

# Opportunities and Domestic Barriers to Clean Energy Investment in Chile

Annie Dufey

June 2010

This paper is a product of IISD's "Bali to Copenhagen" Trade and Climate Change Project.



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**We gratefully acknowledge the generous support of the governments of Denmark, Finland, Norway and Sweden.**

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## 1.0 Introduction

Clean energy includes diverse sources of renewable energies (biomass, small-scale hydroelectric, geothermal, wind, solar and marine) and a wide range of modern transformation and application technologies (combustion, thermal, mechanical, electromagnetic, chemical or photovoltaic). It is used to achieve a variety of results (electricity generation, heating and air conditioning, residential hot water supply, cooking, industrial steam, transport and cogeneration) with a more favourable environmental balance than conventional technologies.

This document focuses on the clean energy sources, or non-conventional renewable energy (*Energías Renovables No Convencionales* [NCRE]), which is defined by the Chilean government as electrical energy generated through non-conventional, renewable, primary energy sources, including biomass, winter, hydropower projects with less than 20MW capacity, geothermal, solar and marine power.

Chile has considerable potential for clean energy production, from wind, solar, geothermal and marine sources. However, some 40 per cent of electricity generated in Chile comes from imported fossil fuels and most of the rest from large-scale hydroelectric projects. According to the National Energy Commission (*Comisión Nacional de Energía* [CNE]). In December 2007, 3.1 per cent of the installed capacity of the national electricity grid came from clean energy sources, mainly biomass and, to a lesser extent, small-scale hydroelectric projects.

Over the next 20 years, electricity demand in Chile is expected to increase at an annual rate of 5.4 per cent. These demand projections—alongside greater technological maturity, a fall in the cost of clean energy production, Chile's strong dependency on imported energy sources, price increases in fossil fuels, future restrictions on greenhouse gas emissions, and growing public opposition to large, conventional energy generating projects (large-scale hydroelectric and coal-fired power stations—are all elements that combine to create a significant window of opportunity to incorporate more renewable energy production into the Chilean energy grid.

In fact, in recent years, Chile has begun to implement concrete measures to incorporate clean energy production into the national grid. These include regulatory instruments, such as the 2008 Law No. 20.257 that establishes a minimum national quota of clean energy production (5 per cent of commercialized energy from 2010 increasing to 10 per cent by 2024), which is without doubt an indication of incipient support to the development of the sector. Also, over the last couple of years, schemes have been developed to offer incentives and low interest loans to pre-investment in clean energy projects.

It is too soon to assess the impact of such measures, and still less feasible to identify any specific effects independently of other influences, such as technology transfer, fossil-fuel price projections and possible carbon emission restrictions. However, private investors have shown a very positive response to the measures. For example, CORFO, the Chilean Economic Development Agency, currently has over 200 initiatives within its clean energy project portfolio, all at different stages of development.

On the other hand, despite undeniable progress with the regulatory changes and incentives to develop the clean energy market in Chile, numerous economic, technological, regulatory and financial barriers are still in place that clearly must be tackled in order to achieve a larger-scale shift to clean energy production in the country.

The objective of this document is to provide a view of the clean energy market for electricity generation in Chile, in terms of its current development, future perspectives and regulatory and policy framework, and to identify the opportunities and principal barriers to its development. To this end, the document is structured as follows. After this brief introduction, Section 2 describes the main trends of the Chilean electricity market, and clean energy production in particular, in terms of: the current situation and future projections; investment trends; greenhouse gas emissions in the sector; and the regulatory, institutional and investment frameworks. Section 3 deals with the main incentives to clean energy production in Chile, both in terms of the general investment climate in Chile and specific clean energy production incentives. Section 4 identifies the main economic, regulatory, technical and financial barriers to clean energy production in Chile. Section 5 concludes and establishes policy recommendations to promote a more wide-scale and integrated development of clean energy production in Chile.

## 2.0 The Chilean Electricity Sector

### 2.1 Trends in electricity supply and demand

#### 2.1.1 The current situation of the electricity grid

The Chilean electricity grid provides nearly 30 per cent of the country's total energy supply. It is divided into three subsectors: generation, transmission and distribution, with a total of 31 generating companies, 5 transmission companies and 36 distribution companies (Arias, 2008). In total, the electricity sector supplied the country with 56.8 thousand GWh in 2008 (CNE, 2008a), with demand growing at a rate of 6.7 per cent over the last 20 years (PRIEN & UTFSM, 2008). In accordance with the economic activity of the country, 37 per cent of electricity is consumed within the mining sector, followed by the industrial sector (31 per cent), residential sector (17 per cent) and the commercial and public sectors (14 per cent) (CNE, 2008a).

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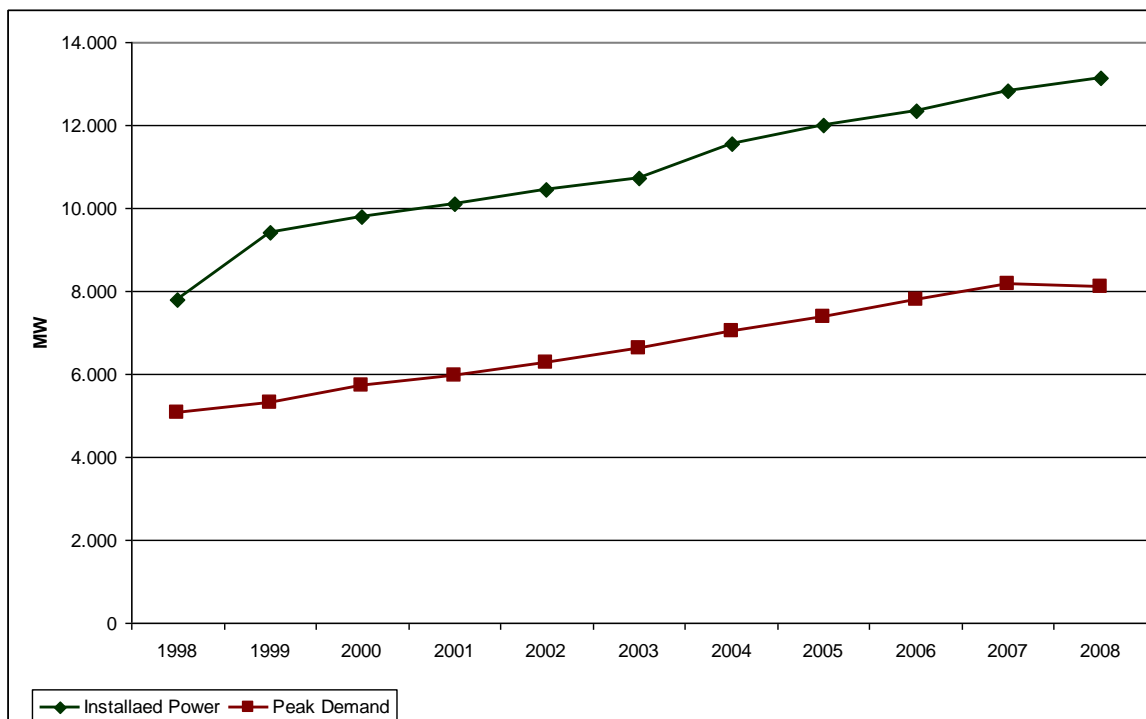
There is a high level of concentration within the Chilean electricity market. For example, in 2006, 89 per cent of the public supply installed capacity of the Central Interconnected Grid (*Sistema Interconectado Central*, or SIC) was owned by three companies and their subsidiaries (Endesa, 51 per cent; Colbún, 20 per cent; AES Gener, 19 per cent). A further 12 companies owned the remaining 10 per cent (CNE/GTZ, 2009).

The Chilean electricity market is composed of four subsystems. There are two main interconnected systems, which together represent 99 per cent of all the subsystems. The Central Interconnected Grid (SIC) provides 71.5 per cent of the country's electricity and supplies over 90 per cent of its population. The Norte Grande Interconnected Grid (*Sistema Interconectado del Norte Grande* or SING) provides 37.4 per cent of electricity and mainly supplies the copper mining industry. The remaining 1 per cent of installed capacity is shared between small subsystems in more isolated areas—the Aysén Grid (*Sistema de Aysén*) and the Magallanes Grid (*Sistema de Magallanes*). There is no interconnection between the subsystems.

As shown in Figure 1, in December 2008 the Chilean electricity grid had a total installed capacity of 13,100MW. This capacity was distributed as follows: 9,386MW in the SIC, 3,602MW in the SING, 40 MW in the Aysén system and 98MW in the Magallanes system.



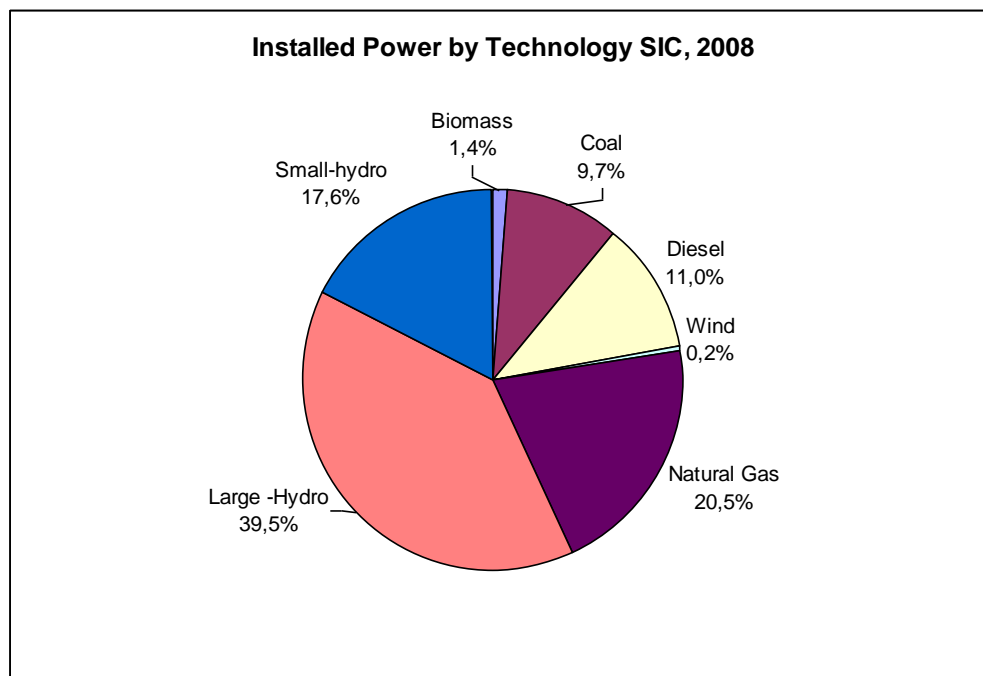
**Figure 1: Evolution of installed capacity and peak demand in the Chilean electricity grid**



Source: author's work, based on CNE statistics

The SIC, as shown in Figure 2, has a combination of different technologies, clearly predominated by hydroelectricity (57 per cent). Although it should be noted that hydroelectricity has fallen considerably in importance since 1998, when it provided 78 per cent of SIC's total electricity production. The SING, however, relies almost exclusively on thermal power generation.

Figure 2: Installed power in the SIC in 2008



Source: author's work, based on CNE data

In 1998, the introduction of natural gas, imported directly from Argentina into Chile, became a milestone that radically changed the nature of the national electricity network (and energy sector in general). The incorporation of natural gas led to an investment boom in gas ducts and natural gas-based generating plants.

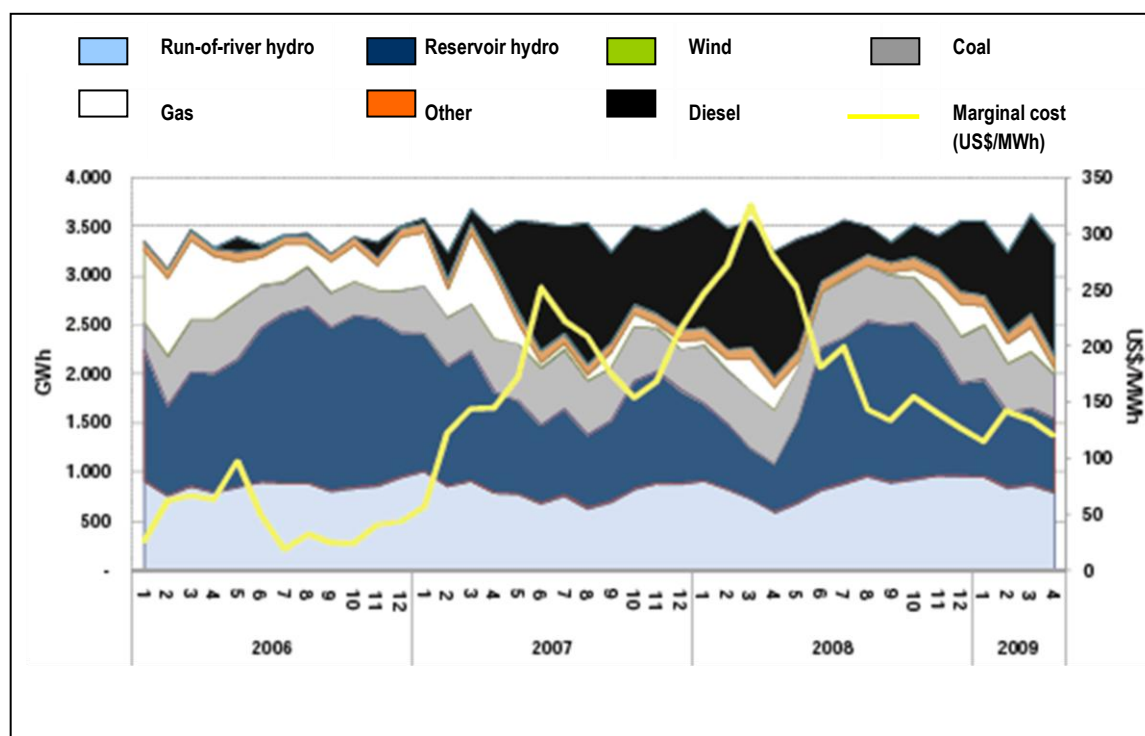
In 1999, a modification to the Electricity Law eliminated the concept of “*force majeure*” that had, until then, protected the electricity generating companies in periods of supply deficit. This change obliged companies to compensate their clients for power shortages brought about by natural phenomena such as drought. Generating companies were discouraged from signing contracts with regulated clients leading to a fall in investment in the sector.

