CHILE

(Updated 2012)

1. GENERAL INFORMATION

1.1. Country Overview

Republic of Chile is a country situated in the southwestern tip of South America, between the Andes Mountains in the east and the Pacific Ocean in the west. Chile spans three continents and its territory includes part of the Americas, Oceania and Antarctica. It has its primary territory on the South American continent, between parallels 17º 30' S and 56º 30' S. Its length is 4,329 km from north to south, making Chile the longest country in the world. At the same time, is one of the narrowest, with an average width of only 180 km (445 km in the widest part, with only 90 km in the narrowest). Chile has a total area of 756,096 km^2, and also claims a territory of about 1,250,000 km^2 in Antarctica.

In Oceania, Chile holds Easter Island, located at 27° S and 109° W, and 3.790 km. distance from the continent. Chile borders on Perú in the north, Bolivia in the northeast, Argentina in the east, the Antarctic in the south, and the Pacific Ocean in the west. It has a total of 6,339 km of territorial borders and a total of 6,435 km coastline. Chilean territory includes the Pacific islands of *Juan Fernández*, *Salas y Gómez*, *Desventuradas*, and Easter Island in Oceania. Chile also has 120,827 km^2 of territorial sea and the corresponding continental shelf.

The capital of Chile is Santiago, and the official currency is the *Peso*.

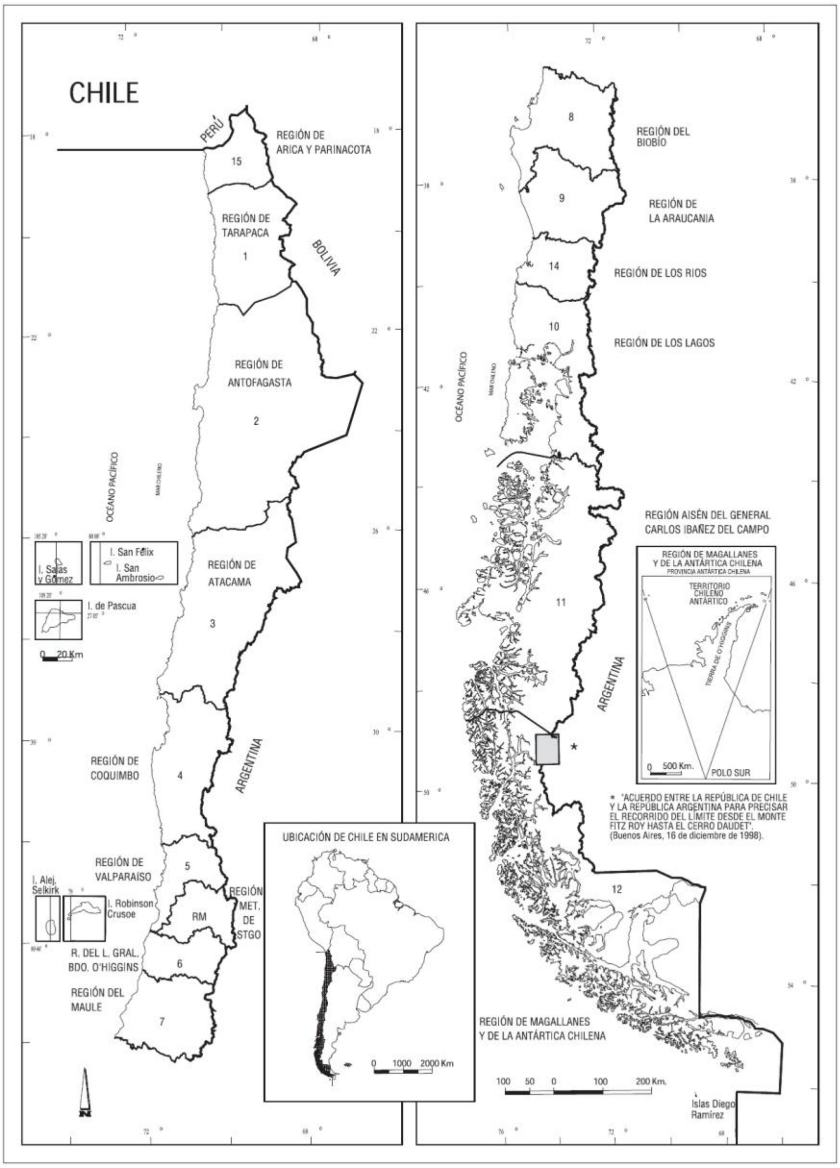

Figure 1: Map of Chile
Source: National Statistics Institute of Chile

1.1.1. Governmental System

Chile is a republic, ruled by a democratic government, and is characterized by the clear demarcation and independence of the three branches of government. The current constitution dates from 1980. The politics of Chile takes place within the framework of a presidential representative democratic republic, whereby the President of Chile is both head of state and head of government, and within the framework of a multi-party system.

Executive power is exercised by the President. Legislative power is vested in both the government and the two chambers of the National Congress. The Judiciary is independent of the executive and the legislature. The bicameral National Congress (www.congreso.cl) consists of the Senate (www.senado.cl) and the Chamber of Deputies (www.camara.cl). The Senate is made up of 38 members, elected from regions or sub-regions. Senators serve eight-year terms. The Chamber of Deputies has 120 members, who are elected by popular vote to serve four-year terms.

According to current legislation, Chile is divided into 15 regions, each headed by an intendant appointed by the president. The regions are further divided into provinces, with provincial governors appointed by the President. The provinces are divided into communes which are administered by municipalities, each with its own mayor and council elected for four-year terms. Regions are designated by a name and a Roman numeral, assigned from north to south. The only exception is the Santiago Metropolitan Region which is designated RM (Región Metropolitana). Two new regions were created in 2006 and became operative in October 2007: Los Ríos in the south (Region XIV), and Arica y Parinacota in the north (Region XV). The numbering scheme skipped Region XIII.

Id.	**Region**	**Capital**
XV	De Arica y Parinacota	Arica
I	De Tarapacá	Iquique
II	De Antofagasta	Antofagasta
III	De Atacama	Copiapó
IV	De Coquimbo	La Serena
V	De Valparaiso	Valparaiso
RM	Metropolitana de Santiago	Santiago
VI	Del General Bernardo O'Higgins	Rancagua
VII	Del Maule	Talca
VIII	Del Biobío	Concepción
IX	De La Araucanía	Temuco
XIV	De Los Ríos	Valdivia
XV	De Los Lagos	Puerto Montt
XI	De Aysén del General Carlos Ibañez del Campo	Coyhaique
XII	De Magallanes y de la Antártica Chilena	Punta Arenas

1.1.2. Geography and Climate

Geography

Chile has a huge diversity of natural terrain: ancient glaciers, salt plains, the driest desert on the planet and a multitude of forests, lakes and active volcanoes. Most of the terrain is mountainous – only one fifth of Chile's surface is flat. When moving west to east, the relief changes, ranging from Pacific Islands to coastline, the coastal range of the *Cordillera de la Costa*, intermediate plains and valleys and the *Cordillera de Los Andes.*

From north to south, the regions of Chile show big contrasts to one another. The Norte Grande and the Atacama Desert become Mediterranean, when moving further south towards the Central Valley. The central region of Chile is the most developed area, due to its abundant resources. Farther south towards Biobío, Araucanía and the Lakes District, the landscape is covered with thick temperate rainforest, lakes and lagoons. At the southernmost point of Chile, the South American continent falls away in many islands, glaciers, icebergs and mountains.

Climate

Because of it topography and its length from north to south, Chile has a great variety of climates. Barren from Arica to La Serena, Mediterranean in the central region until Concepción, temperate– and rainy from Concepción to Punta Arenas, and with the polar ice of Antarctica. Many of the northern deserts have not had any rain for hundreds of years, while on the other hand, in Guarello Island, in the Straits of Magellan to the south, 9,000 mm of rain (354.3 ins) fall each a year.

The climate of the central zone is mild and warm, with rainfall increasing towards the south. The Patagonian south is icy and cold with strong winds, while the Chilean Pacific Islands – Easter Island and the Juan Fernandez archipelago – have warm and subtropical climates. The seasons follow the typical pattern of the Southern Hemisphere, with winter in the months of June-August and summer from December-February.

1.1.3. Population

Chile has an estimated population of 17,248,450[1] inhabitants (2011), of whom 87% live in urban areas, with an average density of 22.81 inhabitants/km^2. The literacy rate is over 95% and average life expectancy is 78.5 years. Over the last few decades, the population has been growing at decreasing rates, in a trend similar to the one emerging in medium-high income economies, and slightly lower than that of other Latin American economies. Social indicators, such as mortality and infant nutrition, show that Chile stands out among its regional peers of similar income, with results similar to those presented by high income economies[2]. The poverty level still remains a challenge for economic and government policies, however, great advances have been accomplished, which have allowed Chile to be placed in the lower poverty level of Latin America[3].

TABLE 1. POPULATION INFORMATION

[1] INE (www.ine.cl)
[2] Mirando el desarrollo económico de Chile: una comparación internacional, Central Bank of Chile (2005)
[3] Social Panorama of Latin America, CEPAL (2008)

Year	1970	1980	1990	2000	2005	2009	2010	2011	Average annual growth rate (%) 2002* to 2011
Population (millions)	9.6	11.2	13.2	15.4	16.3	16.9	17.0	17.2	1.02
Population density (inhabitants/km²)	12.65	14.77	17.42	20.36	21.51	22.39	22.61	22.81	22.6
Urban Population as % of total	75.13	82.23	83.46	86.62	86.82	86.95	86.98	87.0	1.06
Area (1000 km²)	756.63	756.63	756.63	756.1	756.1	756.1	756.1	756.1	-

*Last census data (2002)
Source: -National Statistical Institute (www.ine.cl)
-World Bank World Development Indicators

1.1.4. Economic Data

The Chilean economy has experienced fast growth over the last 10 years. GDP grew at an average annual rate of 3,8%, according to the Central bank of Chile and the International Monetary Fund (IMF), and has maintained stable and sustained growth together with a low inflation rate. This macroeconomic stability is due primarily to institutional strength and to the soundness of the financial system, which relies on natural resource availability and on an open policy of trade and investment with foreign countries.

