

# *Nuclear Power Plants Development Program in Chile, 2009 - 2030*

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*Interregional IAEA-CYTED-UNECE Workshop on Recent  
Developments in Evaluation of Uranium and Thorium Resources  
Lisbon, Portugal, 15 – 18 October, 2012*

## *Nuclear Power Plants Development Program in Chile, 2009 - 2030*

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## *Nuclear Power Plants Development Program in Chile, 2009 - 2030*

### ***EL COLEGIO DE INGENIEROS DE CHILE A.G.***

*It's the professional association of engineers of Chile. It has about 6,000 registered engineers. It is an autonomous institution that is funded with the contribution of engineers and that, in addition to protection of engineering activities, performs studies of national interest through sectoral committees and reports with recommendations to the Government and the national community.*

*For the analysis of energy issues, this institution has a Commission of Energy that makes his studies through specialized committees as the Nuclear Power Committee founded in 2007. In 2009, the Nuclear Power Committee drew up the “Nuclear Power Plants Development Program in Chile, 2009-2030” that it was then proposed by the “Colegio” to the Government of Chile and to the national community.*

*The proposed Program follows the guidelines recommended by the International Atomic Energy Agency of United Nations.*

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### ***THE CHILEAN ECONOMY - OVERVIEW***

*Chile has a market-oriented economy, a high level of foreign trade, strong financial institutions and sound economic policy. Exports account for more than one-third of GDP, with commodities making up some three-quarters of total exports. Copper alone provides one-third of government revenue. Since 1999, growth has averaged 4% per year.*

*The Chilean government conducts a rule-based countercyclical fiscal policy, accumulating surpluses in sovereign wealth funds during periods of high economic growth, and allowing deficit spending only during periods of low growth. As of November 2011, those sovereign wealth funds - separate from Central Bank reserves - amounted to more than \$20 billion dollars.*

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### ***Chile joins the OECD***

*In May 2010 Chile signed the OECD Convention, becoming the first South American country to join the OECD. The economy started to show signs of a rebound in the fourth quarter of 2009, and GDP grew 5.1% in 2010 and 6.5% in 2011.*

### ***Chile's Earthquake February 2010***

*Chile achieved this growth despite the 8.8 magnitude earthquake that struck in February 2010, which was one of the top 10 strongest earthquakes on record in the world. The earthquake and subsequent tsunamis it generated caused considerable damage near the epicenter about 400 km southwest of Santiago. The strongest earthquake recorded in the world occurred in Chile in 1960, a 9.5 magnitude with a big tsunami.*

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### **CHILEAN ECONOMIC INDICATORS 2011**

<i>Population</i>	:	17	millions
<i>Land</i>	:	750.000	sq. km.
<i>GDP (PPP)</i>	:	\$ 300.000	billions dollars
<i>GDP (PPP) per capita</i>	:	about \$ 17.000	dollars
<i>Labor Force</i>	:	8.10	millions
<i>Unemployment rate (2012 est.)</i>	:	6.5 %	(2012 est.)
<i>Fiscal Budget</i>	:	revenues :	\$ 55 billion dollars
		expenditures :	\$ 52 billion
<i>Budget Surplus (2011 est.)</i>	:	1.5 %	of GDP
<i>Public Debt (2011 est.)</i>	:	9.4 %	of GDP
<i>GDP real growth rate (2012 est.)</i>	:	5.0 %	

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### **DATA ABOUT ELECTRICITY GENERATION AND DEMAND**

<i>Installed Capacity 2011</i>	<i>: 17.000 MW</i>
<i>Electricity Demand 2011</i>	<i>: 62.000 GWh</i>
<i>Electricity Demand Growth (2012 est.)</i>	<i>: 6.5 %</i>

#### *Projection of demand 2009-2030*

*A conservative projection estimates that it is required to add 1,000 MW per year to meet the additional demand for 4,000 GWh annually for the period 2009 – 2030.*