Since 2004, restrictions in natural gas imports from Argentina, which have become still more stringent in the last few years, along with the strain on the electricity grid caused by a prolonged drought, have been dealt with by increased participation from other sources of power generation, particularly coal and oil-fired thermoelectric power generation. In fact, 100 per cent of the existing natural gas installed power capacity has been adapted to operate with diesel and turbines and motors have been installed to replace the reduced electricity generation (Tokman, 2008). This energy shortage, faced with the consequent shift towards thermal energy sources, resulted in a rise in energy

costs throughout the country (see Figure 3). This, in turn, has had an impact on the rate of growth of electricity demand (see Figure 4), which has slowed over the last couple of years.

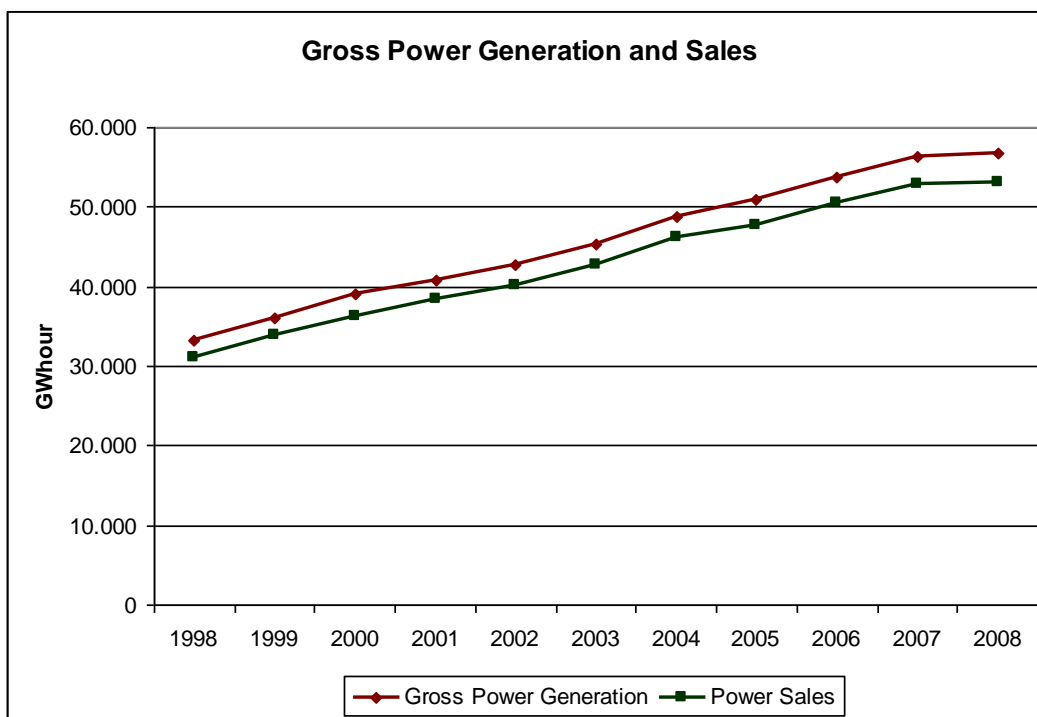
The reserve margins provide another way of making evident the electricity-energy shortage. In the case of SIC, these have fallen from more than 50 per cent (CNE/GTZ, 2009) in 1998 to barely 20 per cent in 2009 (Cerón, 2007). This reveals the low level of investment in electricity generation, which, for a hydrothermal system like the Chilean one, threatens the security of the energy supply (CNE/GTZ, 2009). In the case of SING, although the reserve margin has also fallen, it now stands close to 120 per cent, which demonstrates a significant degree of overinvestment (CNE/GTZ, 2009).

**Figure 3: SIC electricity generation 2006-2009**



Source: Systep, 2009 Report SIC-SING Electricity Sector, May

Figure 4: Evolution of gross generation and sales in the Chilean electricity sector



Source: author's work, based on CNE statistics

Most of the energy resources used in Chile are imported, with the notable exception of hydroelectricity, which is produced internally. Chile currently imports some 72 per cent of its energy needs (98 per cent of oil; 92 per cent of coal and 74 per cent of natural gas); in contrast, in 1990, the country only imported 48 per cent (Fundación Chile, 2008). As mentioned above, when natural gas from Argentina was restricted in 2004, participation from other, more polluting imported sources of energy, such as coal and oil, was increased. For example, coal-based energy production increased from 10 per cent of national energy supply in 2003 to 16 per cent in 2007, while the contribution of natural gas fell from 28 per cent to 16 per cent over the same period. In 2007, coal generated 26 per cent of the national electricity supply and oil generated 22 per cent.

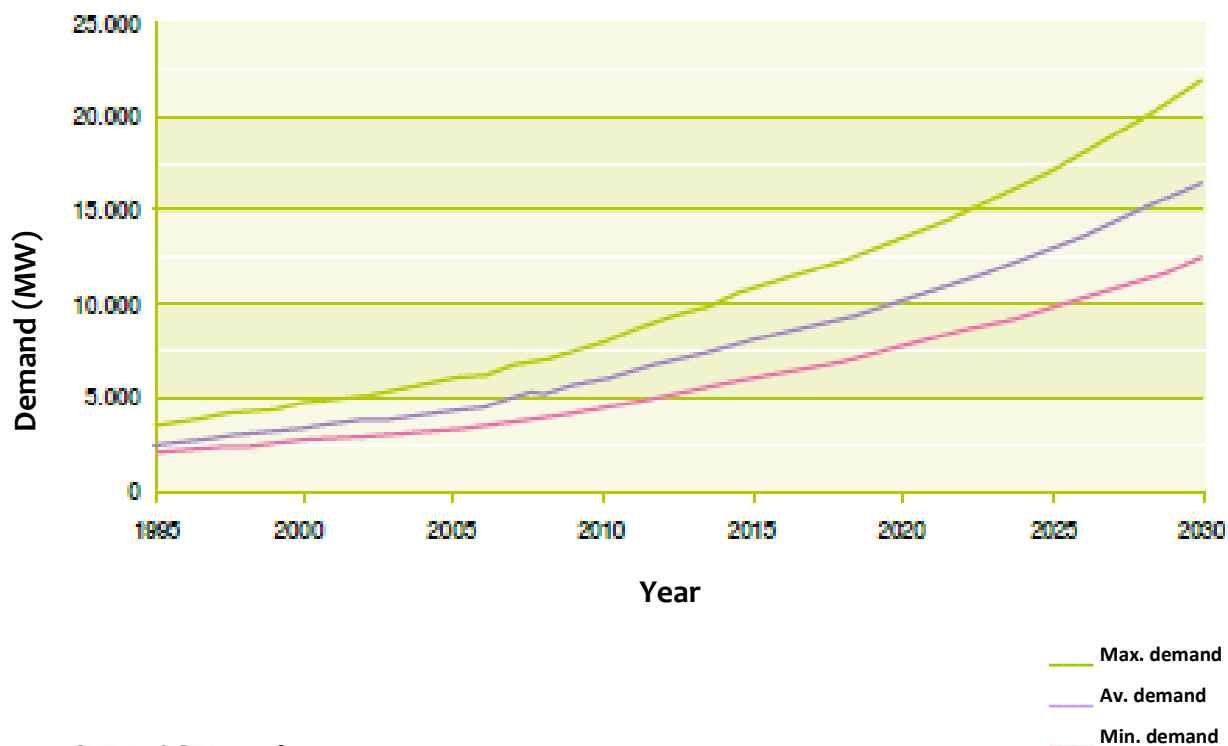
### 2.1.2 Future trends in supply and demand

A recent study, commissioned by the National Energy Commission (CNE) and carried out by the Universidad de Chile (CNE-PROGEA, 2009), predicts that by 2030 energy consumption will have increased by a factor of 3.3, equivalent to an average annual growth rate of 5.4 per cent. The transport sector will be the main cause of this increase, with its energy consumption predicted to rise by a factor of 4.7, a figure considerably higher than the average growth rate from 1982 to 2006 (5.2

per cent).

According to this study, by 2030, demand specifically in the electricity sector will increase by a factor of up to 3.2 (compared to 2007). Broadly speaking, this would mean that, on average, demand would grow by some 600MW annually over this period. In terms of the electricity subsystems, this would imply that SIC must expand their generation capacity to approximately 21,893MW (see Figure 5). The SING, however, would need to almost double their generating capacity by 2030. Throughout all the grids, demand is projected to grow at an average of 5.4 per cent over the period of analysis (CNE-PROGEA, 2009).

**Figure 5: Projected demand for the SIC in 2030**



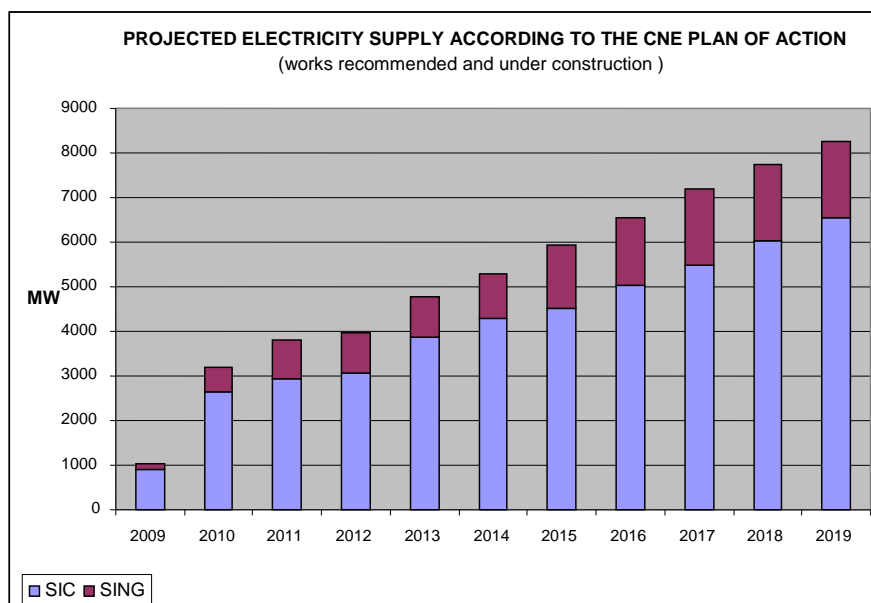
Source: CNE-PROGEA, 2008

Regarding electricity supply, only an additional 8,244MW have been projected for the national electricity grid (SIC and SING) by 2019, according to the CNE Plan of Action (*Plan de Obras*) (see Figure 6), which is the only official source of information on the future installed generating capacity of the electricity grid. In the case of SIC, this would imply an increase in supply of some 600MW annually, barely enough to supply the increased demand. Moreover, infrastructure for only 2,968MW of this total is currently under construction (equivalent to 36 per cent of the total Plan of Action).

This is an important distinction since the Plan of Action only contains indications of *potential* actions, which, according to experts, are rarely fulfilled.

The above implies that energy shortage could be a real possibility in the future.

**Figure 6: Projected electricity supply according to the CNE Plan of Action**



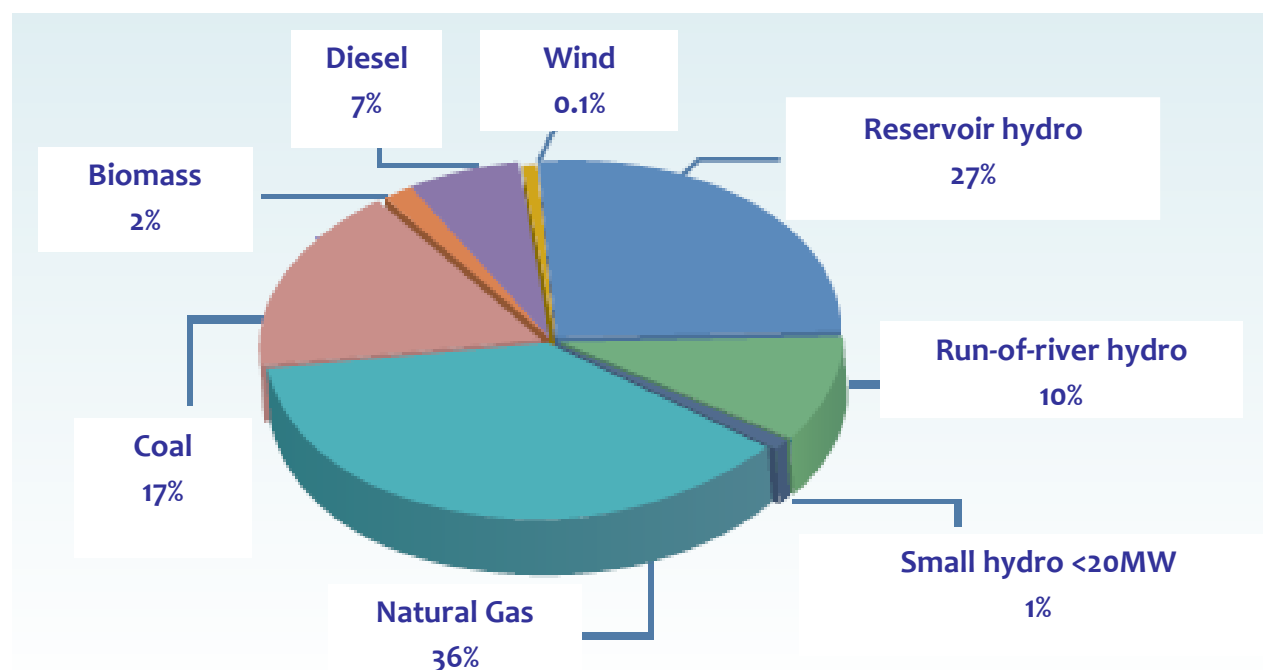
Source: author's work based on CNE data

## 2.2 Clean energy production in the national electricity sector

### 2.2.1 The current situation for clean energy production

Official information on the installed generating capacity of clean energy in Chile dates from the year 2007. The total installed capacity for the Chilean electricity sector that year was 12,847MW; 3.1 per cent of this came from clean energy—biomass (2 per cent), small hydro (1 per cent) and wind (0.1 per cent) (see Figure 7).

Figure 7: Non-conventional renewable energy (NCRE) installed capacity, 2007



Source: CNE/GTZ, 2009

The most recent official figures regarding the contribution of clean energy sources to the national grid by subsystem date from 2005. As seen in Table 1, the SIC has the highest installed capacity (mainly from biomass and small-scale hydroelectric). The Aysén grid has the highest relative contribution from clean energy (basically small-scale hydroelectric), although this subsystem is almost insignificant at a national level.

