Key Figures
Total Primary Energy Supply

Crude Oil Imports by Source (2000-2010)

Gas Demand, by Sector

Source: Monthly Oil Statistics, IEA
Infrastructure Maps

**OIL**
- Oil products pipeline
- Crude oil pipeline
- Refinery

**GAS**
- Existing pipelines
- Existing LNG import terminal
- Gas fields
- Regasification plant

**ELECTRICITY**

These maps are for illustrative purposes and are without prejudice to the status of or sovereignty over any territory covered by these maps.
Chile has experienced several serious energy supply incidents over the last decade, including major droughts, a sustained gas supply cut from Argentina (since 2004), and a major earthquake in early 2010 which affected electricity networks and refineries, and caused several black-outs.

Due to Chile’s unique and sinuous geography - it runs 4 300 kilometres from North to South and only 175 kms from East to West- the country’s energy markets are regionally disjointed, particularly as the regional gas and electricity grids are not connected. In the arid North, energy demand is dominated by the mining industry, and operates based on a separate thermal-based Sistema Interconectado Norte Grande (SING) electricity grid. The more densely-populated central region (including Santiago) operates on the more hydro-dependent Sistema Interconectado Central (SIC) electricity grid. The southernmost, hydro-rich regions of the country are not connected to the rest of Chile in terms of electricity and gas.

The following report is based on an IEA Emergency Response Assessment carried out in 2010 and 2011 which looked specifically at Chile’s capacity to respond to short-term emergencies in oil, gas and electricity.
1. Energy Landscape

1.1 Total Primary Energy Supply

Chile’s Total Primary Energy Supply (TPES) has grown significantly since 1990 in line with its economic development, increasing at a compound average growth rate of 4.2% over the 1990-2009 period. Oil is the dominant fuel accounting for 54% of TPES in 2009.

As is the case in many OECD countries oil is predominantly used as a transport fuel, but a notable difference in Chile is that diesel is used as a substitute for natural gas in power generation.

Regarding natural gas, consumption had grown significantly from the late 1990s to 2004, as direct pipeline connections were built to Argentina, providing a cheap and easily accessible source of fuel. However, from a peak in 2004, when natural gas accounted for some 24% of total TPES, the share of gas in the country’s TPES has decreased significantly due to supply problems from Argentina. In 2009, natural gas accounted for only 8% of TPES. Nevertheless, gas is still extremely relevant in the isolated southernmost regions, both for heating and for generating electricity. Biomass is also commonly used in the isolated southernmost region, notably as a source of heat.

Coal is extensively used in the North of the country for power generation, mainly for the mining industry, while hydroelectricity powers the lion’s share of the SIC grid in central Chile.
1.2 Key Institutions

- Ministry of Energy

An institutionally separate Ministry of Energy was created in November 2009, thereby breaking away from the Ministries of Mining and Economy. Under the new institutional structure, the National Energy Commission (CNE), the Superintendency of Electricity and Fuels (SEC), the Chilean Commission for Nuclear Energy (CCHEN), and the Chilean Energy Efficiency Agency are being overseen by the new ministry.

- Comisión Nacional de Energía (CNE)

The CNE is Chile’s energy regulator. It is a “technical agency responsible for analysing pricing, tariffs and technical standards for production, generation, transmission and distribution of energy in order to provide a service that is sufficient, safe and of a quality compatible with the most economical operation.” The CNE also monitors markets and collects data. There may be overlap with the SEC (see below).

- Superintendencia de Electricidad y Combustibles (SEC)

The SEC supervises and monitors energy companies’ compliance with laws and regulations with respect to technical issues in order to bring energy to population safely and reliably. It has offices in each of the regions. It has the ability to impose penalties when a company is in breach of its obligations. With regard to the country’s 25-day oil stockholding obligation, the SEC monitors compliance, but due to the lack of precision in the legislation on this topic, it is hard to calculate and evaluate actual compliance or lack thereof.

With regard to electricity markets, the SEC is responsible for assessing compliance with the Grid Code.
2. Oil

2.1 Market Features and Key Issues

Supply and Demand

In 1990, Chile produced around 15 kb/d of crude oil, equivalent to some 14% of its oil demand. That percentage has been decreasing steadily, although recent efforts to encourage exploration activities through Special Oil Operation Contracts (CEOP) have somewhat started to reverse that trend. Nevertheless, production only accounted for 2% of total oil consumption in 2010. Production is located in the Southernmost Magallanes region, standing at around 4.8 kb/d (2011).

With oil demand in Chile estimated at around 333 kb/d in 2010\(^1\), Chile is a large net importer of crude oil and oil products.

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\(^1\) From the IEA’s Oil Market Report database.
Gas/diesel oil accounts for 51% of product demand, and gasoline for 19% of demand. Demand for gasoil soared significantly as a result of the Argentine gas supply crisis, as gas-fired power plants switched to gasoil. Indeed, gasoil demand almost doubled between 2003 (before the gas disruption) and 2008 (complete disruption), growing from 87 kb/d to 169 kb/d. In 2000, only 4% of gasoil demand was used for power generation, while this figure reached almost 30% in 2008. The arrival of LNG supplies in Quintero (North) and Mejillones (Centre) as of mid-2009 and 2010 respectively, attenuated the demand for gasoil which has stabilised since.

Figure 4: Oil Demand - Breakdown by Sector (2009)

As is the case in most OECD countries, the transport sector accounts for the majority of oil product demand in Chile (46% in 2009), followed by the industrial sector (23%). More unusual in relation to Chile’s OECD peers is the fact that in 2009 17% of demand came from the power sector (demand for diesel).

Imports/Exports and Import Dependency

Chile is a large net importer of both crude oil and oil products. Some 88% of Chile’s crude imports were sourced from South America in 2010. Domestic product supply is dominated by the Empresa Nacional del Petroleo (ENAP, the Chilean National Oil Company). Nevertheless, distillate imports by other companies made up a larger share of total supply in 2007 and 2008 to replace restricted natural gas supplies. Competitors with product supply from neighbouring Argentina have struggled in light of stricter motor fuel standards in Chile and export restrictions in Argentina. As a result, most imported products are from OECD countries.
Oil Company Operations

An established competitive landscape keep market shares in the retail sector fairly static, although both regional players Petrobras and Terpel entered the Chilean market in 2008 by acquiring existing retail portfolios. With limited ability to compete on prices (because of the price stabilisation mechanism—see section below), many competitors look to branding, location and non-fuel offerings to distinguish themselves and increase throughputs. There are over 1,450 retail sites in Chile.
Below is a breakdown of the key players in the Chilean retail market:

- **Copec**

  Copec, one of Latin America’s largest diversified financial holding companies, dominates the retail motor fuels marketing sector in Chile, with some 665 sites and 14 storage terminals (as of 2010). Wholesale market share stands at 61%, and its retail diesel and gasoline market shares stand at around 50%. Copec has over twice as many retail sites as its closest competitor (Shell—see section below), high throughputs and a strong brand name.

  Around 70% of Copec’s total fuel sales are sourced from ENAP refineries, while the rest is imported directly. In recent years, 70-75% of its diesel sales were imported (equivalent to 4-5 ships a month) to satisfy increased distillate demand for power generation, whereas Copec sourced 75% of its gasoline from ENAP directly (and resorted to 1 ship of imported gasoline a month). Copec acquired a 47% stake in Terpel in May 2010.

  Copec has a strong logistics network that includes 14 terminals and a 52.8% stake in the pipeline company Sonacol. Of note, Copec also has a maritime subsidiary, Sonamar, and is involved in the LPG market through its subsidiary Abastible, which had a 34% wholesale market share.

- **Luksic Group (Quiñeco S.A. & Empresa Chilena de Energía, ENEX)**

  In 2011 Shell’s last assets in Chile were sold to Quiñenco S.A., part of the Luksic Group, one of the largest conglomerates in Chile with stakes in industrial and financial services companies. The business acquired by Quiñenco includes the Shell retail marketing business and associated service stations, which will continue to carry the brand under a trademark licensing agreement. It has a strong presence with some 376 sites (as of 2010) and the second largest market share (15%). ENEX’s (a subsidiary of Quiñeco S.A.) portfolio now includes Shell’s former stake in the Sonacol pipeline network. In 2011 ENEX acquired Copec’s stake in Terpel.