*Mining companies have scheduled investments of the order of 100 billion dollars in Chile until the year 2020, which requires a large amount of electricity.*

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### **A BRIEF DESCRIPTION**

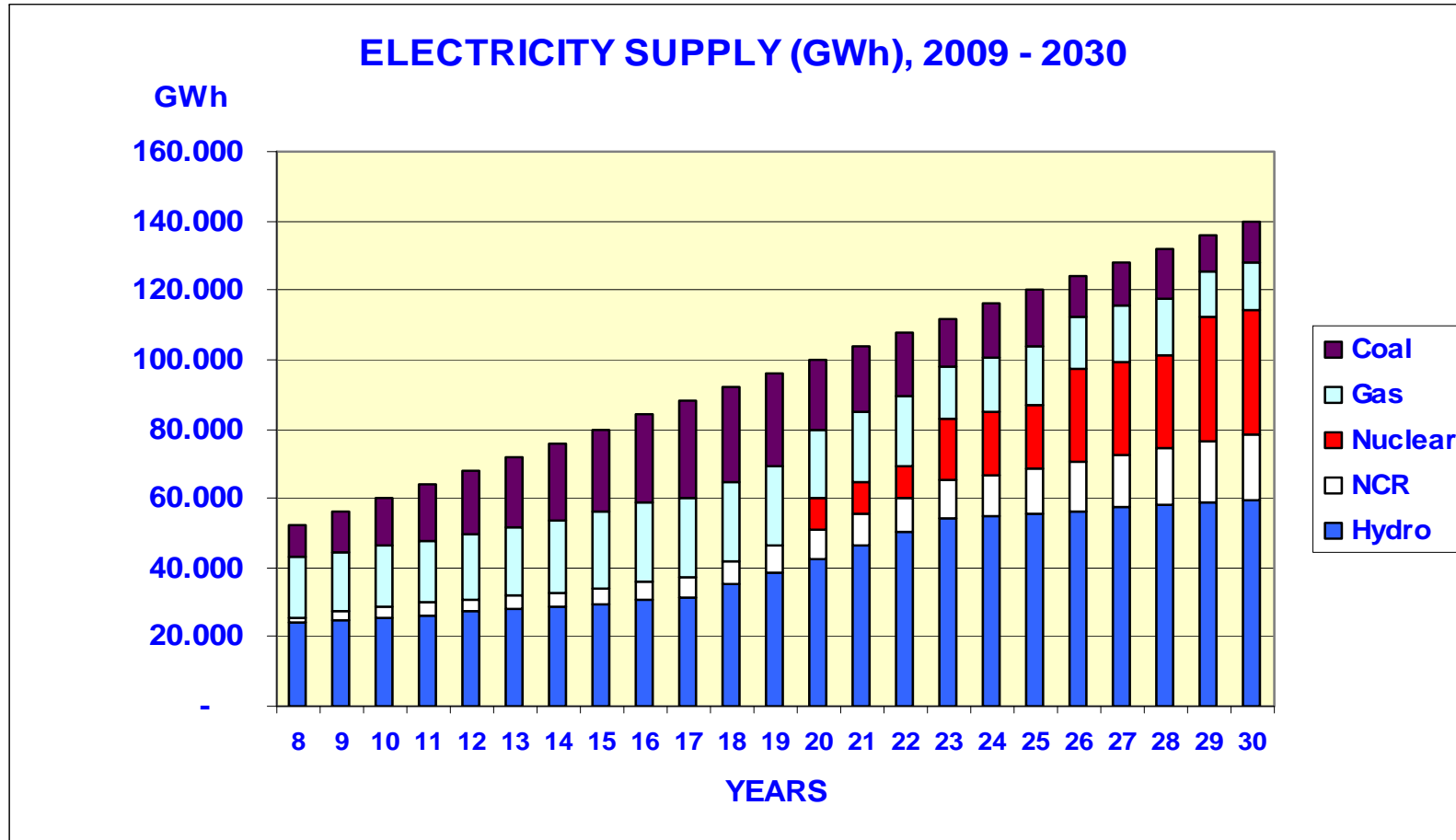
*The program points out the reasons why the country should use nuclear power, recommends the government organization to carry out the program, suggests a consortium that would carry out the project, sets the number of nuclear reactors required before the year 2030, establishing areas in which it would be required to build nuclear reactors, the strengthening of the transmission lines and others. All this according to the guidelines of the IAEA.*

