that cannot be invoked to justify rationing, as Chilean engineers have drawn attention to this matter well in advance and on repeated occasions" (ibid, 126). He mentioned that the engineers started working on this issue in 1935 and published the same year *Política Eléctrica Chilena*. Since "a memorandum of this work was submitted to the President of the Republic and the Minister of Finance in 1935" (ibid, 126), it shows the proactive stance the engineers had endorsed, taking the matter into their hands and trying to influence policy. It seemed to work, since "[a]t the request of the then Minister of Finance, Mr. Roberto Wacholtz, in December 1938, a commission appointed by the Institute focused on studying the Chilean electrical energy problem and the national electrification plan" (ibid, 127).

The warning of the engineers continued during the electricity crisis. In December 1947, the Institute of Chilean Engineers had sent a letter to the Ministry of Economy and Commerce, signed by its president Fernando Palma Rogers. In it, the Institute warns that the rationing that happened in winter 1947 "will become even more acute in the coming years if appropriate measures are not taken to address it" (letter reproduced in Río Aldunate 1948, 129).

Río Aldunate emphasized that the losses in production caused by the electricity rationing, both for the private and public enterprises, was such that it could have amounted to the cost of building a new hydroelectric plant with a capacity of 57 000 kW, which was more than the amount of the deficit and would have prevented the rationing. His argument was a rhetorical point to emphasize that the lack of investment in electricity was also particularly costly and thus employed a logic close to that of opportunity cost.

But the electrical problems continued (notably in Santiago) through the 1950s, due to delays in the interconnection between geographic electrical zones. In 1955, the interconnection of the 3rd and 4th zones happened, finally relieving the Santiago region (Garrido Lepe 2023).

Moore Montero also put forward that there were "resource restrictions during [the plan's] first period of development," which meant that there were still regions that ENDESA had not reached yet (Moore Montero 1955, 550). For the second part of the electrification plan, Moore Montero predicted a "considerable increase in demand, due mainly to the normal development of established consumption and the promotion of new activities and, to a lesser extent, to penetra-

tion into areas not yet electrified, that is, the creation of new consumption areas" (ibid, 550). He thus warned:

> If nothing were done to meet these growing demands, we would once again suffer in the Santiago and Valparaíso area the serious consequences of energy rationing, which caused such significant losses to all activities and reduced national production in the years 1946 to 1949, and from 1951 to 1953 (ibid, 550).

This shows that even after seven years and continuing investment in electric plants, keeping up with growing demand, a normal consequence of development, was challenging. Moore Montero reminded the importance of studying the patterns of consumption to be able to forecast peak consumption in winter and to be able to meet it. Based on existing studies and forecasts, he concluded to a cumulative annual growth in electricity consumption ranging between 6,5 and 10,2%, depending on the region (ibid, 551).

Only for the region of Santiago and Valparaíso, which hosted half the population of the country, they would have to install 420 000 kW in twelve years to meet the prevision of demand increase. Among those, 312 400 kW could be installed by ENDESA, the rest should be installed by the Chilean Electricity Company (ibid, 554). This equalled slightly more than the total capacity installed since 1939 in the whole country, but now only for one region (albeit the most populated one).

Regarding the works that would be carried out by ENDESA, the investments "will be financed in part by operating surpluses from existing plants (income minus operating expenses), which will be fully invested in new projects, and by ENDESA's own revenues. The remainder must be financed with contributions from [CORFO]" (ibid, 559). However, Moore Montero underlined that "over the last three years, CORFO's contribution to ENDESA's projects has been clearly insufficient, as its amount has not been in any way related to the increase in construction cost" (ibid, 560).

He explained that "due to a lack of contributions from the Fiscal Budget to CORFO's budget," they were in the "impossibility of carrying out the planned works program in 1953 and 1954". CORFO only granted a quarter of the necessary contribution for starting the second part of the Electrification Plan, "so the forced postponement of the plan will continue":

> That is, there will be a three-year delay in starting the most important works of the program for the second period. This delay will inevitably have repercussions in the coming years, in the form of restrictions on electricity consumption throughout the country (ibid, 560).

Given the gravity of the electricity restrictions, Moore Montero emphasized that "it is essential that new resources be authorized for ENDESA, *independently* of the Treasury." (ibid, 560, italics in original).

The situation of shortages in the Santiago region contrasted with that of the rest of the provinces, particularly in the South, where electricity generation grew steadily because of the investments by CORFO and ENDESA, leading to increased electricity consumption.