Table 1: Conventional versus clean energy sources in 2007 by system (MW)

Source	SIC	SING	Magallanes	Aysén	Total
Hydropower > 20MW	4,771	0	0	0	4,771
Fossil Fuels	4,035	3,589	80	26	7,729
<b>Total Conventional</b>	<b>8,806</b>	<b>3,589</b>	<b>80</b>	<b>26</b>	<b>12,500</b>
Hydropower < 20MW	104	13	0	20	136
Biomass	191	0	0	0	191
Wind	18	0	0	2	20
<b>Total NCRE</b>	<b>313</b>	<b>13</b>	<b>0</b>	<b>22</b>	<b>347</b>
<b>National Total</b>	<b>9,118</b>	<b>3,602</b>	<b>80</b>	<b>48</b>	<b>12,847</b>

Source: CNE/GTZ, 2009

The energy generated by clean energy sources in remote areas should be added to the information above, although the current contribution is only marginal. In the north and centre of the country, photovoltaic solar energy projects, developed by a rural electricity supply scheme without connection to the national grid, are one such example (see Box 1).

**Box 1: Photovoltaic solar energy for electricity generation in Chile**

There is no official or systematic information on the use of photovoltaic solar energy in Chile. Where it does exist, modules have been installed through international cooperation projects on photovoltaic technology. There are virtually no studies on investment costs and generating costs.

Based on the available information, the use of solar energy in Chile is clearly still at a very incipient stage. Although there are isolated examples of solar power use from the past (e.g., industrial level use in Antofagasta in 1972), its use in the country as a whole only really began in the 1990s, particularly in isolated rural localities in the north and central zones, as a scheme for rural electricity supply in areas outside the national grid (homes, schools and hospitals) and for telecommunication systems. Likewise, between 1992 and 2000, some 2,500 photovoltaic electricity systems of different designs and models were installed in Chile, and by the year 2000 these had a total installed capacity of 530,916Wp, with the potential to generate 866.5MWh annually. According to figures from the government rural electricity supply project, co-funded by the GEF and the Chilean government, it was estimated that by 2005 there would be some 6,000 photovoltaic panel systems operating in the region of Coquimbo.

Furthermore, within the same project, four solar irrigation schemes were recently inaugurated with 500W capacity generators in each scheme to provide water for 0.5 to 1ha of land. When this energy is not needed for irrigation, it can be fed back into the electricity grid. In addition, the first initiative for solar-powered public lighting is being implemented by the Universidad de Tarapacá. There is also a mining company-funded social project underway to produce solar panels in Antofagasta prison.

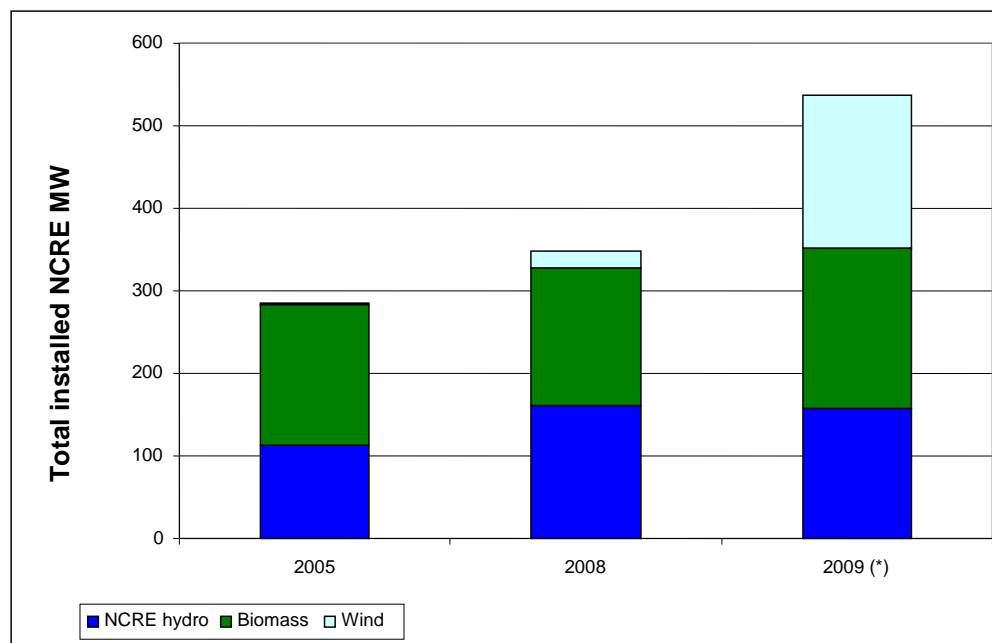
Source: Fundación Chile, 2008

Clean energy is a new but emerging market in Chile and, as discussed in the following section, it shows significant growth prospects. In fact, as seen in Figure 8, between 2007 and 2009 clean energy installed generating capacity (MW) in the SIC almost doubled, and according to CNE it reached 4 per cent of the total electricity grid supply in 2009. Moreover, in September 2009, the Environmental Impact Assessment System (*Sistema de Evaluación de Impacto Ambiental* [SEIA]) had records of nearly 60 renewable energy projects, either approved or in progress, with a total generating capacity of over 1,700MW. In addition, nearly all the country's electricity generation companies are developing or considering projects of this nature; new companies have already been set up with the sole purpose of starting such initiatives and a further significant number hope to



follow suit in the near future (CNE/GTZ, 2009).

**Figure 8: Clean energy installed capacity in the SIC**



Source: author's work, based on CNE/GTZ, 2009 and Ricke, 2009

### 2.2.2 Future trends in clean energy production

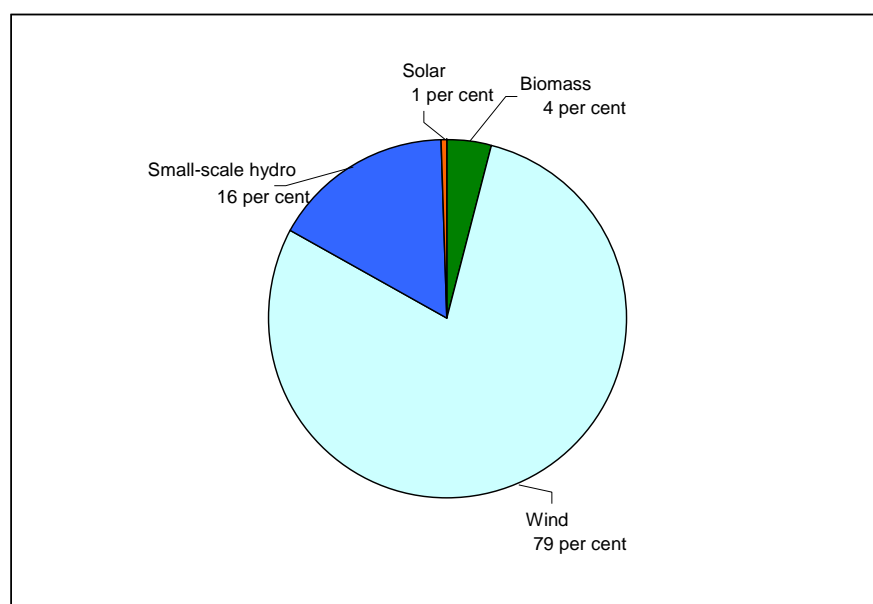
As already mentioned, the Plan of Action drafted by the CNE advised the creation of a further 8,244MW installed capacity by 2019 (see Figure 6). Of this total, 783MW, or 12.7 per cent, corresponds to clean energy production through wind power (5.3 per cent), small-scale hydroelectric (2.2 per cent) and geothermal (2 per cent). On the other hand, as stated above, it must be noted that any such CNE Plan of Action is only indicative and rarely fulfilled.

Alternatively, Table 2 presents a summary of the approved and in-progress electricity generation projects registered in the Environmental Impact Assessment System (SEIA). As seen here, the projects registered up until 2009 could offer a total capacity of 10,225MW. These are mostly thermoelectric projects (74 per cent), particularly coal-fired schemes. A total of 59 projects are for clean energy production, representing 17 per cent of the aforementioned total MW capacity, with the majority of projects involving wind power.

**Table 2: Investment projects for electricity generation in the SEIA**

Energy source	Approved or underway	MW	( per cent)
Reservoir hydro	40	900	8.8
Thermoelectricity	48	7,600	74.3
Wind	21	1,360	13.3
Run-of-river hydro	32	284	2.7
Biomass	5	72	3.5
Solar	1	9	0.09
<b>Total</b>		<b>10,225MW</b>	

Source: author's work based on SEIA webpage and CNE/GTZ, 2009

**Figure 9: Investment projects in clean energy production registered in the SEIA**

Source: author's work based, on SEIA and CNE/GTZ, 2009

It must be emphasized that future scenarios point towards greater incorporation of clean energy production. On one hand, the 2008 Law No. 20.257 establishes a quota for clean energy participation in the national grid of 5 per cent of sales from the year 2010, rising to 10 per cent by 2024 (see Section 2.5). Also, in a strategic discussion exercise on the Chilean electricity grid organized by a group of several institutions,<sup>1</sup> representatives of numerous national stakeholders

<sup>1</sup> Iniciativa Matriz Energética 2010-2030: “*Construyendo escenarios, innovando y rompiendo paradigmas: Discusiones hacia una visión energética-eléctrica para Chile*” organized by the Asociación de Empresas Eléctricas, Fundación Avina, Fundación Futuro Latinoamericano, Fundación Chile and Universidad Alberto Hurtado. For further details, see: [www.escenariosenergeticos.cl](http://www.escenariosenergeticos.cl)

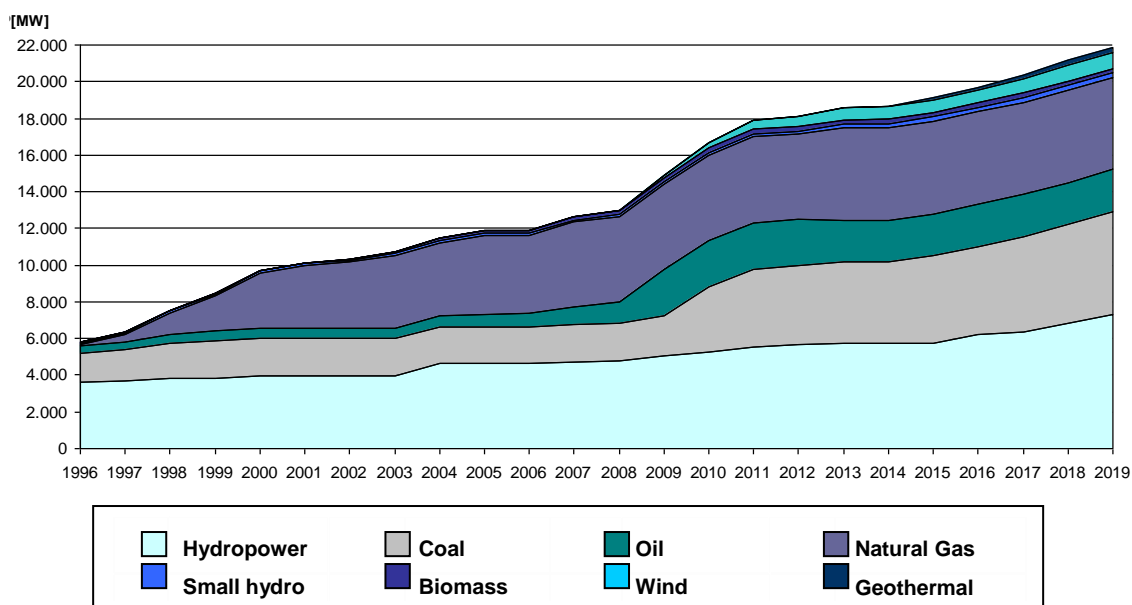
formulated different scenarios for the electricity sector in the year 2030, all of which highlighted greater participation from clean energy production. Nonetheless, it should be noted that these scenarios demonstrated a high level of variability in the figures themselves, with clean energy contributions to the national grid varying between 14 per cent and 48 per cent, with wind, geothermal and solar energy offering the most significant contributions. On the other hand, conventional energy such as large-scale thermoelectricity and hydroelectricity continued to be the principal energy sources (Borregaard, Dufey & Rudnick, 2009).

Finally, a study by the Universidad Federico Santa María and the Universidad de Chile (PRIEN-UTFSM, 2008) has calculated the potential contribution from clean energy production and energy efficiency to the SIC for the 2008-2025 period. This study concludes that, under different scenarios, clean energy could contribute between 16.8 per cent and 28 per cent of the SIC's installed generating capacity by the year 2025.

Therefore, according to the CNE, in a “business as usual” scenario, clean energy participation in the national grid would reach 10 per cent of installed capacity by 2020. This would mainly come from the realization of wind-powered and geothermal projects (see Figure 4) (Tokman, 2009). It is worth noting that this level of growth in clean energy production would be higher than that established by law (Law 20.057; see Section 2.5), which sets a goal of 10 per cent clean energy participation by 2024.

It is also important to emphasize that, under this scenario, thermoelectric generation (coal, oil and natural gas) also demonstrates considerable growth. The net contribution from coal-fired generation alone reaches 26 per cent by 2020. Without doubt, this raises considerable concern regarding corresponding greenhouse gas emissions. This is an issue that requires extremely urgent attention (see Section 2.4) considering that climate change is today considered to be the number one environmental problem at a global level.