*The program aims to build 4 nuclear reactors of 1,100 MWe each one to enter in operation in the period 2020-2030, from Santiago to the North of Chile, to avoid the construction of 15 coal-plants of 300 MWe each one.*

*In the future, in addition to generating electricity, these nuclear reactors would allow, the operation of desalination plants and improve the supply of water in the North of Chile and in the long term hydrogen generation.*



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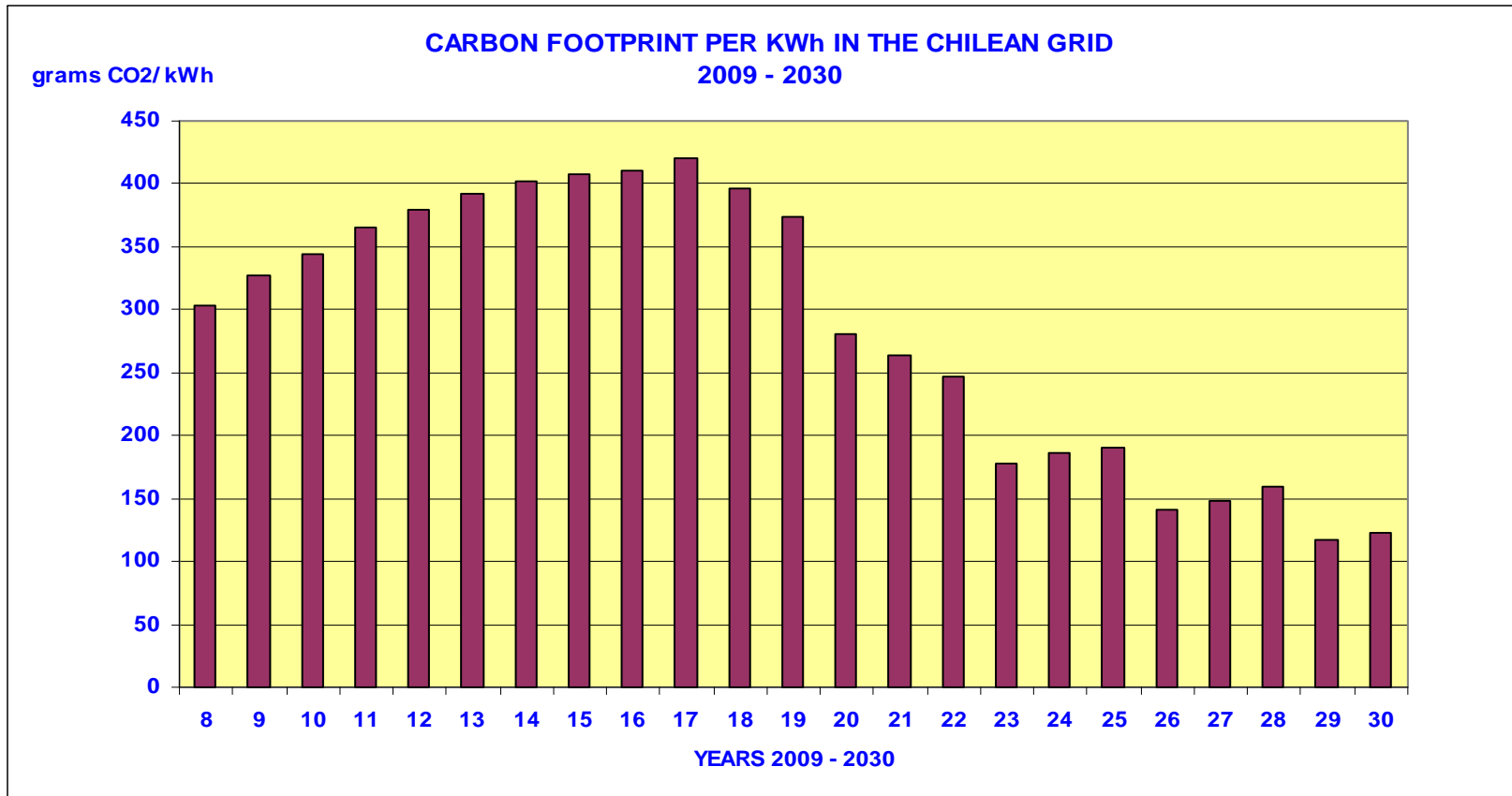
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### ***ELECTRICITY SUPPLY - Description***