In term of rankings, in the 2011 World competitiveness Yearbook[4], Chile took 25th place out of 59 economies. Similarly, Chile is one of the world's freest countries according to the index of Economic Freedom 2011, taking 11th place in the international ranking. According to the Global competitiveness Business index 2010-2011[5], Chile also placed 30th out of 139 economies, maintaining a position of leadership and competitiveness in Latin America and the Caribbean.

In December 2009, the OECD invited Chile to become a full member, after a two year period of compliance with organization mandates, and in May 2010 Chile signed the OECD Convention, becoming the first South American country to join the OECD. In 2010, the OECD

[4] Published by the Institute for Management development (IMD)
[5] World Economic Forum (WEF)

anticipated that GDP growth in Chile would reach 6.5% in 2011, while the World Bank forecast an average expansion of 5.4% between 2010 and 2012, one of the most promising forecasts since the boom period from 2004 to 2007.

Chilean foreign policy is part of a market economy characterized by a high trade level, and supported by the most pro-openness customs regime in the region. Chile is considered to have an open economy, with high protection levels, compared to most developed economies. Chile claims to have more bilateral or regional trade agreements than any other country. It has 59 such agreements (not all of them full free-trade agreements), including with the European Union, Mercosur, China, India, South Korea, and Mexico[6]. In 2010, foreign direct investment (FDI) in Chile reached US$15.1billion, up 17.3% from the previous year. At the same time, the Foreign Investment Committee (CIE) authorized the entry of over US$13 billion, a record amount and a clear sign of foreign investors' confidence in Chile. This occurred despite the earthquake of February 2010, a disaster by which we did not allow ourselves to be paralyzed, but instead harnessed our efforts to the task of recovery and reconstruction[7]

During 2010, financial and business services contributed the greatest amount to GDP in Chile (17.7%), followed by the manufacturing industry (15.2%), personal services (12%), retail, restaurants and hotels (12%), communications (3.6%), transport (7.9%), construction (7.3%) and mining (6.9%)[8]. The main commercial product is copper mining, satisfying 36% of world market, although the exploitation of other mineral resources is also important (molybdenum, silver and gold), as is the exploitation of raw materials such as cellulose and of food sector products, like salmon and wine. Exports represent 40% of the GDP, dominated by copper, which alone represents 30% while also generating nearly one third of government income. Copper mining exploitation is led by the national company Codelco Chile. This is one of the largest mining companies in the world, and exploits some of the principal deposits in the country.

Chilean government has implemented an anti-cyclical fiscal policy, in which fiscal income obtained in isolation of the economic cycle is estimated. Public expenditure consistent with this income is subsequently determined. The surplus is accumulated in the sovereign wealth funds during periods of high copper prices and economic growth, while deficit expenditure is allowed only during periods of low copper prices and growth. This has generated a balance in fiscal accounts for more than a decade and, along with a low

6 World Fact book, Chilean Economic Overview.

7 Foreign Investment Committee, www.inversionextranjera.cl.

8 Central Bank of Chile

corruption index (the lowest corruption perception in Latin America[9]), places the State as a solid, reliable institution.

In terms of financial regulation and supervision, the Chilean market appears among the most solid in the world, particularly in banking sector, and has been developed for investment under a clear and stable legal framework. This has given Chile the reputation for having robust financial institutions of good policies, which is reflected in the fact that Chile has the best qualification of South America sovereign bonds. Furthermore, Chile shows a high level of property rights protection, and heads the Latin American region[10].

TABLE 2. GROSS DOMESTIC PRODUCT (GDP)

	1970	1980	1990	2000	2005	2008	2009	2010	Average annual growth rate (%) 2000 to 2008
GDP (millions of current US$)	8,981.1	27,572	31,559	75,211	118,250	170,741	160,859	212,741	13
GDP (millions of constant 2000 US$)	21,084	27,950	40,456	75,211	92,415	104,806	103,044	108,400	3,14
GDP per capita (PPP* US$/capita)	N/A	2,338	4,519	9,265	12,168	14,542	14,313	15,779	5,36
GDP per capita (current US$/capita)	938	2,466	2,393	4,878	7,254	10,166	9,487	12,431	11,87

* PPP: Purchasing Power Parity

Source: -World Bank World Development Indicators

-IMF World Economic Outlook Database (www.imf.org/external)

1.2. Energy Information

1.2.1. Estimated available energy

TABLE 3. ESTIMATED AVAILABLE ENERGY SOURCES

	Estimated available energy sources					
	Fossil Fuels			Nuclear	Renewables	
	Solid[1]	Liquid[2]	Gas[3]	Uranium[4]	Hydro[5]	Other Renewable[6]
Total amount in specific units*	700.00	1.13	16.75	1,034	0.02	0.012***
Total amount in Exajoule (EJ)	13.18	0.05	0.65	0.565**		

* Solid, Liquid: Million tons; Gas: Billion m3; Uranium: Metric tons; Hydro, Renewable: TW

[9] Transparency International (www.transparency.org).
[10] International Property Right Index (IPRI), (2012)

** light water reactor open cycle assumption
***CNE estimates. Includes geothermal, wind power, biomass and small-scale hydraulic energy(<20MW)
Source: Energy Policy: New Guidelines (National Energy Commission 2008)

Source:
(1), (2), (3) CNE (www.cne.cl)
(4) Reasonably Assured Resources (RAR) under < USD 130/kgU, Uranium 2007, Resources, Production and Demand ("Red Book").
(5) Hydropower: technically exploitable capability, the amount of the gross theoretical capability that can be exploited within the limits of current technology, CNE.
(6) Energy Policy: New Guidelines, CNE 2008.NCRE: potential for electricity generation.

1.2.2. Energy Statistics

TABLE 4. ENERGY STATISTICS (EJ)

	1970	1980	1990	2000	2005	2008	Average annual growth rate (%) 2000 to 2008
Energy Consumption**							
- Total	0.372	0.419	0.600	1.054	1.228	1.322	2.87%
- Solids***	0.057	0.052	0.110	0.134	0.134	0.196	4.87%
- Liquids	0.205	0.222	0.286	0.488	0.543	0.742	5.37%
- Gases	0.033	0.044	0.060	0.185	0.264	0.082	-9.63%
- Nuclear	-	-	-	-	-	-	-
- Hydro	0.015	0.026	0.032	0.069	0.095	0.087	3.06%
-Other Renewables	0.061	0.074	0.111	0.178	0.192	0.214	2.33%
Energy Production							
- Total	0.309	0.304	0.339	0.368	0.397	0.404	1.15%
- Solids***	0.046	0.027	0.064	0.011	0.012	0.012	0.96%
- Liquids	0.076	0.069	0.039	0.012	0.007	0.006	-8.99%

- Gases	0.110	0.107	0.092	0.095	0.090	0.082	-1.79%
- Nuclear	0.000	0.000	0.000	0.000	0.000	0.000	-
- Hydro	0.016	0.027	0.033	0.072	0.096	0.090	2.78%
- Other Renewables	0.061	0.074	0.111	0.178	0.192	0.214	2.33%
Net import (Import - Export)							
- Total	0.138	0.178	0.285	0.719	0.841	0.939	3.39%

** Energy consumption = Primary energy consumption + Net import (Import - Export) of secondary energy.
*** Solid fuels include coal, lignite
Source: Chilean Energy Balance (National Energy Commission – www.cne.cl)

1.2.3. Energy policy

During the last 30 years, Chile's energy policy has been based on open, competitive markets. Within this framework, the State plays a regulatory role, and its entrepreneurial activities are limited. It is presumed that the market will provide adequate security of supply[11]. However, one of the lessons of the global energy reality -- marked by the gradual exhaustion of fossil fuels, increasing concern about security of supply and problems associated with climate change -- is that the market alone is not able to address new challenges, and that a more proactive role by the State is needed to reconcile energy and competitiveness objectives with those of security and sustainability.

The State takes responsibility for assessing complex topics which require decisions that are beyond the role and responsibility of the private sector, as well as for establishing a long-term energy policy which is coherent with the overall policy for national development. This policy is explicit, clear, well-founded and widely accepted[12,] such that it can guide private investment decisions. Bearing in mind that the growth of the energy sector is strategic to Chile's development, the State has gradually taken on a more proactive role, with regard to tracking energy development, systematically assessing risks and reconciling the basic objectives of energy policy (efficiency, environmental sustainability, security of supply and equality).

In addition to local energy issues, there are a number of external challenges, particularly concerning climate change. This concern has led a number of countries to make commitments with regards to their GHG emissions and to develop policies to mitigate these emissions through direct and indirect mechanisms. The implementation of these mechanisms will affect the economic development of Chile.

11 IEA (2009a)
12 CNE (2008)

Given Chile's increasing economic and political interaction with the world, it is quite probable that Chile will not only face demands to implement emissions mitigation actions, but also to tailor its export business to reduce its “carbon footprint” to us or similar mechanisms. These scenarios present a clear example of how the energy sector can have a transversal effect on the national economy. Bearing in mind these challenges, the government has implemented a series of measures designed to promote the development of NCRE[13] and energy efficiency[14]. These measures not only address global environmental problems, but are also in line with the explicit government objectives. These objectives are to increase energy security by diversifying sources, to reduce external dependence, to increase the sustainability of the energy mix and to increase equal access to energy.

1.3. The Electricity System

1.3.1. Electricity policy and decision making process

Chilean installed electricity capacity is around 16,500 MW, while its total gross electricity generation exceeds 58,000 GWh (2011 figures). Its principal generation technologies are hydroelectric power plants, coal-fired thermal power plants and “dual” (natural gas and diesel) thermal power plants. Chile also relies on new renewable energy sources, although on a much smaller scale. The principal electricity systems are the Central Interconnected System (Sistema Interconectado Central, or SIC) and the Far North Interconnected System (Sistema Interconectado del Norte Grande, or SING) with respective installed capacities of 12,365 MW and 3,964 MW. Two other systems exist, namely the Aysén System (Sistema de Aysén, 52 MW) and the Magallanes System (Sistema de Magallanes, 100 MW).