Figure 10: Past and projected installed capacity for SIC and SING



Source: Tokman, 2009 (PowerPoint seminar)

### 2.3 Investment trends in the electricity sector

The privatization of the Chilean electricity companies, initiated in the 1980s, was the main incentive for private investment in the national electricity sector, which had been completely state-owned and controlled until then (see Section 2.5). Private investment came mainly from within the country itself, for example, through the private pension funds (*Administradoras de Fondos de Pensiones* [AFP]), up until the mid-1990s. By the end of the 1990s, the Chilean electricity network was largely controlled by foreign companies.<sup>2</sup>

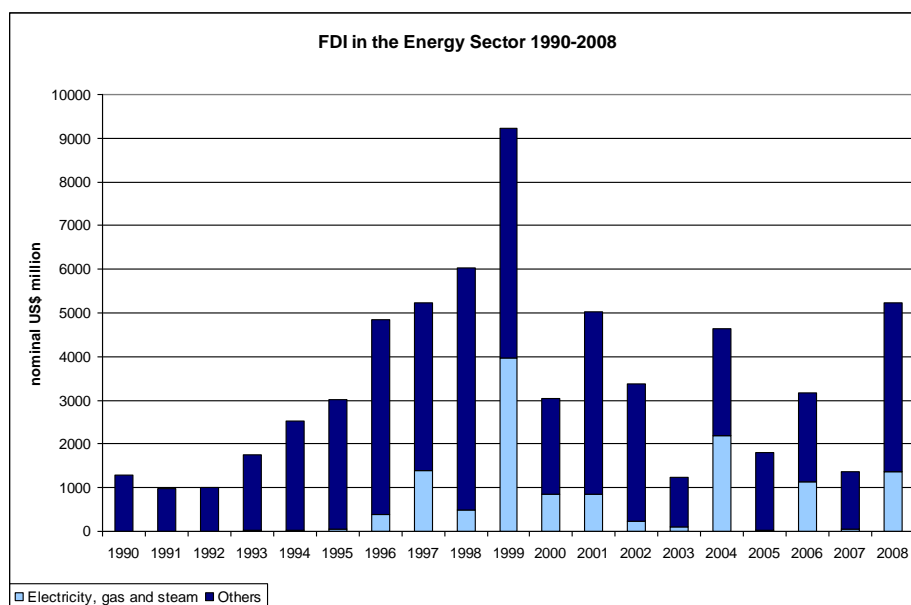
As shown in Figure 11, total foreign direct investment (FDI) in the country between 1990 and 2008, through the law D.L.600,<sup>3</sup> reached US\$64,788 million. Of this total, US\$13,182 million (equivalent to 20.3 per cent of the total FDI over this period) was invested in the energy sector (electricity, water and steam). Other major sectors attracting foreign investment over the aforementioned period were mining (with 32.6 per cent of FDI), financial services and insurance (12.7 per cent), and communications (10.2 per cent).

<sup>2</sup> For more information on the reform of the electricity system and its privatization, see Pollitt, 2004.

<sup>3</sup> Law No. 600 of 1974 is the instrument by which direct foreign investment enters Chile.

As seen in Figure 11, foreign investment in the energy sector was particularly high in the second half of the 1990s. Foreign investment peaked between 1997 and 1999, to coincide with the incorporation of natural gas into the Chilean energy network, and again from 2004, with the sector accounting for over 40 per cent of total FDI. It should be noted that most FDI in the energy sector were mergers and acquisitions (M&A) of privatized national companies rather than new investments.

**Figure 11: Energy sector and total foreign direct investment (FDI) flow**



Source: author's work, based on statistics from the Foreign Investment Committee (Comité de Inversiones Extranjeras)

Foreign and particularly European investments dominate the electricity generation and transmission network today, especially in the hydroelectric sub sector. For example, the Spanish company ENDESA owns over 30 per cent of the installed hydroelectric capacity in the country (51 per cent of the SIC). Likewise, until 2006, the second most important electricity generating company in the country (responsible for 25 per cent of the SIC), Colbún SA had as one of its main shareholders, GDF Suez, linked with Tractebel, a Belgian company; however, the company is now entirely controlled by Chilean capital (Colbún, 2007). A significant flow of DFI also comes from the United States, such as AES Gener (19 per cent of the SIC), Semptra, PPL (recently bought by CGE) and PSEG Global.

It should be highlighted that the clean energy segment has also become a pole of attraction for foreign investors who could play a vital role in the sector's development, especially regarding wind power and small-scale hydroelectric centres. Some examples of FDI in this segment include:

- Endesa Eco—a subsidiary of Endesa España—has carried out two clean energy projects: the wind farm Parque Eólico Canela (18MW) and the small-scale hydroelectric project Ojos de Agua (9MW).
- The Spanish group, Generadores Eólicos de Navarra, currently has two wind-power projects: the Parque Eólico Hualpen (20MW) and the small-scale hydroelectric plant, Balalita (11MW).
- Iberdrola, also Spanish-owned, through Iberoamericana de Energía (Idener)—its subsidiary in Chile—has a small-scale hydroelectric plant, Ruca Cura, in the Bío Bío region (4.7MW) (Ecodesarrollo, 2008).
- In 2004, the Australian company Pacific Hydro set up a joint venture with the Norwegian company SN Power to develop two hydropower projects, one of which was registered under the Clean Development Mechanism (CDM) of the Kyoto protocol (Australian Embassy, n.d.).
- In parallel, SN Power, through its subsidiary Norwind, is developing the wind farm, Parque Eólico El Totoral, with a total capacity of 46MW.
- The Irish group Mainstream Renewable Power announced a joint venture with the Chilean company Andes Energy involving a series of projects for US\$1,000 million to generate some 400MW of clean energy over the next five years (Minergia, 2009).

Regarding geothermal energy, Italian company Enel, together with the Chilean state-owned ENAP and CODELCO, are developing a polemic geothermal exploration project in the Géiseres del Tatio National Park in the north of Chile<sup>4</sup>. Meanwhile, in July 2009 GTN LA, the Latin American subsidiary of the German geothermal company GTN, began operations in association with Fundación Chile (although this project is to generate heat rather than electricity). Also, the Chilean generating company Colbún recently announced an alliance with the US company Geoglobal Energy (GGE), whose main shareholder is the New Zealand company Mighty River Power, to develop geothermal projects in Chile.

To sum up the above, it must be noted that private investment in the electricity sector has always been a significant component of total investment in the country's productive sector and this trend continues to date. Hence, according to the Capital Goods Corporation (*Corporación de Bienes de Capital* [CBC]), total investments in the energy sector for the period 2008-2012 will reach US\$24,459 million, equivalent to 43 per cent of the total investments projected for the country over this period (US\$57,377 million). The sector's investment boom can be explained in part by the numerous projects undertaken in the effort to solve the energy shortage faced by the country in recent years, and by the need to satisfy the ever-rising energy requirements of the mining sector, the main energy consumer at a national level.

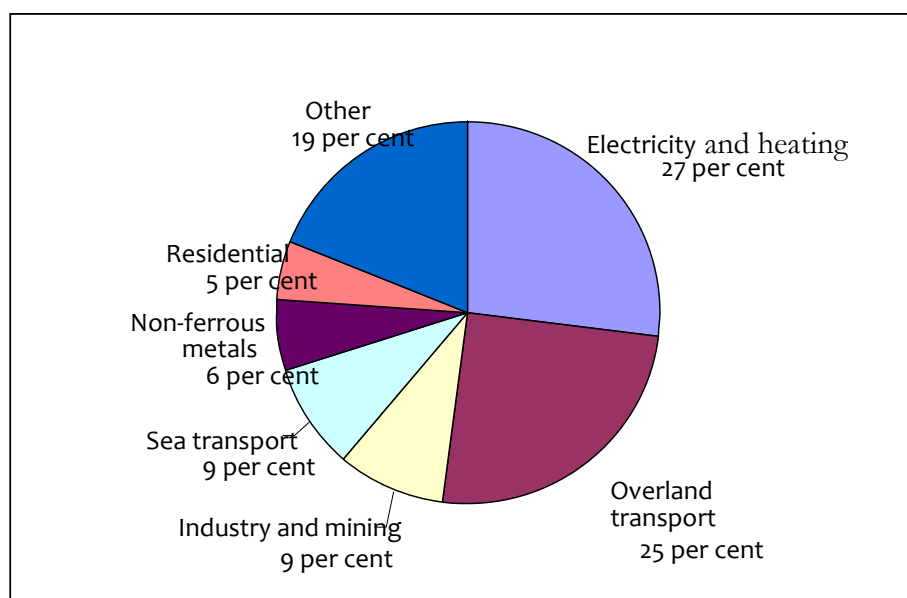
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<sup>4</sup> This project was halted in October 2009 by the environment agency due to serious deficits in its environmental management.

## 2.4 The electricity sector and greenhouse gas emissions

Chile is responsible for 0.2 per cent of global greenhouse gas (GHG) emissions (Government of Chile, n.d.). As shown in Figure 12, the electricity and heating sector is the main GHG emitter in the country, responsible for 27 per cent of emissions, followed by overland transport with 25 per cent (Poch Ambiental/Deuman, 2008). Moreover, emissions have shown a significant increase over recent decades, compared with 16 per cent in 1984.

**Figure 12: GHG emissions by sector of IPCC, 2006**



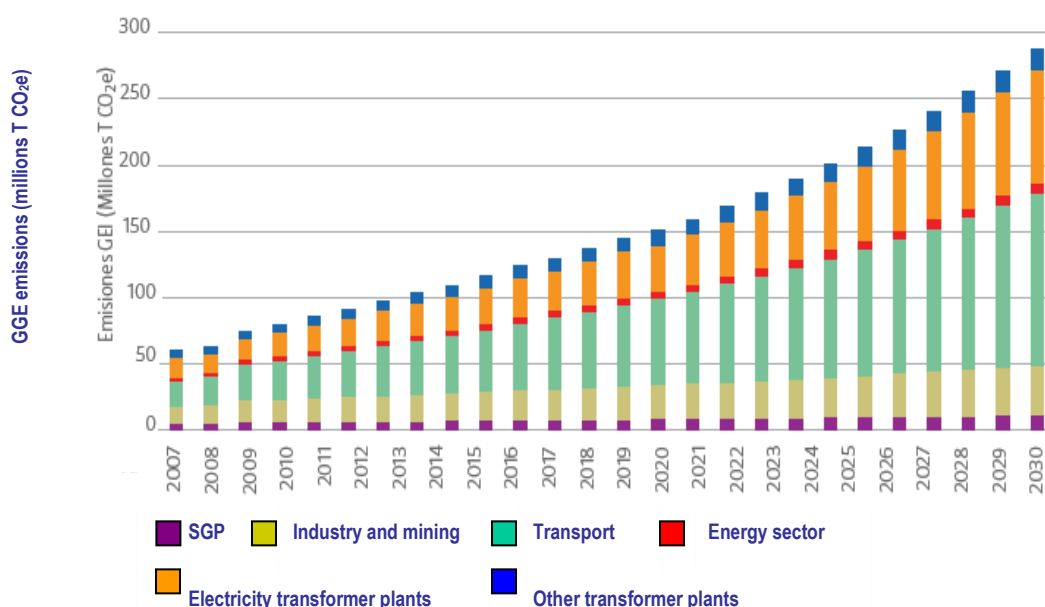
Source: author's work, based on Poch Ambiental/Deuman, 2008

Everything would seem to indicate that this rising trend of emissions will continue. For example, the study carried out by the Universidad de Chile (PROGEA, 2009) projects a 390 per cent rise in CO<sub>2</sub> emissions from the energy sector, with the increase led by the transport sector and electricity generation (see Figure 13). A more recent study (CEPAL, 2009) suggests a lower but still extremely alarming 280 per cent rise. The increase in CO<sub>2</sub> emissions is largely explained by the creation of numerous coal-burning thermal power stations (see Figure 13), which have the highest GHG emissions of all currently available electricity generating technology.

The start of operations of these coal-fired power stations and the resulting increase in GHG emissions from the electricity sector is a cause for concern in many sectors not only due to the environmental implications—energy security issues and deterioration in the country's balance of payments due to dependency on coal imports—but also due to the effects on the country's long-term

competitiveness. This situation has generated debate across different sectors over how to tackle the problem and the role that clean energy might play in its solution. For example, in terms of GHG mitigation, in the Copenhagen Summit in December 2009, the Chilean government made a unilateral voluntary commitment to reduce CO<sub>2</sub> emissions by 20 per cent by 2020, 18 per cent of which is based on implementation of the Renewable Energy Law (*Ley de Energías Renovables*) and measures to improve energy efficiency (see Section 2.6). Many issues have been raised in the debate, including questions about which future scenario was used to calculate these reduction figures (i.e., what is the “business as usual” or BAU scenario). The electricity and heating sector are responsible for 27 per cent of GHG emissions and there is discussion over what measures will be implemented to achieve reductions.

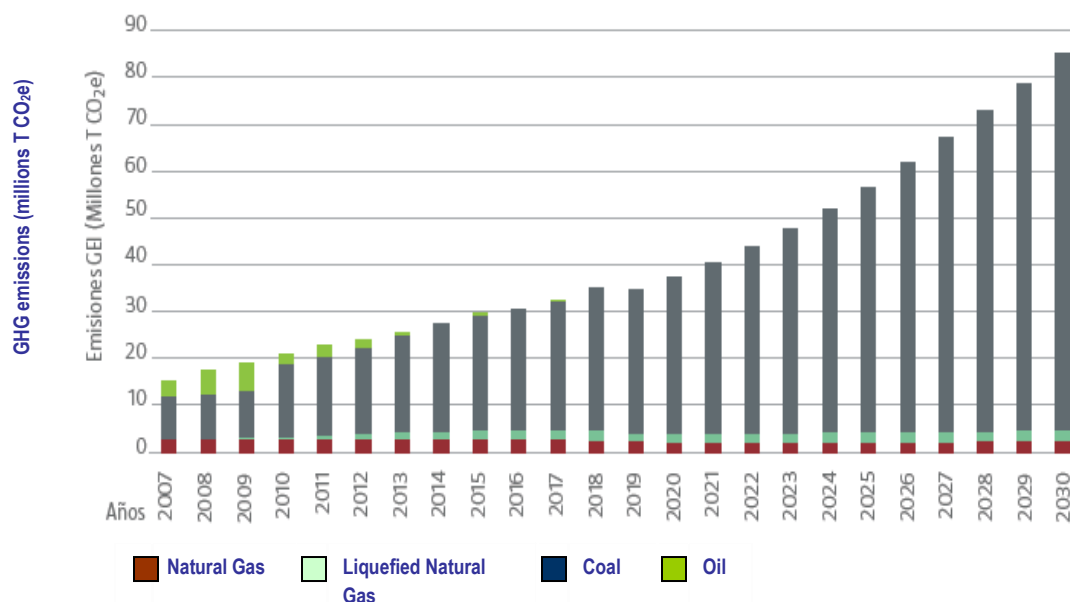
**Figure 13: Projected GHG emissions for the energy sector, 2007-2030**



Source: PROGEA, 2009



Figure 14: Projected GHG emissions for the electricity generation sector, 2007–2030



Source: PROGEA, 2009

## 2.5 Trends in energy policy and institutions

### 2.5.1 Energy policy

Chile was the first country in the world to implement, in recent decades, comprehensive reform of its electricity grid (Pollitt, 2004). The first modifications to the Chilean Electricity Law were made in the early 1980s with the 1982 General Electricity Services Law (*Ley General de Servicios Eléctricos* also known as DFL1), which is still the main regulatory instrument for the sector. Key modifications to the law resolved the vertical integration problems of the market, separating the electricity generation, transmission and distribution segments, which also allowed the private sector to participate in an area that had been until then 100 per cent state-controlled (Pollitt, 2004). Large-scale privatization of the electricity companies began in 1986 and the grid is now 100 per cent privately owned.