- 1. Hydroelectric energy (blue bars)  
Includes Hydroaysen, a 2700 MW project in the South of Chile*
- 2. NCR – Non Conventional Renewables (yellow bars) It's  
a conventional name. Includes wind energy, solar energy, geothermal, minihydro (below 20MW), biomass, and others. The Chilean law requires that an increasing percentage of the total energy must incorporate NCR up to 10% the year 2022.*
- 3. Nuclear Power (red bars) The first Nuclear Power Plant, NPP, will be connected to the grid by 2020. The second NPP in 2023, the third NPP in 2026 and the fourth NPP in 2029. Each NPP will have 1.100 MWe and generates about 9.000 GWh annually.*
- 4. Gas energy (green bars) The use of gas will decrease with the increasing use of clean energy such as hydroelectricity, nuclear and NCR.*
- 5. Coal energy (black bars) The use of coal will decrease with the increasing use of clean energy such as hydroelectricity, nuclear and NCR.*

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# Nuclear Power Plants Proposed



***Diablo Canyon NPP between San Francisco and Los Angeles. Two 1100 MWe reactors***

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## ***NPPs SITING, SEISMICITY AND GRID STRENGTHENING***

- 1. Diablo Canyon NPP is a paradigmatic model for nuclear power stations to be built in Chile. It is built on a hilly terrain of high seismicity, near several geological faults, very similar to the Chilean coast.*
- 2. 1100 MWe PWR reactors will adapt well to the Chilean network and they are being built in several countries by suppliers of United States, France, Russia, Japan and South Korea.*
- 3. Diablo Canyon NPP is built 25 meters above the sea level. This feature is very important for Chile due to the tsunamis and this plant could withstand 25 meters high tsunamis. The tsunami in Fukushima had a height of 15 meters above sea level and the Japanese were prepared for a tsunami of only 6 meters above sea level. The Fukushima nuclear accident was not caused by a failure of nuclear technology but because the Japanese seismologists did not foresee the likelihood of a tsunami of 15 meters high above sea level. In consequence, the Fukushima nuclear power plant was badly located and exposed to being struck by a 15 meter tsunami.*
- 4. Our Nuclear Power Committee proposes that NPPs in Chile are built on the coast for cooling and at a height between 25 and 30 meters above the sea level.*
- 5. In addition, we propose that NPPs in Chile are built on seismic isolators since nuclear power plants in Chile should be prepared to withstand earthquakes of magnitude 9.5 or more. Cruas NPP in France was built on seismic isolators 30 years ago.*

## NPPs SITING AND GRID STRENGTHENING



<b>SING</b>	<b>2008</b>	<b>2030</b>
Installed Capacity (MW)	3.600	10.000
Maximum Demand (MW)	1.900	4.900
Annual Generation (GWh)	14.500	35.000
Population (%)	6	6

<b>SIC</b>	<b>2008</b>	<b>2030</b>
Installed Capacity (MW)	9.400	26.000
Maximum Demand (MW)	6.150	20.100
Annual Generation (GWh)	41.800	105.000
Population (%)	92	92