- **Petrobras**

  Petrobras purchased ExxonMobil’s retail network in August 2008, and has announced plans to begin importing biofuels from Brazil and is targeting the industrial sector. With 246 sites (as of 2010), the company controls around 16% of the national retail network and accounted for 18% of gasoline retail sales. The acquisition also included a 22% stake in pipeline company Sonacol, and six terminals (two joint ventures, four wholly owned). Over 10% of Petrobras’s fuel volumes are imported.

- **Terpel**

  The Colombian retailer is prioritising regional expansion and entered Chile in 2008 with the purchase of Repsol YPF’s national network, giving it a 11% network share, and some commercial and logistics infrastructure. However, Repsol YPF retained its aviation fuel, Liquefied Petroleum Gas (LPG) and lubricants business in Chile. Terpel has expressed interest in Compress Natural Gas (CNG) distribution if Liquefied Natural Gas (LNG) imports were to provide enough natural gas for vehicular use. Of note, Copec acquired a 47% stake in Terpel in May 2010. Antitrust authorities approved the operation provided that Copec divested all of its Terpel assets in Chile within eighteen months.
Taxes and Price Stabilisation Mechanisms

Chile has no price capping or subsidies for fuels. The following taxes are paid on fuel in Chile:

(i) import taxes on imported products;
(ii) specific taxes for fuels used in transport vehicles; and
(iii) a value-added tax paid on all fuels.

Import taxes or tariffs are paid on all imported products, and rates are around 6% under the general regime. This rate varies depending on the country of origin and whether it has signed a trade agreement with Chile. Specific taxes for fuels used in transport vehicles are applied to gasoline, diesel oil, LPG for vehicles and CNG. The value-added tax (VAT) is a direct tax on consumption and stands at 19%.

There is an explicit government policy to reduce price volatility for final consumers. Until 2011, this was done through two price stabilisation funds, first by the Oil Price Stabilisation Fund (FEPP – established in 1991) and then by the Fuel Price Stabilisation Fund (FEPC – created in 2005). As of 2011, the FEPC was officially disbanded and a new mechanism, the SIPCO, was established.

In 1991 the US$ 200 million Oil Price Stabilisation Fund (FEPP) was created to cover gasoline, diesel, fuel oil, LPG and kerosene price volatilities. In practice, for each fuel a price band was established that reflects its average import parity price level over the recent past. Every week, the National Energy Commission (CNE) recalculated the import parity price. If this price exceeded the price band ceiling, a price reduction was applied to benefit final fuel consumers and paid for by the fund. If, on the contrary, the import parity price of the week was below the price band floor, a tax was applied to make up the difference, paid for by final consumers. In this case, revenues generated were used to replenish the fund. The aim of the fund was to reduce the volatility of end-user fuel prices from one year to another, while remaining neutral in the long term, with credits financed by the taxes generated. However, credits were systematically larger than taxes which meant that the fund depleted rapidly. In 2005 the FEPP operations for gasoline, diesel and kerosene were frozen and the FEPC was established.

The FEPC expired in 2010 and a new mechanism was created to reduce price volatility: the SIPCO (“Sistema de Protección al Contribuyente ante las Variaciones en los Precios Internacionales de los Combustibles”). This new mechanism was established in February of 2011 and works by varying the taxation on motor fuels. This system uses a price band and functions in a similar manner as FEPC (the price band is smaller than FEPC band and the period of adjustment is shorter). However, unlike the FEPC, the SIPCO is not a fund but a subsidy/tax that reduces/increases the specific tax for fuels used in transport vehicles when prices exceed the price band ceiling or falls short the band floor. The difference between that ceiling price and the import parity price is subtracted from the specific tax for each fuel (this quantity in USD/m3 is converted into UTM2/m3). Similarly, the difference between the floor price and the import parity price is added to the specific tax for each fuel.

The SIPCO has a limited scope. It applies only to fuels used for transport purposes: gasoline and diesel. Therefore, it benefits only those consumers who do not recover the specific tax (leaving out most major industries, including mining and electricity generation companies). The specific tax is not paid by final consumers. The importers or the first buyers pay that tax. Currently, kerosene is covered by FEPP, and fuel oil, LPG, and LNG are not being covered by any fund or mechanism anymore.

2 UTM: is an internal economic index calculated on a monthly basis.
2.2 Oil Supply Infrastructure

Refining

ENAP is Chile’s National Oil Company and is engaged in the exploration, production, refining, and marketing of hydrocarbons and their derivatives. ENAP was created by Law No. 9618, on June 19, 1950. ENAP is the only refiner in Chile, operating three refineries (Concon/Aconcagua, Concepcion/Bío Bío, and Magallanes/Gregorio) with a total topping capacity of 227 kb/d. These refineries meet around 70% of total oil product demand in the country.

<table>
<thead>
<tr>
<th>Province / State / Region</th>
<th>Location</th>
<th>Company</th>
<th>Distillation</th>
<th>Thermal Cracking (VR)</th>
<th>Catalytic Cracking (FCC)</th>
<th>Hydrocracking (HDO)</th>
<th>Coke</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Aconcagua/Concon</td>
<td>Empresa Nacional de Petróleos</td>
<td>108.6</td>
<td>31.4</td>
<td>22.0</td>
<td>22.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Bío Bío/Concepción</td>
<td>Empresa Nacional de Petróleos</td>
<td>111.3</td>
<td>19.2</td>
<td>33.3</td>
<td>14.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Gregoría/Magallanes</td>
<td>Empresa Nacional de Petróleo</td>
<td>18.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total Refineries: 226.6 - - - 80.6 53.3 37.2

All data are in barrels per calendar day (bbl/d) unless otherwise indicated. *Conversion relax, used when refineries reported in barrels per stream day (bbl/d), are crude and vacuum (VR) and all other units (bbl/day).

*Source: Chilean Ministry of Energy*

ENAP’s refining portfolio is among the most sophisticated in the region. The crude slate has moved towards intermediate and heavier crudes as domestic refining complexity has increased, allowing the company to take advantage of more abundant heavier, cheaper crudes available in South America.

*Figure 7: Refining Infrastructure*

*Figure 8: Domestic Refinery Output Relative to Total Demand*

*Source: Chilean Ministry of Energy*
The February 2010 earthquake severely damaged the Bío Bío refinery (Concepcion), placing it out of operation for 3-4 months. The other large refinery (Concón/Aconcagua) was out for 6 weeks.

**Ports and Pipelines**

Sonacol, originally created in 1957, is a joint venture between Copec, ENAP, Petrobras (previously ExxonMobil), Abastible and ENEX\(^3\), and is the main oil pipeline operator in Chile, owning and managing some 460 km of domestic oil product pipelines. Sonacol owns six pipelines and three terminals in the regions of Valparaiso, Bernardo O’Higgins and Metropolitana. Sonacol was until recently considered a “strategic” company, which meant that its workers were forbidden to go on strike, but this is no longer the case.

Sonacol’s logistics assets are particularly important in the Santiago Metropolitan region, where it supplies more than 98% of all products. Products are imported from Quintero Bay and loaded from ENAP’s Aconcagua Refinery, and transported to Santiago by means of a multi-product pipeline and a separate LPG pipeline. In 2008, Sonacol transported 45.3 million barrels (7.2 mcm) of oil products. Utilisation of the products pipeline is estimated at around 70-80%.

There is also a dedicated LPG pipeline to Santiago, which transported 7.5 million barrels (1.2 mcm) of LPG in 2008. Utilisation of the LPG pipeline is estimated at around 50%.

In addition, a dedicated jetfuel pipeline supplies Santiago’s Arturo Merino Benítez airport and is operating at full capacity. This may constitute a bottleneck in the supply network.

Sonacol also owns a product pipeline from San Fernando (south of Santiago) to Santiago. This pipeline is bidirectional and is connected to ENAP’s Concepcion to San Fernando pipeline, which is supplied by the ENAP Bio Bio refinery.