The Chilean electricity market has a high level of concentration. For example, in 2006, just three companies and their subsidiaries owned 89 per cent of the installed capacity of SIC's public supply (Endesa, 51 per cent; Colbún, 20 per cent; AES Gener, 19 per cent). A further twelve companies owned the remaining 10 per cent (CNE/GTZ, 2009).

One of the fundamental principles of the Electricity Law is that resources from investment, wholly determined by the private sector, are administered by the national electricity market based on

economic efficiency (to operate safely for the lowest possible costs) with a guarantee of equal treatment for all energy sources. The law establishes two kinds of clients—regulated and unregulated. Those clients with a maximum connection capacity of 500kW are subject to a regulated node price set by the relevant governing body. Those clients with electricity demands exceeding 500kW, or with other non-standard requirements, are the unregulated clients, since they are free to negotiate their own energy contracts. Unregulated clients account for about 55 per cent of the market (Trade Chile, 2006).

Under the Chilean Electricity Law, the distribution segment and part of the transmission segment are regulated and must provide cost-efficient services and prices. In the case of the electricity-generating segment, the law establishes a competitive system based on peak-load pricing, where consumers pay a price for the energy and a price for the electric potential or capacity associated with times of peak demand. This system is known as “marginal cost pricing.”

Marginal cost pricing theory states that when the electricity-generating infrastructure is well adjusted to demand, income from marginal cost energy sales plus income from electricity sales, after the cost of developing cutting edge potential, is equal to investment costs plus producer operating costs (CNE/GTZ, 2009).

In addition, the functioning of the Chilean interconnected electricity grids is characterized by the existence of a “spot” market where electricity prices correspond to the short-term marginal cost resulting from the fluctuating on-the-moment balance between offer and demand. Electricity grids with over 200MW installed capacity, of which there are only two in Chile (the SING and the SIC), are operated by the *Centros de Despacho Económico de Carga* or CDEC) (CNE/GTZ, 2009).

Therefore, faced with a national electricity market that administers its resources based on economic efficiency (i.e., operating safely for the lowest possible costs) with investments wholly determined by the private sector, development has been based solely on traditional generation technologies (Galaz, 2007).

However, in recent years, initial steps were taken to diversify the energy network. This development was triggered by a number of causes; among them were the energy shortage caused by the Argentinean natural gas crisis, a period of draught and the high international prices for fossil fuels. Also important was the dearth of investment in energy generation, in part the result of the 1999 modification to the Electricity Law that eliminated the concept of “*force majeure*” (see Section 2.1.1). Modifications were made to the electricity legislation in an attempt to provide a more favourable environment for clean energy production.

Some of the key changes to the DFL1 in recent years are:

**The 2004 Law no.19.940 or *Ley Corta* (literally, ‘Short Law’) I:** This seeks principally to improve the electricity transmission payment system. It basically regulates the electricity transport systems, establishing a new tariff structure for mid-scale systems and introducing adjustments to comply with the general law of electricity services. It opens the “spot” market, guaranteeing small-scale plants (i.e., the size of many clean energy plants) the right to connect to distribution networks and exempting them from main transmission tolls (full exemption for plants producing less than 9MW and partial exemption for plants producing between 9MW and 20MW).

**The 2008 Law no. 20.257 or *Ley Corta* III:** This defines the NCRE (see Box 2) and seeks to create favourable conditions for investment projects in this kind of energy. It basically establishes that from 2010 all electricity companies of the SIC and SING that operate over 200MW installed capacity must obtain 5 per cent of their electricity annual sales from NCRE. From 2014, this percentage will gradually increase by 0.5 per cent annually to reach 10 per cent in 2024. Any electricity company failing to fulfil this obligation must pay a surcharge for every megawatt of deficit.

**Box 2: Definition of non-conventional renewable energy according to Law 20.257**

**Methods of non-conventional renewable energy generation:** those presenting any of the following characteristics:

1. Those using biomass as the primary energy source, obtained from organic biodegradable matter, which can be used directly as fuel or converted into other liquid, solid or gaseous biofuels. This includes the biodegradable part of domestic and non-domestic solid waste.
2. Those using hydropower as the primary energy source and with a maximum electric potential of less than 20,000 kilowatts.
3. Those using geothermal energy as the primary energy source, defined as energy obtained from the natural heat stored in the earth.
4. Those using solar energy as the primary energy source, obtained from solar radiation.
5. Those using wind power as the primary energy source, corresponding to the kinetic energy of the wind.
6. Those using marine power as the primary energy source, corresponding to all forms of mechanical energy produced by the movement of tides, waves and currents, as well as that obtained from marine temperature gradients.
7. Other means of generation determined by the CNE that use renewable energy to generate electricity, contribute to diversify the sources of energy supply in the electricity grid and have low environmental impact, according to the procedures established by this law.

**Non-conventional renewable energy:** energy (electricity) generated by non-conventional renewable energy methods.

Source: Law 20.257, available at: [http://www.cne.cl/archivos\\_bajar/20\\_257\\_1.pdf](http://www.cne.cl/archivos_bajar/20_257_1.pdf)

At the end of 2008, the government placed the document Energy Policy: New guidelines (Política Energética: nuevos lineamientos) in the public domain, a document that made manifest the importance of clean energy with policy instruments to achieve strategic objectives such as an increase in energy offer, improved energy security and the fulfilment of environmental and social equality objectives. It must be emphasized that the new energy policy arose out of a period of deep reflection following the severe energy crisis Chile has faced since 2004. Therefore, the global objective pursued by energy policy is stated as follows: “*to convert the current crisis into an opportunity to achieve an ample, efficient, safe, fair and sustainable energy development*” (CNE, 2008, p. 52).

## 2.52 Energy institutions

The key electricity organisms include:

**National Energy Commission (Comisión Nacional de Energía, CNE):** The CNE is the main state organism in charge of regulating the electricity sector. Since February 2010 it has been part of

the Ministry of Energy (previously part of the Ministry of Economics, Growth and Reconstruction). It draws up and coordinates plans, policies and regulations for the functioning and development of the Chilean electricity grid and provides information and recommendations for the different government organisms on energy matters. It is the organism responsible for setting tariffs (node prices) and making the indicative planning for investments in the sector.

**Superintendence of Electricity and Fuel (*Superintendencia de Electricidad y Combustibles, SEC*):** The SEC monitors the fulfilment of legal regulatory requirements and technical standards. Although the SEC previously acted through the Ministry of Economics, Growth and Reconstruction, as of February 2010 it has operated through the Ministry of Energy.

**Economic Load Dispatching Centre (*Centro de Despacho de Carga, CDEC*):** The CDEC is a private entity formed of generating companies supervised by the SEC. It regulates the coordinated functioning of the generating power stations and interconnected transmission lines. One of its functions is to monitor the safety of the grid system and ensure all operations run smoothly and at minimum cost.

**National Energy Efficiency Program (*Programa País de Eficiencia Energética, PPEE*):** The PPEE was set up in 2005 under the Ministry of Economics, Growth and Reconstruction as the first public initiative to promote energy efficiency in the country. In 2008, the PPEE became part of the CNE and since February 2010 it has acted through the Ministry of Energy.

**Ministry of Energy:** In August 2009 a law was passed establishing the creation of the Ministry of Energy. Under this law, regulatory functions were separated out and placed under control of the CNE, which became part of the Ministry of Energy. The development of a long-term strategic vision (preparation of plans and policies for the energy sector; drawing up and proposal of legal standards for the energy sector; and the study and preparation of national energy offer and demand projections) remains directly under the control of the Ministry of Energy. Moreover, the law gives incentives for coordination between environmental and energy policy by stipulating that the Ministry of Energy be part of the Executive Committee of the National Commission for the Environment (*Comité Ejecutivo de la Comisión Nacional del Medio Ambiente, CONAMA*). In the words of the previous Minister for Energy “*The new institutional structure will avoid duplicating functions, diminishing responsibility or over focusing on electricity offer, as has occurred over the last 30 years*” (M. Tokman, cited in Government of Chile, 2010).<sup>5</sup>

**Renewable Energy Centre (*Centro de Energías Renovables, CER*):** The CER was set up in August 2009, acting under the auspices of the Ministry of Energy. The purpose of the CER is to work alongside the CNE and CORFO, with their respective clean energy promotional and

<sup>5</sup> Marcelo Tokman was Chile’s Minister of Energy until March 2010.

regulatory functions, to promote and facilitate new projects and to act as a radar following new technologies in order to generate knowledge and skills and diversify the energy grid. Its specific objectives include:

- To study the evolution and development of NCRE technologies and their applicability in Chile, thus facilitating the removal of barriers to potential projects;
- To promote and develop a network of agreements with centres and institutions that are working to promote and innovate with NCRE;
- To serve as an information and guidance centre for government bodies, investors, project developers and academic researchers;
- To generate records of natural resources for developing NCRE;
- To campaign for accreditation of human resources and certification of products and services related to NCRE projects (such as consultancy or engineering services, laboratories, technology providers and maintenance services).

## 2.6 Trends in environmental and climate policy

Environmental policy and institutional structure in Chile is relatively new and was basically established with the approval of the 1994 Environmental Law (*Ley de Bases del Medio Ambiente*, Law No.19,300). This provides the base lines upon which the different regulations, quality standards, emission limits and prevention and decontamination plans are built. The National Environmental Commission, CONAMA, was set up in the same year, based on this law, with the purpose of: proposing environmental policies; reporting on the application and fulfilment of environmental standards; administrating the environmental impact assessment system and the process of drawing up environmental quality and emission standards; and providing consultancy, analysis, communication and coordination in environmental issues.<sup>6</sup> In 2008, the legal process was initiated in order to set up a Ministry of the Environment.

Chile is part of the United Nations Framework Convention on Climate Change and the Kyoto Protocol. Chile, as a developing country, is not required to make any commitment to reduce emissions, but must deliver periodically a “National Communication” containing an inventory of greenhouse gas emissions, information on climate change vulnerability, impact and adaptation options, and alternatives to mitigate emissions of greenhouse gases (CONAMA, 2009).

With the aim of fulfilling the commitments made with regard to climate change, such as the development of national communications, the National Assessment Committee of Global Change (*Comité Nacional Asesor sobre Cambio Global*) was set up in 1996. The committee acts as a national consultancy organism to tackle the issue in Chile. Its presidency lies within the CONAMA.

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<sup>6</sup> See <http://www.conama.cl>.

In 2000, Chile delivered the First National Communication (FNC), in which, amongst other things, it assessed the vulnerability of agriculture to climate variations, the vulnerability of the different types of forest to water resource availability, variations in surface water due to climate change, and the concentration of greenhouse gases and projections up to the year 2040.

In January 2006, the National Strategy on Climate Change (*Estrategia Nacional de Cambio Climático*) was approved and its technical committee and directorship was named. The strategy is structured around three thematic lines of development (Table 3): Adaptation, Mitigation, Creation and Reinforcement of National Capacities. Each line of development includes objectives to tackle the phenomenon of climate change in an integral way, with the third line of development (capacities) as a central and transverse line from which to tackle the other two (adaptation and mitigation).

**Table 3: National Strategy on Climate Change**

Line of Development	Objectives
Adaptation to Impacts of Climate Change	<ol style="list-style-type: none"> <li>1. Assessment of environmental and socioeconomic impacts of climate change in Chile.</li> <li>2. Definition of adaptation measures.</li> <li>3. Execution and monitoring of adaptation measures.</li> </ol>
Mitigation of Greenhouse Gas Emissions	<ol style="list-style-type: none"> <li>1. Analysis of options of mitigation of greenhouse gas emissions in Chile.</li> <li>2. Definition of adaptation measures.</li> <li>3. Execution and monitoring of adaptation measures.</li> </ol>
Creation and Promotion of Climate Change Knowledge and Skills	<ol style="list-style-type: none"> <li>1. Disseminate knowledge and create awareness of climate change amongst general public.</li> <li>2. Promote education of and research into climate change.</li> <li>3. Improve systematic observation of climate in Chile.</li> <li>4. Generate high quality accessible information for the decision-making process.</li> <li>5. Develop institutional capacities for mitigation and adaptation.</li> <li>6. Develop and transfer technology for mitigation and adaptation.</li> <li>7. Periodically review and update greenhouse gas inventory.</li> <li>8. Participate actively in the international agenda on climate change.</li> <li>9. Strengthen international cooperation on climate change.</li> <li>10. Establish synergies with the implementation of other global agreements.</li> </ol>

Source: CONAMA, 2009

Chile is currently working on the Second National Communication (SNC). Over the period it is being written (2008-2010), it will: provide up-to-date information on the evolution of greenhouse gas emissions; develop programs with measures to mitigate climate change; and identify the country's vulnerabilities to climate change and facilitate appropriate adaptation measures. The report will also develop relevant information to help integrate into the public policy agenda such issues as technology transfer, systematic climate research and observation and education. The SNC will be presented to the Secretariat of the United Nations Framework Convention on Climate Change in 2010.

In 2009, the *National Plan of Action on Climate Change 2008-2012* was published. The Plan was designed in response to the lines of development and objectives of the 2006 National Strategy on Climate Change; it outlines guidelines and actions following the strategy's three lines of development—Adaptation, Mitigation, Creation and Reinforcement of Capacities. The Plan will be informed by the contents of the SNC and its objective is to become an instrument that serves to articulate a series of policy guidelines, to be taken up by the competent public organisms in the field of climate change.<sup>7</sup>

Recently, in the context of the December 2009 Copenhagen Summit, the Chilean government announced a unilateral voluntary commitment to cut greenhouse gas emissions by 20 per cent by 2020. According to calculations from the relevant authority, 18 per cent of this reduction would come from implementation of the Renewable Energy Law (*Ley de Energías Renovables*) and higher levels of energy efficiency.

In view of the transverse and cross-sector nature of climate change and the respective Plan of Action, implementation of the plan will necessarily imply the need to strengthen institutional structure. Although this aspect is included in the Plan, it is seen as one of the greatest challenges to its implementation.

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<sup>7</sup> For more details on the Plan of Action, see CONAMA, 2009.