<b>CHILE (SIC + SING)</b>	<b>2008</b>	<b>2030</b>
Installed Capacity (MW)	13.000	36.000
Maximum Demand (MW)	8.050	25.000
Annual Generation (GWh)	56.300	140.000
Population (%)	98	98



**AREA OF HIGH ELECTRICAL DEMAND**



**PROPOSED AREA FOR NPPs SITING**

## NPPs SITING AND GRID STRENGTHENING



1. The territory from Santiago to the northern border is a desert and semi desert one. Without hydroelectric resources. High electrical demand for mining.
2. From Santiago to the South, the territory has significant hydropower resources.
3. So, our NPPs development program has been oriented to supply electricity to Santiago and the region North of Chile, mainly.
4. Our Nuclear Power Committee has proposed three 200 km - long coastal areas to locate four 1100 MWe reactors up to 2030.
5. The first proposed area is located about 300 km north of Santiago.
6. The second proposed area is located at Antofagasta region, about 1400 km north of Santiago.
7. The third proposed area is located about 300 km south of Santiago.
8. All the proposed areas are located in low population zones.
9. The Chilean Government is promoting the construction of a large transmission line from Santiago to Antofagasta. This line would come into operation about the year 2018.



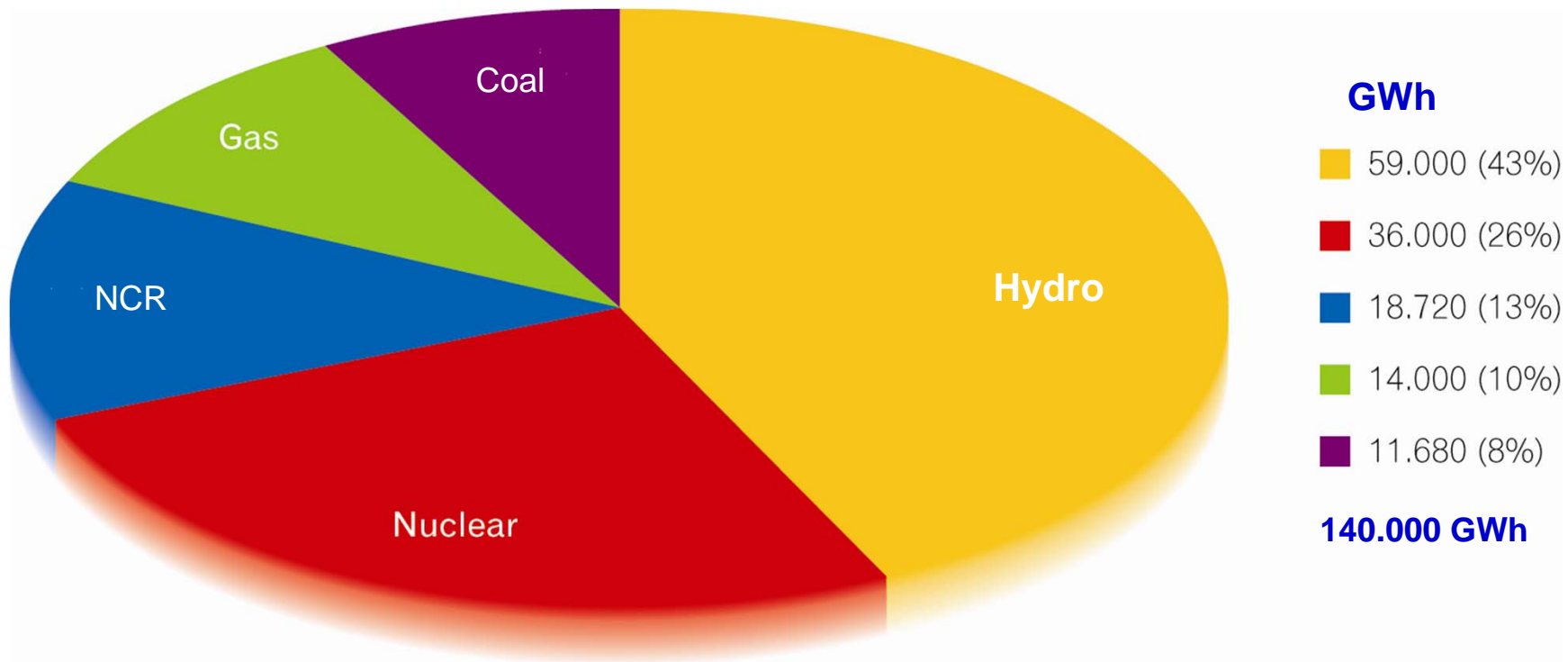
**AREA OF HIGH ELECTRICAL DEMAND**



**PROPOSED AREA FOR NPPs SITING**

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### **ENERGY MIX IN THE CHILEAN GRID IN 2030**



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### ***Uranium Exploration***

*a) In the past two years, CODELCO, the big Chilean copper mining company, has been prospecting uranium in the North of Chile, in partnership with an Australian company.*

*b) In one of its mines, CODELCO has found uranium as a by-product of copper extraction. The company has built a pilot plant to determine the best way to extract uranium and other metals from the leaching process and tailings. With this plant, CODELCO has obtained the first kilograms of yellow cake, the raw material to produce nuclear fuel.*

*c) Chilean geologists have indicated that in Chile there would be enough uranium to activate all nuclear reactors that will be built in Chile.*

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### **RELEVANT INFORMATION ( I )**

- 1. The Chilean Government is strengthening its knowledge in nuclear power, training engineers and improving the institutional framework. Chile has signed nuclear agreements with France and United States among other countries. Also, the Government has decided to build a strong transmission grid between Santiago and Antofagasta, about 1.500 kilometers, in Chile Northern.*