Distribution logistics have been especially tight during recent unexpected events (e.g. the gas crisis and the earthquake). Trucking bottlenecks developed because of the cut of Argentine gas,

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3 ENEX (Empresa Nacional de Energía) was created to manage the assets Quiñeco acquired from Shell in June 2011.
as many end-users switched to trucked gasoil/diesel as an alternative fuel. More recently, the February 2010 earthquake caused the Bio Bio refinery to close for several months, thereby affecting product supplies to the Concepcion region.

Thanks to Chile’s long coastline, there are seventeen ports which are able to receive crude oil and oil product deliveries. These ports generally have one or two docking terminals, with the exception of San Vincente (location of the BioBio refinery – 3 terminals) and Quintero (location of the Aconcagua refinery – 5 terminals).

**Storage Capacity**

Total storage capacity stands at 22 million barrels (3.65 million cubic metres), of which one third is crude storage and two-thirds is product storage.

The most important storage company is ENAP, which has significant storage capacities in its Aconcagua, Biobío and Gregorio refineries. In addition, ENAP operates fuel storage facilities in Maipú, San Fernando and Linares. ENAP has 43.6% of the Chilean LPG storage, 71% of middle distillates and gasoline storage, and 80% of Heavy Fuel Oil (HFO) storage.

However, other companies have their own storage facilities, such as Copec, Shell, Petrobrás, Terpel (which rents infrastructure to OXIQUIM), JLC and Hugo Najle.

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<table>
<thead>
<tr>
<th>Company</th>
<th>Crude</th>
<th>Refined Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abastible</td>
<td>302,574</td>
<td></td>
</tr>
<tr>
<td>CAP</td>
<td>175,931</td>
<td></td>
</tr>
<tr>
<td>Codelco Chile</td>
<td>93,761</td>
<td></td>
</tr>
<tr>
<td>Compañía de Aceros del</td>
<td>179,825</td>
<td></td>
</tr>
<tr>
<td>Copec</td>
<td>638,980</td>
<td></td>
</tr>
<tr>
<td>Copec/Shell</td>
<td>1,446,522</td>
<td></td>
</tr>
<tr>
<td>Copec/Shell/Petrobras Chile</td>
<td>644,115</td>
<td></td>
</tr>
<tr>
<td>Copec/Shell/Petrobras</td>
<td>421,430</td>
<td></td>
</tr>
<tr>
<td>Electroandina</td>
<td>150,123</td>
<td></td>
</tr>
<tr>
<td>ENAP</td>
<td>6,199,309</td>
<td>9,003,307</td>
</tr>
<tr>
<td>Gasco GLP S.A.</td>
<td>46,057</td>
<td></td>
</tr>
<tr>
<td>Gasmart S.A.</td>
<td>601,324</td>
<td></td>
</tr>
<tr>
<td>Hugo Najle</td>
<td>49,377</td>
<td></td>
</tr>
<tr>
<td>Jose Luis Capdevilla</td>
<td>25,160</td>
<td></td>
</tr>
<tr>
<td>Lipigas</td>
<td>116,415</td>
<td></td>
</tr>
<tr>
<td>Norgas</td>
<td>14,976</td>
<td></td>
</tr>
<tr>
<td>Transandino pipeline (ENAP)</td>
<td>973,717</td>
<td></td>
</tr>
<tr>
<td>Oxiquim</td>
<td>334,848</td>
<td></td>
</tr>
<tr>
<td>Petrobras Chile</td>
<td>535,908</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>7,173,026</strong></td>
<td><strong>14,780,633</strong></td>
</tr>
</tbody>
</table>

*Source: Chilean Ministry of Energy*

The country’s storage capacity is limited relative to demand, ranging from between 12 and 30 days of consumption, as per 2010 figures and depending on the fuel. Diesel storage capacity is particularly low standing at just 12 days of consumption.

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4 Shell assets were acquired by Quiñenco S.A., part of the Luksic Group in 2011.
### Figure 11: Breakdown of Storage Capacities by Fuel (as of end 2010)

<table>
<thead>
<tr>
<th>in thousand barrels</th>
<th>Crude</th>
<th>LPG</th>
<th>Gasoline</th>
<th>Kerosene</th>
<th>Diesel</th>
<th>Fuel Oil</th>
<th>Total Products*</th>
<th>Total *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity</td>
<td>7,267</td>
<td>1,867</td>
<td>3,552</td>
<td>1,264</td>
<td>4,817</td>
<td>2,041</td>
<td>13,540</td>
<td>20,807</td>
</tr>
<tr>
<td>Average stock levels</td>
<td>3,477</td>
<td>704</td>
<td>1,430</td>
<td>562</td>
<td>1,648</td>
<td>706</td>
<td>4,346</td>
<td>7,823</td>
</tr>
<tr>
<td>Utilisation rate</td>
<td>48%</td>
<td>38%</td>
<td>40%</td>
<td>44%</td>
<td>34%</td>
<td>35%</td>
<td>32%</td>
<td>38%</td>
</tr>
<tr>
<td>Average daily consumption</td>
<td>176.7</td>
<td>37.7</td>
<td>60.4</td>
<td>18.9</td>
<td>136.5</td>
<td>30.2</td>
<td>283.7</td>
<td>460.4</td>
</tr>
<tr>
<td>Days of demand cover</td>
<td>19.7</td>
<td>18.7</td>
<td>23.7</td>
<td>29.8</td>
<td>12.1</td>
<td>23.4</td>
<td>15.3</td>
<td>17.0</td>
</tr>
</tbody>
</table>

*Excludes LPG

Source: Chilean Ministry of Energy

Storage capacity is not evenly distributed across the country, with two-thirds of the storage located in the regions (V and VIII) where the two large refineries are located and most of the demand is concentrated. As such, supply lines can be quickly stretched, particularly in certain isolated regions, in the event of an emergency. However, the construction of additional storage capacity faces considerable administrative hurdles, as public opposition is strong in some regions.

### 2.3 Decision-making Structure for Oil Emergencies

Chile does not have a specific National Emergency Strategy Organisation (NESO) but does have an organisation for handling national emergencies caused by natural disasters or other events that affect the population. The National Emergency Office (ONEMI), overseen by the Ministry of the Interior, is responsible for coordinating public and private efforts to control emergencies, disasters and catastrophes and to coordinate all of the actions and operations executed by National Civil Protection System agencies.

However, the Superintendent of Electricity and Fuels (SEC) and the Chilean Nuclear Energy Commission (Comisión Chilena de Energía Nuclear, or CCHEN), both of which are part of the Ministry of Energy, have their own emergency plans which are activated by events that alter the normal operation of the energy market.

The Chilean government has taken significant steps in recent years in order to improve its monitoring and communications in the event of an oil crisis. Firstly, a market-monitoring system for supply and demand is been developed, assessing the level of coverage for the country as a whole in terms of days of demand cover. Three categories are distinguished, namely “normal” (over 25 days of cover), “alert” (between 15 and 25 days of cover) and “serious” (less than 15 days of cover).

Secondly, it has designed a 24-hour reporting system that can be implemented in the event of an oil crisis, so as to enable key actors to take well-informed decisions, based on the latest available information. Likewise, in 2011 the government was undertaking a study into the communications framework between the government and the oil companies, notably in the event of an oil crisis, and was considering developing a handbook that outlines emergency policies and procedures for ensuring an efficient and streamlined decision-making process in the event of a crisis.
2.4 Stocks

Stockholding Structure

Based on the IEA calculation methods\footnote{IEA option 1: \( \text{crude} + 1.065 \times (\text{all products} - \text{naphtha}) \)}, in 2010, Chile held 30.8 days of stocks in terms of net imports.

- Existing obligation on industry

Producers (refineries) and importers of liquid, petroleum-based fuels are required to maintain an average stock of these products equal to 25 days of sales during the previous 6 months, or average imports over the same period, if imports are for own consumption.

Article 7 of Decree with Force of Law N° 1 of 1978 of the Ministry of Mining states the following: “Every producer or importer of liquid, petroleum-based fuels is required to maintain an average stock of each product which is equal to 25 days of average sales during the previous six months or average imports for the same period of time, if it is for own consumption”.

However, this legal provision does not include a regulation to determine how such reserves are quantified, administered, or managed in emergency situations. Companies which maintain reserves administer them freely based on their own operating needs. In situations of supply problems distribution companies assist one another in maintaining supply to the country, in coordination with ENAP and the energy authorities.