Table 4: National Plan of Action on Climate Change 2008–2012: Priority Lines of Action

PROGRAMME OF ACTION 2008-2012	2008	2009	2010	2011	2012	INSTITUTION RESPONSIBLE
<b>ADAPTATION</b>						
Generation of climate scenarios	X	X	X			DMC
Determination of climate change adaptation impacts and measures in:	X	X	X			
Water resources: determine degree of vulnerability of water courses		X	X			DGA, CONAMA, INIA, CNR, ARMADA
Biodiversity: identify most vulnerable ecosystems, habitats and species		X	X			CONAMA, IGM
Agriculture, fisheries and forestry sector: update knowledge on vulnerability to climate scenarios	X	X				MINAGRI, CONAMA, INFOR
Energy: determine vulnerability of hydroelectric generation in Chile	X	X	X			CNE
Coastal and urban zones and infrastructure: assess impacts on major infrastructure in coastal and riverside zones and incorporate these in planning instruments		X	X	X	X	MOP, MINVU, DIRECTEMAR, SSM
Fishing: estimate vulnerability of fishing resources		X	X			ECONOMIA
Health: strengthen health systems in the face of climate change			X	X	X	MINSAL
Formulation of National and Sectorial Adaptation Plans for Climate Change			X	X	X	CONAMA / SECTORS
<b>MITIGATION</b>						
Updating of emissions inventories	X	X				
Create annual update system for national and regional GHG emissions inventories and summaries	X	X				CONAMA, MINMINERIA
Assessment of the country's potential to mitigate GHG emissions		X	X			
Determine estimates of total and sector-based emission reduction potentials	X	X				CNE, MTT, MINECOM, MINVU, MINAGRI, CONAMA
Draw up proposal of impact indicators when applying different plans, policies and strategies	X	X				CNE, MTT, MINECOM, MINVU, MINAGRI, CONAMA
Generation of mitigation scenarios in Chile		X	X			
Draw up GHG mitigation scenarios for given time horizons (2015, 2020, etc.)		X	X			CNE, MINAGRI, CONAMA
Formulation of national programme and sector plans to mitigate GHG emissions	X	X	X			CONAMA / SECTORS
<b>CREATION AND PROMOTION OF CAPACITIES</b>						
Drawing up of a national programme for education and awareness on climate change		X	X			MINEDUC
Creation of a national fund to research biodiversity and climate change	X	X				CONICYT
Technical and economic assessment of climate change monitoring network		X	X			DNC, IMIA, DIRECTEMAR, SHOA
Drawing up of national glacier registers	X	X	X			DGA, CONAMA, MINDEFENSA
Development of negotiation strategies for Chile post-Kyoto		X	X	X	X	CNACG
Strengthening of national institutional structure to tackle climate change	X	X				CONAMA, MINREL
Designing of instruments to promote the reduction of emissions and adaptation measures		X	X			CORFO, CONAMA, CNE, INIA, CIREN, INFOR, MTT
Preparation of the Second National Communication (SNC)	X	X	X			CONAMA

Source: CONAMA, 2009

It must be noted that, in the face of post-Kyoto negotiations (post-2012) on climate change—to be decided in Copenhagen in December 2009—Chile expects considerable increases in its CO<sub>2</sub> emissions by 2030 (see Section 2.4). Although Chile only represents some 0.2 to 0.3 per cent of total global CO<sub>2</sub> emissions, and as an Annex I country is not subject to specific restriction goals over the next period of compliance, there is concern amongst the different sectors over the diverse scenarios the country will sooner or later have to face.

On the other hand, the post-Kyoto negotiations and the recent government announcement of 20 per cent reductions in CO<sub>2</sub> emissions by 2020 must be achieved through the country's own financial

resources. Although such an announcement puts Chile in an excellent position internationally considering its Annex-I listing, at a national level it has raised concerns and questions, such as: Upon what scenario is the aforementioned reduction based (i.e., what is the BAU scenario)? How can the BAU be improved? What is the real added value of the government proposed 20 per cent reduction to emissions by 2020, considering that 18 per cent of this reduction is justified by the existing Renewable Energy and Energy Efficiency laws? What are the most cost-effective measures to tackle such a reduction?

Furthermore, the pressure to try to mitigate CO<sub>2</sub> emissions in Chile comes from at least two sides. On one hand, in January 2010, Chile officially entered the OECD. This prestigious group of countries promotes the implementation of action to mitigate CO<sub>2</sub> emissions amongst its members. Although mitigation measures are not demanded of all mid-level members, voluntary action or specific reduction commitments are valued. On the other hand, there is the carbon footprint of Chilean exports. Chile has one of the most environmentally sensitive export structures in the region and is therefore highly vulnerable to future climate-related demands (Samaniego, 2009). In this context, the main importing countries subject to emission reduction commitments do not rule out applying unilateral measures on CO<sub>2</sub>-intensive imports from countries failing to implement equivalent measures.<sup>8</sup> In fact, in the private sector, for example, some supermarkets in Europe are already starting to distinguish products according to their carbon footprint.<sup>9</sup> Over the last year this has led to the development of diverse initiatives within the country to quantify and eventually mitigate the carbon footprint of the different economic sectors, industries and specific companies.

### 3.0 Main Incentives for Clean Energy

#### 3.1 The general investment climate in Chile

As was made clear in Section 2.3, private investment has been a key factor in the development of the Chilean electricity generating sector, including the clean energy subsector.

The macroeconomic reforms implemented in Chile from the mid-1980s onwards—trade liberalization, fiscal balance, controlled inflation, international integration, strengthened institutional structure and political stability—and which have been maintained to the present day, have led to a macroeconomic environment favourable to private investment. The following “key factors” are landmarks in the process that Chile has undertaken to encourage investment in the country:

Unilateral trade liberalization (tariff reductions): Chile applies a single general import tariff that was lowered to 6 per cent in 2003, with the conclusion of a program to reduce unilateral import taxes by

<sup>8</sup> For example, the United States with the Waxey-Markey Bill.

<sup>9</sup> For example, through “food miles” in the food sector.

1 per cent annually from 1999 onwards. This program, along with the numerous free trade agreements (see next point) signed by Chile and a reduction in its non-tariff barriers, have made the country one of the most liberal economies in the world, with an effective import tariff of 1.2 per cent in 2008.<sup>10</sup>

Signing of free trade agreements and investment agreements: According to the Foreign Investments Committee (*Comité de Inversiones Extranjeras*), Chile has signed over 20 trade agreements with 56 countries and has three further agreements currently under negotiation, as listed in Table 5.

**Table 5: List of trade agreements**

Agreement / partner	Date signed
<b>FREE TRADE AGREEMENTS</b>	
Australia	July 30, 2008
Canada	December 5, 1996
China	November 18, 2005
Colombia	November 27, 2006
Central America (Costa Rica, El Salvador, Honduras)	October 18, 1999
EFTA	June 26, 2003
Japan	March 27, 2007
Mexico (ACE 41)	April 17, 1998
MERCOSUR (ACE 35)	June 25, 1996
Panama	June 27, 2006
Peru	August 22, 2006
Republic of Korea	February 15, 2003
United States	June 6, 2003
<b>ECONOMIC PARTNERSHIP AGREEMENTS</b>	
P-4 (Brunei – New Zealand- Singapore)	July 18, 2005
European Union (EU)	November 18, 2002
<b>PARTIAL SCOPE AGREEMENTS</b>	
India	March 8, 2006
Peru	June 22, 1998
Ecuador	December 20, 1994
Colombia	December 6, 1993
Venezuela	April 2, 1993
Bolivia	April 6, 1993
Argentina	August 2, 1991
<b>AGREEMENTS UNDER NEGOTIATION</b>	
Malaysia	
Ecuador	
Turkey	

Source: author's work, based on data from the Foreign Investment Committee (*Comité de Inversión Extranjera*) (and the OAS (<http://www.cinver.cl/english/estadisticas/estadisticas.asp>))

<sup>10</sup> *Comité de Inversiones extranjeras*: <http://www.cie.cl>.

According to the Foreign Investments Committee, to date, Chile has signed Investment Promotion and Protection Agreements with 51 countries, 38 of which are still valid.

**Non-discriminatory treatment of foreign investment:** Chile has made foreign investment a fundamental pillar of its development. The DL 600 administrates the entry of foreign investors and ensures non-discriminatory treatment. According to the 2008 World Investment Report, published by the United Nations Conference on Trade and Development (UNCTAD), Chile is third amongst the ten most successful economies for attracting foreign investment in Latin America and the Caribbean.

**Institutional structure:** Above and beyond the aforementioned macroeconomic reforms, the country has undertaken numerous changes to its institutional structure in order to achieve greater economic stability and credibility, the most noteworthy of which is the establishment of its environmental institutions and three market capital reforms. Also, for example, the pension system was reformed in 1985 to allow the Private Pension Administrators (*Administradoras de los Fondos de Pensiones* [AFPs]) to invest in private companies or in state companies in process of privatization. From the 1980s onwards, this process, alongside stimulation of the domestic capital market, created the right conditions for the large-scale privatization of state-owned companies, including the electricity companies. Foreign investment in the sector was relatively low until the second half of the 1990s due to restrictions preventing the AFPs from investing abroad (Pollitt, 2004).

In summary, as shown in Table 6, on an international level, the different specialized institutions all agree that Chile presents a favourable investment climate, particularly compared to other Latin American countries, despite a slight deterioration over the last year.

**Table 6: Chile's position in international Investment Climate Rankings (\*)**

Country	Doing Business/ World Bank		World Competitiveness Report/ World Economic Forum		Index of Economic Freedom/ Heritage Foundation	
	2009	2010	2008-9	2009-10	2008	2009
Argentina	112	118	88	85	108	138
Brazil	127	129	64	56	102	105
Colombia	49	37	74	69	67	72
Chile	40	49	28	30	8	11
Mexico	55	51	60	60	44	49

Source: World Bank, 2009; WEF, 2009; Heritage Foundation, 2009; Heritage Foundation, 2008

(\*): The lower the number assigned, the higher the country's position in the ranking.

In fact, the assessment on investment climate in Chile made by the United States government in 2008, stated that over the last three decades the country has made foreign investment an essential part of its national development strategy. The implementation of market policies and a direct and transparent business climate have been key factors in creating opportunities for foreign investors to participate in the country's sustained growth (U.S. State Department, 2008). However, this assessment also emphasises certain challenges to be overcome in order to further improve the investment climate in Chile. These include the following:

**Intellectual property rights:** Chile, as a member of the World Trade Organization (WTO) and a developing country, must obey the obligations imposed by the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS). As a consequence, at the start of 2005, the country passed a law to reinforce intellectual property rights according to TRIPS standards. However, concern has been expressed regarding failure to enforce this legislation. For example, the Government of the United States has manifested its concern about Chile's apparent lack of commitment to prosecute those contravening the intellectual property rights law. Therefore, in its 2008 Investment Climate Statement for Chile, the United States government highlighted the fact that despite legislative progress made to protect intellectual property rights "*current criminal penalties have proven inadequate in deterring growing piracy of computer software, music and video material in Chile.*" (U.S. Department of State, 2008) As a result, in 2007, the United States placed Chile once more in the "Special 301 Priority Watch List (PWL)" due to their concern over the poor commitment to protecting intellectual property rights.<sup>11</sup> According to this report, the worst violations of these rights relate to pharmaceutical products and clinical examination data.

**Corruption:** Whilst corruption levels in the country are relatively low, a number of corruption cases within government institutions have come to public attention in recent years. In spite of this, Transparency International's 2008 Corruption Perception Index, published in September 2008, awarded Chile 6.9 points on a scale from 0 to 10, where 0 represents a country perceived as totally corrupt and 10 a country perceived as free from corruption. Therefore, Chile lies 23rd in the world ranking out of the 180 economies analyzed, one place below its 2007 ranking (Chile Transparente, 2009).

### 3.2 Clean energy incentives

In Chile, the first steps towards encouraging greater development in the production of clean energy or NCRE (as they are defined by Chilean law) have only just been taken in the last few years (see Box 2). The government objective is to establish conditions to attract investment in clean energy projects by encouraging market development through removing the main entry barriers. Two main

<sup>11</sup> Chile had been on the Special 301 Watch List since 1989 and was subject to an Out-of-Cycle Review during much of 2006, which ultimately resulted in the PWL designation.

government actions that seek to achieve this end can be identified: regulation and the development of instruments offering incentives to investment in clean energy projects.

### 3.2.1 Legal instruments

In terms of the legal material, there are numerous modifications to the law, as mentioned in Section 2.6.1—specifically, *Ley Corta* I (2004) and III (2008) (Short Law I and III). The main objective of these two laws is to facilitate the incorporation of clean energy sources into the Chilean electricity grid and their subsequent operation in the market. While *Ley Corta* I creates investment incentives by regulating access to the grid for lower capacity generators (of less than 20MW), *Ley Corta* III creates a demand for clean energy or NCRE within the electricity sector by setting a minimum participation quota (5 per cent from 2010 rising to 10 per cent by 2024).

Moreover, modifications made to Decree 291 in 2009, require that small-scale generators (less than 300MW installed capacity) are included in the Directory of the Economic Load Dispatching Centre (*Directorio del Centro Económico de Despacho de Carga* or CDEC). This change improves the negotiating position for small-scale generators (the condition of many NCRE), giving them direct access to negotiations, whereas prior to this legal modification they were obliged to act through one of the larger generators.

### 3.2.2 CORFO incentive instruments

In parallel, the Economic Development Agency, CORFO, together with the National Energy Commission, CNE, have set up diverse instruments to support investment in development of the clean energy sector. The most important of these include:

**Program of pre-investment in preliminary studies in NCRE:** The program seeks to support energy generating projects, based on renewable energy and eligible for the Clean Development Mechanism of the Kyoto Protocol, with investments of over US\$400,000 subsidizing pre-investment studies or specialized assessments. The value of the subsidy is up to 50 per cent of the total study or the consultancy costs up to a maximum of US\$60,000, as long as this value is no more than 2 per cent of the estimated total investment in the project.<sup>12</sup>

**Program of pre-investment for advanced studies in NCRE:** This instrument co-finances part of the basic and detailed engineering costs, electricity connection studies and assessments and/or environmental impact declarations. The subsidy covers up to 50 per cent of the total study or the consultancy costs up to a maximum of 5 per cent of estimated total investment or US\$160,000 per

<sup>12</sup> See

[http://www.corfo.cl/lineas\\_de\\_apoyo/programas/programa\\_de\\_preinversion\\_en\\_energias\\_renovables\\_no\\_convencionales\\_\(NCRE\)](http://www.corfo.cl/lineas_de_apoyo/programas/programa_de_preinversion_en_energias_renovables_no_convencionales_(NCRE)).

project. The instrument is intended for projects that have already undergone the preliminary processes of the pre-investment phase.