Hence, between 1940 and 1960, electricity generation only increased by 5,4% per year in the third region, where Santiago and Valparaíso are and which was under the control of the Company, which was private. In contrast, electricity generation increased respectively by 17,1% and 12,1% per year in the 4th and 5th regions, where electrification was led by the public sector. During that period, the fourth region experienced significant industrial growth. Indeed, CORFO was parallelly implementing an import substitution industry plan as part of its State-led industrialisation plan which led to structural changes in the industrial sector. There were thus significant increases in chemical, textile, and metallurgy production, particularly in the Southern regions of Chile (Garrido Lepe 2023, 50-51).

With the electrification efforts led by the public sector in the South, Santiago and Valparaíso were no longer the regions with the largest supply of electricity (ibid, 54). The creation of important hydroelectric plants by ENDESA changed this situation, as was the case with the building of the Abanico plant in 1948, situated in the fourth region, which had an installed capacity of 135 mW (CEPAL 1962, 166). Hence, "by 1955, industrial establishments in the southern region had nearly twice as much electricity as those in the central region" like Santiago (Garrido Lepe 2023, 54)[14].

Garrido Lepe points to some causes for this electricity crisis. He stresses that financial problems prevented ENDESA from completing on time the stages of the National Electrification Plan that concerned the interconnection of the regional electrical grids, and that CORFO's contributions were rather limited. Besides, he contends that inflexible tariff regulations in place since the 1931 electricity law discouraged private investment in expanding installed capacity, notably in the Santiago region, because it limited profitability. What helped end the crisis were new regulations in 1959 that modified the tariff-setting mechanism. With this, installed capacity was expanded and the growth of public service electricity generation accelerated, as shown in Figure 1 (Garrido Lepe 2023, 49).

6. The engineers' solutions: increase both private and public investments

Río Aldunate suggested both short-term and long-term measures to respond to the electricity shortage. On the short-term, aside from repairing the machinery, he suggested eliminating new non-lighting installations. He had in mind specifically the new apartment buildings that installed "electric heating, cooking, bathroom heaters, etc." On the longer-term, he suggested relocating large industries from Santiago to the South through a "system of attraction [...], for example, tax forgiveness for a number of years, [...] or a moderate price of power during the first few years." Finally, Aldunate said that the construction of "new, high-power plants, both thermal

[14] ENDESA had also built important hydroelectric plants in the third region such as the Cipreses plant near Talca, which started operating in 1955 with an installed capacity of 101,4 mW. Although it suffered from delays, ENDESA built the Rapel plant in the province of Santiago with an installed capacity of 350 mW, which started operating in 1968 (CEPAL 1962, 164; Garrido Lepe 2023, 60).

and hydroelectric" was "the ultimate measure par excellence" (Aldunate 1948, 135).

The necessity to construct new plants seemed evident, but they needed to find the financing. Besides, the private Chilean Electricity Company was the one in charge of the struggling area. Río Aldunate reproduced a letter written by the Company to the General Director of Electrical Services in October 1947, in which it suggested constructing a thermoelectric plant that would function with oil and coal, but argued that the Company would not be able to find the needed capital or credit in Chile. It claimed that the Company's main shareholder and creditor, the South American Power Company, would help financing this investment as long as "the Government provides sufficient foreign currency in dollars to cover the value of the materials that need to be imported and, at the same time, those required to cover expenses, interest and amortization of debts and dividends on shares abroad". Furthermore, the Company asked to be allowed to increase its prices (ibid, 136-137).

Río Aldunate disagreed with the utility of building a thermoelectric plant instead of a hydroelectric plant arguing that "a KWH has an operating cost of 4.7 cents in a hydroelectric plant and a KWH in a thermoelectric plant has 60 cents, given the price of coal", without taking into consideration interests and amortization of capital (ibid, 137). Besides, he said that the construction costs for both plants were very close. However, he agreed that the Chilean Electricity Company should be able to increase its prices. He compared the mean price per kWh in the United States with that of the Company and concluded that the latter was five cents cheaper. Río Aldunate also examined the balance sheets of the Company since 1931, concluding that, except for the years 1945-1947, it had "not produced enough profit to distribute dividends" (ibid, 139). Hence, he concluded that the company only needed to increase the price of the kWh by 0.06 pesos (8%) to have enough profit and be able to satisfy its commitments: "The important thing is to quickly resolve this problem to end this situation as soon as possible and proceed immediately with the construction of new plants" (ibid, 139).

Moore Montero also saw favourably changing the prices of electricity "in line with rising generation costs and for the revaluation of fixed capital" (Moore Montero 1955, 561). If Río Aldunate had the Chilean Electricity Company in mind, Moore Montero extended the benefits to ENDESA:

> With adequate tariffs, ENDESA could cover almost the entire program's development with its operating revenues, simply retaining the dividends and interests that the [CORFO] should receive. If other financing ideas are pursued, such as a tariff surcharge for capitalization and the exemption of customs duties on imported equipment, the Works Program could be financed almost without recourse to the fiscal sector (ibid, 561).