The electricity generation matrix has evolved considerably over the last decade. During 1996 and 1997, average electricity generation was 70% hydraulic, 25% coal-based and 5% from oil and biomass sources. The importance of hydroelectricity to Chile's electricity generation creates an element of risk due to variability in hydro energy availability. Hydro generation data from the past few decades illustrates that hydro generation capacity can be three times greater in a rainy season (around 30,000 GWh) than during a dry season (around 12,000 GWh), based on current installed capacity.

13 By making legal and regulatory changes, creating tax incentives, eliminating barriers to this technology and adjusting the institutional framework (by creating the Renewable Energy Division within the Ministry of Energy as well as the Center for Renewable Energy).

14 Through a massive increase in the budgets for different measures, legal and regulatory changes, tax incentives and adjustments to the institutional framework by creating the Energy Efficiency Division in the Ministry of Energy and the Agencia de Eficiencia Energética (Energy Efficiency Agency).

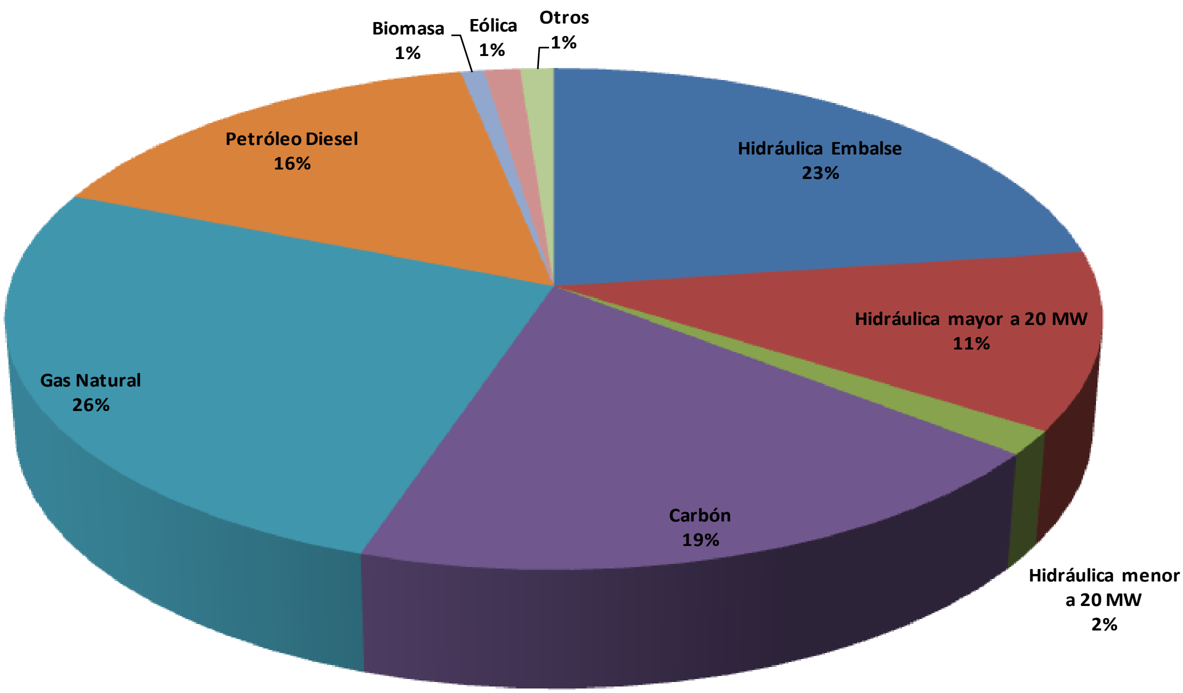

Figure 2: SIC & SING Capacity (December 2011)
Source: CNE (www.cne.cl)

Between 1998 and 2004, natural gas replaced coal-based generation (with natural gas-based generation peaking in 2001). Beginning in 2005, due to cuts in natural gas supplies from Argentina, the situation began to reverse, and coal-based generation increased.

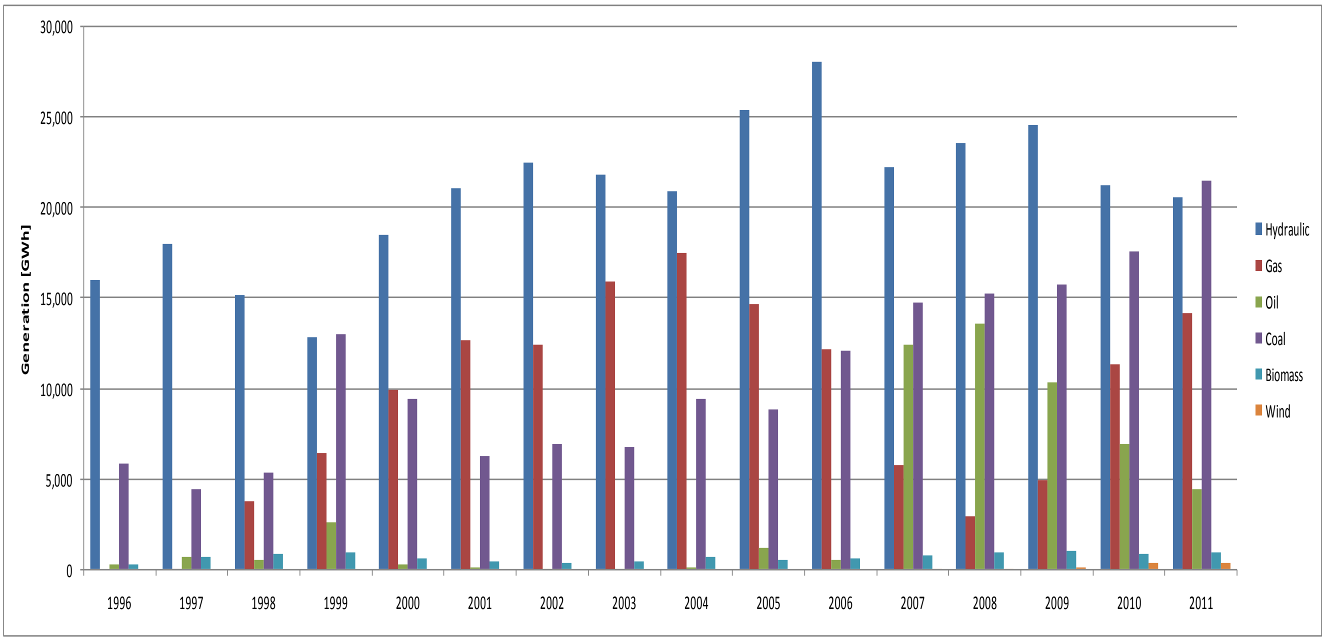

Figure 3: SIC + SING Electricity Generation
Source: CNE (www.cne.cl)

To compensate for gas restrictions and dry years, generation with petroleum derivatives, particularly diesel, was escalated. This was made possible by investments to "dualize" plants originally designed to operate with natural gas, by efforts by fuel distributors to address logistical issues and by the installation of turbines and diesel motors. Restrictions were also counteracted by a 2008 law, which established the immediate return of diesel taxes[15].

Nuclear Scenario:

The potential inclusion of nuclear electricity in the national energy mix brings with it a series of challenges which are analyzed in detail later in this report. This chapter merely assesses the economic and environmental advantages of introducing the nuclear option.

According to development projections for Chile, the SIC and SING systems (which are not connected at present) are expected to have a combined installed capacity in excess of 30,000 MW by 2030, and of close to 39,000 MW in 2035. This is based on the IAEA recommendation that a nuclear reactor should not exceed 10% of the capacity of installed electricity generation[16]. For the purposes of this analysis, 1,100 MW uranium-based models were used as these are the most common models at the present time[17].

The introduction of nuclear energy into the mix would be economically beneficial as it would enable Chile to (i) reduce generation costs by replacing coal-fired generation and (ii) further diversify the mix, thus strengthening the security of supply and stabilizing costs.

The key result from the models is that nuclear electricity generation is part of the ideal mix for Chile. Although the average current cost of nuclear generation is already more competitive than that of other forms of thermal generation[18], the model only recommends its incorporation from 2024 onwards. This apparent paradox is explained by two factors.

First, the model was restricted so that nuclear generation would only begin after 2020, because the country will not have the conditions necessary for safe implementation of an NPP prior to this date. Second, during the first years of the decade 2020, the model projects that Chile's electricity needs will be fully met by the inclusion in the matrix of renewable energy projects (mainly conventional hydroelectric, but also some small hydro,

15 Law 20,258 (March 2008): "Establishes a transitory mechanism for returning the specific tax on diesel oil to electricity generation companies".
16 If the two systems are not interconnected, the SING would not be large enough to safely incorporate the nuclear plants being considered in the model, and they would therefore only be introduced in the SIC.
17 The size range for nuclear reactors is: 800 to 900 MW, 1,000 to 1,100 MW, and around 1,600 MW. The first category includes PHWR reactors; the second includes PHWR, PWR and BWR reactors; and the third comprises mainly BWR and PWR reactors. However, the trend is towards ever larger modules. This analysis does not consider thorium reactors, because these technologies are rarely the subject of commercial development, due to the lack of available information and because they present other problems than those addressed in this document.
18 As can be seen in Table 3, for 2009 the average cost of nuclear generation is lower than that of coal, LNG and oil-based generation. As future fossil fuel costs are projected to increase, nuclear electricity generation maintains its cost advantage throughout the period.

geothermal and biomass projects). As the average cost of generation from these sources is lower than that of nuclear energy, the optimal time to bring the first plant on-line will be when the expansion of renewable energy generation (mainly hydro) is insufficient to keep pace with increasing demand. This may make it necessary to bring coal back into the energy mix by 2024. Between 2024 and 2035, five 1,100 MW nuclear plants would come into operation[19]. During this period, all the additional requirements for installed capacity would be satisfied with investment in nuclear energy and renewable sources.

1.3.2. Structure of electric power sector

In recent decades, many countries around the globe, including Chile (since 1982), have opted for economic models in which the private sector plays a central role in the provision of basic services, while the government has primarily a regulatory role.