To monitor compliance with this requirement, the Superintendency of Electricity and Fuels (SEC) has ordered producers and importers of liquid, petroleum-based fuels to submit a monthly Excel spreadsheet by a specific deadline and in a predetermined format, detailing sales for the period, daily stocks of liquid petroleum-based fuels and crude oil in their facilities, and imports of liquid petroleum-based fuels during the period.

Because the law is unclear about who is strictly responsible for holding these stocks, there is no auditing of compliance with this obligation, and no penalties have ever been levied for non-compliance. There is also no mechanism or procedure in place for using these reserves in case of an emergency.

- Strategic reserves

According to a study commissioned by the Chilean government on stockholding (April 2011) average stock levels (of all products, including naphtha and other products) for the last months of 2010 stood at some 9.3 million barrels (1,479,308 cum), with a breakdown of 3.47 mb (552,769 cum) of crude stocks and 5.82 mb (926,539 cum) of product stocks. This suggests an utilisation rate of storage facilities of 48% for crude and just 38% for products.

The study lays out three ways in which Chile could meet the 90-day IEA obligation, all of which are based on stockholding obligations on industry:
- Place the totality of the obligation on importers;
- Require distributors to hold 15 days of stocks, and the remaining obligation on importers;
- Require distributors to hold 25 days of stocks, and the remaining obligation on importers.
As such, public stockholding is not considered outright, but the study does indicate that these obligated stocks could be controlled by a public, private or public/private agency.

Based on certain assumptions the study estimates the total cost of building up Chile’s stocks to 90 days of net-imports at some US$ 3.678 billion.

### 2.5 Other Measures

**Demand Restraint Measures**

As of 2011, Chile did not have a clearly established demand restriction policy for liquid fuels.

The Ministry of Energy is studying possible measures to restrict demand in the case of emergencies, which would enable the government to define a policy on this matter. Demand restraint measures are expected to focus primarily on diesel and LPG, because of the large share of these fuels in Chilean demand. A key focus of the study will be to determine priority customers.

**Surge Oil Production**

Domestic production is negligible, and as such does not allow for surge production as an emergency measure.

**Fuel Switching**

Fuel switching from oil to other fuels is very limited. On the contrary, most fuel switching in Chile has occurred into oil, with power plants adapting to an acute gas supply disruption subsequent to the curtailment of gas supplies from Argentina. More often, during droughts oil consumption spikes as hydro power generation needs to be replaced with oil-based thermal generation.

**Lowering Fuel Specifications**

Chile’s motor fuel specifications for gasoline (50 ppm – lowered to 15 ppm in Santiago in September 2011) and diesel (50 ppm sulphur and 46 centane) are stricter than those of its neighbouring countries. Therefore, product imports are sourced from OECD countries, which are located further away from Chile. In particular, the diesel specifications stipulated by Chilean regulations mean that diesel can only be supplied by a small number of refineries located in Chile, Japan, Singapore, South Korea and the United States. In the case of neighbouring countries, since they don’t produce enough diesel to satisfy internal demand, they are not a supply alternative.

In situations of fuel supply shortages, these restrictions can exacerbate a supply disruption. This is notably the case for diesel oil, the imports of which in some years (such as 2008) have accounted for more than 60% of domestic consumption, potentially posing a short-term supply risk due to the lack of available fuel in the international market to meet Chile’s standards.
This occurred in 2008, following the gas disruption from Argentina and in the midst of a worldwide scarcity of high-quality diesel and a drought affecting the SIC grid. Indeed, the transport sector did not have substitute fuels for diesel, and moreover diesel oil constituted an essential input as a back-up fuel for replacing gas in the country’s electricity generation. Furthermore, the situation of the electricity market was already quite tenuous, and a rationing decree was already in effect in the SIC. Diesel consumption had doubled since 2004 as a result of cuts in imported natural gas and the dry hydrology in the country during 2007 and 2008.

In response to these imperatives, the government lowered the specifications for B-grade diesel oil in 2008 for a one-year period, in order to expand Chile’s options in terms of purchasing from foreign refineries.

3. Natural Gas

3.1 Market Features and Key Issues

Supply and Demand

Much like Chile’s electricity networks, Chile has disconnected gas consumption centres. The far North of the country is supplied via the Mejillones Liquid Natural Gas (LNG) terminal, and gas in that region is used predominantly for electricity generation by the mining industry. In the Central Metropolitan Region (including Santiago), gas is primarily supplied by the Quintero LNG terminal. In the far South (Magallanes), gas supplies come from local production (1.2 bcm in 2009) and are mostly used in methanol production, for electricity generation and by the residential sector for heating purposes.

Figure 12: Gas Demand by Sector

Source: IEA
A key issue affecting natural gas supplies in Chile has been the abrupt curtailment of piped gas supplies from Argentina as of 2004. Consumption has plummeted as a result, from a peak of 8.3 bcm in 2004 to just 2.2 bcm in 2008. Demand has grown again in 2009 to 2.7 bcm with the advent of the new Quintero LNG terminal. With the addition of the Mejillones terminal and the growth in volumes to Quintero, demand is estimated to have increased by some 50% in 2010, reaching close to 5 bcm.

Chile is an attractive market for LNG, as it is short of gas and its demand is counter-seasonal to northern hemisphere markets. The LNG terminals are now able to replace the Argentina gas in the north and centre. The methanol plant in the South hardly receives any gas (around 1 production train, out of 4 in operation) as domestic production remains insufficient to meet the plant’s needs.

The bulk of gas demand (41%) in 2010 came from the power generation sector. Industry and the petrochemical sector accounted for 24% each, and residential/commercial for the remaining 11%.

There is, however, no transparent and liquid wholesale spot market for natural gas in Chile.

**Liquid Petroleum Gas (and LPG Aire)**

In the case of a natural gas shortage, “LPG aire” is marketed, mixing LPG with air in order to simulate synthetic natural gas. Since Argentina began curtailing gas supplies in 2004, some 170,171 tons (some 2 million barrels) of LPG have been consumed in the form of “LPG aire”, in replacement of natural gas. As such, the LPG and gas markets overlap in Chile. LPG is predominantly used as a residential fuel in Chile (notably for cooking), and particularly in relatively remote regions.

With regards to security of supply, whereas an oil, gas or electricity supply cut has an immediate impact on end-users, an LPG supply disruption does not immediately impact end-consumers, as each end-consumer can regulate remaining volumes in his tank.

40% of Chile’s LPG supplies come from upstream oil and gas production in the southernmost Magallanes region. Another 20% is produced in ENAP’s refineries, and another 40% is imported.
**Gas Import Dependency**

The Northern and Central regions are entirely dependent on imports to meet gas demand. Although production in the southernmost Magallanes region remains insufficient to meet the needs of the local Methanex plant, the absence of import options means that the region is de-facto not import dependent.

![Figure 14: Gas Imports by Source](image)

Argentina was the sole supplier of gas to Chile from 1996 to 2008. However, the recent construction of Chile’s two LNG terminals now provides far greater diversity in Chile’s supply options.

**Gas Company Operations**

The Asociacion de Distribuidores de Gas Natural (AGN-Association of Natural Gas Distributors), represents the four natural gas distribution companies operating in Central-Southern Chile, namely Metrogas, GasValpo, GasSur, Intergas and Gasco Magallanes. AGN-members have no stake in the Mejillones LNG plant, and do not distribute gas in the Far North. In total, the gas distribution market represents around 620,000 clients in the Metropolitan, V, VI, VIII and XII regions.

Innergy is the main merchant company for the Concepcion area (some 400 km south of Santiago). Innergy receives on average 210,000 m³/d of gas from Argentina to meet residential consumption, but there are large seasonal swings in the delivery pattern. This gas comes through Gasoducto del Pacifico. To cover its Biobio Refinery demand, ENAP developed a “virtual pipeline”, through which LNG supplies are transported by truck from Quintero to Pemuco, in the Concepción area. In Pemuco there is a regasification plant with capacity to process 600 Mcm/d of gas. Currently, ENAP is injecting 340 Mcm/d exclusively to Biobio. Innergy has approached ENAP to discuss the option of injecting additional gas for residential and other industrial customers. This LNG trucking option, although expensive, could provide a higher level of energy security.