- 2. Comisión Chilena de Energía Nuclear, CCHEN, is a government institution that combines several functions related with nuclear energy: regulatory, research and isotopes production. It was created 50 years ago. CCHEN has about 300 people and two research nuclear reactors.*
- 3. The University of Chile is preparing engineers in the aseismic calculus of nuclear reactors and in the use of seismic isolators. The Catholic University of Chile has initiated a Diploma course in nuclear power aimed at professionals in various disciplines.*

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### **RELEVANT INFORMATION ( II )**

*4. CONICYT, the governmental Commission on Science and Technology, offers scholarships to Chilean students to carry out internships in other countries on issues related to nuclear energy and also offers Chilean centres of research resources to strengthen its links with centres of nuclear energy in other countries.*

*5. At Chile, there are major utilities like ENEL - ENDESA and GDF - SUEZ operating nuclear reactors in their countries of origin. The presence of these companies could facilitate the implementation of a nuclear power program in Chile. These companies have indicated that they expect the green light from the Government to present their projects.*

*6. After the nuclear accident of Fukushima NPP, more than 70% of Chileans polled oppose the construction of nuclear power plants in Chile. However, most of them recognize their absolute ignorance about nuclear energy.*

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### **RELEVANT INFORMATION ( III )**

*7. Public acceptance has a great importance for construction of nuclear power plants. So, our Nuclear Power Committee has concentrated its efforts on reversing this unfavourable opinion in Chilean society, through meetings and conferences with the Government, parliamentarians, universities and students. Tirelessly, our Committee members give lectures, write articles in newspapers, magazines and websites, explaining the advantages of nuclear power to the Chilean community.*

*8. As you can see, our Nuclear Power Committee has a lot of work ahead, but we are confident of achieving our goals, because we understand that is the best thing for the Chileans and the planet. We appreciate your support and the cooperation of your institutions and countries so our Nuclear Power Committee can be successful in the development of nuclear power in our country.*

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***MANY THANKS FOR YOUR ATTENTION !***

***¡ MUITO OBRIGADO !***



***VALLE NEVADO – SANTIAGO DE CHILE***

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