The main policy strategy for institutional matters is described below:

- The powers related to the design of policies, legal and regulatory provisions, plans and programs become the responsibility of the Ministry of Energy, which shall govern the country's energy sector.
- The CNE (National Energy Commission) is a decentralized and independent public service in charge of technical and economic regulation of the energy sector, by means of analyzing prices, tariffs and determining the technical and quality standards that must be complied with by companies producing, generating, transporting and distributing energy, thus ensuring that a secure and adequate energy service of sufficient quality is provided in the most economical way.
- Coordination and integration of Chile's regions. The Ministry's highest authority is the Minister of Energy. Internal administration and coordination of public energy services is the responsibility of the Undersecretary of Energy.
- Coherence in the actions of energy sector public services. This sector is organized according to the structure laid out in the Organic Framework Law on Public Administration, under which definitions of policies, plans and standards in the sector are the responsibility of the Ministry of Energy. Thus, this Ministry oversees all energy sector public services. The following services report to the President of the country through the Ministry of Energy: the National Energy Commission, the Superintendence of Electricity and Fuels, and the Chilean Nuclear Energy Commission.

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19 In the event that the SIC and the SING are not interconnected, nuclear energy would still be part of the ideal development of the electricity sector, but this would only begin in 2025, and during the period in question only three units would be brought into operation (all in the SIC, of course).

- The Chilean Nuclear Energy Commission has missions to assist the Government in all affairs related to nuclear energy dealing with problems related to the production, purchase, transfer, transportation and the peaceful uses of atomic energy and of the fertile, fissionable and radioactive material. (www.cchen.cl)
- The SEC (Superintendence of the Electricity and Fuels) function is to supervise and control the fulfillment of the legal framework provisions for the generation, production, transportation, distribution and storage of liquid fuels, gas and electricity according to the technical quality framework applied to the customers (users) and to the operations and use of the energetic resources, to ensure that this is not be a risk to people or things. (Law 18410 Fuel and Electricity Superintendence – www.sec.cl)

The Chilean electricity grid has four separate systems, widely distributed throughout the country. They are Far North Interconnected System (known by its Spanish initials SING) in the north, Central Interconnected System (Spanish initials SIC) in the central and southern zone of the country, and Aysen Electrical System and Magallanes Electrical System, located in the extreme south of Chile.

The following is a brief explanation of the two main electrical systems:

- SING: The Far North Interconnected System extends from Tarapacá to Antofagasta, First and Second Regions of Chile respectively, and covers an area of 185,142 km^2 which is equivalent to 24.5% of the continental territory. It serves 6.1% of the national population, according to 2002 census.
- SIC: The Central Interconnected System of the Republic of Chile consists of transmission systems and generation plants which operate interconnected, from *Rada de Paposo* (Paposo Roadsted) in the north (Second Region of the country) to *Isla Grande de Chiloé* (Big Island of Chiloé) in the south (Tenth Region.) This system is the largest of the four electrical systems providing energy to Chile. As of December 31st, 2011, it has reached a power of 12,365 MW, and its supply coverage reaches close to 92% of population.

The electrical systems SIC and SING have independent operators called the Economic Load Dispatch Center (CDEC), denoted CDEC-SIC and CDEC-SING respectively. These CDECs have based their operation on regulatory framework and the electrical service quality standards in order to ensure correct operation of the system in terms of voltage, frequency, and dispatch of generating units at the lowest marginal cost available in the spot market.

The Electricity Sector regulatory model (1982) is a global pioneer in terms of market liberalization, allowing industry development. This model assumes that investments develop based on private initiative in response to economic signals provided by the market, and the regulations established by the authority. Reference prices for the sector are fixed twice a year. Currently, the Minister of Energy sets the tariff decrees for different segments and the expansion decrees, through the National Energy Commission (CNE.) On the other hand, an Expert Panel resolves disagreements among electricity sector companies, and between the companies and the electricity regulator (CNE).

1.3.3. Main indicators

TABLE 5. ELECTRICITY PRODUCTION, CONSUMPTION AND CAPACITY

							Average annual growth rate (%)
	1970	1980	1990	2000	2005	2008	2000 to 2008
Capacity of electrical plants (GWe)							
- Thermal			1.42	5.62	7.23	8.17	4.80%
- Hydro			2.36	4.04	4.72	4.94	2.54%
- Nuclear							
- Wind					0.01	0.02	-
- Geothermal							
- other renewable							
- Total			3.78	9.66	11.96	13.14	3.92%
Electricity production (TW.h)							
- Thermal			9.46	19.13	23.14	31.31	6.35%
- Hydro			8.92	18.88	25.92	23.77	2.92%
- Nuclear							
- Wind					0.01	0.04	-
- Geothermal							
- other renewable							
- Total (1)			18.37	38.01	49.07	55.12	4.75%
Total Electricity consumption			15.43	36.60	45.28	50.87	0.0000?

TW.h)							

(1) Electricity transmission losses are not deducted.
Source: - Balance Nacional de Energía (www.cne.cl)
- Statistic National Institute (www.ine.cl)
- Load economical dispatch center (www.cdec-sic.cl and www.cdec-sing.cl)

TABLE 6. ENERGY RELATED RATIOS

	1970	1980	1990	2000	2005	2008
Energy consumption per capita (GJ/capita)	38.83	37.50	45.52	68.45	75.51	78.86
Electricity consumption per capita (kW.h/capita)	N/A	N/A	1,171.0	2,376.8	2,783.4	3,034.3
Electricity production/Energy production (%)	N/A	N/A	19.50%	37.10%	44.45%	49.10%
Nuclear/Total electricity (%)	-	-	-	-	-	-
Ratio of external dependency (%) (1)	37.20%	42.39%	47.58%	68.25%	68.46%	71.05%

Source: - Balance Nacional de Energía (www.cne.cl)
- Statistic National Institute (www.ine.cl)
- Load economical dispatch center (www.cdec-sic.cl and www.cdec-sing.cl)

2. NUCLEAR POWER SITUATION

2.1. Historical development and current organizational structure

2.1.1. Overview

In March 2007, President Michelle Bachelet established a working group (also known as the Zanelli Commission) to assess whether nuclear energy would be an option for Chile. The group consisted of ten independent professionals from academia, the business sector and government, with diverse backgrounds and no prior positions regarding nuclear energy or representing any interest group. The main conclusions of the group were that there are no reasons to discard the nuclear option for Chile, but that further studies need to be performed before making any decisions.

By the end of 2007, the president charged the Minister of Energy with continuing the work of the Zanelli Commission, and making all advances needed to enable the country to make a decision on whether to develop the national infrastructure required to produce nuclear power.

In 2008 the Minister of Energy established the Nuclear Advisory Group (Grupo Consultivo Nuclear, or GCN) to deliver the mandate, which has directed a series of activities to determine whether it is advisable for Chile to adopt a Nuclear Power Program (NPP). The GCN had the permanent support of a work team.

During 2008, four studies were awarded through international public bidding and completed that same year. In 2009 four more studies were developed following the same process.

In December 2009 an IAEA Verification Mission, made up of four experts, reviewed the self-assessment exercise performed so far. The purpose was to determine if Chile was working in the right direction, and to provide feedback to prepare for an INIR Mission which would visit the country in late 2010. The Verification Mission sent by the IAEA concluded that the self-assessment exercise was complete, well-prepared, and complies with IAEA recommendations.

In March 2010, the Nuclear Advisory Group (GCN) issued a report for the President, summarizing the work performed so far before the change of the government.

In March 2010, a new government also came to power. This new government has announced that, during their period, they will not take any decisions regarding implementing a NPP, but that they will continue studying this option in close cooperation with the IAEA.

Since 2010, two important events have taken place that have impacted negatively on national plans for implementing a NPP: Chile's 8.8 earthquake (2010) and Japan's earthquake and Fukushima accident (2011). These two events increased public awareness of the highly seismic characteristic of our country and the fear that we may not be prepared enough to withstand these kinds of events.

Even though the government has announced that they will not take a decision either for or against implementing nuclear power and that they will continue study into the option, the pace has slowed down significantly. However, some specific areas of work have been identified as crucial and been given priority. These are: reviewing available nuclear reactor technologies, site selection, environmental protection, electrical grid and public opinion. Some budget allocations have already been made in order to hire external consultants to perform some studies on the first two topics. These studies are expected to be concluded by 2013.

2.1.2. Current organizational chart(s)

No official organization has yet been nominated to address the issues of nuclear infrastructure.

2.2. Nuclear power plants: Overview

Not applicable

2.3. Future development of Nuclear Power

2.3.1. Nuclear power development strategy

a. Main strategic decisions:

During the past 4 years, the country has been evaluating the 19 issues, as stated by the IAEA guidelines, in order to analyze and assess the option of nuclear power for Chile. A series of activities has been taken place within this framework, including scientific visits, visits by international experts and technical studies intended to clarify some key aspects of nuclear power generation in Chile.

Now, in the light of the post-Fukushima scenario, the work has been narrowed and focused on the 5 topics previously mentioned: review of technology options and fuel cycle, site selection, environmental protection, electrical grid and public opinion.

b. Technology:

For assessing the nuclear-power energy option for Chile, only proven technologies are being considered, meaning technologies that have been applied to a significant number of reactors and that have impeccable records from operational and safety perspectives. A general recommendation for newcomers is that experimenting with new technologies is not appropriate. This decision will allow greater levels of safety to be objectively guaranteed for the reactors. Similarly, obtaining public support becomes extremely complex if the decision is made to implement technologies that have not been widely used.

c. Project framework (time scales, number of units, etc.).

There is no a set framework for developing the project. The emphasis will be on 5 main topics: review of technology available, site selection, environmental protection, electrical grid and public opinion. Additionally CCHEN should keep being informed of international developments and should working closely with IAEA.

d. Type of contract (Turnkey, Split Package, Multi Packages).

The turnkey approach is being considered. However, local participation is expected in some non-critical areas, such as materials, civil works, services, engineering, design and management.

e. Application of nuclear power: electricity supply, heat supply, water desalination

To be decided.

f. Policy for nuclear fuel cycle

Regarding the fuel cycle, a series of decisions need to be taken in order to keep the analysis focused on the technical, economic and environmental viability of incorporating nuclear energy into the Chilean electricity grid. These decisions take both the international context and current Chilean electrical capacities into account. Even when more studies still need to be performed, we can foresee that the country is likely to implement the following:

(i) Open Fuel Cycle: Abstaining from both sending fuel to be reprocessed and from developing its own capacity to do so. This takes into account the international community's concerns regarding proliferation, as well as the fact that reprocessing is not economically viable for small-scale programs.