**Low-interest loans for renewable energy investment:** This CORFO program was launched at the end of 2008 and co-financed by the German bank KfW. The loans were designed for refinancing long-term credit and leasing operations for investments contributing to environmental improvements. The loans in this scheme operate at fixed rates, either in dollars or local currency, for periods of 3 to 12 years, including a grace period of up to 30 months. There is a maximum loan value of US\$10,000 per project (InvestChile CORFO, 2008).

**Capital guarantee and risk capital funds for clean energy and energy efficiency:** This instrument was only introduced in 2009. In the case of capital guarantee funds, the instrument applies to both self-funded projects and CORFO-funded projects up to a total of US\$7.5 million.

- In addition, the following instruments are still at a design phase:<sup>13</sup>
- Subsidies for transmission lines for clean energy
- Subsidies for geothermal exploration
- Tender to build two solar energy plants to generate 0.5MW of photovoltaic energy and one 10MW solar concentrator power station.

Table 7 and Figure 15 summarize the CORFO projects by instrument and clean energy type.

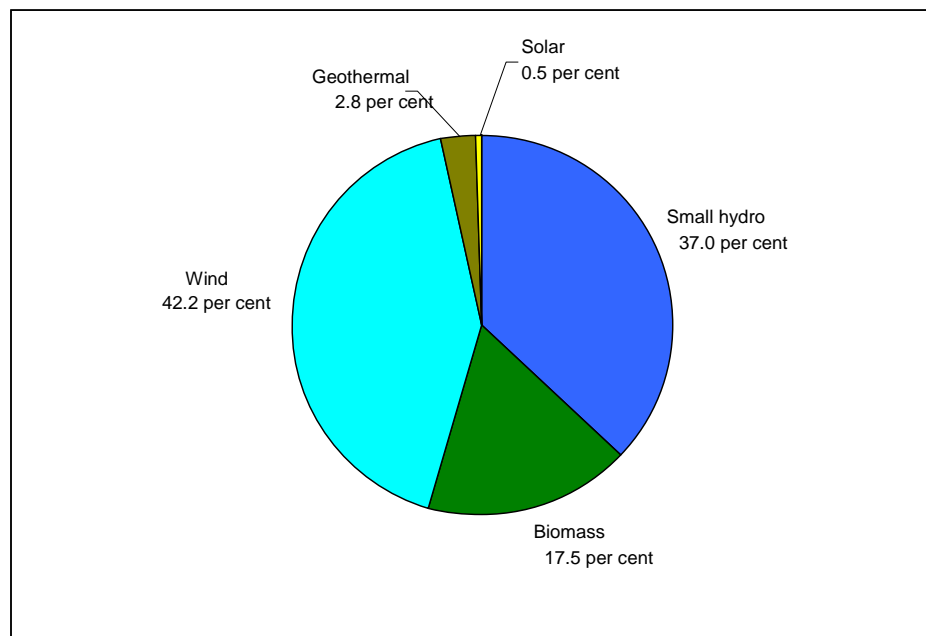
**Table 7: CORFO NCRE projects by instrument**

Instrument	2005	2006	2007	2008	2009	Total projects	Unsuccessful projects
Basic pre-investment	49	45	62	20	35	211	17
Advanced pre-investment	-	-			5	5	2
NCRE loan	-	-			5	5	5
Environmental loan			1	2		5	

Source: CORFO, 2009

<sup>13</sup> For further details, see InvestChile CORFO, 2009.

Figure 15: Total CORFO projects by clean energy type



Source: CORFO, 2009

### 3.2.3 International cooperation

Above and beyond the regulatory modifications and incentive instruments, international cooperation programs for the development of clean energy in Chile should also be highlighted, such as that developed by GTZ alongside CNE and described in Box 3.



### Box 3: Cooperation project between GTZ and CNE to develop clean energy in Chile

The project “Renewable Energy in Chile” involves the Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung (BMZ) and the Comisión Nacional de Energía (CNE). The CNE is the body responsible for regulating, preparing and implementing energy policy, with advisory services on creating favourable conditions for electricity generation from NCRE sources. This includes regulation of grid access, integration into the electricity market, and development of expansion strategies and promotional instruments for renewable energies.

A second priority area is the removal of structural market constraints hindering the rapid expansion of renewables in Chile. These include, besides lack of knowledge about energy resources and their geographical distribution, lack of experience with planning and approval procedures and with grid connection. Lack of experience with technical and economic evaluation and financing of projects together with innovation risks hinder investments in new technologies.

The project supports investigation of the technical and economic energy potential in the biomass, biogas and wind energy sectors. To facilitate planning and approval procedures, guidelines for project planning and environmental impact studies are prepared for the respective renewable energy technologies. In cooperation with private investors and project developers, the project is also conducting feasibility studies for four electricity generation projects on the basis of biomass, biogas and wind energy. This approach permits detailed analysis of existing investment constraints, from which future needs for action and promotional strategies can be derived.

The project also promotes local capacity building and encourages dialogues over policy between policy-makers, the private sector and civil society. It gives methodological, technical and financial support for the preparation and implementation of analyses, studies, seminars and training. PPP measures are also planned.

The project started in August 2004 and is expected to be finished by October 2010

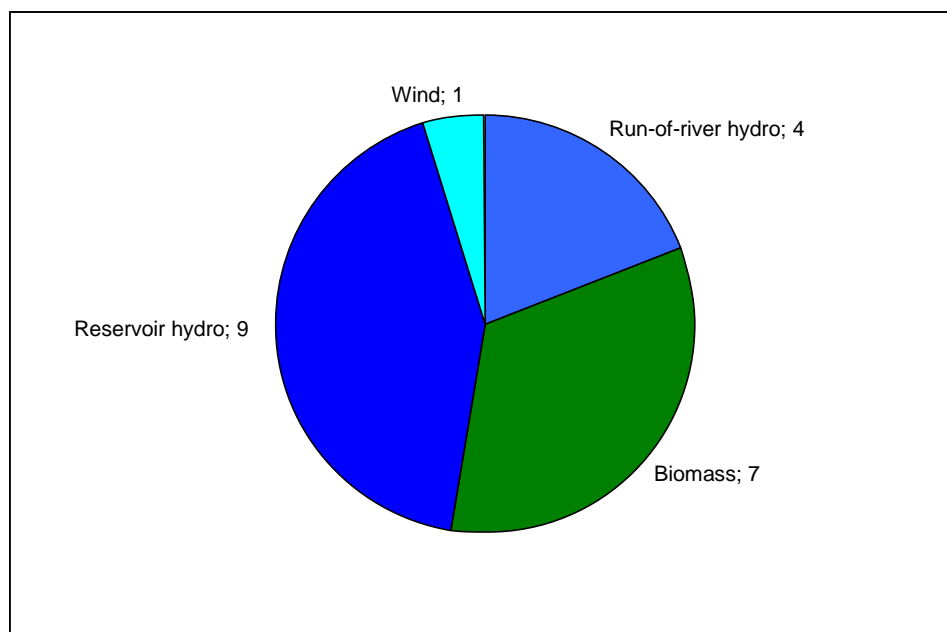
Source: GTZ, n.d.

#### 3.2.4 Clean Development Mechanism

To date, the relevant national authority has approved a total of 51 projects under the Clean Development Mechanism (CDM). Of this total, 22 are electricity generation projects, mostly small hydropower (13), and forestry biomass for co-generation (7). Only one was a wind-power project (see Table 6). However, it should be noted that although the CDM was designed under the Kyoto Protocol as an instrument to encourage investment in projects with low greenhouse gas emission rates in developing countries by means of carbon credit sales, in practice the tangled bureaucracy of the system has meant that CDM in Chile has not acted as a financial incentive for companies (Jara, 2009). Those companies that apply for CDM do so more for the enhanced reputation it can provide

than for the earnings incentive of carbon credit sales.

**Figure 16: Electricity generation projects approved for the CDM**



Source: author's work, based on data from <http://www.conama.cl>.

Although the legal modifications and incentive instruments to promote clean energy in Chile are undoubtedly important, it is still too early to assess their impact, especially considering that many of them are still in the design phase of development. They have, nevertheless, been well received in the different sectors. For example, in their *Directory of Renewable Energy Projects in Chile* (InvestChile CORFO, 2009), the CORFO states that since 2005 over 211 clean energy projects have been approved. While some projects are already at a development phase, others are still at an earlier initial stage—measuring resource availability—and others are completing their feasibility studies and analyzing financing or construction. On the other hand, some projects have opted not to apply for the subsidy. According to the CORFO, there are currently some 133 projects in their files.

In their assessment of the CNE project to develop the clean energy market,<sup>14</sup> the German development agency GTZ, emphasize that the creation of a more favourable investment climate through a combination of legal modifications and promotional instruments has effectively propitiated greater interest from private investors and project developers. Modifications to the law improve the legal and economic conditions for clean energy projects, facilitating the arrival of new stakeholders and investors to the market. The GTZ also highlights the existence of training and information exercises as a positive path to market development. One such example is the training

<sup>14</sup> See <http://www.gtz.de/en/themen/umwelt-infrastruktur/energie/8956.htm>.

provided for local suppliers in wind measurement according to international standards, which definitely reduces investment risks in wind-power projects for both investors and the finance sector. Likewise, improvements made to databases, creating more reliable information on the different sources of renewable energy, not only serves investors but also provides solid grounds for arguments promoting greater political acceptance of renewable energy.

The clean energy incentives have also been popular amongst private investors. For example, the Ontario Exports agency, part of the Canadian Ministry of Economic Development and Trade (TradeChile, 2006), identifies both the Pre-Investment Programme for Renewable Energy and the legal modifications as providing significant business opportunities. They emphasize:

*The flow on effect from the development of this market should create an opportunity for Ontario machinery and equipment in renewable energy projects... motivating investment to match energy requirements. The projected growth for the energy market will provide established Ontario companies with chances to expand their current operations... Professional expertise will also be in high demand over the next 5 - 10 years, creating opportunities for Canadian professionals in the service sector. Ontario companies benefit from the Canada Chile Free Trade Agreement (CCFTA) that came into effect in 1997 and which continues to give import-duty advantages of up to 6 per cent. The Chilean power and energy market has been identified by the Canadian Trade Commissioner Service as a priority sector for opportunity in 2006. (TradeChile, 2006, p. 2).*

Similarly, the Galaz 2007, in an analysis of the legal modifications made by the *Ley Corta I for UNDP and Endesa-Eco*, states that “the aforementioned legal modifications evidently make a positive impact upon projects from the perspective of their economic and financial performance, thus generating new investment incentives.” (Galaz, 2007, p. 36; trans. Dufey). These incentives will be stronger or weaker depending on the specifics of each project. However, the analysis also emphasized the importance of introducing additional incentives; the existing ones are insufficient as they do not address the numerous barriers to project implementation

On the other hand, there are also important criticisms to consider, particularly regarding Law No. 20.257, which establishes quotas of participation for renewable energy. The most significant criticisms include:<sup>15</sup>

- The technological neutrality, because in a quota system like the Chilean one, incentives are only given to the development of mature and low-cost energy production.
- The quota establishes a maximum participation of 10 per cent by 2024, but this should be reviewed periodically as the technology learning curve progresses.
- The surcharge established is too low to act as an incentive to fulfil the quota.

<sup>15</sup> For further information, see Dufey, 2010.

- The generating sector rather than the distribution sector is responsible for fulfilling the quota, reducing its effectiveness.
- In a quota system, given that the State sets the quota level and the market determines prices, the risk to investors is very high.
- The quota system is less cost-effective than other existing support instruments such as feed-in tariffs and systems auctions.
- Some critics of Law No. 20.257 from more traditional sectors claim that the obligation distorts prices by imposing additional costs that will eventually be paid by the consumer (LyD, 2008). However, this criticism fails to take account of the positive external environmental factors that clean energy production has over conventional generating technologies.

## 4.0 Key Barriers to Clean Energy Production

The development of policies and instruments to foment clean energy production in Chile arises from the acknowledgement that there are numerous barriers hindering the potential development of these technologies. In spite of the undeniable progress made with regulation and instruments to promote clean energy in Chile, a number of these barriers to its development still persist. The main barriers to the development of renewable energy in Chile are identified below.

**High economic risk of clean energy projects:** Although the positive value of technological development of clean energy and its good future prospects are widely acknowledged, the cost per installed MW of clean energy (particularly in the case of the newer technologies) is still higher than that of conventional energy production. The higher investment costs refer not only to the technology costs, but also to the numerous implementation costs, such as: hiring experts to develop the projects, developing studies to ascertain resource availability and specialized labour for construction/installation. This characteristic of clean energy production—high investment costs and low operation costs—make long-term price stability a key condition to ensure the economic viability of these projects. However, the system chosen to promote clean energy development is a quota system (*Ley Corta III*), where the authorities set the quota level and the market defines prices, which creates increased risks for investors compared to other support instruments (e.g., feed-in tariffs or auction systems).

Moreover, the lack of long-term price stability is one factor inhibiting the possibility of long-term contracts, particularly in the case of wind-power projects, due to their low capacity factor. Under current conditions, the existence of a contract obliges the clean energy project to supply energy for the length of the established contract. If it fails to generate the stipulated quantity of energy it must purchase the shortfall on the “spot” market in order to comply with the contract. According to the Electricity Law, purchases and sales on the “spot” market are made through the CDEC at the marginal price of the moment for the energy and at node price for the potential, thus exposing the purchaser to the risk of variability in the “spot” market price. Moreover, in the case of wind-power projects, due to the variable nature of this form of electricity generation, it is highly likely that energy will have to be purchased on the “spot” market in order to fulfil the contract, with the risk of having to purchase at a higher price than that established in the long-term contract. This current form of remunerating clean energy or NCRE projects—with an absence of stable long-term prices—means a significant portion of clean energy projects never manage to negotiate the necessary resources in the finance system (see the following point on access to financing).