There are few LPG distributors in Chile (notably Gasmar, one of the key players and importers). Gas storage is generally estimated to cover around five days of peak winter demand at any one time. In the North (Antofagasta/Arica), storage levels are higher, equivalent to around 10 days of peak demand.
3.2 Natural Gas Supply Infrastructure

Ports / LNG Terminals

Chile has two LNG terminals, located at the ports of Quintero (Central region) and Mejillones (Far North). These terminals provide a strong degree of energy security, in that the very nature of the LNG market means that volumes can be contracted from different sources.

Nevertheless, poor weather conditions can disrupt supplies, particularly to the Quintero terminal that supplies the Santiago Metropolitan area, making sufficient storage essential to avoid a supply disruption because of weather conditions. Expansions of the LNG terminals are a possibility, particularly for the Quintero terminal. Neither of these terminals grants third-party access to the facilities.

- Quintero (3.9 bcm / year)

The regasification terminal in Quintero Bay was completed in July 2009, and feeds the central gas market of the Santiago Metropolitan and V Region by pipeline. Quintero was the first land-based regasification facility in the southern hemisphere.

The plant is designed with 3 vaporisers (5 Mcm/d each), but only 2 are used at a time, so as to have one spare as back up for major emergencies. As such, the maximum draw-down rate for Quintero is 10 Mcm/d. Quintero has an average send-out capacity of 8 Mcm/d, with a historical peak of 10 Mcm/d, which is reached during dry seasons when there is not enough hydro capacity and all gas power units of the central area are dispatched. In the past, demand has been very volatile and unpredictable, causing operational headaches at the re-gasification, because there is no storage capacity available for gas. A ship normally arrives every two weeks, but the bay has stormy weather, and ships sometimes have to wait for days before they can be unloaded.

BG Group is a 40% shareholder in Quintero and has contracts to supply three customers (ENAP, Endesa and Metrogas), each with 20% stake in the terminal. By contract, BG is obliged to ensure a diversified supply to the terminal so that a supply cut from a specific production terminal (e.g. in Trinidad) would not affect supplies to Chile. It is estimated that with an additional investment in regasification the send-out capacity could be doubled to 20 Mcm/d.

- Mejillones (2 bcm / year)

Mejillones is located in the Far North of the country, and is a 50/50 joint venture between Chilean state copper miner Codelco and GDF Suez. Unlike Quintero, Mejillones is a floating off-shore storage terminal. The LNG regasification (which is located on-shore) terminal began commercial operations in May 2010, and has the theoretical capacity to send out 5.5 million cubic metres of gas per day, enough to produce 1100 megawatts of electricity. In 2011, send-out levels have stood at around 2.2-2.5 Mcm/d, and the customers are predominantly industrial consumers who use the gas for electricity generation.

Mejillones is considered well-located, with calm weather conditions and a protected port meaning that ship docking is perturbed on average only 3 or 4 days a year. A capacity expansion is under consideration.
LPG port access

Chile has 17 ports that can be used for delivering oil products to the market, but only two are actually equipped for the import of LPG. As a result, LPG supplies (particularly in some of the more isolated regions in the South of the country) are dependent on road deliveries. There is no clearly defined emergency plan for transporting LPG supplies, and transport is merely left to the private sector to organise.

Pipelines

Since the late 1990s, a series of six pipelines were built, linking Chile to Argentina. These pipeline flows were restricted as of 2004, and then almost completely cut in 2007/2008, rendering the pipeline infrastructure relatively useless. Notable pipelines from Argentina are NorAndino and GasAtacama in the North, GasAndes to Santiago, the Gasoducto del Pacifico to Concepcion, and several smaller pipeline links to Magallanes. For most pipeline companies, the constructions costs have still not been recuperated.

The Quintero LNG terminal now supplies gas to the Santiago pipeline network, through the reversible ElectroGas pipeline, which links the Terminal with the power stations in Quillota and then with the GasAndes pipeline. ElectroGas maintains some 850,000 cum in its pipes for distribution companies. There were concerns about capacity constraints on the ElectroGas pipeline, as it has a very high utilisation rate. If the LNG terminal at Quintero were to be expanded, the ElectroGas pipeline could become a bottleneck for increasing supplies to Santiago.

The unused pipelines from Argentina can to some extent be used for storage purposes (e.g. up to 4 Mcm in GasAndes), but this option has not been explored much at present due to pending legal issues between the project partners.

Storage

Chile does not have any stand-alone gas storage sites. This is partly due to the geology and seismic nature of the country, which makes gas storage problematic. The fact that gas storage is notably more costly than oil storage is an additional impediment to developing gas storage sites.

However, storage capacity does exist at the country’s two LNG terminals of Quintero and Mejillones, equivalent to 334,000 cubic metres and 160,000 cubic metres respectively. However, there is no obligation on the LNG terminal operators to hold a minimum amount of stocks, despite the fact that weather conditions can disrupt supplies (particularly for Quintero). There is no meaningful LPG storage in the country.

3.3 Emergency Policy for Natural Gas

Chile does not have a specific response system for handling a natural gas supply emergency. However, in response to the 2004 crisis resulting from the restriction of the natural gas supply...
from Argentina, the government issued SEC Exempt Resolution No 754. This resolution established a priority order for gas supplies in case of shortage. Once the crisis was over and the LNG terminals were built, the resolution was revoked. Therefore, the Ministry of Energy is developing a regulation that establishes how the industry must respond to situations in which the natural gas supply is at risk, so as not to require the authorities to issue instructions in each emergency situation activated by Resolution 754.

In addition, Decree 67 of 2004 issued by the Ministry of Economy, which approved the Regulation on the Network Gas Service, contains Article 63, which establishes the following obligation for gas distribution companies: “supply security must be guaranteed by concessionaires in order to satisfy the demands of clients or consumers with firm contracts, projected for the next two years.” Toward that end, the companies must have supply and gas transportation contracts and/or their own production and/or storage facilities in order to meet at least the maximum daily consumption projected for its services for the following two years and at least the total firm consumption projected for the next two years.

Article 66 of the same Decree 67 indicates that a gas distribution company must inform the SEC of any emergency immediately or within 24 hours of learning of the event. These companies are required to have an emergency or crisis management plan describing the measures to be taken. In these cases, the company may interrupt any client or consumer’s gas service if the facilities providing the service are affected. When this happens, the company must report this to the SEC. After the event, the SEC will investigate the situation in order to determine whether the lack of service continuity is due to a fortuitous case or force majeure, or is the company’s responsibility.

4. Electricity

4.1 Market Features and Key Issues

Supply and Demand

Chilean electricity demand grew rapidly over most of the last decade, from just under 40 TWh in 2000 to nearly 60 TWh in 2010, at an average rate of around 4.1% per annum. Growth slowed toward the end of the decade from an average rate of around 5.4% per annum between 2000 and 2007 to around 1.4% per annum during the global financial crisis and in the wake of the 2010 earthquake. Growth in demand is forecast to rebound strongly, with levels of around 6% per annum, for the remainder of the decade, resulting in an expected near doubling of demand by 2020 to over 100 TWh per annum. Much of the growth in demand is forecast to occur in the Sistema Interconectado Central (SIC) power system.
Industrial users accounted for nearly 70% of total electricity demand in 2009, with residential and commercial sectors accounting for most of the remainder. Relative market shares are forecast to change little over the next decade with the industrial sector representing around two-thirds of demand by 2020.

Chile’s power system includes around 15,500 MW of generating capacity distributed across 4 regional power systems. The SIC power system, which serves the populous central region including the main consumption centres around the capital Santiago, had installed generating capacity of around 11,600 MW in 2010, while the Sistema Interconectado Norte Grande (SING) power system, which serves the major mining and minerals processing operations in the north of the country, had installed capacity of nearly 3,700 MW in 2010. The Aysén System in the
south and the Magallanes System in the far south are relatively small and isolated remote area power systems with a combined installed generating capacity of around 150 MW in 2010.

Hydro power dominates Chile’s electricity generating mix, representing over 40% of total capacity, and around 45% of capacity supplying the SIC power system. Gas-fired or dual fuel (gas-diesel) plant and coal-fired plant each represent around one-quarter of the remaining generating capacity. Thermal capacity dominates the SING power system where it represents nearly all of the available generating capacity.