(ii) Fuel supply: Chile only has the ability to build fuel elements for research reactors, not yet for nuclear power reactor. Regarding uranium mining, although uranium deposits have been found and there is a pilot project in place to extract uranium from copper mining waste, this still remains a pilot project.

2.3.2. Project Management

A formal NEPIO has not been created, and it has been decided not to do so before a formal decision to construct a NPP has been made. Currently, there is a working group composed of a team from the Chilean Nuclear Energy Commission (CCHEN) and from the National Energy Commission (CNE). The CCHEN team is in charge of leading the work, working directly with IAEA and proposing new studies to the Ministry.

2.3.3. Project funding

Some funding has been allocated for performing studies on site selections and for technology and fuel cycle assessment. Additionally, there is some funding considered for education and training in order to prepare people to help evaluate the best options for a future NPP.

2.3.4. Electric grid development

The self-assessment process performed by the country for studying and analyzing the feasibility of the nuclear option has, with the help of the International Atomic Energy Agency, allowed the development of several studies aimed at identifying existing gaps in Chile in the 19 issues including the electric grid.

The electric grid analysis has been performed jointly by the National Energy Commission and the Chilean Nuclear Energy Commission. These institutions have been developing projects of energy projections for the long term, using IAEA models, elaborating on studies related to the identification of modifications needed by the electrical regulation, and elaborating on an action plan regarding additional studies in order to conduct an analysis of the reliable and stable connection of nuclear units to the grid.

Among the activities performed, we can highlight the following:

- The “Electrical Regulation” study in order to identify the barriers facing the entry of nuclear power generation into the Chilean electrical market and to analyze implication for the market. The results of this first study showed that electrical regulations need to be modified under the General Law of Electrical Services, Technical Regulation of Service Safety and Quality, Internal Rules for CDEC Operators, and Manuals for CDEC Procedures, integrating general safety aspects of the nuclear plants and coordination between the nuclear regulator and the institutions in charge of operating the electrical system.
- The first “National Workshop on Electric Grid Reliability and Interface with Large Generation Units” was held on December 2011, with the participation of professionals related to electrical market, from CDEC operators to representatives from electrical regulator authority CNE, universities and Chilean Nuclear Energy Commission. The objective was to introduce information from a technical perspective about the operation of nuclear power plants and about interaction between the NPP and the grid, and to get some feedback from the experts in order to evaluate the work performed so far and the feasibility of introducing a NPP into our electrical grid.

As an action plan developed through the self-assessment process, a series of matters were identified that need to be analyzed and studied, for the technical feasibility of the operation of a first commercial nuclear unit (possibly 1000 MWe). These include the dynamic analysis of the electric grids in the main electrical systems of the country (SIC and SING), incorporating nuclear energy into both and using both the current and projected future scenario, in order to assess the stability of possible connection points.

Every four years, the electrical market regulatory authority (CNE) presents a proposal to expand the trunk grid of the electrical system. This proposal is adopted in the sector's work plan and assessed annually by CDEC operators, with regard to demand evolution and system capacity. In this context, there has been a proposal within the action plan of making a study of grid expansion in the long term, in order to project the structure and topology that the grid shall have with the connection of nuclear units.

2.3.5. Site Selection

At this time, no potential sites have been identified for the location of nuclear power plants in Chile.

A first study was performed in order to assess natural hazards such as earthquakes and surface faulting, tsunamis, flooding, geotechnical issues, and volcanism. Based on the results of those studies, the need for further information for future site studies was identified.

A second study will be performed in 2012. This will be a site survey and screening, in order to select potential sites.

The selection of the final site will be made only once the country has made the definite decision to launch a nuclear power program.

2.4. Organizations involved in construction of NPPs

Not applicable

2.5. Organizations involved in operation of NPPs

Not applicable

2.6. Organizations involved in decommissioning of NPPs

Not applicable

2.7. Fuel cycle including waste management

Chile has no nuclear power reactors. However, based on identified local restrictions, the government has set out a series of strategic definitions and guidelines in case of the undertaking of a nuclear power program. These guidelines and definitions consider the adoption of an open fuel cycle, importing the fuel from abroad, and the purchase of the first "turnkey" power plant. This means that, during the preliminary phase, Chile will not need to make any decisions on developing or acquiring technology for the extraction of fuel elements, conversion or fabrication stages, despite having experience in some of these areas due to the work developed for research reactors.

In Chile, there are two research reactors, managed by the Chilean Nuclear Energy Commission (www.cchen.cl), which have boosted the nuclear fuel cycle development in the country and encouraged complementary activities that allow for the safe operation of nuclear facilities.

Front-end and back-end stages developed in CCHEN for research reactors include:

a. Uranium Exploration and Reserves

To date, nearly 7% of the national territory has been prospected using geochemical, radiometric-geological, aeroradiometry, analytic, and metallurgic prospecting techniques in order to look for natural atomic material[20] and for material of nuclear interest[21]. More than 1,200 radiometric and geochemical abnormalities have been detected, of which 80 occurrences of Uranium and Thorium have been studied. These studies created 10 prospects of uranium, thorium and rare earths, with 70 further sectors of interest requiring more studies. A detailed summary of main exploration projects can be found in the Red Book [3].

b. Extractive Metallurgy

Through its Section of Extractive Metallurgy, CCHEN has developed the necessary knowledge and skills to produce nuclear purity uranium ore concentrate (UOC), which is the raw material for the conversion stage. The knowledge acquired by the Section in obtaining, concentrating and purifying uranium, found in natural minerals, is used to research and/or develop processes applicable to national mining.

c. Conversion

The conversion process from UF6 to metallic uranium has been developed. This process has 3 stages:

i. Obtaining UO_2F_2 through hydrolysis of UF_6
ii. Obtaining UF_4 through UO_2F_2 reduction, by adding $SnCl_2$ and hydrofluoric acid.
iii. Obtaining metallic uranium through metal-thermal reaction of UF_4 with powdered magnesium, Mg.

[20] Uranium and thorium
[21] Zirconium, niobium, titanium, hafnium, beryllium, cadmium, cobalt, lithium, heavy water, helium, gadolinium, uranium and thorium

Currently, the Conversion Laboratory is studying alloys of Uranium-Molybdenum for its use as fuel for research reactors, in order to obtain a reduction greater than 20% of 235U required for the reactor's operation.

d. MTR fuel elements fabrication

The Fuel Element Plant (known by its Spanish initials PEC) began operation in 1982, with laboratory research into the necessary technologies for fabricating nuclear fuel. Nowadays, the PEC fabricates fuel for MTR research reactors. This fuel is used in the first Chilean research reactor RECH-1.

It is noteworthy that Chile is one of the 5 acknowledged manufacturers of this type of fuel, and it is qualified under international standards by the Peten High Flux Reactor (HFR) in the Netherlands, within the framework of the contract signed among CCHEN, NRG (Nuclear Research and Consultancy Group) and the IAEA.

e. Spent fuel Management[22]

Operating RECH-1 under normal conditions generates 3 to 4 spent fuel elements per year, which need to be managed in an adequate manner. Today, spent fuel is stored in situ in RECH-1 pools and continuously monitored, maintaining the pool water quality. The pools have enough capacity to store spent fuel for at least 30 years, and therefore long-term strategies have not been established as of yet.

Spent fuel is transported to the USA after cooling in the reactor's pool. A total of 129 high-enriched fuel elements (40 elements of 45% of 235U, 58 of 80% of 235U, and 31 of 90% of 235U), fabricated in UK and France, have been shipped. This management is part of the "Global Threat Reduction Program", promoted by the US Department of Energy (DOE), according to the technical acceptance criteria of the "Research Reactor Spent Fuel Acceptance Program of the USA".

Fuel elements currently in use in RECH-1 are low-enriched and fabricated from Russian fuel in the Fuel Element Plant (PEC). The final disposal of these elements shall be in Chile, and there are no plans for spent fuel reprocessing. These elements will change the current scope of radioactive waste management, as they will introduce the long-term management of high level waste to the country.

f. Policy for ultimate high level waste disposal[23]

[22] National Diagnosis Regarding Radioactive Waste: Current Status and Projections. CCHEN, 2009.
[23] National Diagnosis Regarding Radioactive Waste: Current Status and Projections. CCHEN, 2009.

Chile has asked the IAEA for support and has participated in technical cooperation projects aimed at defining a generic methodology to manage spent fuel elements of research reactors, in accordance with other countries in the region (Argentina, Brazil, Mexico and Peru). Among these initiatives, projects RLA/4/018, RLA/3/004 and RLA/4/020 were developed.

In general terms, the work focused on defining the basic conditions for a strategy of regional management of research reactor spent fuel, focusing in particular on determining the needs for interim storage of waste in participant countries. Chilean experts assessed several interim storage options for spent fuel from both research reactors and finally chose dry storage. Thus, the expected management of burned fuel is interim storage in pools followed by subsequent dry storage. To comply with this, a facility gathering the required safety conditions for these storage arrangements shall be needed for some decades, prior to making decisions about final confinement of spent fuel. As a result of these projects, Chile is working on the conceptual design of interim dry storage containers for the MTR spent fuel.

Finally, CCHEN has been working with the Swedish company SKB, studying copper's resistance to corrosion and its use as material for high level containers. In order to do this, studies aimed at determining copper's corrosion rate were developed, simulating the real environmental conditions undergone by containers in repositories, including temperature, sulfide content, water chemistry, and especially salinity.

2.8. Research and development

2.8.1. R&D organizations

Peaceful applications of both nuclear energy and ionizing radiation represent a major contribution to the development of nations. The varied fields which benefit from their use include health, industry and mining, agriculture, environment, and food industry.

The Chilean Nuclear Energy Commission (CCHEN) is the State institution responsible for development, applications, regulation and inspection of nuclear energy-related activities in our country. It is required to implement action aimed at providing answers within a wide range of activities in many different fields.

CCHEN works on the basis of a series of objectives and strategic products, with committed goals and results established on a yearly basis with various government entities. This implies major work involvement, in terms of planning and management control, to ensure that our institution will achieve said goals and results.