**High market concentration impedes new stakeholder entry:** One of the strategic objectives sought by the authorities within the regulatory framework of clean energy production was to create a market providing access for new participants by setting up long-term contracts between new

generating companies and distribution companies. However, in practice, the access of new participants into the market has been hindered by several different factors. Primarily, a number of traditional generating companies are undertaking their own clean energy projects in order to comply with the legal quota. In view of the high existing level of concentration in the Chilean electricity market in the generation and distribution segments, this has meant that contracts have been given to the big conventional generators and distributors, excluding the new and smaller generating companies. A high level of concentration in the electricity sector has been identified in the literature as one of the conditions that might lead to the risk of the market being hampered or losing transparency (Comunian, 2007). The negative attitude of the Chilean electricity market towards new stakeholders is an issue that has already been highlighted as a serious impediment to the development of the clean energy sector.<sup>16</sup> In fact, the recent IEA report on Chilean energy policy revealed this to be a key point, highlighting it as “*a barrier for new and small-scale participants who must compete in a highly concentrated market?*” (IEA, 2009).

**Failure to incorporate external factors and other impacts:** Countries with successful clean energy development strategies, such as Germany and Sweden, are seen to employ policies seeking objectives that reach far beyond the cost of energy generation, such as positive impacts on the environment, employment and industrial development. In Chile, on the other hand, the clean energy sector is being driven by a vision strongly structured around the immediate economic costs of energy so as not to hinder the country’s competitiveness. However, this vision fails to take into account that energy options affect the country’s competitiveness not only through the direct economic production costs, but also through other factors relating to global concerns, such as climate change. Chile only partially acknowledges externalities and only those local to the region.

Apart from environmental impact studies, which recommend mitigation measures for projects when necessary, there is a preliminary project for regulating local emissions of thermoelectric power stations that was approved recently, in December 2009, after several years of debate. The regulation sets emission levels for this kind of generation for particulate matter (PM), sulphur dioxide (SO<sub>2</sub>) and nitrogen oxide (NO<sub>x</sub>) amongst others. However, it does not regulate CO<sub>2</sub> emissions for the thermoelectric power plants. In practice, this means that, at present in Chile, the valid regulatory instruments only partially incorporate local environmental externalities. The aforementioned situation implies that clean technologies, which generally have a much lower environmental impact than traditional technologies, both locally and globally, cannot compete under equal conditions in Chile. There is a clear and urgent need to make the costs and benefits of the different kinds of energy transparent in order to draw real comparisons between clean energy and conventional energy sources and hence the country’s strategic decisions can take “non-price attributes” into consideration.

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<sup>16</sup> For example, see Maldonado & Herrera, 2007.

**Access to financing:** The way the current framework remunerates clean energy projects (an absence of stable long-term prices alongside lack of technical knowledge, failure to incorporate externalities, etc.) means a significant number of these projects fail to attract the necessary resources from the finance system.<sup>17</sup> This problem is further aggravated by the finance sector's lack of interest and knowledge in the different kinds of clean technologies. All this translates into a dramatic shortage of funding instruments, high interest charges and demands for developers to provide extra-project guarantees.<sup>18</sup> The problem of access to financing is particularly strong for projects linked to small stakeholders, since they lack the necessary guarantees or backing to raise funds. This creates a huge bottleneck considering that most small developers in Chile hope to finance their projects through loans. It makes clear the urgent need to generate new instruments and capacities to finance the sector. In this sense, although low-interest CORFO loans, operated by private banks, and the new CORFO instrument for guarantees mark an improvement in this situation, it is unlikely that these measures are sufficient to completely resolve the problem.

**Lack of knowledge and capacitated human capital:** The issue of the generation of local capacities in clean energy is rarely raised in Chile, but this matter is crucial for maximizing the benefits associated with these technologies. The only barriers to the development of the clean energy market addressed by energy policy have been the lack of local complementary goods and services providers. However, the need to form capacities to capture all the benefits associated with clean energy is a much broader issue involving many different levels. In this field, capacities must be developed to prepare the technical scene to reduce the gaps in offer and demand, in the public and private sectors, and at every level, including: high level human capital able to participate in international research networks with centres of excellence; professionals able to innovate and adapt technologies to the local situation; professionals and technical experts able to install, operate and maintain the technology; professionals able to develop suitable monitoring and certification systems right through the value chain. This would allow a strengthened and efficient market development, thus reducing project costs. The recent creation of the Renewable Energy Centre (*Centro de Energías Renovables* [CER]) is a step towards addressing this issue. Apart from this, there is only one very small-scale pilot initiative aimed at developing capacities for goods and services for the NCRE industry, led by the regional government of Bio Bio and Fundación Chile. However, the development of capacities in this sense urgently needs much more, concrete action. There is a limited window of opportunity to capture the benefits of clean energy, which would include the development of a technopole and quality workforce, thus helping Chile to establish itself in the knowledge society—one of the country's biggest challenges.

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<sup>17</sup> For small hydro projects, given the financial investments, technological maturity and operational costs involved, the financial sector would provide funding with the existence of guarantees.

<sup>18</sup> CORFO, according to its organic law, cannot assign resources directly but must instead channel them through the finance system.

Capacities must also be built up in the finance sector. This involves forming knowledge and skills in the finance sector on the different kinds of clean technologies, a crucial measure to achieve accurate financial assessment and risk assignment for projects. It is also necessary to disseminate the availability of finance instruments and foster the creation of new instruments. Finally, the forming of knowledge and skills crucially requires the strengthening of capacities in the public sector. The issue of new Chilean energy policy is only recently starting to be discussed. The clean energy regulatory changes and incentive instruments are very recent so it is still not fully understood how the market will operate and therefore which are the best mechanisms or adjustments to develop the sector over the coming years in accordance with local and global challenges. Also urgently needed is the development of the ability to measure and capture externalities of the different technological options in the context of the transition towards a low carbon economy.

**Better coordination between institutions:** It follows from the above points that promoting a clean energy market that maximizes positive impacts requires the joint efforts of diverse public institutions, including at least: Energy Policy, Environmental Policy, Production Development Policy, Education Policy and Science, Technology and Innovation Policy. So far, policy in clean energy use in Chile has mainly come through the National Energy Commission in coordination with the CORFO. It is evident that much more effort is clearly needed in this field. A first step towards better coordination is the recent creation of the Ministry of Energy, which establishes participation in the CONAMA's Executive Committee as a fundamental part of its function.

**Lack of adequate technical studies:** As seen in the previous section, significant efforts are being made to generate both technical and administrative information on clean energy, but there are still considerable barriers. For example, the lack of basic technical studies on renewable resource availability is a barrier frequently mentioned across different sectors. For instance, Chile has exceptionally favourable conditions for solar resources but there has only ever been one extremely basic series of measurements taken, in 1987.<sup>19</sup> In the case of wind-power, critics claim that measurements are taken with systems intended for meteorological purposes, which work at very different heights and are thus unsuitable for establishing wind resources for energy generation (Jara, 2009). This lack of basic technical studies means that, in practice, each project developer must dedicate time and resources to carrying out their own individual studies. Although the government has recently begun to generate information of this kind, the barrier still persists and must continue to be addressed.

**Network connection issues:** In spite of regulatory changes to improve the situation of clean energy in terms of access to transmission lines and networks (*Ley Corta I*), in cases where new transmission lines must be built, this can become a crucial factor. For example, the UNDP study estimates that, in projects requiring transmission line construction due to their distance from the

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<sup>19</sup> See UFSMA, 1987.



points at which they can connect to the system, project construction costs can increase by 20 per cent. This clearly demonstrates how line construction can become a key element in determining whether a renewable energy project is viable (Galaz, 2007). Although this point is currently being addressed by the government and a subsidy to transmission lines for clean energy projects is up for approval in the National Comptroller Office (*Contraloría*), there are no details of the instrument's scope or when it will be put into operation. Finally, considering that in the case of wind-power there was only 185MW installed capacity in one single stretch of line in Chile at the end of 2009 (between Los Vilos and Pan de Azúcar in the III and IV regions), this is definitely a relevant issue.

## 5.0 Conclusions

Undoubtedly, the clean energy sector in Chile has experienced significant development in recent years and shows important growth potential. Between 2007 and 2009 installed MW of clean energy almost doubled in the SIC to reach nearly 4 per cent of installed capacity by 2009. Future scenarios offered by diverse institutions for the electricity sector indicate a stronger presence of clean energy in the country. Although such reports differ considerably regarding their predicted capacities of clean energy in Chile, all point to a higher percentage of clean energy than that dictated by law.

Since the 1980s reform of the Electricity Law the private sector has played a predominant role in the development of the Chilean electricity sector, with notable participation from foreign investors from the second half of the 1990s. This high proportion of foreign investors is a trend that is common to the clean energy segment.

In recent years, Chile, like other countries around the world, began to take the first concrete steps towards incorporating clean energy production into the electricity grid. Action taken includes regulatory instruments and the development of incentive instruments to reduce investment costs for clean energy projects. An example of the former is the 2008 enactment of Law No. 20.257, which establishes a minimum clean energy quota in the grid—5 per cent as of 2010 up to 10 per cent by 2024. Clear examples of the latter are the CORFO subsidies for preliminary and advanced pre-investment studies of clean energy projects, as well as low-interest loans, guarantees and the creation of a Renewable Energy Centre. There are also numerous instruments still in the design phase.

Although it is still too early to assess the impact of these measures, and still less possible to identify their specific impact independently of other factors present (e.g., change in technology, fossil-fuel price prospects and possible international carbon emission restrictions), they have been very well received by private investors. However, diverse barriers still remain (including high economic risk, high market concentration, lack of financing, failure to incorporate externalities, lack of technical knowledge and capacitated human capital), which put the brakes on stronger development of this sector in the country.

It must be noted that, based on the experiences of countries with successful strategies in clean energy development, it is clear that instruments designed to reduce investors' risk levels and to capture externalities play a primordial role in the development of the clean energy sector. In fact, international experience indicates that the impact of a quota system like Chile's, upon development of the clean energy sector, is limited compared to other public policy instruments. Therefore, the following complementary measures are recommended to strengthen sector development.

Subsidy systems (e.g., those applied to prices, such as feed-in tariffs) can be used to develop less mature or higher-cost clean energy production. A key element in the design of these instruments is that they should diminish with time, as the different technologies progress along their learning curves. The introduction of this kind of instrument in Chile is undoubtedly challenging. On the one hand, the Chilean market holds a negative view of market intervention; on the other hand, the energy authority claims to have provided all the incentives necessary to develop good clean energy projects. The new government that took over in March 2010 holds an even more conservative view.

Another element that needs urgent attention is to make clean energy genuinely comparable with other more conventional options. This necessarily involves making the costs and benefits of the different energy types transparent. Such a step would allow strategic decisions to be made regarding the energy network, decisions that go beyond an equation that only includes energy security at minimum cost (the current objectives of the energy authority) to include other crucial non-price aspects, such as environmental and social impacts at a local and global level. In fact, if conventional fossil-fuel energy production were to internalize all their local and global environmental costs, their competitive position compared to clean energy would be considerably weakened. The current and future growth patterns for greenhouse gas emissions from the national electricity sector are a cause for concern amongst diverse sectors. Alarm arises not only from environmental concerns, but also, crucially, due to effects on the country's long-term competitiveness. Added to this is the possibility of concrete reduction demands following Chile's recent entry into the OECD and concerns about the country's image. There has been incipient debate across numerous sectors regarding how to tackle this problem and asking what role clean energy could play in mitigation measures. The increased carbon footprint of the country's production sector has a negative effect on the environment and should be addressed proactively to avoid more expensive remedial action in the future. The panorama for clean energy is undoubtedly much more favourable if other benefits are taken into the equation, such as energy security and diversity, potential to create economic activity and local development and employment.

The aforementioned points indicate a significant window of opportunity for clean energy to play a more important role in Chile. This would require an ambitious and integral strategy for the country with a vision that goes beyond incorporating any specific percentage of clean energy into the national grid. Such a vision must also focus on seizing opportunities for: mitigating greenhouse gas emissions (alongside widespread energy efficiency programs and carbon compensation through forestry plantations); reducing local environmental impact; and recognizing opportunities to generate employment, local development and for innovation. This long-term vision must be based on clear identification of all the positive and negative impacts of the different technological options available and their possible trade-offs. It would constitute the basic foundation for serious formulation of integral policies, discussed and coordinated with all relevant stakeholders and with the support of

the necessary instruments to put them into practice. Such a strategy would include both private investment and state incentives working together.

In parallel to the direct action already taken by the energy authorities and CORFO, the materialization of a long-term vision on clean energy production, one that maximizes opportunities and addresses existing barriers to give clean energy a leading role, requires coordinated action from diverse fields and institutions.

From the perspective of environmental policy, all economic, social and environmental costs of the different energy options and their connections with any impacts must be made transparent and quantified in order to draw accurate comparisons and thus favour those technologies with lower integral costs and greater net benefits. Improvements are also needed in the Environmental Impact Assessment system, currently impeded by the lack of specific knowledge on new technologies, such as clean energy production, and poor coordination between the different national and local organizations involved. This problem raises the costs and risks perceived by investors and project developers.

Regarding educational and science and technology policy, capacities must be developed to prepare the technical scene to reduce the gaps in offer and demand, in the public and private sectors and at every level, including: high level human capital able to participate in international research networks with centres of excellence; professionals able to innovate and adapt technologies to the local situation; professionals and technical experts able to install, operate and maintain the technology; professionals able to develop suitable monitoring and certification systems.

Industrial and production development policy must identify niches of opportunity in the clean energy market and foster a goods and services industry (along with all the value chain associated with these niches), making use of local materials and know-how.

From the perspective of innovation policy, it is necessary to foment technological intelligence and competition, technology transfer, innovation and all clean energy-related undertakings in order to seize new business opportunities and encourage Chilean companies to take on clean energy projects, thus improving their competitiveness.

In the case of the finance system, the government must get more involved in the provision of guarantees and the promotion of new financing instruments, such as project finance. With instruments like project finance, apart from participation from private banks, developing countries also crucially require the involvement of a multilateral financial organism and support from the government itself to act as risk mitigator. Furthermore, opportunities must be generated to educate the finance system with regard to clean energy projects, so that their specialists are able to adequately assess the risks of this kind of project and impose the respective due diligence.

In terms of the private sector in general, companies need to show willingness and open-mindedness to address innovative initiatives, since these are often of complex articulation or the “business not as usual” kind. The technological and business entities require creativity to articulate solutions and set up a portfolio of realistic feasible projects, but they also need indications from the government regarding the obligations and incentives to be implemented to achieve this vision.

The international community must continue to generate information on the costs, benefits and technologies of clean energy, as well as on assessment methods. It must also continue to generate financial structures for funding clean energy projects, such as the aforementioned collaboration between the CORFO and KfW, and support the generation of guidelines for risk assessment of clean energy projects. The support of multilateral organisms such as the IFC, the World Bank and the UNEP (through the Sustainable Energy Finance Initiative) are also important.

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