Over the last decade, significant gas-fired power generation was built (especially in the SING power system where it represents around 60% of total capacity), with the intention of relying on Argentine gas imports. Many of these gas-fired power plants were upgraded to become dual fuel (gas-diesel) capable, whilst others began sourcing their gas from the Mejillones LNG plant following the cessation of Argentine imports in 2008.

Although Chile enjoys relatively comfortable reserve capacity margins by OECD standards\(^7\), the combination of recent major droughts, continuing concerns over access to competitively-priced gas supplies and expectations of strong demand growth into the medium-term, have encouraged plans for substantial investment in new generating capacity. New investment is focusing on diversification of base-load generation capacity with coal-fired plant representing around half of the additional generation capacity under construction. The Chilean Government is also analysing instruments to foster the penetration of electricity from new renewables to help diversify the electricity generation mix while reducing carbon emissions.

**Electricity Import Dependency**

An Argentinean power plant (located near Salta) was connected to the SING power system until 2010. It typically provided 10% to 15% of power consumed per annum prior to its disconnection. Chile has not imported or exported any electricity on a regular basis since then. Although there are no firm plans to develop a cross-jurisdictional regional transmission network, some preliminary discussions are proceeding on the potential for international interconnections.

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7 Reserve capacity margins are typically between 15% and 30% in OECD countries.
4.2 Networks

The reliable supply of electricity is integral to economic growth, and electricity transmission assets provide the critical link for transmission of electricity from generators to electricity consumers.

Transmission ownership in the SIC power system is dominated by Transelec, which operates around 7,500 circuit kilometres of transmission lines (50% of total SIC transmission capacity) including all of Chile’s 500 kV transmission lines linking the main centres of hydro generation in the south to the main centres of load in the central region around Santiago. By contrast, transmission ownership in the SING power system is distributed among several owners with five companies controlling between 10% and 20% of the transmission capacity each and around 75% of total capacity. Distributed ownership reflects the more decentralised development of the SING power system which has grown to meet the needs of the mining and minerals processing sectors.

New regulated transmission investment is determined through a centralised process involving a holistic planning phase (the transmission ‘trunk’ study) and subsequent tendering process. Twenty-one new transmission system investments valued at around USD 880 million were tendered following the most recent process. Merchant interconnector investments are permitted but there is little incentive to make such investments in the absence of a certain regulated return on investment.

As noted previously, Chile’s electricity sector comprises four distinct electrical systems. The distribution of electricity generation and load combined with the country’s geography makes development of an integrated transmission system spanning the whole of Chile impractical. In 2000, Transelec investigated connecting the SIC and SING power systems. The proposal involved a 600 MW line running for over more than 1,000 km. The analysis concluded that such an investment would not be cost-effective at that time. However, the potential for interconnecting the two larger power systems has been raised in 2011 by the Piñera Administration as a means of bolstering power security.

Dispatch and system operation in the SIC and SING power systems are managed by separate Economic Load Dispatch Centres (Centros de Despacho Económico de Carga - CDEC’s). Distribution systems are managed by companies operating under a public service distribution concession regime with service obligations and regulated prices.

4.3 Electricity Security Experience

Generation has proven to be quite resilient in the face of varying disruptions. However, transmission and distribution networks can be more fragile, reflecting the “radial” nature of much of the power system. In some cases network paths are served by single lines and ancillary equipment, exposing the system to critical infrastructure weaknesses and making application of the N-1 standard more problematic than in other more integrated power systems. A power system is considered N-1 secure when it is capable of maintaining normal operations in the event of a single credible contingency event, like the loss of a transmission line, generator or transformer.
Four major electricity emergency events between 2008 and 2011 have exposed some weaknesses in emergency preparedness and management arrangements.

The first was the severe drought in 2008 that substantially affected the hydro-dominated SIC power system. Its impact was exacerbated by transmission network constraints and the cessation of gas supplies from Argentina.

More recently, the major earthquake on 27 February 2010 severely disrupted distribution networks within the SIC power system, particularly in Regions VI and VII. Restoration procedures operated successfully with around 95% of consumers in the Santiago area reconnected within 4 days and services restored to the remainder of the SIC power system within two weeks.

A related disruption occurred on 14 March 2010, some 2 weeks after the earthquake, when a transformer on a line bringing electricity up from the southern part of the SIC power system failed. This failure created an overload on the other transformer, which led to a cascading system failure and blackout across the SIC power system.

At the end of September 2011, Chile suffered another major blackout across the SIC power system. In December 2011, the SEC determined that the cause of the blackout was an electrical short circuit in a capacitor bank at an electrical substation and the subsequent malfunction of the relay equipment that should have prevented the cascading failure. SEC also determined that the time needed to restore power was prolonged by both procedural and equipment issues.

These recent events especially highlighted opportunities to improve communication and coordination between key parties responsible for implementing emergency responses.

### 4.4 Electricity Emergency Policy

#### General Issues

A governance framework incorporating a substantial body of legislation and related regulations has been established to support the development of a more reliable and resilient electricity sector. The Ley General de Servicios Eléctricos 1982 (General Electric Services Law), as amended, remains the principal legislative instrument governing electricity security. Key electricity security provisions under the legal and regulatory regime include:

- Obligations for distribution concession holders to supply regulated customers;
- Measures establishing administrative procedures to ration electricity supply in response to an expected or actual extreme event, whether in real-time or of a longer duration (the rationing decree);
- Obligations for regulated network owners to undertake prescribed investments in the ‘trunk’ transmission system;
- Obligations for distribution companies to enter into long-term supply contracts with generators for up to 15 years;
- A range of technical standards including frequency, voltage and system stability requirements, and establishing the N-1 standard for system planning and operations; and
- Coordination of integrated electricity systems by a single system operator to maintain power system security.
Key institutions responsible for electricity security policy, regulation and implementation include:

- Ministry of Energy, which is responsible for developing and coordinating implementation of forward-looking policies, legal and regulatory standards, and plans to promote electricity security in a timely, effective and efficient manner.

- National Energy Commission - Comisión Nacional de Energía (CNE), which is the technical body responsible for analysing and developing technical standards, including developing rate processes and drawing up and coordinating plans, policies and standards for the smooth functioning of the electricity sector. It reports to the President through the Ministry of Energy.

- Supervisor of Electricity and Fuels - Superintendencia de Electricidad y Combustibles (SEC), which is responsible for monitoring and enforcing compliance with legal, regulatory and technical standards regarding safety, quality, price, generation, production, storage, transport and distribution, including imposing penalties and dealing with consumer complaints. It is overseen by the Ministry of Energy.

- Separate CDEC’s are responsible for planning and coordinating least cost and reliable electricity dispatch in the SIC and the SING. Both CDEC’s are owned and governed by the industry, with supervisory boards including representatives from generators, transmission owners and large users.

Recent emergency events, including the February 2010 earthquake, the March 2010 blackout of the SIC and the March 2011 Fukushima tsunami alert incident, have highlighted some opportunities to clarify and improve electricity security governance arrangements. The Ministry of Energy is in the process of developing clearer emergency operating procedures, and improving monitoring and coordination during emergency events.

**System Security**

In Chile, as with most other power systems around the world, power system security is based on application of the N-1 standard. In Chile, Service Recovery Plans have been developed to guide service restoration activities in the event of a power system failure. These plans specify roles, responsibilities, obligations on responsible parties and prescribe procedures for restoring services in a timely and efficient manner.

The system operators – CDEC-SIC and CDEC-SING – are responsible for monitoring and managing system security, including implementing and coordinating emergency response and recovery actions with other responsible parties, which include regional operation centres and local control centres operated by generators and transmission owners.

Chilean system operators can monitor and partially manage real-time power flows using their supervisory control and data acquisition system (SCADA). In Chile, real-time resources include various kinds of generation reserves for managing frequency and supply, reactive power reserves for managing voltage, and various forms of automatic and manual generation and load shedding.

The Government can complement Chilean system operators’ activities through regulatory intervention in response to potential or actual medium-term events that could threaten power supplies, such as a drought or other fuel shortage. In the event of an extreme fuel supply...
shortage or other on-going emergency event, the Government can issue a rationing decree to control electricity consumption.