Also similar to Río Aldunate's proposition of tax exemption, Moore Montero mentioned a bill that sought to "exempt from import duties and all other taxes the machinery and elements necessary for the installation of generating plants and primary electrical power substations that must be imported because they cannot be economically produced in Chile" (ibid, 561). He stressed that "with the passage of the law in question, the contribution that CORFO would need to make to finance ENDESA's projects would be reduced to a minimum" (ibid, 561).

7. Conclusions

The engineers studied in this work – in particular, Reinaldo Harnecker and Raúl Simon, but also Guillermo Moore Montero and Hernán del Río Aldunate – had a complex approach to economic development that linked (electrical) engineering, economics, and politics. Their works were directed towards policy action and were guided by their engineering expertise and their comprehension of economic phenomena. Their objective was to increase the opportunities for Chile's economic and social development, and they envisioned that electrification was an indispensable (but not sufficient) element.

Planning was of paramount importance, as was a clear definition of objectives. Electricity was to be available for everyone – thus its price had to stay affordable – and everywhere in the country. Abundant and stable supply of electricity would promote the growth of existing industries and the emergence of new ones in Chile. It was also important that CORFO's electrification plan was designed in conjunction with its plans for industrialization and for agriculture. The engineers had a global vision of development and stressed how electrification would benefit both the industry and agriculture.

Their electrification plans encompassed electricity generation, distribution, and the interconnection between regional grids: large-scale infrastructure works were required and they would change the structure of the electrical industry. Hence, they raised the question of the place of the private and public actors in the electrification process. Given the costs of building such infrastructures and the low profitability of the endeavour, the State had to lead the process – especially in less populated areas. While the engineers did not question the distribution monopoly of the Chilean Electricity Company in the Santiago, Valparaíso, and Aconcagua regions, it was clear for them that the Company alone could not (and would not) expand in less populated areas. Other private actors like copper multinationals did have capital and they generated their own electricity but would not invest it in public service. Since the electrification plans allowed for the coexistence between public and private actors in the electricity market, the issue of electricity tariffs had to be revised: in the early years the engineers insisted in maintaining low prices, but Río Aldunate and Moore Montero argued for a slight increase in prices that would benefit all public service electricity companies (either public or privately owned), which eventually happened in 1959.

Their emphasis on the creation of hydroelectric plants showed as well their complex vision: not only it resulted from a careful analysis of Chile's geographical specificities and resource endowment, but it also took into consideration the country's economic needs. By using water for electricity, Chile's limited coal reserves could be used for industrial purposes or in arid areas. It also avoided using imported oil for electricity: saving it for other non-replaceable uses would be wiser since foreign currency was scarce. They also considered the

finite nature of fossil fuels, giving once again the advantage to water wherever it was possible to use it.

These engineers were aware that the lack of electricity was a major bottleneck for the productive development of a country. In that sense, the disagreement between the authors of *Política Eléctrica Chilena* on the one hand, and Cox and Arturo Aldunate on the other hand regarding the State's priorities is telling. The latter focused on important problems such as food, housing, and clothing, but failed to understand the long term and strategic vision of the group of authors led by Harnecker, for whom solving the bottleneck of electricity would benefit the other sectors of the Chilean economy. Not only would it increase the country's productive capacity; it would also increase the standard of living of the population and decrease poverty. During the periods of electricity rationing, Hernán del Río Aldunate and Moore Montero talked about the economic losses due to rationing and the lost opportunities of investment, both in creating new electrical plants and in other productive activities. Their reasoning shows that reducing investment in electricity because of other urgent problems related to poverty might not solve those problems, precisely because electricity created more possibilities for productive development. This could be confirmed by the industrialization of the Southern regions. It was thus important to solve the bottleneck due to the lack of electricity. To do so, a supply-led policy was needed first to create demand for electricity, which in turn would call for a new supply expansion: supply and demand of electricity would mutually reinforce each other. The engineers were aware of this phenomenon and of the challenge it represented, thus insisted on the need to find more ways of financing such increasing investments.

This work shows the importance of studying practitioners. In a country where economics was incipient, topics that are today seen as central from an economics perspective were tackled by experts like these engineers that had to make policy recommendations and, often, make policy decisions about investment and development. In this task they needed to engage with topics of economic development such as planning, industrialization, identifying key bottlenecks, the role of the State and of the private sector, the dynamics of supply and demand and pricing policy. They also had to think about the social and political impacts of electrification, as it meant to include a large part of the population in the electrical grid, change their employment conditions and improve their standard of living. These engineers not only provided an early and rather complete vision of development; they showed the importance of an often-overlooked factor that was electrification and embedded it in a coherent economic reasoning.

Competing interests

The author declares no competing interests exist.

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