Within the functions assigned to CCHEN by current legal regulations, nuclear and radiological safety as well as radiological and environmental protection play an important role. To attain its goals in this area, CCHEN has sections in charge of managing radioactive waste, responding to radiological emergencies, and rendering personal dosimetry services for workers exposed to ionizing radiation in their work places.

CCHEN is a supplier of the radio-isotopes and radio-pharmaceutical products used for diagnosis and treatment. Moreover, it contributes to the treatment of burns through the biological tissue bank and renders blood irradiation and medical-surgical product services. It is also involved in radiological and environmental vigilance in collaboration with diverse institutions across the country.

The above commitment includes calibration of radio-therapy and radio-diagnostic equipment used in nuclear medicine, to ensure flawless operation that protects the patients as well as the professionals involved in treatment.

The industry sector also benefits from peaceful applications of nuclear energy, through studies using radioactive tracers that contribute to improve process efficiency. In a different sphere, nuclear densimeters are being used more frequently, to conduct measurements ensuring the quality of certain products.

Development in the manufacturing of fuel elements for use in the research nuclear reactor located at CEN La Reina (RECH-1) represents a major step in the progress of nuclear technology in Chile. Fine-tuning of this technology has been the result of years of study and testing which, in addition to contributing to technological development, has led to savings in foreign currency by making Chile self-sufficient in this area.

In terms of basic research, major progress has been achieved in the study of plasma physics and so-called “pulsed power”. The work carried out in this field by our professionals is of utmost relevance within a global context.

Technical cooperation and international relations play important roles in all of the above through the International Atomic Energy Agency (IAEA). CCHEN is in charge of representing Chile in everything related to international technical cooperation, both in training and joint projects with several institutions, financed by the IAEA.

CCHEN is equipped with numerous facilities, equipment, and trained personnel to carry out these activities.

a. CHILEAN NUCLEAR ENERGY COMMISSION – CCHEN

The purpose of the CCHEN, established by law, is to address problems related to production, acquisition, transfer, transportation, and peaceful use of atomic energy and of fertile, fissionable, and radioactive material.

Its mission has been to engage in Research & Development, including that of applications of nuclear energy, and its regulation, control, and inspection. CCHEN thus provides both technological and research and development services to external sectors, such as Ministries, State institutes, Public and Private Enterprise, Universities, and Educational establishments. This is designed to achieve effective contributions to scientific and technological knowledge, to the well-being and safety of persons, and to protection of the environment.

CCHEN is directed and managed by a Council of Directors, consisting of seven members, which delegates some of its administrative functions to an Executive Director

CCHEN is regulated by Law No.16,319/1965, the Organic Law of CCHEN (Ley Orgánica de la CCHEN), which establishes the institution's main functions, and by Law No.18,302/1984, as amended by Law 19,825/2002 on Nuclear Safety, which confers to CCHEN the character of regulatory organism for nuclear and category-one radioactive facilities.

a. CCHEN's FUNCTIONS

The law establishes seven functions of CCHEN:

i. To advise the government in all matters relating to nuclear energy, and in particular relating to the study of treaties and agreements with other countries or with international organisms, and to contracting loans or help for the above purposes; to advise in the study of legal or regulatory provisions related to the ownership regimen applicable to ore bodies and to fertile, fissionable, and radioactive material; and to advise on the dangers of nuclear energy and other matters in its charge;

ii. To prepare and propose to the government the national plans for research, development, use and control of nuclear energy in all its aspects;

iii. To execute, either on its own or in agreement with other persons or entities, the plans referred to in item b);

iv. To promote, undertake or investigate, as applicable and in compliance with current legislation, exploration, exploitation, and processing of natural nuclear material, commerce involving said material already extracted and concentrates, derivatives, and compounds of the same, stockpiling of material of nuclear interest, and production and utilization of nuclear energy in all its forms for peaceful ends, among them its application for medical, industrial, or agricultural purposes, as well as for generation of electrical and thermal energy;

v. To promote learning, research and dissemination of the use of nuclear energy;

vi. To collaborate with the National Health Service in prevention of risk inherent to the use of nuclear energy, especially in the areas of occupational hygiene, industrial medicine, environmental pollution and contamination of food and air. CCHEN must maintain an effective risk control system for the purposes of protecting its own personnel, and in order to prevent and control possible environmental pollution problems within and around its nuclear facilities;

vii. To exert, as determined by regulations, control of production, acquisition, transportation, import and export, use, and handling of fertile, fissionable, and radioactive elements;

viii. On an annual basis, the Commission must provide the Mining, Economy, and Commerce Commission of both branches of Congress with an executive summary reporting on development of all its activities.

b. INFRASTRUCTURE

CCHEN has constructed and operates a US$ 200 million scientific-technological infrastructure, which is unique in the country and consists of three facilities.

i. Headquarters

The building which houses CCHEN's central offices is located at Amunátegui No. 95, commune of Santiago. This building houses the offices of the President, Executive Director, plus the following offices and units:

- Judicial
- Planning and Management Control
- Assistant Management Department
- Technical Cooperation and International Relations
- Public Information and Promotion
- Auditing

ii. La Reina Nuclear Studies Center

The “La Reina Nuclear Studies Center” is located at Av. Nueva Bilbao No. 12,501, Las Condes (Eastern Sector of Santiago.) including:

- A nuclear research reactor, referred to as RECH-1 (Chilean Experimental Reactor Number 1.), used for preparation of radioactive isotopes and to conduct various physical-chemical studies of material.
- An 18/9 Cyclone cyclotron, used for preparation of Fluor, sodium fluoride, and for research and development of new radio-pharmaceutical drugs.
- A pulse power generator, referred to as Speed 2, used for research and development of thermonuclear plasmas.
- Three Cobalt-60 and Cessium-137 radiators, of great use for irradiation of human blood for transfusions in immunosuppressed patients, among various other applications.
- Laboratory for Production of Radio-isotopes and Radio-pharmaceutical Drugs
- Neutron Activation Analysis
- Environmental Radioactivity
- Radio-medicine
- Radioactive Tracers
- Environmental Isotope Laboratories
- Nuclear Techniques in Agriculture
- Personal Dosimetry
- Physical Characterization
- Plasma Physics
- Biological Tissue Processing
- Chemical metrology and Ionizing Radiations
- Workshops

Currently, a complete retrofit of the Laboratory for Production of Radio-isotopes and Radio-pharmaceutical Drugs is being performed, with an estimated budget of 1.5 million dollars. The new laboratory is expected to be ready during the first semester of 2013.

iii. Lo Aguirre Nuclear Studies Center

The “Lo Aguirre Nuclear Studies Center” is located on kilometer 20 of Route 68, going to Valparaiso, including:

- A nuclear research reactor, referred to as RECH-2
- The Radioactive Waste Management Unit. This is where radioactive waste produced by CCHEN and by external entities is treated and also stored.

- A Multi-purpose Radiation Plant, capable of continuous, semi-industrial sterilization-processing of various products, such as foods and raw materials.
- A Fuel Elements Plant, where the basic structures for spent nuclear fuel used by CCHEN's nuclear research reactors are prepared.

2.8.2. Development of advanced nuclear technologies

The department of Thermo-nuclear Plasmas began operating at CCHEN towards the end of 1993. Its current line of work is centered on plasma physics in small devices, in which basic science problems in plasma physics that are of relevance to nuclear fusion are studied, such as the dynamics and stability of dense plasmas produced by electrical discharges.

At the same time, the study and development of technologies associated with a field of research referred to as pulsed power is being promoted. These technologies have applications in several fields of science and engineering, such as production of transient electronic discharges, generation of radiation and bundles of ions, high-density matter, production of intense pulsating magnetic fields, and shock waves.

What is being done	Achievements	Contributions to Chile
PLASMA PHYSICS SPEED-2 Pulsating radiation generator, the most powerful in the Southern Hemisphere. (2.4MA, 400ns) Developed by the Department: • PF 400J (130kA, 300ns) • PF 50 J (50kA, 150ns) • Small multipurpose pulse power generator (180kA, 300ns) • PF-2J (10kA,	Transient electrical discharges. Ionization processes in hollow cathode discharges. VUV radiation from capillary discharge. Transient studies in Z-pinches: gas embedded and wires array. Miniaturized Plasma Focus as non-radioactive sources of	Generation of highly advanced knowledge. Experimental center of nationally and internationally acknowledged excellence, an acknowledged leader in small-device plasma physics. Undergraduate and graduate education of professionals. Projected industrial application of miniaturized devices (detection of antipersonnel mines, among others).

60ns) • Nanofocus NF 0.1 J (5kA, 16ns)	neutrons and X-rays for field applications.	Research network: Center for Application in Plasma Physics and Pulsed Power Technology.

2.8.3. International co-operation and initiatives

Chile seeks to participate actively in international energy organizations, recognizing the importance of international bodies for understanding and regulating Chile's increasingly interdependent economic and social processes.

The government effectively coordinates its participation in international arenas in order to add to its store of public knowledge and to provide key agents with information that can improve both public and private decision-making. To enhance the analysis of Chilean energy policies, closer ties have therefore been forged with major players, such as the International Energy Agency (IEA), the International Atomic Energy Agency (IAEA), the Asia Pacific Economic Cooperation (APEC) forum and the International Renewable Energy Agency (IRENA).

Chile also participates actively in regional entities that analyze, coordinate and design energy policies, including the Latin American Energy Organization (Organización Latinoamericana de Energía, or OLADE), the Energy Experts Group of the Union of South American Nations (Union de Naciones Sudamericanas, or UNASUR), the Commission for Regional Energy Integration (Comisión de Integración Energética Regional, or CIER), the Ibero-American Association of Energy Regulators (Asociación Iberoamericana de Entidades Reguladoras de la Energía, or ARIAE) and the Mercosur Energy Subgroup. Chile is also a member of APEC's Energy Working Group.

In the nuclear field, CCHEN's interaction with external entities, national as well as international, is carried out by the institution's Technical Cooperation and International Relations Office, which coordinates cooperation within the topic of nuclear energy in the country with direct support from the IAEA. The Technical Cooperation Unit coordinates participation of CCHEN officials and of other national entities in training activities abroad. It also coordinates training in Chile of international trainees, sponsored by the IAEA.