There have been substantial power outages since 2008, as discussed in paragraph 4.3, which have exposed some weaknesses in emergency preparedness and management arrangements.

These events highlighted some strengths, especially in relation to the execution of recovery plans and processes which were generally implemented effectively and supported timely restoration in most parts of the system. They also exposed several weaknesses, including some communication and coordination difficulties that hampered restoration efforts during some blackouts. The Government is examining these events to identify key lessons and to develop responses including:

- Improving CDEC’s capacity to monitor and analyse power systems in real-time;
- Improving technical criteria for management of system security;
- More active involvement of system operators in network planning processes;
- Giving greater consideration to reliability in the context of network development decisions;
- Undertaking more holistic planning and network development reflecting anticipated changes in generation and usage patterns;
- Establishing maintenance programs, operational procedures and practices that reflect international best practice; and
- Establishing more effective training and certification systems that build expertise and competence, especially in managing emergency events.

**Technical & Operating Standards**

Chilean system operators apply the N-1 standard to manage all credible contingencies, reflecting operational resource constraints and system operator judgement and experience. However, infrastructure constraints, especially in the SIC system have meant that the system may not always operate in a manner that ensures N-1 security for all potentially credible contingency events. For example, N-1 is not fully applied to transformers, which are a critical component in any power system. Contingency planning also does not take into account the possibility of abnormal operation of protection and control systems. The March 2010 blackout of the SIC system highlighted the risks associated with this approach.

Significant new transmission investments are underway, which will facilitate the full application of the N-1 standard to major transmission paths within the SIC power system. However, application of the N-1 standard to date raises concerns about the nature and scope of N-1 application. There may be other key elements that are not compliant or credible contingencies which have not been examined and properly addressed.

**Real-Time Emergency Management Practices**

At present, the CDEC-SIC manages system security with limited real-time SCADA data and without the benefit of a real-time emergency management system that can support real-time modelling of the impact of credible contingencies and formulation of appropriate response actions.

The Government has committed to upgrading CDEC-SIC’s real-time data and emergency management systems to improve situational awareness and analytical capability. Recent Chilean
electricity emergency events discussed above have highlighted the importance of resilient and effective emergency communications, protocols and control capability. There have also been recent efforts to address the communications infrastructure and procedural deficiencies exposed during the March 2010 blackout in the SIC.

The CDEC-SIC does not possess an independent back-up control centre, and in the event of a primary control centre failure would be reliant on local control centres operated by generators and network owners.

Emergency management responses rely heavily on various forms of automatic load and generation shedding and supply-side contingency reserves. A six-step load shedding protocol has been developed for the SIC, which in the event of an emergency could be rapidly deployed to disconnect up to 21% of load. Similar arrangements could be rapidly deployed to shed up to 37% of load in the SING system.

Automatic generation control and load shedding has proven a very effective initial response to help avert power system failures, especially in radial power systems with relatively ‘thin’ transmission paths and which are prone to ‘islanding’, like Chile’s power systems. Automatic response capability needs to be complemented with effective manual response capability to ensure that system operators are able to respond effectively in real-time to any credible contingency. This requires well trained personnel and access to adequate, flexible resources.

In Chile, responsible generators and network owners are legally obliged to have contingency plans which enable them to effectively support emergency management and restoration activities. SEC is responsible for monitoring and verifying compliance.

Recent emergency events have served to highlight the importance of effective business continuity planning and management, clear communication, the ability to effectively coordinate responses with other responsible parties in real-time, and predictable and reliable operation of key infrastructure during an emergency event, especially blackstart facilities.

- **Medium-Term Emergency Management Practices: The Rationing Decree Mechanism**

Chile has developed an administrative approach – the Rationing Decree mechanism - for managing its exposure to medium-term fuel supply shortages that can affect the electricity sector. The approach reflects the isolated nature of its power systems and their exposure to upstream fuel supply risks, especially droughts affecting the SIC where hydro-power is the dominant form of power generation.

A rationing decree is a ‘last resort’ mechanism which is only declared in response to an expected or actual extreme and prolonged disruption to fuel supplies or extended failure of a power plant that have the potential to substantially disrupt normal power production. Declarations are made by the Ministry of Energy on the advice of CNE.

The mechanism incorporates a preventative phase in the lead-up to an expected emergency fuel event which involves deploying of measures to help avoid a projected deficit. It also sets the rationing measures to be deployed and specific rules governing the rationing strategy to be implemented in the event that the preventative measures prove unsuccessful. The full rationing strategy phase involves more prescriptive and stringent electricity rationing which applies for the duration of an emergency fuel shortage.
Key principles and features of the rationing decree mechanism include:

- Preventative nature of the instrument, which allows measures to be taken in advance to avoid a projected deficit;
- Proportional distribution of any rationing to ensure equity;
- Declaration of essential users, where service cuts can unduly threaten public health, safety, access, or economic activity;
- Payment of compensation by generators through distribution companies to end users for any shortfall in supply resulting from the rationing program. The level of payment is determined by the regulator as the difference between the assessed failure cost and the basic power price;
- CDEC coordination of production from all deep-storage hydro-plants to ensure maintenance of an effective water reserve;
- Ordering generators and distribution companies to adopt energy saving measures in addition to rotating cuts;
- Adoption of lower service quality standards, such as reduced voltage; and
- Fast-tracked connection of new generating capacity.

A full rationing decree was declared in 1998-99 and a preventative decree declared in 2008 for the SIC system. Another preventative decree was declared for the SIC system in February 2011 in response to two of the driest years on record. It remains in force as of the end of 2011.

- Training & Capacity Building

Emergency management training is undertaken annually and includes key operations personnel from generators and network owners with responsibility for system security. CDEC-SIC training programs focus on restoration processes and implementation, based on a more theoretical approach that does not incorporate a practical emergency response exercise component. CDEC-SING training incorporates practical simulations.

The Government has proposed to review options to establish more effective on-going training and certification systems for key personnel responsible for maintaining power system security.

Adequacy

Rapidly growing demand, especially within the SIC system, and the dominance of industrial consumption has implications for the way in which existing infrastructure is operating to provide adequate electricity services today and for the nature, location and timing of generation and network investment needed to maintain adequate electricity services into the future.

- Generation

Trends in generating capacity and demand indicate that very comfortable reserve margins were maintained over the last decade and that the reserve margin should be more than adequate to deliver reliable and resilient electricity supplies. On a national basis, reserve margins grew over the course of the last decade from around from around 4,400 MW, or 63% of peak electricity demand in 2004, to around 7,100 MW, or around 84% of peak electricity demand in 2010.
Reserve generating capacity for the SIC system more than doubled from around 2,400 MW in 2004 to over 5,300 MW in 2010, representing an increase in capacity margin from around 44% to nearly 82% of peak demand over the period. Reserve generating capacity for the SING system changed little over the period, falling marginally from 2000 MW in 2004 to around 1,800 MW in 2010, representing a modest reduction from very high capacity margins of around 127% in 2004 to around 92% in 2010.
Substantial and growing reserve margins may be partly explained by the combination of: rapidly growing demand; the isolated and radial nature of these power systems, requiring higher levels of redundant capacity to ensure system security and adequacy than more highly meshed and integrated regional systems; and by their proven vulnerability to fuel supply disruptions.

For instance, deep storage and run-of-river hydro plants represented around 45% of total generating capacity in the SIC system in 2010. Reducing capacity utilisation factors for these facilities to 15% to simulate the potential impact of an extreme and sustained drought would effectively reduce the reserve margin by over 4,500 MW, from a comfortable 5,300 MW to around 730 MW, leaving a relatively tight capacity margin of around 11.3% of peak demand in 2010. If these conditions were to persist with no new capacity added and peak demand were to grow at projected rates of around 6% per annum, then the reserve capacity margin would disappear within two years.