CCHEN also contributes its professionals for participation in congresses and international scientific meetings, where they disseminate information on its current work in the areas of research and development and in the area of peaceful applications of nuclear energy.

Between 2008 and 2011, thanks in part to the IAEA's Technical Co-operation Programme (TCP), Chilean professionals participated in 4 interregional projects, 34 regional projects, 18 of which were sponsored by the ARCAL agreement (Regional Cooperation Agreements for Latin America and the Caribbean), and in 6 national projects. The assistance approved and provided to Chile by the IAEA's TCP, between 2008 and 2010, amounted US $ 3.1 Million.

CCHEN manages the Technical Co-Operation offered to Chile by the IAEA, generating infrastructure and specialized technical competencies for the resolution of national problems.

BODY	BENEFICIARY ORGANIZATIONS	IAEA * CONTRIBUTIONS TO CHILE
The Office of Technical Cooperation and International Relations functions as a link between CCHEN and IAEA.	**National Institutions that benefit through IAEA's technical cooperation program:** CCHEN, Institute for Nutrition and Food Technology, Public Health Institute, Water Management Office, Agriculture and Livestock Service, National Agricultural Engineering Institute, Metropolitan Sanitary Works Company, Environmental Health Service, National Environmental Commission. **Universities:** Universidad de Chile, Pontificia Universidad Católica de Chile, Universidad Austral de Chile, Universidad de Concepción, Universidad de la Frontera, Universidad de Antofagasta, U de La Serena **Hospitals:** José Joaquín Aguirre, San Juan de Dios, Salvador, Clínico Pontificia Universidad Católica de Chile, Fundación	**Since 1976 up to 2011** **117** national projects completed. **110** regional and inter-regional projects completed **Between 2008 and 2011**: **6** active national projects. **38** active regional and interregional projects Contribution of MUS$ 3.1 by IAEA for project development. **119** foreign expert missions. **335** Chilean professionals participated as international(85) and national(21) experts, and as meeting participants (229) **50** fellowships and **29**

	Arturo López Pérez, Instituto del Cáncer, Posta Central, Hospital Regional de Valdivia. **Clinics:** Alemana, Instituto de Radiaciones Médicas, and others.	scientific visits granted to Chilean professionals. **58** foreign fellows and scientific visitors trained in Chile

**** IAEA Country Profile and TCPRIDE (April 13, 2012)***

IMPACT OF TECHNICAL COOPERATION IN THE NUCLEAR FIELD

PROJECTS	BENEFITS
Introduction of radio-therapy and nuclear medicine into the country.	Currently 200,000 patients per year. Higher life expectations, reduction in the mortality rate and better quality of life. Activity began in the mid-70s.
Eradication of the fruit fly in Chile, via nuclear techniques. (Agriculture and Livestock Service, Food and Agriculture Organization, International Agency Energy Atomic)	Chile declared “fruit-fly free” in 1995. The fly was eradicated from Arica in 2004. Export of Chilean fruit totaled US$ 1,226 million in 1996, reaching US$ 2,144 in 2005.
Characterization of copper minerals in underground mining (Institute for Innovation in Mining and Metallurgy, IM-2, CCHEN, IAEA.)	Makes it possible to measure in-situ copper resources in underground mine craters, mine disposal sites, and dump-leaching operations. At El Teniente Division of Chilean Copper Corporation, it is estimated that the economic impact of this project amounts to 5% of VAN of that Division, i.e., MUS$ 30.
Radio-analyses, detection and quantification of marine toxins (red tide). (Universidad de Chile, National Fishing Service.)	Decreased red tide mortality rate as a result of early alerts. (From 1972 to date, 29 persons have died from that cause.)
Stable isotopes in human nutrition (INIA, CCHEN, IAEA).	Measurements of consumption and use of vitamin and mineral supplements in national nutrition programs. Measurement of effectiveness of food fortification programs.

2.9. Human resources development

In Chile, human resource development in the nuclear field has focused mainly on the two research reactor facilities in the country. Until now, this strategy of training has occurred through agreements with institutions in foreign countries such as England, the United States, Argentina and Spain. Since 1965, the Chilean Nuclear Energy Commission (CCHEN) has been dedicated to the research, development and transfer of peaceful applications results of nuclear energy. Since its beginnings, CCHEN has taken the responsibility for training its professionals at PhD, Masters, and technical levels, in different areas related to nuclear energy, radiation protection and radioactive waste management.

When Chile officially decides to start a Nuclear Power Program, it will be necessary to have a constant flow of prepared human resources, but as the country has not taken any decision yet, preparing these human resources is not an immediate priority. However, the country is currently involved in preparing and training people to help in the process of making this decision and to be able to advise the government on best technologies and procedures for a future NPP.

2.10. Stakeholder Communication

The Chilean Nuclear Energy Commission (www.cchen.cl) is the institution in charge of interacting with stakeholders concerned in the country’s current situation in the nuclear field. One of its roles is to spread information about nuclear energy uses, a task carried out by the Public Information and Promotion office by means of presentations, seminars, visits to nuclear and radiological facilities, and through its website.

It is worth noting that communication with stakeholders meets the current needs of the country and its two research reactors, but that a strategy for communication with stakeholders regarding a possible nuclear power program has not yet been implemented. At present, Chile is moving forward in identifying the most important actors and ways of interacting with them, in case of a possible decision on a nuclear power plant.

3. NATIONAL LAWS AND REGULATIONS

3.1. Legislative framework

3.1.1. Regulatory authority(s)

Article 2 of the Nuclear Safety Law (Law No. 18,302) establishes that the regulation, supervision, control and inspection of activities related to the peaceful uses of nuclear energy, facilities and nuclear substances correspond to the Chilean Nuclear Energy Commission (CCHEN) and the Ministry of Energy, where appropriate.

Article 4 of the same law indicates that for site exploration, construction, commissioning, operation and decommissioning of the facilities, plants, centers, laboratories, establishments and nuclear equipment, the authorization of the Chilean Nuclear Energy Commission will be needed. On the other hand, nuclear power stations, enrichment plants, reprocessing plants and the permanent storage of radioactive waste will be authorized by supreme decree, through the Ministry of Energy.

Of the two regulatory bodies for nuclear facilities, the Ministry of Energy has the responsibility of licensing the facilities covered by the Convention on Nuclear Safety. This Ministry depends directly on the central government. The Chilean Nuclear Energy Commission reports to the government through the Ministry of Energy.

The authorities on radiation protection are the following:

- CCHEN in its own facilities and those relevant installations defined in the decree law No. 133/84, and
- The Health Ministry through its regional offices defined in the decree law No. 133/84.

The promotion and use of nuclear energy (Law No. 16,319) created by the Chilean Nuclear Energy Commission, functions to foment, perform or investigate the exploration, exploitation and the benefit of natural atomic material, its trade and its production and use with peaceful aims, for nuclear energy in all its forms.

As part of the studies related to the decision to launch a nuclear power program in Chile, the independence of the regulator is being considered a key issue.

Two draft laws have been delivered to the authority, one related to improving the actual Nuclear Safety framework and the other proposing the separation of the promotion roles from the regulatory one that either CNEC or MoH hold at present. This new situation might be reflected in a unique Regulatory Council of Nuclear and Radiological Safety and Physical Protection.

3.1.2. Licensing Process

Nuclear Power

Chilean regulations do not establish a procedure to grant licenses, other than mention in the Nuclear Safety Law that nuclear facilities require a site, construction, commissioning, operations and a decommissioning license.

Nuclear Research Facilities

The Nuclear Safety Law establishes that nuclear facilities require a site, construction, commissioning, operations and a decommissioning license. CCHEN internal standards are applied. These standards are currently under a revision process.

3.2. Main national laws and regulations

The hierarchy status of the legal documents in Chile is as follows:

1° **National Constitution**:	Approved by the National Congress by qualified quorum.
2° **Constitutional Laws**:	Approved by the National Congress by qualified quorum.
3° **Laws**:	Approved by the National Congress by simple majority and have power over the other legal national instruments (except over National Constitution and Constitutional Laws).
4° **Decrees**:	Approved by the Executive. They are issued when the National Congress delegates to the Executive the faculty to regulate matters that have to be included in a law (that should be issued by the National Congress). This faculty is given by the National Congress through a law. They have the same power as a law.
5° **Supreme Decrees**:	Approved by the Executive. They are proposed by the Ministries. Usually, the National Congress, through a law, designates the Ministry that has to propose this type of instrument. They have less power than a law or a decree law.
6° **Norms**:	Issued by the Regulatory Authority.

3.2.1 Main National Laws

The legislative framework applicable to nuclear facilities in Chile is defined by the following Laws:

a) LAW No. 18,302 - NUCLEAR SAFETY LAW, published in the Official Gazette No. 31,860 of May 2, 1984. This law consists of six titles, that is:

   i. TITLE I - REGULATORY AUTHORITY, in which the different regulatory bodies and their jurisdiction fields are defined.
   ii. TITLE II - DEFINITIONS
   iii. TITLE III - NUCLEAR SAFETY, in which the general approach related to nuclear safety is established, including authorizations and their requirements to operate a nuclear facility.
   iv. TITLE IV - INFRACTIONS TO THE LEGAL AND REGULATION REQUIREMENTS ON PROTECTION AND NUCLEAR SAFETY, which establishes the sanctions that can be applied in case of non-compliance.
   v. TITLE V - CIVIL RESPONSIBILITY FOR NUCLEAR DAMAGE, which establishes the amount and the modes of insurance to cover nuclear damage.
   vi. TITLE VI - RADIOACTIVE FACILITIES, which establishes the competent authority for the control of the radioactive facilities and responsibility for the preparation of the associated rules applicable to these facilities.

b) LAW No. 18,730 - MODIFIES THE NUCLEAR SAFETY LAW, published in the Official Gazette No. 33,143 of August 10, 1988. This law only modifies the Title VI of the previous Law, with regard to the competent authority for the control of the radioactive facilities. The Chilean Nuclear Energy Commission is incorporated as competent authority for the control of the facilities of the first category, as established in the Decree Law No. 133, indicated later on.

c) LAW No. 19,825 – MODIFIES THE NUCLEAR SAFETY LAW, published in the Official Gazette of October 1, 2002. This law mainly modifies Title III of the previous Law, with regard to the competence of the Chilean Nuclear Energy Commission (CCHEN) as competent authority for the control of transportation of radioactive material in or through the exclusive economical zone, “presential sea” and national air space.

d) LAW No. 20,402 – MODIFIES THE NUCLEAR SAFETY LAW, published in the Official Gazette of February 1, 2010. This law mainly modifies the dependency of the CCHEN from the Ministry of Mining to dependency on the Ministry of Energy.

e) LAW No. 19,300 – LAW ON ENVIRONMENT GENERAL BASES, published in the Official Gazette of April 9, 1994. This law consists of six titles, that is
   i. TITLE I – GENERAL ASPECTS.
   ii. TITLE II – ENVIRONMENTAL MANAGEMENT TOOLS.
   iii. TITLE III – RESPONSIBILITY FOR ENVIRONMENTAL DAMAGE.
   iv. TITLE IV - INSPECTION.
   v. TITLE V – ENVIRONMENTAL PROTECTION FUND.
   vi. TITLE VI – NATIONAL ENVIRONMENTAL COMMISSION.

f) LAW No. 20,417 – MODIFIES LAW ON ENVIRONMENT GENERAL BASES, published in the Official Gazette of January 26, 2010. This law primarily creates the Ministry of Environment, which replaces the National Environmental Commission.