Similarly, for the SING system where gas-fired plant represented around 57% of total generating capacity in 2010, reducing gas-fired plant capacity utilisation to 25% to simulate a sever loss of gas supplies would reduce the effective reserve margin by nearly 1,600 MW to a little over 250 MW, representing a reserve capacity margin of around 12.7% of peak demand in 2010. If these conditions were to persist without the addition of new capacity and with peak demand growing at projected rates of 6% per annum, then the reserve capacity margin would be almost completely absorbed in two years. Such an outcome is highly unlikely in the SING given the substantial investment undertaken to convert much of its gas-fired capacity into dual-fuel capable plant, and the diversification in gas supplies (LNG) in the wake of the declining availability of Argentinean gas from 2004.

Securing sufficient, timely and well located generation investment up to 2020 will be crucial for maintaining secure and reliable electricity supplies, given expected rapid growth in electricity demand and demonstrated vulnerabilities to fuel supply shocks.

Substantial new generation investment is either under construction or planned over this period. In 2011 nearly 1,800 MW of new capacity was under construction in the SIC system, mostly either coal-fired or hydro plant. An additional 530 MW of new capacity was under construction in the SING system, mostly coal-fired. Planned new generation is also substantial. The Government anticipates construction of a further 4,390 MW of generating capacity in the SIC and a further 1,920 MW in the SING over the remainder of the decade. Capacity under construction and expected new capacity additions during the next decade total over 8,600 MW, which if realised would be more than sufficient to meet projected demand growth and leave a comfortable maximum reserve capacity margin of around 60% of peak demand on a national basis.

However, realisation of all these investments is far from certain. Substantial risks exist that could delay or defer some of these projects including: growing community opposition to new generation investment, especially large-scale hydro projects; poor coordination with network development; and difficulty securing sufficient, affordable finance in the wake of the global economic slowdown. However, the most significant of these risks would appear to be securing relevant construction, environmental and operational approvals.

To illustrate: a proponent may need to obtain up to 59 different regulatory approvals before a project can proceed, 24 of them relate to environmental matters while the remaining 35 are specific to the electricity sector. All of the environmental approvals are grouped into a single process. Typical approval processing periods for a new generation facility are around 333 days
for obtaining environmental approvals, 204 days for construction approvals and a further 138 days for the generation concession. A series of measures are being developed to streamline approval processes.

Experiences with droughts and gas fuel shortages (see paragraph 4.3) have reinforced the importance of seeking to diversify the generation technology and fuel mix, to help improve reliability and resilience of electricity supply. Diversification is reflected in recent and proposed new generation capacity additions, with increasing deployment of coal-fired technologies offering the potential to moderate existing fuel supply risks. However, coal-fired generation technologies are relatively carbon intensive, which may make them a less economically and environmentally sustainable option in the longer-term.

Policies to encourage the timely and cost-effective deployment of new renewable technologies have the potential to improve diversification of the generation mix and to support the development of a more reliable and resilient electricity supply. In this context the Government has announced initiatives aimed to expand the share of new renewable generation in the electricity mix. A range of measures have been implemented to support new renewable generation, most significant of which is a legal obligation on industry to generate 10% of its electricity from new renewable sources by 2024. A penalty of around USD 30 MWh applies to responsible parties that fail to meet specified volume targets. However, these penalties may not be sufficient to ensure effective compliance.

- Networks

The two major power systems – the SIC and SING – are radial in nature with limited transfer capability in places. Power flows are in places reliant on single transmission paths that can be prone to congestion and have limited resilience in response to the loss of a key component like a transmission line or transformer. Breaking down of these integrated systems into smaller electrical regions, commonly referred to as ‘islanding’, is a serious and ongoing risk in this context, which can weaken overall system security and reliability of power supplies.

Emerging patterns of generation investment and rapidly growing demand are combining to change power flows, especially in the SIC, creating new points of congestion that have the potential to constrain system flexibility and jeopardise the adequacy. These weaknesses were exposed during the 2008 drought, where network congestion in the north of the SIC constrained the ability of thermal generators to compensate for the loss of hydro generating capacity from the south, prolonging and intensifying the impact of the drought on power supplies in the region.

Substantial new regulated investment is identified in the first ‘trunk’ transmission study of 2011. ‘Trunk’ transmission studies are to be made every four years to identify and prescribe regulated investments to be undertaken over the subsequent period. Only projects identified in the ‘trunk’ transmission study can be included in the regulated asset base. Projects are tendered, with the winning tenderer legally obliged to make the approved investments within the agreed period. Successful tenderers under the regulated work program have five years to complete their projects. Merchant network projects are permitted but they must recover costs directly from market participants.

Under the first work program 21 projects worth around USD 880 million have been tendered, representing nearly 60% of the value of the Chilean transmission trunk system and more than
doubling the average annual transmission system investment levels. Key projects will reinforce north-south power flows in the SIC, improving system integration when it is under stress, and add new circuits to improve the resilience of key transmission paths, with the potential to support more effective application of the N-1 standard.

Timely and well located transmission network augmentation will be required to remove undue bottlenecks to efficient and more flexible power flows that can help to improve power system reliability and resilience. Like with new generation capacity delays in approvals processes have the potential to undermine timely investment responses, leading to undue congestion that could jeopardise reliability and power system security. The typical approval processing periods for new transmission projects are around 155 days for obtaining environmental approvals, 132 days for construction approvals and a further 290 days for the transmission concession. Distribution concession approval processes are even more protracted with a typical processing period of around 554 days.

Uncertainty over transmission investments have the potential to delay or defer related generation investment which can magnify the potential negative impact on power system reliability and resilience.

Previous studies into SIC-SING integration have concluded that the economic benefits would be insufficient to justify a regulated investment. These studies focused on the economic benefits, not on the reliability and resilience dividends. Integration could bring diversity benefits and possibly lower overall system prices, but energy losses could be significant and extensive transmission system augmentation may be required to realise the full benefits of integration.

**Fuel Security**

Chilean electricity systems are particularly vulnerable to hydrological conditions and fuel shortages as demonstrated during 2008 where the combination of drought and gas supply shortages following the effective cessation of imports from Argentina simultaneously affected power production in the SIC and SING systems.

Following these events, substantial efforts were made to increase power system flexibility and resilience in response to fuel supply shortages. A major program of retro-fitting existing thermal plants with dual-fuel capability has been undertaken since 2008. By the end of 2011, over 4,500 MW of thermal power capacity has dual-fuel capability, with around 2,450 MW of dual-fuel thermal plant in the SIC system and nearly 2,100 MW in the SING system. Substantial investments have also been made to create and upgrade upstream fuel importing facilities, notably the new Quintero LNG receiving terminal, as discussed in the earlier gas chapter. These initiatives have served to improve diversity of fuel supply and generator flexibility, providing a substantial response to the main fuel security issues facing the Chilean electricity sector.
Map of Chile’s Regions

These maps are for illustrative purposes and are without prejudice to the status of or sovereignty over any territory covered by these maps.
The International Energy Agency (IEA), an autonomous agency, was established in November 1974. Its primary mandate was – and is – two-fold: to promote energy security amongst its member countries through collective response to physical disruptions in oil supply, and provide authoritative research and analysis on ways to ensure reliable, affordable and clean energy for its 28 member countries and beyond. The IEA carries out a comprehensive programme of energy co-operation among its member countries, each of which is obliged to hold oil stocks equivalent to 90 days of its net imports. The Agency’s aims include the following objectives:

- Secure member countries’ access to reliable and ample supplies of all forms of energy; in particular, through maintaining effective emergency response capabilities in case of oil supply disruptions.
- Promote sustainable energy policies that spur economic growth and environmental protection in a global context – particularly in terms of reducing greenhouse-gas emissions that contribute to climate change.
- Improve transparency of international markets through collection and analysis of energy data.
- Support global collaboration on energy technology to secure future energy supplies and mitigate their environmental impact, including through improved energy efficiency and development and deployment of low-carbon technologies.
- Find solutions to global energy challenges through engagement and dialogue with non-member countries, industry, international organisations and other stakeholders.

IEA member countries:

- Australia
- Austria
- Belgium
- Canada
- Czech Republic
- Denmark
- Finland
- France
- Germany
- Greece
- Hungary
- Ireland
- Italy
- Japan
- Korea (Republic of)
- Luxembourg
- Netherlands
- New Zealand
- Norway
- Poland
- Portugal
- Slovak Republic
- Spain
- Sweden
- Switzerland
- Turkey
- United Kingdom
- United States
- The European Commission also participates in the work of the IEA.