3.2.2 Main National Regulations

The legislative framework applicable to nuclear facilities in Chile is defined by the following Regulations:

a) DECREE LAW No. 87/84 - REGULATION ON PHYSICAL PROTECTION OF NUCLEAR MATERIAL AND FACILITIES, published in the Official Gazette No. 32,117 of March 9, 1984. It is based on IAEA document INFCIRC/225.
b) DECREE LAW No. 133/84 – REGULATIONS ON AUTHORIZATIONS FOR RADIOACTIVE FACILITIES OR IONIZING RADIATION GENERATING EQUIPMENTS, PERSONNEL OPERATING SUCH EQUIPMENTS AND OTHER RELATED ACTIVITIES, published in the Official Gazette No. 31,955 of August 23, 1984. This ordinance categorizes the different radioactive facilities, according to the associated risk of practice, the required authorizations and the associated requirements of both facilities and workers; it includes the import, export and transportation of radioactive material, as well as the way to apply sanctions.
c) DECREE LAW No. 3/85 - REGULATION ON RADIATION PROTECTION OF RADIOACTIVE FACILITIES, published in the Official Gazette No. 32,153 of January 3, 1985. This establishes the limits of acceptable dosage (based on the ICRP No. 26) and requirements for the Services of Personal Dosimetry, laid down in the country.
d) DECREE LAW No. 12/85 - REGULATION FOR THE SAFE TRANSPORTATION OF RADIOACTIVE MATERIAL, published in the Official Gazette No. 32,192 of June 10, 1985. It is a transcription of the 1985 version of the Safety Guide No. 6 of the IAEA – Regulations for the safe transport of radioactive material.
e) SUPREME DECREE No. 95/01 – REGULATION ON ENVIRONMENTAL IMPACT ASSESSMENT SYSTEM. Published in the Official Gazette of December 7, 2002.

3.2.3 Norms

The technical requirements for nuclear research reactor operators are established in standards approved by CCHEN. The regulatory position in the case of technical matters not defined in national regulations, including the case of nuclear facilities, is to adopt the IAEA recommendations or the regulations of the supplier's country, if no specific guidance appears in the IAEA documents.

CCHEN Safety Standards

a) NCS-DR-01 "Radioactive Waste Management"
b) NCS-GG-02 "Procedure for Licensing Nuclear and Radioactive Facilities "
c) NCS-GG-04 "Specific Safety Procedures"
d) NCS-PM-01 "Calibration of Radiation Detection Devices"

e) NCS-PP-01 "Radioactive Facilities Operator Licensing"
f) NCS-PP-02 "Nuclear Research Reactor Operator Licensing"
g) NCS-PR-01 "Radiation Protection Standards"
h) NCS-SI-01 "Occupational Health"
i) NCS-SV-01 "System of Accounting for and Control of Nuclear Material"
j) NCS-TR-01 "Nuclear and Radioactive Material Transportation Licensing "

CCHEN Regulatory Guides

a) GR-C-01 "Design Criteria for Structures of Nuclear Research Facilities"
b) GR-E-01 "Design Criteria for Electric Systems of Nuclear Research Facilities"
c) GR-G-02 "Nuclear Safety and Radiation Protection Criteria"
d) GR-G-03 "Nuclear Research Reactor Safety Reports"
e) GR-G-08 "Nuclear Research Facilities Emergency Planning"
f) GR-G-09 "Nuclear Research Facilities Commissioning"
g) GR-G-10 "Quality Assurance for Commissioning and Operation of Nuclear Research Facilities"
h) GR-G-11 "Nuclear Research Reactor Operation"
i) GR-G-13 "Periodic Inspection of Nuclear Research Facilities"
j) GR-G-14 "Organization and Procedures of Nuclear Research Reactors"
k) GR-G-15 "Radiation Protection for Nuclear and Radioactive Facilities"
l) GR-M-01 "Design Criteria for Hydraulic Systems of Nuclear Research Reactors"
m) GR-N-01 "Design Criteria of Pool-type Nuclear Research Reactor Core"
n) GR-P-01 "Radiation Protection Design Considerations of Nuclear Research Facilities"

Appendix 1: International, Multilateral and Bilateral Agreements

The Chile Government, through the existent legal and normative structure in the country, has demonstrated his concern and interest in the matter, which has been ratified with the subscription and ratification of the following conventions:

a) Decree Law No. 272/97, Promulgates the Convention On Nuclear Safety. Issued On June 3, 1997.
b) Supreme Decree No. 381/05 – Promulgates the Convention On Early Notification Of A Nuclear Accident. Issued On April 25, 2006.
c) Supreme Decree No. 8/04 - Promulgates the Convention On Mutual Assistance In The Case Of A Nuclear Accident Or Radiological Emergency. Issued On April 12th, 2005.
d) Supreme Decree No. 18/90 – Promulgates the Vienna Convention On Civil Liability For Nuclear Damage. Issued On March 8, 1990.

e) Supreme Decree No. 1,212/94 – Promulgates the Joint Protocol Relating To The Application Of The Vienna Convention And The Paris Convention. Issued On January 3, 1994.

f) Supreme Decree No. 709/84 – Promulgates the Treaty For The Prohibition Of Nuclear Weapons In Latin America (The Tlatelolco Treaty). Issued On December 14, 1974.

g) Supreme Decree No. 132/94 – Promulgates Amendments To The Treaty For The Prohibition Of Nuclear Weapons In Latin America (The Tlatelolco Treaty). Issued On April 26, 1994.

h) Supreme Decree No. 1121/94 – Promulgates the Convention On The Physical Protection Of Nuclear Material. Issued On October 17, 1994.

i) Supreme Decree No. 797/95 – Promulgates the Treaty On Non-Proliferation Of Nuclear Weapons. Issued On September 25, 1995.

j) Supreme Decree No. 17/04 – Promulgates the Additional Protocol To The Safeguards Agreement. Issued March 20, 2004.

CCHEN's ROLE IN COMPLIANCE WITH AGREEMENTS ENTERED INTO BY THE GOVERNMENT OF CHILE

Chile has been an IAEA Member State since 1966 and is party to the following Multilateral Agreements:

	Title	In Force	Status
P&I	Agreement on the Privileges and Immunities of the IAEA	1988-22-04	acceptance: 1987-12-08
VC	Vienna Convention on Civil Liability for Nuclear Damage	1990-08-03	Signature: 1988-08-18 ratification: 1989-11-23
CPPNM	Convention on the Physical Protection of Nuclear Material	1994-10-17	accession: 1994-04-27
CPPNME	Amendment to the Convention on the Physical Protection of Nuclear Material		acceptance: 2009-03-12
NOT	Convention on Early Notification of a Nuclear Accident	2005-12-15	Signature: 1986-09-26 ratification: 2005-11-15
ASSIST	Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency	2004-10-23	Signature: 1986-09-26 ratification: 2004-09-22
JP	Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention	1994-01-03	Signature: 1988-09-21 Ratification:1989-11-29
RADW	Joint Convention on the Safety of Spent Fuel Management and on the	2011-12-25	accession: 2011-09-26

	Safety of Radioactive Waste Management		
NS	Convention on Nuclear Safety	1997-03-20	Signature: 1994-09-20 ratification: 1996-12-20
RSA	Revised Supplementary Agreement Concerning the Provision of Technical Assistance by the IAEA (RSA)	1980-08-29	Signature: 1980-08-29
ARCAL	Co-operation Agreement for the Promotion of Nuclear Science and Technology in Latin America and the Caribbean (ARCAL)	2006-04-25	Signature: 1998-09-25 ratification: 2005-11-15

And the following Safeguards Agreements:

Reg.No	**Title**	**In Force**	**Status**
1661	Agreement between the Republic of Chile and the IAEA for the Application of Safeguards in connection with the Treaty for the Prohibition of Nuclear Weapons in Latin America and the Caribbean (Tlatelolco)	1995-04-05	Signature: 1995-04-05
1762	Protocol Additional to the Agreement between the Republic of Chile and the International Atomic Energy Agency for the Application of Safeguards in connection with the Treaty for the Prohibition of Nuclear Weapons in Latin America and the Caribbean	2003-11-03	Signature: 2002-09-19

Arrangements are generally in place for liaison with relevant regional and international groups and organisations i.e.: Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO.)

Chile has expressed support for the Code of Conduct on the Safety and Security of Radioactive Sources.

Appendix 2: main organizations, institutions and companies involved in nuclear power related activities

Organization:

Name: Comisión Chilena de Energía Nuclear (Chilean Nuclear Energy Commission)
Address: Amunátegui 95, Santiago Centro, Santiago, Chile
Phone number: (56-2) 470 2500

Fax number: (56-2) 470 2570

Website: www.cchen.cl

Name of report coordinator: Bárbara Nagel

Institution: Chilean Nuclear Energy Commission (CCHEN)

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